

*The*  
**COLORADO**  
*Engineer*

MARCH 15, 1963



**EYES MADE FOR DARKNESS** Westinghouse scientists expect that airplane pilots are going to be able to see the ground clearly on a cloudy, moonless night. Astronomers will be able to see vastly beyond the present range of their telescopes, perhaps to the final boundary of the universe, if there is one. Policemen will peer into dark alleys and see through special binoculars. Scientists at Westinghouse are working on the proposition that no matter how dark it looks to us, there is plenty of "light" everywhere: on a black night, in a coal mine, in a sealed room. We just have the wrong kind of eyes to see it all. So they have developed a device that "sees" infrared light which we can sense only as heat...another device that "sees" ultraviolet light, which we can detect only when it gives us sunburn...still another that picks up a single "packet" of light, the smallest amount that can exist, and multiplies it into a visible flash. You can be sure...if it's

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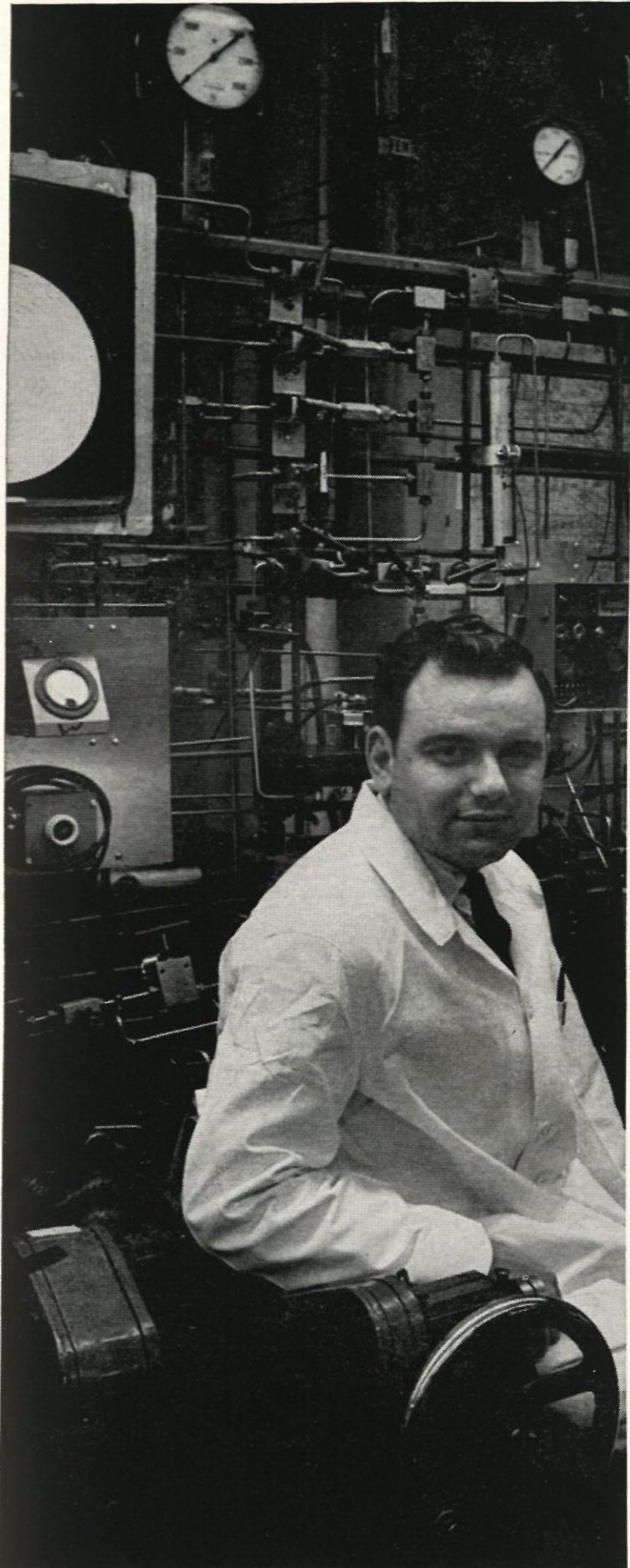
Compared to steel, the tubular-shaped glass filament composition has greater energy storage potential—is stronger and more flexible under heavy load. It may well prove to be the automobile suspension material of tomorrow . . . cars suspended on glass!

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by Jim Koller*

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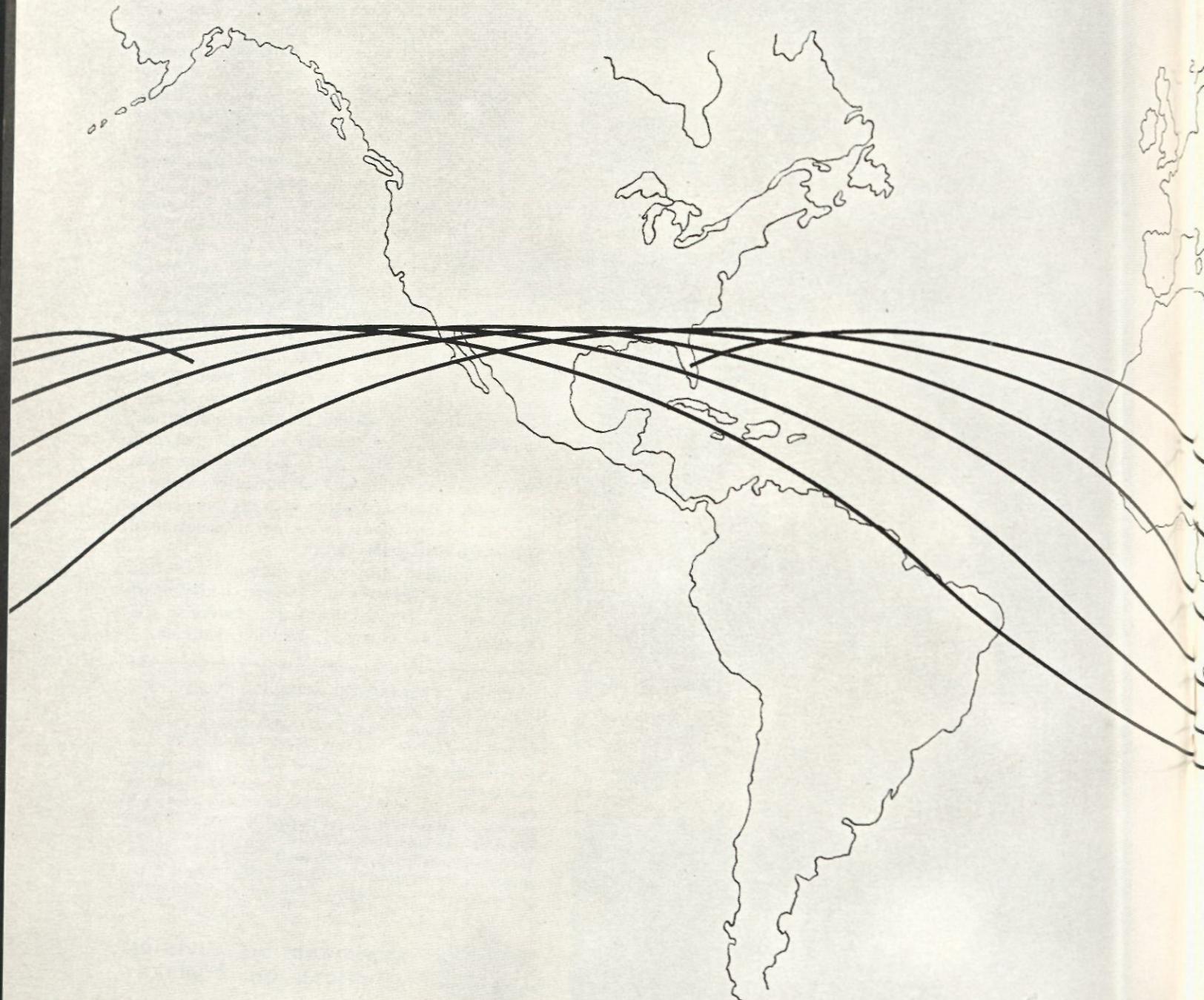


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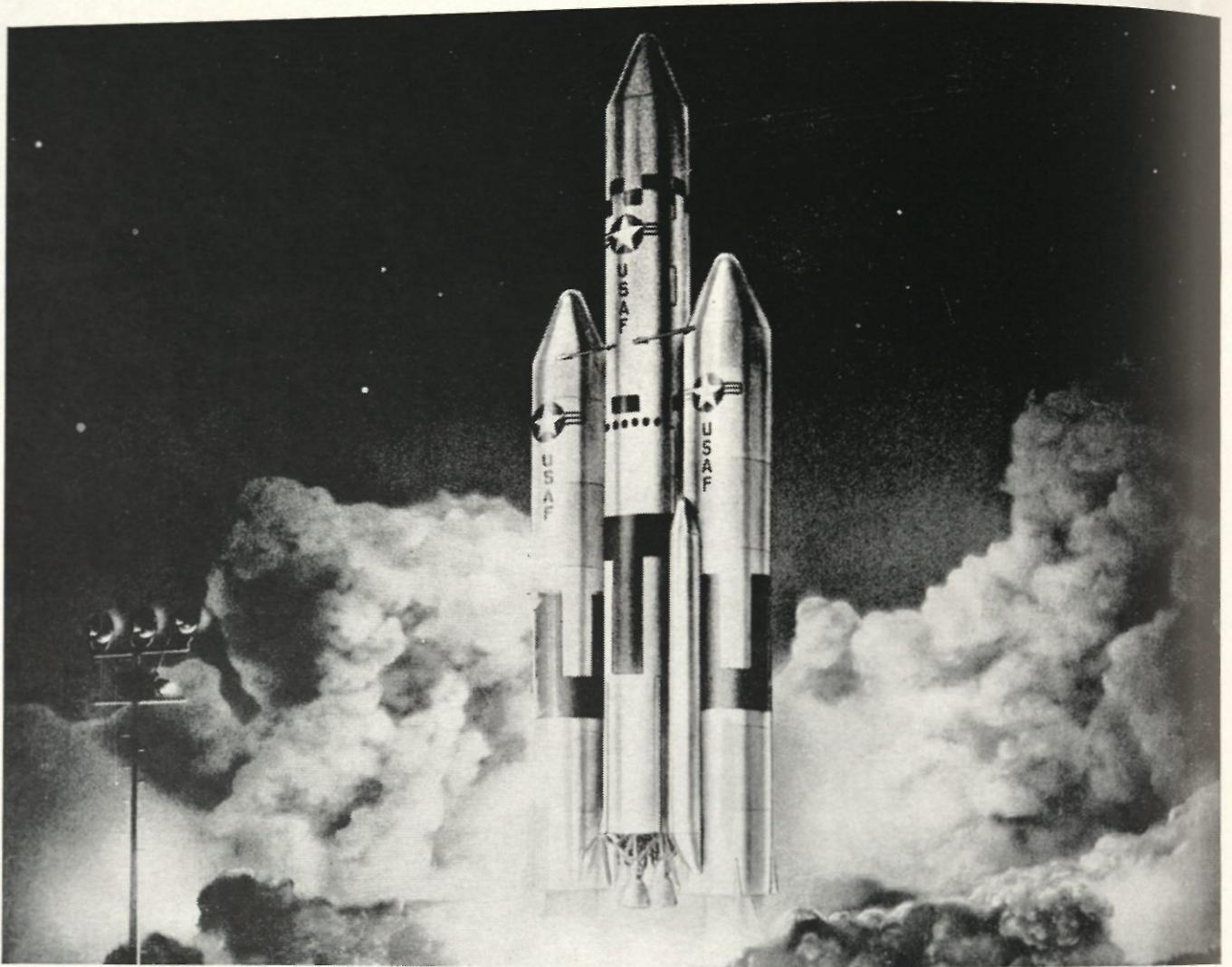


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# The COLORADO Engineer

UNIVERSITY OF COLORADO, BOULDER, COLORADO

VOLUME 59

NUMBER 3

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The cover depicts the Solarimeter designed by Camp Tibbals. This Instrument is used to help biologists and ecologists measure the energy exchange between plants and their environment. (See page 11)

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# The University and Political Mud

In November 1962, Charles D. Bromley was re-elected to the office of Regent of the University of Colorado. His campaign platform—to rid the University of its president. In that same election Dr. Dale Atkins was also elected. In his campaign he had expressed a desire to rid the University of its president. On December 5, 1962, President Quigg Newton resigned his position as president of the University of Colorado. In February, an article appears in the "Perspective" section of the Denver Post which explained why spirits were low on the C. U. campus. One of the reasons was that many people on campus felt that the Board of Regents would keep the University in a political turmoil. Another—it was felt that many top flight administrators and faculty would now leave the University. In that same month, the Board of Regents met, ostensibly, to consider removal of a certain professor from his position as head of a department. The meeting degenerated into a sordid free-for-all. Supposedly educated men shouted personal invectives that would make a sailor blush. There were threats of bodily violence. Said one observer, "I was shocked to think that supposedly educated, civilized men could act in this manner." One week later the Provost of the University, a man of international reputation, resigned to take a job elsewhere.

The University of Colorado has become a political toy. Feeling runs high. People are "removed" from office, not because they are incompetent—note Newton and Tippo moved to better jobs not worse ones—but because a politician decides to create an issue, or else has a personal axe to grind. Nobody any longer cares for the fact that the University has made tremendous strides towards academic excellence in the past six years, rather they consider only those things which our political sadist wants them to consider. e.g. The editor of the campus newspaper says some things which are admittedly in exceedingly bad taste, and is not immediately squashed. Let us hang the man who allowed this to happen, let us hang the man who believes students are capable of thinking for themselves, who believes in freedom of thought on a University campus. It's a shame that he happens to at the same time be the man who is leading the University towards a place of national prominence. But we must have our scapegoat. The University is a political football. The government of Colorado makes a complete change in political parties. The University of Colorado is hunting for a new president. Every two years the University community looks around in dread. The politicians are grinding their axes.

What kind of president will move in to the University? There are two years between elections, that means he will have two years to build. Absolutely nothing can be accomplished in two years. Therefore a man who knows that he can accomplish absolutely nothing anyway will accept the job. Good farmers don't attempt to farm in sterile soil, they move elsewhere. Good administrators don't try to guide a university to excellence when the people want mediocrity, they move elsewhere. Poor farmers who can't go anywhere else stay on sterile soil. Poor administrators who can't go anywhere else stay with a mediocre school.

Hail the politicians, they emerge victorious. But the University did have such nice plans.

The University should not be a political football. The University need not be a political football. If the Board of Regents were appointed rather than elected, the University would come before the critical eyes of the public in a natural manner. When the University is doing exceedingly poorly it should be brought to the attention of the public. Have no fear that this will not be the case. There are many people around who love to keep an eye on the University. But the University *should not* be artificially aired before the public eye every two years, just because some politician wants to be elected. Let us make the office of Regent an appointed office. Let us get the University of Colorado out of the political mud.

—Lowell Brooks



**Design**

**And**

**Use**

**Of a**

# SOLARIMETER

CAMP TIBBALS

Biologists and ecologists interested in the energy exchange between plants and their environment have difficulty using the normal engineering form of the radiation heat transfer equation. For most engineering applications an equation of the following type is suitable.

$$Q = \alpha_2 \epsilon_1 S_{1,2} A_2 \sigma (T^4_1 - T^4_2)$$

Q = Net energy transferred to surface 2 by surface 1

$\alpha_2$  = Absorptivity of surface 2

$\epsilon_1$  = Emissivity of surface 1

$S_{1,2}$  = Geometrical shape factor relating the two surfaces

The reason why this equation is of little value to ecologists is realized when the complexity of the surroundings of a leaf is considered. Imagine, for example, the difficulty in determining the temperature of the surroundings of a plant in its natural habitat. The plant of course receives radiation not only from the sun, but from the clouds, from the sky, from the ground, and from other plants surrounding it. Try to evaluate the temperature of each of these sources

of radiation and its geometric relationship with the plant, or more exactly with the particular leaf in question, would be an almost impossible task.

From these considerations it is apparent that a different approach to this problem is required. If the basic radiation equation is examined it is noted that any surface loses energy by radiation according to the following

$$Q_{\text{lost}} = \epsilon A \sigma T^4$$

$Q_{\text{lost}}$  = Energy lost by radiation from surface

A = Area of surface

$\epsilon$  = Surface emissivity

$\sigma$  = Boltzman's Constant

T = Absolute temperature of surface

This energy loss is relatively easy to evaluate if the emissivity of the surface is known. All that is required is to measure the area and temperature of the surface.

If then, the total incoming radiation,  $Q_{\text{incoming}}$ , is known then a simple difference will yield a measure of the

net energy gained or lost by the plant.

$$Q_{\text{net}} = Q_{\text{incoming}} - Q_{\text{lost}}$$

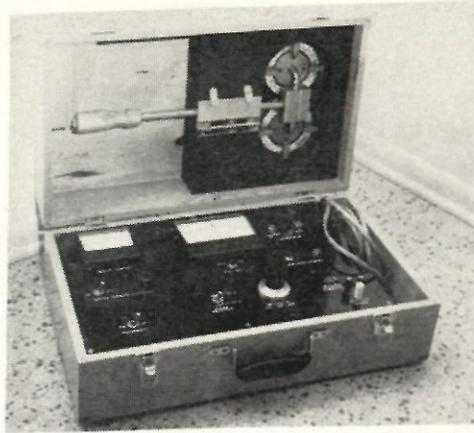
It is obvious at this point that an instrument which could measure incoming radiation directly without reference to its source will be very useful to the ecologist.

Instruments of this type have been built in laboratories in Europe. However, none are commercially available in this country. The need for this instrument became known to me through work which I am doing for Dr. David M. Gates on an NSF Grant for investigation of energy exchange between plants and their environment. The instrument, called a solarimeter, because one of the principal sources of radiation it measures is the sun, was designed and entirely constructed at the University of Colorado.

## Principle of Operation

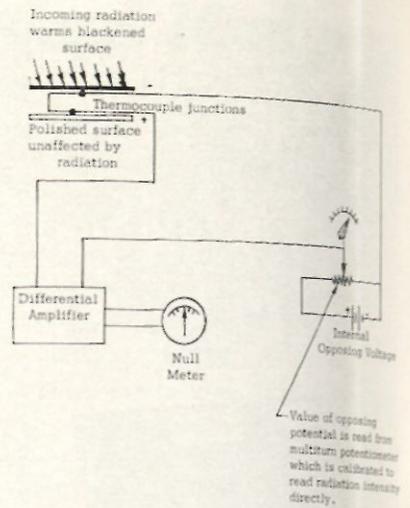
This instrument, like most other radiation measuring devices, actually measures a surface temperature which is influenced by the amount of radiation received by the surface. There are two surfaces which are blackened

and two surfaces which are mirror polished in our instrument. One of the blackened surfaces and one of the polished surfaces are heated electrically. The heating is used to compensate for convective heating and cooling which cannot be eliminated. There is a difference in temperature between the blackened surfaces and the polished surfaces caused by the radiation which is to be measured. This temperature difference is measured by means of a thermopile. The signal from the thermopile is measured by a potentiometer circuit, employing a transistorized DC differential amplifier for null detection. The instrument has a sensitivity of .001 calories per square centimeter per minute, and a range from 0 to 2 calories per square centimeter per minute. This range is sufficient for most all measurements made at this altitude and can be extended for use in the tundra where the radiation intensity at times exceeds the solar constant. The response of the instrument is relatively slow, and 35 seconds to reach 85% of a step increase. This however, effects no serious limitation on the use of the instrument because all of the proposed uses of it will be in equilibrium or steady state conditions. The slow response also provides stability a-



SOLARIMETER IN CARRYING CASE.

gainst changes due to sudden wind gusts and other momentary changes. The solarimeter will be used by Dr. Gates and others in the Institute of Artic and Alpine Research in their investigations of energy transfer between plants and their environment. The ultimate goal in this study is to enable an ecologist to make certain physical measurements on a given plant and then predict the effect of placing the plant into a new environment. This project shows well the benefits which can be gained by applying engineering skills to problems in the life sciences.



SIMPLIFIED SCHEMATIC SHOWING INSTRUMENT OPERATION.

The author, a 1962 graduate in Mechanical Engineering, won the regional American Society of Mechanical Engineers' Paper competition in 1962 with somewhat similar type of radiation detector used for temperature measurement (COLORADO ENGINEER page 9, May 1962). The author is presently enrolled in the University Graduate School pursuing a M.S.M.E. Degree. The research which is described in this article was done under the supervision of Dr. David M. Gates, Consultant to the Director of the National Bureau of Standards, and supported by a National Science Foundation Grant to the Institute of Artic and Alpine Research.



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## To catch an atom...

Did you know that only one in every 140 uranium atoms found in nature can be split to produce usable nuclear energy? It takes fantastically intricate equipment to capture these elusive atoms. The people of Union Carbide are doing it in a plant at Oak Ridge, Tennessee, large enough to hold 35 football fields. ► Many people thought the uranium separation process too complex to work. For example, pumps had to be developed, that run faster than the speed of sound . . . filters made with holes only two-millionths of an inch across. Union Carbide scientists and engineers not only helped design such a plant and made it work, 20 years ago, but they have been operating it ever since. Union Carbide also operates other vital nuclear energy installations for the U.S. Atomic Energy Commission. One is Oak Ridge National Laboratory, the largest nuclear research center in the country. ► To handle such big research and production jobs requires big, experienced industrial companies. It is only because of their extensive resources and skills that it is possible to take the giant steps needed to bring laboratory developments to full-scale production quickly and successfully.

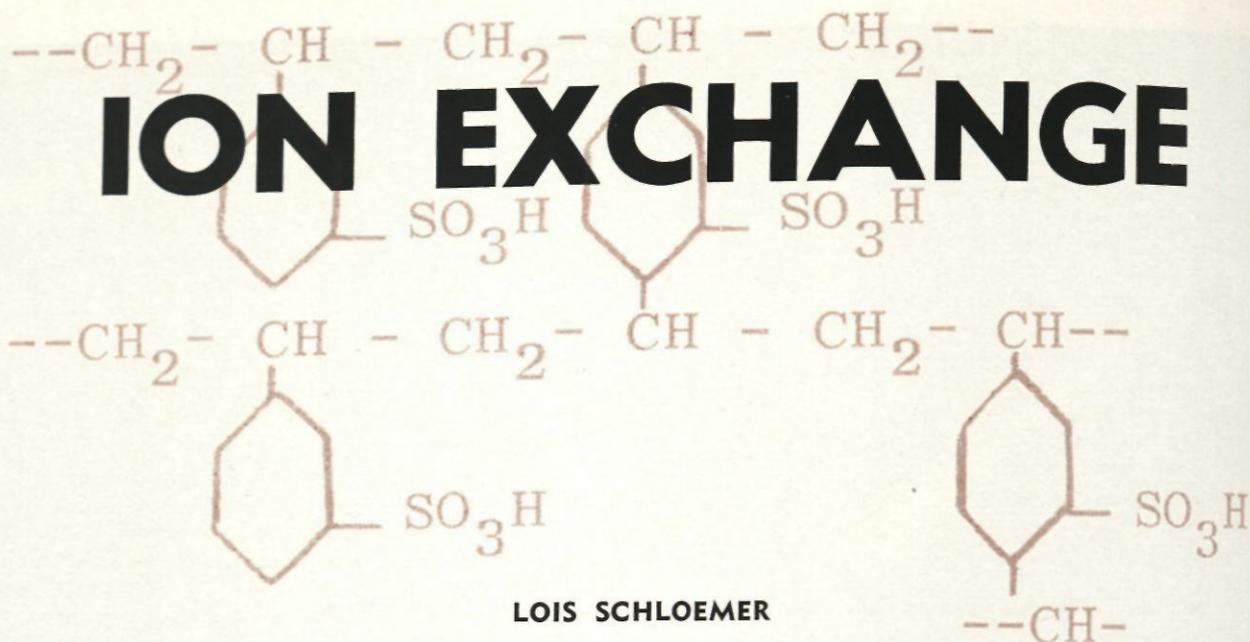
**A HAND IN THINGS TO COME**

**UNION  
CARBIDE**

**WRITE** for the booklet, "Union Carbide's Twenty Years in Nuclear Energy."

January 18, 1963, marked the 20th anniversary of the Corporation's work at Oak Ridge.

Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada, Union Carbide Canada Limited, Toronto.

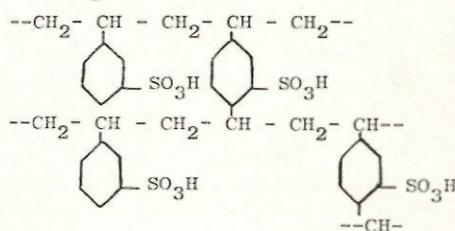


The chemistry of separation and purification was revolutionized when a spectacular evolution began in 1935 with the discovery of two English chemists, Adams and Holmes, that crushed phonograph records exhibit ion-exchange properties. Today, ion-exchange is firmly established as a unit operation and is an extremely valuable supplement to other proton, extraction and adsorption. Ion-exchange is a type of chromatography which utilizes resinous exchangers. The process has become valuable in separating, from mixtures, traces of substances in dilute solutions; in concentrating and removing impurities; and in separating metals through complex ions. The study and development of the principles and applications of elution chromatography have been explored in the research of Dr. Harold Walton of the Chemistry Department. The intensive study is being supported by the U. S. Atomic Energy Commission.

The first successful ion-exchange, 1944, was a carboxylic acid resin prepared by co-polymerizing a cross-linking agent such as ethylene dimethacrylate with a vinylic acid such as acrylic acid  $\text{CH}_2 = \text{CHCOOH}$ . Later in the year d'Alelio introduced the most successful of all current resins—that obtained by first preparing a cross-linked aromatic resin by co-polymerizing styrene,  $\text{C}_6\text{H}_5 \cdot \text{CH} = \text{CH}_2$  with divinyl benzene,

$\text{CH}_2 = \text{CH} \cdot \text{C}_6\text{H}_4 \cdot \text{CH} = \text{CH}_2$ , and subsequently sulfonating it with concentrated sulfuric acid, a reaction which proceeds quantitatively

throughout the resin grains, introducing one sulfonic acid into each benzene ring. The structure of the resulting resin is:



The proportion of cross linking rings is directly controlled by the proportion of divinylbenzene to styrene used in the reactive mixture.

By the end of 1945, d'Alelio's sulfonated polystyrene resin was put on the market by the Dow Chemical Co. under the name "Dowex 50." This is a strongly acidic cation exchanger. Chloromethylation, rather than sulfonation, followed by treatment with a tertiary amine, produces the chloride form of a strongly basic anion exchanger.

Most of the modern resins meet the following requirements: (a) stability to hot water, (b) stability to common chemicals in solution, (c) only one type of functional group present, (d) obtainable in bead form of any desired size range, (e) range of weak and strong, acidic and basic-type available, (f) the degree of cross-linking controllable.

To understand the procedures and results of the experimentation, one must have some understanding of the physical properties of the resin and the principles of elution chromatography. The interior of a resin bead resembles a drop of concentrated electrolyte solution, and much of the behavior of ion-exchange resins can be explained by the use of this model. At the same time, there are important

differences between the interior of the resin and concentrated electrolyte solution. The properties of a polymer network, including its low dielectric constant, affect the ion-exchange behavior and in addition, the polymer acts to a certain extent as a solvent or adsorbent for certain organic compounds.<sup>1</sup>

The most common method for employing ion exchange is column operation in which the substance to be treated passes through a fixed bed of ion-exchange resin. There are two basic types of column operation, displacement and elution. In the first, the column is originally saturated throughout with an ionic species, A, and this is displaced and forced out of the column by an excess of species B. In elution chromatography, species A which is to be displaced, occupies only a thin band at the top of the column at first, the rest of the column being occupied by ions B; this band is gradually moved down the column by an excess of B, which in this case is more weakly bound by the exchanger A.

The principle of theoretical plates can be successfully applied to the elution type ion-exchange column. This principle treats the column as though it were composed of a finite number of segments, within each of which the solution and resin are presumed to come into equilibrium. Thus the "thickness of the theoretical plate" is really an experimental parameter which expresses the closeness with which resin and solution flows down the column. The slower the flow, the closer one comes to equilibrium and the narrower is the "theoretical plate," but the "plate" can never be much narrower than the diameter of the resin beads themselves. The distribution of the solute

Lois Schloemer is a junior pre-med majoring in chemistry. she will attend the University of California Medical School next fall.

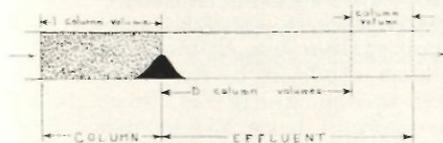
between the resin and solution can be expressed as a distribution coefficient  $D$ , where  $D$  is the amount of solute in the resin divided by the amount of solute in the solution in any given plate. The solute supposedly comes to equilibrium in each plate between the solution and resin before progressing to the next plate. This process continues on down the column as fresh solvent from above replaces the excess solute in plate  $b$ , and a portion of the remaining solute now comes into equilibrium in plate  $c$ . The solute which originally occupied a thin disk at the top of the column, is now spread out in a band, having its maximum concentration in a certain segment with smaller concentrations following and preceding it.

### Mathematical Analysis

Through mathematical analysis of the equilibria in each plate, the important conclusion emerges that

$$n_{\max} = p_{\max} \cdot D,$$

where  $n$  is the number of multiples of  $\Delta v$ , which is the volume of solution in one theoretical plate that has equilibrated with the  $p^{\text{th}}$  plate.  $D$  is the distribution coefficient. A very simple relationship exists between the volume of solution that must be passed through a column to elute the peak of a very narrow band of absorbed solute and the distribution coefficient. If the volume of solution retained in an ion-exchange is  $v$ , the column volume, and the volume of eluting solution  $V$ , the eluting volume, that has to be passed in order to move the peak of the elution band from the top of the column to the bottom, then the relationship will be  $D = V/v$ .



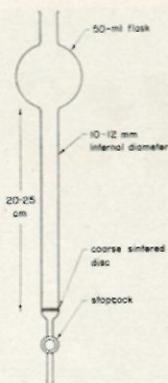
RELATIONSHIP BETWEEN ELUTION VOLUME, COLUMN VOLUME, AND DISTRIBUTION COEFFICIENT. THE "COLUMN VOLUME" IS THE VOID BETWEEN THE RESIN PARTICLES IN THE COLUMN. THE QUANTITY,  $D$ , IS THE DISTRIBUTION COEFFICIENT, EXPRESSED AS

$$\frac{\text{SOLUTE IN RESIN}}{\text{SOLUTE IN SOLUTION}}$$

IN ANY SEGMENT OF THE COLUMN.

One of the projects in the ion-exchange research is the establishment of the various  $D$  values for different systems. This is accomplished by equilibration tests. One measures the amounts of solute and solvent in the resin and in the solution at equilibrium. With this information one can predict column behavior, i.e., length of column necessary for separation, and optimum concentration of elutant.

All ion-exchanged resins have preference for a particular ion species



TYPICAL COLUMN USED IN ION-EXCHANGE CHROMATOGRAPHY.

which they will hold if given a choice. This preference is expressed as the selectivity of the resin. A relationship for the selectivity coefficient is formulated in analogy to the equilibrium constant expression of solution chemistry. For a monovalent-monovalent exchange and for a resin containing ion  $B$  placed in a solution of ion  $A$  and allowed to come to equilibrium, this equation applies:

$$A_{\text{sol}} + B_{\text{res}} \text{ greater than or less than } A_{\text{res}} + B_{\text{sol}}$$

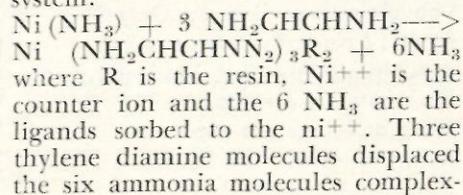
In this case, the selectivity coefficient,  $K$ , is defined as

$$K = \frac{[A_{\text{res}}] \cdot [B_{\text{sol}}]}{[A_{\text{sol}}] [B_{\text{res}}]}$$

where  $[A]$  and  $[B]$  are the concentrations of  $A$  and  $B$  in resin and solution at equilibrium. More complex relationships apply to exchanges between ions of different net charge. The more dilute the solution the more selective the exchange becomes for the polyvalent ion.

### Ligand Exchange

One of the newest adaptations of ion-exchange has been titled "ligand exchange." The method combines two fields of chemistry, namely ion exchange and co-ordination chemistry, in order to achieve a task that neither could do alone. One loads onto the resin beads metal complexing ions, such as  $\text{Cu}^{++}$ ,  $\text{Ni}^{++}$ , or  $\text{Ag}^+$ . Ligand exchange resembles ion exchange in that molecular species are exchanged—usually in stoichiometrically equivalent amounts—between the solid ion exchanger and an external solution. The essential difference is that in conventional ion exchange, counter ions are exchanged, whereas in ligand exchange, ligands are exchanged while the counter ion remains in the solid. The following equation may clarify the system:



ed with the  $\text{Ni}^{++}$ . The now complexed ethylene diamine is then eluted from the column by a concentrated solution of ammonia.

The successful application of ligand exchange hinges on keeping the complexing metal ion in the resin. Displacement of the metal ion from the resin by ion exchange with other cations from the external solution would not only result in metal losses but would also counteract ligand sorption and ligand-exchange selectivity since complex formation would then occur in the solution also.

### Advantages

Ligand exchange has several advantages over other more conventional chromatographic methods. The most important of these is its high selectivity. The exchanger prefers the ligand which has the stronger tendency to form complexes with the metal ion. Complex formation is a highly specific interaction, much more specific than mere adsorption or ion exchange. According to the differences in strength of complexes of a metal ion with different ligands, high selectivity is achieved. In research, Dr. Walton has successfully separated various amines (e.g., 1,2-propane diamine from 1,3-propane diamine) from mixtures in dilute solutions.

This method has a high developmental potential. Besides the advantage of high selectivities, ligand exchange offers the additional advantage that within wide limits, the selectivity can be adjusted at will by varying the concentration of the external solution when separating compounds having different co-ordinative valences. Dilution of the solution increases the preference of the resin for the ligand having the higher co-ordinative valence and vice versa.

The future of analytical separations become quite exciting when one foresees the full development of such a tool as ligand exchange. Those ligands which can be isolated or separated include ammonia, organic amines, polyhydric alcohols, olefins, acetylene derivatives and anions of organic acids and amino acids. This method is still an infant in the family of chemistry, but already the list of separable ligands is long and rapidly growing.

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# How long've you been out of school?



Since '52. Purdue. Then two years in the Navy and a year for my Masters at Caltech.



I came to Jet Propulsion Laboratory right after that. '55. I like it very much. It's a nice atmosphere for engineers to work in. There's a lot of work, a lot of hard work. But interesting.



And because we're operated by Caltech, we can work closely with some of the top scientific minds in the country. I think that makes a difference. We have a lot of freedom within our individual disciplines, too.



I'm an Engineering Group Supervisor. Our group is among those responsible for communications with spacecraft designed by JPL to go to the moon and planets.



Among other things, we want to find out what the moon is made of, and if there's life on other planets. Contributing to space exploration is a challenging vocation.



We've excellent facilities here. One of the largest technical libraries, for example. There are at least two support people for every scientist and engineer at JPL. And they're all great to work with.



I bought a home close by. Only 20 minutes from coffee cup to coffee cup. My wife likes that. The kids like where we are, too. We like hiking and there are excellent trails minutes from our house.

You've just been chatting with Dick Mathison, JPL engineer. He likes his work. He likes where he works. Would you like to share in the challenging and important work he does? Maybe you can...why not write to JPL and see.



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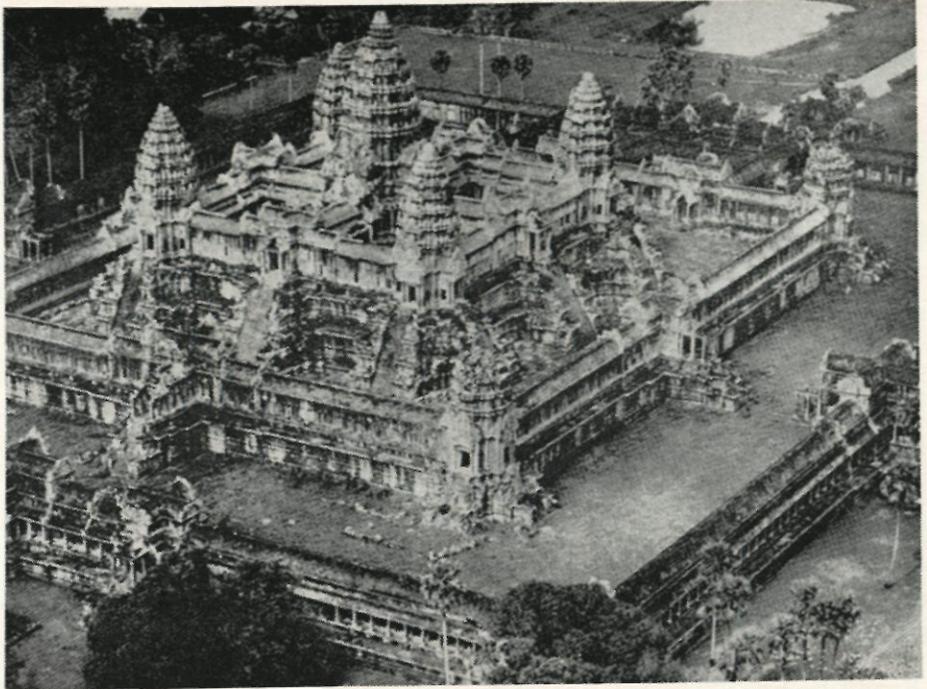
## JET PROPULSION LABORATORY

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It was monsoon season. With the intermittent blaze of the sun, after seemingly endless torrents of rain, the jungle steamed. The penetrating dampness of the air pierced to the very marrow of the bone, making the men of the expedition almost unbearably hot the one minute, cold and shivering the next. Yet the work simply had to be done. The time—1861. The place—the jungles of Cambodia near the tiny native village of Siem Reap. The expedition—Henry Mouhot and his party seeking rare jungle flora and insects to take back to Paris to be classified and recorded. As they hacked their way through the almost impenetrable jungle Mouhot cut away a large banyan tree covered with a vine entanglement. Imagine his surprise when there stood before his astonished gaze a vast stone structure, silhouetted apparently endlessly against the red blaze of the setting sun! Surely here was the largest and most magnificent monument ever raised by man! Further searches proved this true, for the French naturalist had stumbled upon the vast Angkor city-temple building complex that had been raised by the Khmer civilization which flourished from 850 to 1200 A.D. Now it was inhabited only by a few scantily clothed and wild natives.

The time changes—it is now one hundred years later—August 1961. The place—the same. The expedition—an international tourist party on a French bus leaving Siem Reap to visit Angkor. After the bus squeezed through a much too narrow opening in a huge sculptured gateway, it came to a grinding halt. The twenty of us alighted. Imagine our surprise when a small band of scantily clothed and wild looking natives rushed at us brandishing swords and pulling their bow strings ready to discharge deadly arrows at us! The group soon proved to be some of the local hawkers of novelties. However, upon discovering this fact, my relief was such that I promptly bought a sword, a machete and a bow and arrow set, all artfully engraved with local motifs!

Naturally the purpose of my visit



ANGKOR VAT FROM THE AIR SHOWING THE GALLERIES, TERRACES AND TOWERS. THE CONCENTRIC RINGS OF GALLERIES BECOME APPARENT AS DO THE OPEN SPACES, ALTHOUGH THE STRUCTURAL SYSTEM ALLOWED OF NO SIGNIFICANT INTERIOR ROOMS. THE ENCROACHMENTS OF THE JUNGLE ARE A CONSTANT THREAT TO ITS RESTORATION AND PRESERVATION.

to Cambodia was to see and analyze the Angkor complex and particularly Angkor Vat, the largest and best preserved of the temple-monuments. At last here it was—looming up in all its majestic and awe-inspiring vastness.

The Khmers, the ancestors of the present Cambodians, and the highly developed civilization they produced were not known to the Western world until Mouhot's accidental discovery in 1861. In their prime they were governed by kings, supposed to have divine powers, and in a sort of theocracy of Indian origin. They spawned great warriors and about 1100 A.D. the empire encompassed all of present day Cambodia, part of Thailand, Laos and Vietnam and produced the most brilliant civilization ever to flourish in Southern Asia. The theocratic governmental form practiced made for plenty of slave labor and included a whole system of warriors,

nobles and priests, culminating in the god-king, at whose behest the cities and principal temple-monuments were built. Finally in the 13th century, the subjugated peoples became restive and in particular the encroachments of the neighboring Siamese nation diminished their territories. Their revenues vanished which impoverished the Khmers. The final straw in the undoing came as a result of the introduction from Siam of Buddhism, which was a much more democratic and passive religion. This weakened the ardor of the people to fight for theocracy, which amounted for most to slavery. When the Siamese conquered the three western provinces of Cambodia, the nobles and people fled to escape raids and the burdens of the maintenance of the monuments. The area around Angkor declined to a frontier province—difficult of access and sparsely inhabited.

# Angkor—What?

C. A. BRIGGS, Professor of Architecture C.U.



LEFT: A CORNER TOWER SHOWING THE INTEGRATED ARCHITECTURAL SCULPTURE, MUCH OF WHICH HAS LONG SINCE DISAPPEARED. RIGHT: A PORTION OF THE GALLERY CIRCULATION SYSTEM. UNDER THESE PORTICOS ARE A RUNNING HALF-MILE OF EXQUISITE BAS RE-



LIEFS. THE TROPICAL RAINS AND BACTERIA HAVE EATEN AWAY MUCH OF THE FINE SCULPTURAL DETAIL. MANY PARTS OF THE BUILDING COMPLEX WERE TORN ASUNDER BY THE SINUOUS ROOTS OF THE JUNGLE GROWTH.

The few Cambodians remaining became poor and their new Buddhist religion had little need of such magnificent temples. Consequently most of them were abandoned and forgotten. The jungle gradually took over. Any wooden structures did not have a chance. The tropical climate and growth simply destroyed them. Even the stone buildings were not immune from the rigors of the sinuous tree roots which gradually ripped stone from stone. The rains washed at the stone and brought with them forms of bacteria which assisted in the deterioration process. In 1907 the French government began the stupendous task of releasing the remains from the jungle's grasp and the restoration of Angkor has become the most fantastic job of archeological restoration ever attempted.

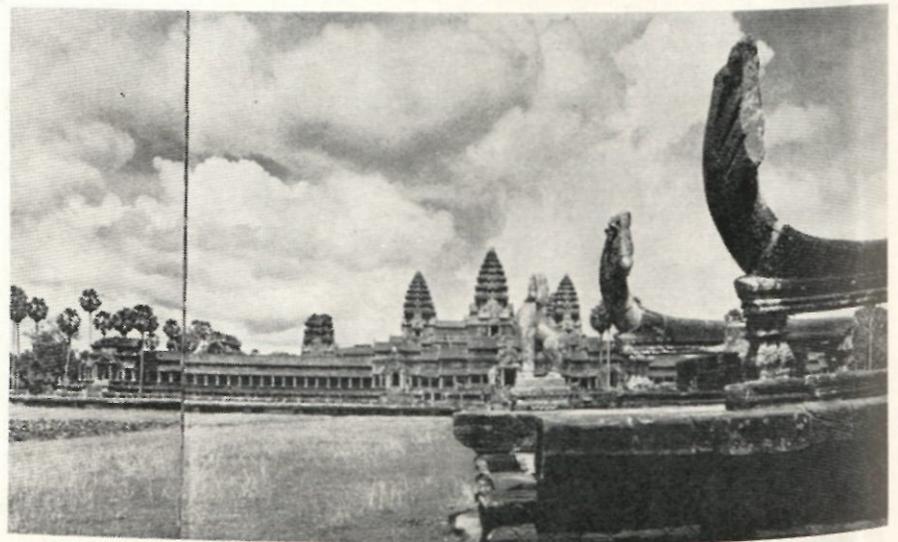
The principal city, Angkor Thom, at its height contained over a million people, was more spacious than any of the contemporary walled cities of Europe, and could have contained easily the then Rome.

Angkor is a Cambodian corruption of the Sanskrit word NAGARA which means "city." Thom is a Khmer corruption of the Sanskrit word DHAMA meaning "grand." Angkor Thom, then, in modern Cambodian means "great walled city," which is what it was called by the natives when the first Europeans arrived. Within the city was a walled enclosure nearly two miles square, built of red sandstone, of considerable height and pierced at intervals with a series of ornamental gates, had major temples at the corners, with a boulevard 25 yards wide incorporated on top and the whole surrounded by a large moat. The space

within the walls was devoted to the religious, administrative and aristocratic center, where lived, clustered around the capital and the principal temple the civic and military functionaries, the rich families, the priesthood, the king-god and the army. The markets and homes of the masses of the people were in suburbs along large artificial lakes to the east and west of the city.

Life in Cambodia has always depended on the monsoon. The recurrent floods over the terrain brought with them the alluvial soil which made possible the original pastoral life of the people. Without this base of society the nation would not have been in position by virtue of the lack of a stabilized society to receive the foreign influences which were to have such vitalizing effects on creative accomplishment. This analysis will be

confined to only one, Angkor VAT, (meaning *enclosed ground or temple*), the greatest and best preserved of the Khmer monuments. Except for the Khmer temple of Bantay Chmar, in the jungle a few miles to the northeast, Angkor at is the largest religious edifice ever built by man. It was erected during the reign of Suryavarman II (1113-1150), and dedicated to Paramavishnuloka, the posthumous personality of Suryavarman, identified with the god Vishnu. The purpose of it was a funerary temple, partaking of the character of both temple and tomb. There can be no doubt but that the initial architectural concepts for the Khmer monuments were Hindu from India. As the civilization flowered, however, the buildings took on more peculiarly Cambodian characteristics. Nearly all of the monuments in the Angkor group consist of two or three concentric, rectangular galleries, the space between each ring being terraced up and culminating in central towers. Angkor Vat is no exception in that incorporated in the plan are the typical three concentric galleries, (See Plan), forming two large exterior enclosures and the whole reaching at climax in an elaborate tower system. Twelve towers reach upward—smaller ones on the four corners on the two outer concentric square rings; three at the west entrance, four much larger towers at the turning points of the inner quadrangle. The composition is centered by a huge middle tower, which rises to a height almost that of the Mile High Center in Denver. The outer walls are surrounded by a moat about 200 yards wide which extends nearly a mile in each direction. One would have to go almost four miles if he wished to walk around this single building complex. From the above dimensions it can be appreciated



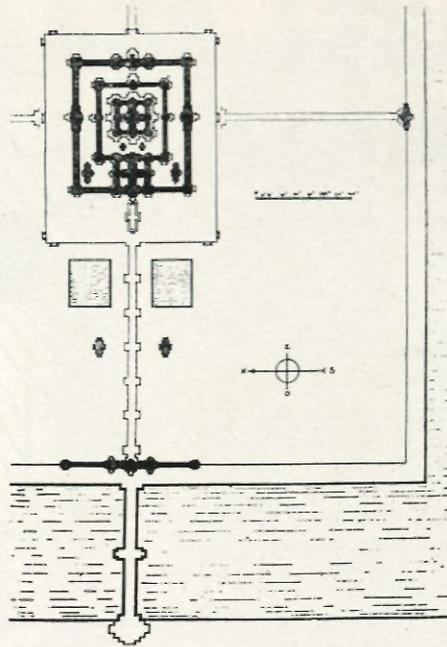
MAIN WEST FACADE OF ANGKOR VAT SHOWING IN THE FOREGROUND ONE OF THE STEPS OF THE 360 YARD-LONG PAVED CAUSEWAY OVER THE MOAT. SACRED SNAKES GUARDED THE MAIN ENTRANCE AND BRIDGE.

readily that the Khmers operated on the vast scale! The main approach comes from the west over an ornamental stone bridge spanning the moat and as one nears the central tower mass he notices that each successive terrace within the rings is at a higher elevation.

The great temple of Angkor Vat is remarkable not only because of its size and scale, but because of the running half-mile of fine stone has reliefs, the 10,000 finials (some of large proportions) which once graced its appearance, the major sculptures incorporated into the scheme and because of the refinement of the architectural details forming the galleries, windows and doorways. One is immediately struck by the enormous labor and expense involved in this single project.

In contrast to the contemporary Gothic cathedrals of Europe where magnificent interior spaces were achieved by means of isolated structural posts and vaulting systems, Khmer architecture is one of heavy mass, with no significant interior spaces involved. The builders of Cambodia did not know the principle of the true arch and used only the false arch or a process of corbelling, by which each successive pair of stones projects over the opening to be bridged until they approach sufficiently close for a single stone to close the gap. Consequently the width of their rooms was limited. Furthermore, the vault were hidden by carved wooden ceilings.

The materials employed were stone; laterite, a hard native rock found in the vicinity, for the principal structural elements; and sandstone, which was more conducive to precise carving. Wood (long since disintegrated) formed the ceilings, doors and minor



LEFT: PLAN, SHOWING PORTIONS OF OUTER RING AND SURROUNDING MOAT. APPROXIMATE SCALE: 1 INCH = 120 YARDS.

RIGHT: "ASPARAS" OR CELESTIAL DANCERS WERE A FAVORITE KHMER THEME — HERE SHOWN CARVED INTO THE STONE STRUCTURE. AT ONE TIME ANGKOR VAT USED THE

trim. One finds no evidence of mortar as employed by the Romans. The precision of the stone cutting is a marvel, the individual pieces being held in place by compression.

One of the truly remarkable features of Angkor Vat is the bas reliefs carved in the sandstone. These bas reliefs are of great importance as historical documents. They indicate that the religion and mythology of the Khmers were entirely of Indian origin and show great familiarity with the two great Indian epics — Ramayana and Mahabharata. Some depict the daily life of the people, in peace and war, and prove that the



SERVICES OF 615 LIVE DANCING GIRLS. IN MODERN CAMBODIA THE DANCE PATTERNS, THE GESTURES, THE COSTUMES AND POSSIBLY THE GIRLS REMAIN THE SAME TODAY. NOTE THE BEAUTIFULLY TURNED STONE WINDOW BALUSTRADES.

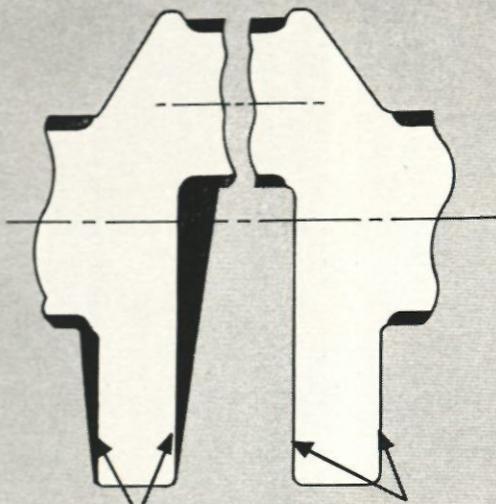
Khmers who built the monuments were the same people as the modern Cambodians in appearance, dress, habits and daily life—they have not changed much since the days when the bas reliefs were carved. Some give specific historical information showing the construction of former temples, the kings and their armies at war, as well as the peace time ceremonies at the court. In the more protected parts, unravaged by time and the jungle, faint traces of the original polychrome still appear. And yet there is a perfect subordination of the carving to the architectural composition as a whole. The decoration everywhere, and this includes the larger sculptural features which, like the Gothic, are an integral part of the main masses, is treated as a background embellishment or texture which does not interfere with the broad composition of the architecture. Even now the general forms and masses remain awe-inspiring, silhouetted against the tropical sky. The deep colonnaded galleries and the undercuts of the architectural sculpture provided ever changing patterns of light and shade and breathe into the whole a great vitality, in spite of the basic lack of dynamic space concepts.

As one mounts the endless solid exterior steps he finally arrives in a comparatively small series of chambers under the central tower mass. A statue of the Compassionate Buddha sits serenely amidst a cluttered debris.

(Continued on page 49)



A SMALL PORTION OF THE LONG "CINEMA IN STONE" DEPICTING AN INCIDENT FROM THE LEGEND OF VISHNU HERE SHOWN SHEDDING HIS BLESSINGS ON HIS FOLLOWERS.

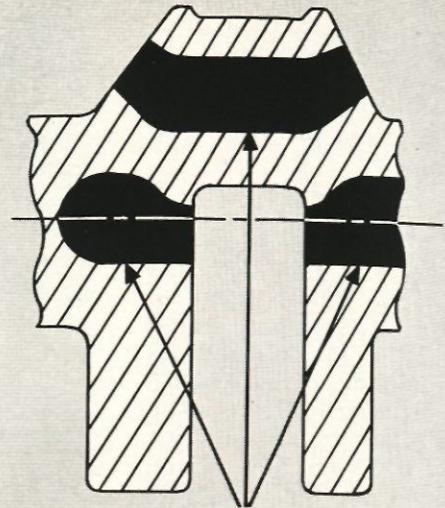


NORMAL CHEEKING STOCK

CHEEKING STOCK ELIMINATED WITH MALLEABLE

**Eliminate Draft Allowance Metal**

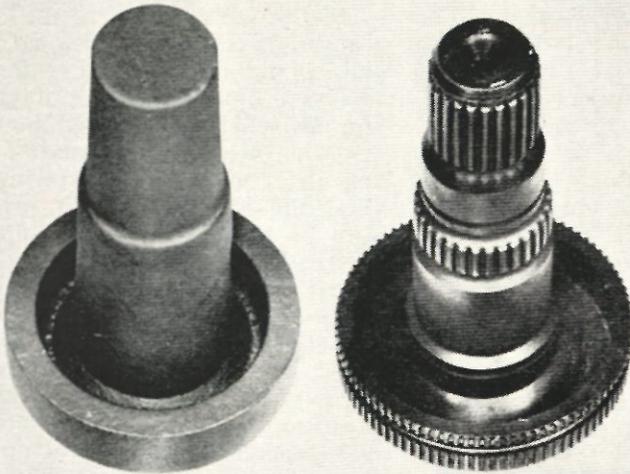
In designing surfaces perpendicular to a parting line, minimum draft angle requirements can be important to finished cost. By changing these automotive crankshafts to high strength pearlitic Malleable iron castings, the draft angle on sides of counterweights was reduced to one-half of one degree. This eliminated all excess stock formerly required in forming... and the machining operations to remove it.



CRANKPIN AND MAIN JOURNAL CORED

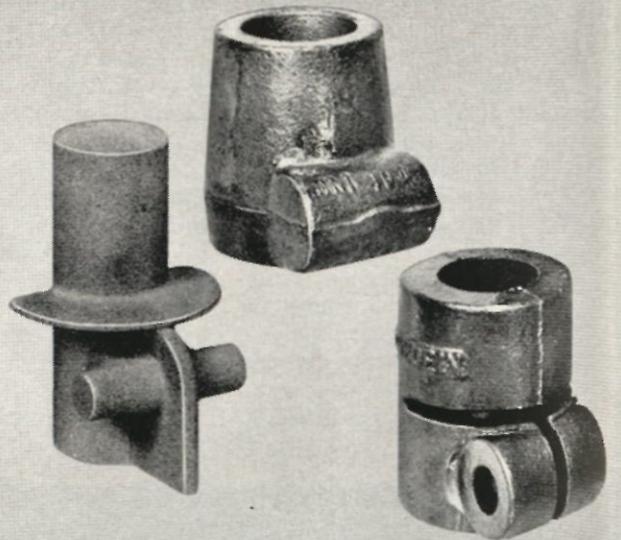
**Desired Size Without Excess Weight**

These same crankshafts are excellent examples of how to eliminate metal that serves no function. Crankshaft main journals and crankpins are usually solid because of the method used to form them. Made of pearlitic Malleable iron, these areas can be cored out. This substantially reduces the weight of the crankshaft... with no loss in functional strength.



**Put Metal Only Where It Is Needed**

The deep recess at the base of this automotive transmission gear was formerly machined out. Now manufactured of pearlitic Malleable, the recess is created as the part is cast. This eliminates buying unnecessary metal... and reduces machining time and cost.



**Start Closer To The Finished Part**

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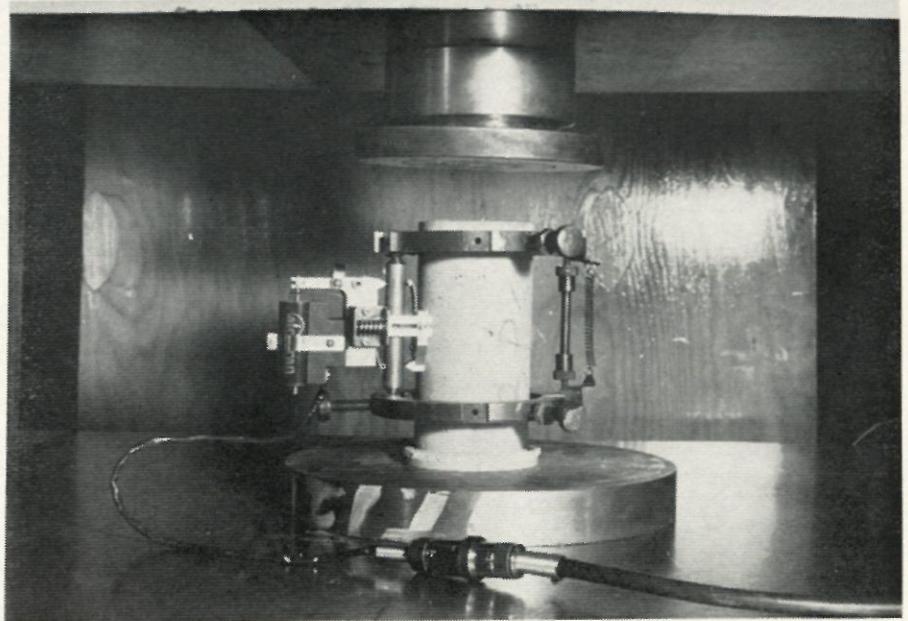
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Send for this 16 page Malleable Engineering Data File. You will find this informative brochure is an excellent reference piece.



# ULTIMATE STRENGTH

G. L. AGRAWALL



CONCRETE CYLINDER BEING TESTED UNDER COMPRESSION.

Since primitive ages, man has had the concept of ultimate strength. Even in the stone and iron age, people used this idea in picking up tools for their daily uses. Human understanding developed along with the progress of civilization, and gradually the idea of shelter was conceived to save man from sun, chill, and wild beasts. While selecting tree branches for different members of such shelters their ultimate strengths were predicted on the basis of common sense and personal experience.

How this science developed in those days is not known. Nearly 5000 B.C. many temples and monuments were erected in the valleys of the Nile. Perhaps Egyptians had developed some empirical formula for the construction of such monstrous structures, many of which are still existing. No history is available regarding the analytical design methods of architects and engineers of the classic times.

So far as is known, the design of structural members on the basis of strength of material obtained from results of laboratory tests on the basis of mathematical calculations was started in the 15th century. Most experiments were performed using steel samples which showed a very pronounced elastic range (AB in fig. 1) up to a certain stage of loading. The end of this stage was termed the "Proportional Limit." Most design calculations were developed using steel strength below the proportional limit. This practice gave birth to a working stress theory. At times samples of engineering materials were tested to find out their ultimate strengths, but design calculations were limited to the determinations of working stresses which were much below the proportional limits. This discrepancy was explained by the term "Safety Factor" which is still defined as the ratio of ultimate strength to working load.

In the latter half of the nineteenth century, after the invention of Portland Cement, concrete became one of the building materials. As its uses increased in number, its properties were tested in laboratories, and it was found that concrete does not have an elastic range like other building materials. The typical stress-strain curve of steel is shown in figure II by full lines. In order to apply existing theories of design, stress and strain relation of concrete was approximated by a linear curve up to working stress (chain dotted line in Fig. II).

Since the beginning of the twentieth century, it has been realized that existing elastic theories do not explain the behavior of structures at collapse, and at some working stresses such as at places of stress concentration (point A in Fig. III). These theories give a very misleading safety factor in case of a statistically indeterminate structure. This can be very well explained by a simple example given below.

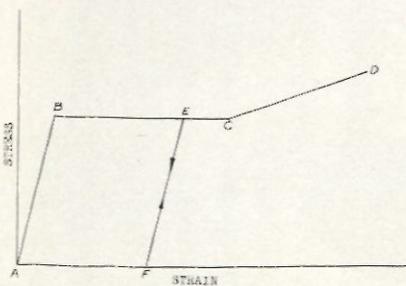


FIG. 1. IDEALIZED STRESS-STRAIN DIAGRAM FOR STEEL.

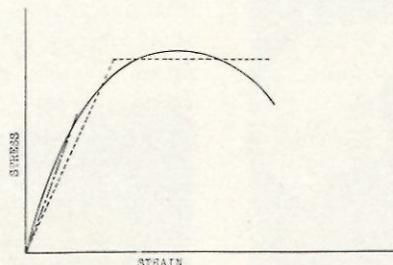
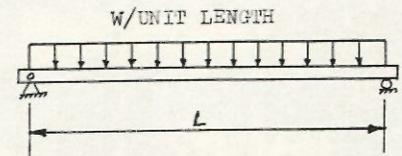


FIG. 2. STRESS-STRAIN DIAGRAM OF CONCRETE  
FULL LINES:—ACTUAL  
DOTTED LINE:—IDEALIZED  
CHAIN DOTTED LINES:—LINEAR CURVE UP TO WORKING STRESS.



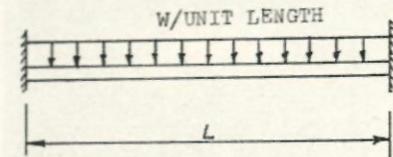
a) Simply supported beam  
Let  $M_p$  = ultimate load on any section  
Let  $M_a$  = allowable load on any section

$$\text{Maximum moment} = \frac{WL^2}{8}$$

$$W \text{ allowable} = \frac{8M_a}{L^2}$$

$$W \text{ collapse} = \frac{8M_p}{L^2}$$

$$\text{Therefore, safety factor} = \frac{W \text{ allowable}}{W \text{ collapse}} = \frac{3M_a}{4M_p}$$



b) Fixed beam

$$\text{Maximum moment} = \frac{WL^2}{12}$$

$$W \text{ allowable} = \frac{12 M_a}{L^2}$$

It has been found by calculation and by experiment that  $W$  collapse in this case is  $\frac{16M_p}{L^2}$ .

$$\text{Therefore, safety factor} = \frac{W \text{ collapse}}{W \text{ allowable}} = \frac{M_p}{M_a}$$

It is thus seen that the safety factor based on the elastic analysis in the case of fixed beam is  $4/3$  times that in the case of a simply supported beam.

So far as the collapse of the structure is concerned design based on ultimate strength can safely be applied. But sometimes it may happen that deflection in the structure may become so pronounced that it will make the structure useless long before collapse; therefore, deflection must be checked. Such a deflection for a member in bending can be calculated by knowing the moment curvature relation. In the case of a statistically

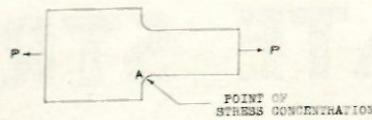


FIG. 3

indeterminate structure such relation is necessary to satisfy geometry.

Under a few circumstances, it is found that for a structure such as a railway bridge where live load is higher than dead load deflection will increase after each cycle of loading and that will lead to incremental collapse of the structure at a load lower than the actual collapse load.

The maximum load at which deflection becomes stable after a few cycles and does not increase in subsequent loading is called shakedown load. To find this shakedown load, a moment curvature relation in repeated loading is necessary. Present work at the University of Colorado is an effort to find out moment curvature relations of reinforced concrete beams under cyclic or repeated loading experimentally and analytically.

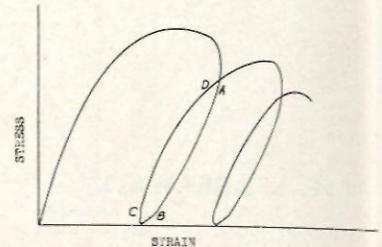
### Analytical Work

In order to find moment curvature relations analytically, stress-strain relations of concrete cylinders and steel rods were found experimentally. In photo 1 a concrete cylinder is being tested.

Steel at the end of its elastic range, showed a very distinct yield point (point in Fig. I). In the inelastic range strain hardening (CD in Fig. I) was observed, which was taken into account. Unloading (EF in Fig I) and loading (FE in Fig I) curves in the inelastic range were found parallel to the initial loading curve. Steel rods are being tested in cyclic tensile and compressive load, so that the theory may be extended to doubly reinforced beams where reversed loading may take place. Unloading and reloading curves (Fig. VI) of con-

crete were expressed by families of equations.

Moment curvature curves were obtained with the help of a Bendix G-15 computer using technical beam theory. The above analytical curves were obtained also using the idealized flat topped stress-strain curve (dotted line in Fig. II) of concrete. In this case also the Bendix G-15 was used, but expressions could be expressed in simple algebraic equations instead of differential equations.



STRESS-STRAIN DIAGRAM OF CONCRETE IN UNLOADING AND RELOADING  
AB — UNLOADING  
CD — RELOADING

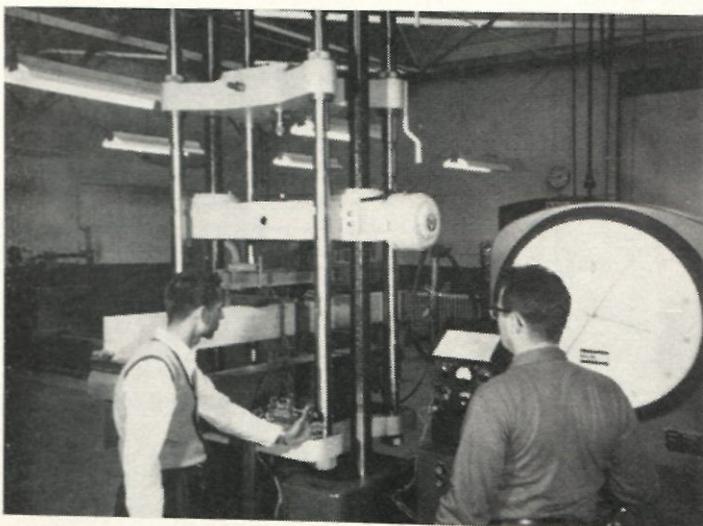
Under-reinforced and over-reinforced beams were tested to plot moment curvature relationship under repeated loading. A Tinius Olsen testing machine (photo 2) of maximum capacity 120 kips was used.

A curvature meter (photo 3) was designed, which when mounted on the beam gave directly, the average curvature for a length of four inches. Before using this curvature meter was calibrated by mounting on a steel beam whose deflection in the elastic range was measured by a simple formula, and the corresponding curvature was calculated by the simple formula  $M$

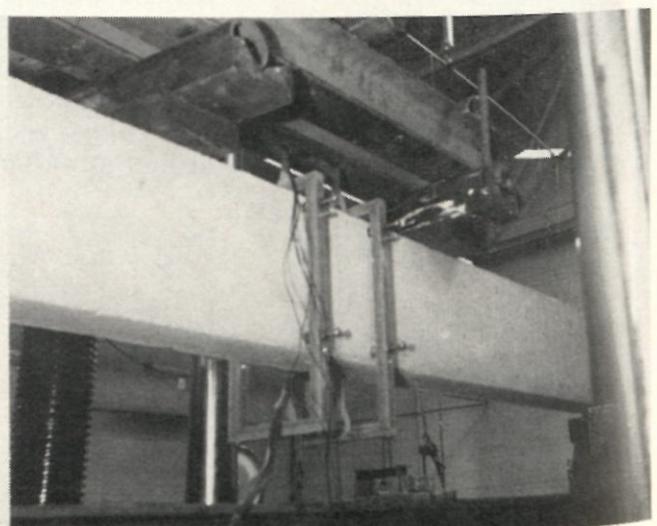
$$\frac{M}{EI}$$

(Continued on page 37)

G. L. Agrawal is a graduate student from India. He is working on his Master's in Civil Engineering.



LEFT: PROFESSOR I. G. TULIN AND GRADUATE STUDENT G. L. AGRAWAL RUN A TEST ON A CONCRETE BEAM.



RIGHT: CLOSEUP OF THE TEST APPARATUS SHOWING ARRANGEMENT OF STRAIN GAUGES TO RECORD CURVATURE OF THE BEAM DIRECTLY.



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For more detailed information, get your copy of the Western Electric career opportunities booklet from your Placement Officer. Or write College Relations Coordinator, Western Electric Company, Room 6305, 222 Broadway, New York 38, New York. And be sure to arrange for a personal interview when the Bell System recruiting team comes to visit your campus this year—or during your senior year.

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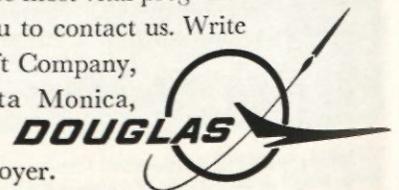


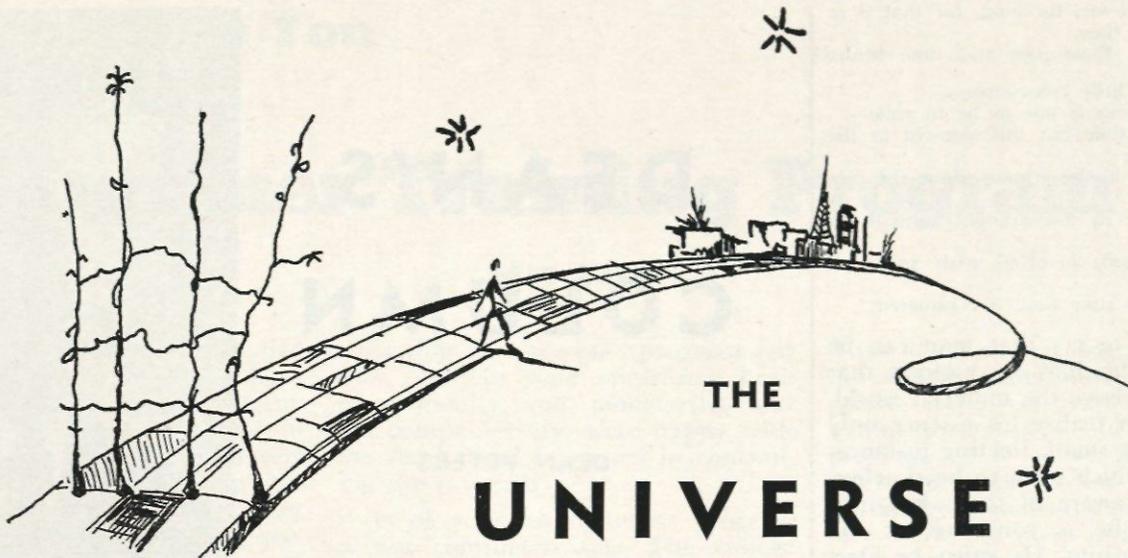
The design is thousands of years old. Called "Man," it has evolved reasonably efficient techniques for coping with weather, saber-toothed tigers, city traffic, floods and income taxes. □ But now it faces a problem of a new order of magnitude...survival beyond the protective cocoon of the earth's environment. In this airless, weightless, radiative region, man needs a big assist. Douglas is working to provide it. □ Douglas scientists are far along in studies of ecological systems for the maintenance of human life under

**EARTH'S MOST COMPLICATED SYSTEM** extra-terrestrial conditions.  
...A STIMULATING AREA FOR CREATIVE ENGINEERS These research areas cover the varied life and physical sciences and engineering systems which are involved. They range from psycho-physiological analyses to the actual planning of the establishment and support of cities on the moon.



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# THE UNIVERSE

## AND T. S. ELLIOT

JIM TOEVS

The poetry of T. S. Eliot contains many ideas that parallel philosophies of science. This paper will discuss several of the parallelisms through two specially rich poems, "The Hollow Men," and "Burnt Norton." The parallelisms discussed here will be concerned with two main scientific from Einstein's Theory of Relativity, and the fate of the universe predicted by the Second Law of Thermodynamics. I will begin with a short summary of the developments of the philosophies mentioned above.

In the Special Theory of Relativity, Einstein introduced the concept of time as a fourth dimension, having properties that relate it to the three spatial dimensions. The General Theory of Relativity expanded this idea, and then showed that all the spatial-temporal properties of the universe are determined by the existence and behavior of all the bodies in it, from the flutter of an eyelid to the rotation of the largest galaxy. This concept has led to a deterministic philosophy. Since, at any instant, we can describe all the properties of space from the arrangement of the matter within it, and since the properties of space control the behavior

of matter, then we can predict the future. What is more, the past, present, and future were all determined when time began.

Statistical thermodynamics defines entropy ( $S$ ), as a function of the thermodynamic probability, ( $W$ ), of the system:

$$S = K \ln W,$$

where  $K$  is a proportionality constant. Every thermodynamic system tries to reach a state of equilibrium. A system is said to be in an equilibrium state when it is in a state of maximum thermodynamic probability, and therefore, maximum entropy. It is seen, then, that the total entropy of the universe is always increasing. Since entropy can also be expressed as the ratio of the heat in a system to the temperature of the system, then the average temperature of the universe is decreasing.

For example, if a warm body is surrounded by cold bodies, heat will flow from the warm body until all the bodies are at equal temperature. The concentration of heat in the warm body represents higher organization or lower entropy than the even distribution of heat in all the bodies. The universal prediction is that heat from the stars will dissipate throughout the universe until eventually everything is at the same temperature, which will be absolute zero.

This situation is called the "heat-death of the universe."

Both of these philosophies make man seem meaningless because his attempts to execute his will must be futile. The desolation and hopelessness resulting from these philosophies is well represented in Eliot's works.

The first few lines of the poem, "Burnt Norton" definitely show the influence of Einstein's concepts of time:

"Time present and time past  
Are both perhaps present in time future,  
And time future contained in time past.  
If all time is eternally present  
All time is unredeemable.  
What might have been is an abstraction  
Remaining a perpetual possibility  
Only in a world of speculation.  
What might have been and what has been  
Point to one end, which is always present."<sup>1</sup>

In the second section of this poem, Eliot finds some hope for the cause of man even though the future is already planned for him.

"At the still point of the turning world.  
Neither flesh nor fleshless;  
Neither from nor towards; at the still  
point, there the dance is,  
But neither arrest nor movement. And do  
not call it fixity.  
Where past and future are gathered. Neither  
movement from nor towards,  
Neither ascent nor decline. Except for the  
point, the still point.  
There would be no dance, and there is  
only the dance.  
I can only say, *there* we have been: but  
I cannot say where.

Jim Toevs is a Junior in Engineering Physics. This is his third year of participation in the Superior Student Program.

And I cannot say, for long, for that is to place it in time.

Time past and time future

Allow but a little consciousness.  
To be conscious is not to be in time  
But only in time can the moment in the  
rose-garden,  
The moment in the arbour where the rain  
beat,  
The moment in the draughty church at  
smoke-fall  
Be remembered; involved with past and  
future.  
Only through time time is conquered."

Eliot seems to say that man can be man, that he has an essence that places him above the material world, but man can realize his essence only by witnessing small, fleeting instances of beauty, which seem to be timeless. Yet man is aware of these instances only when he is conscious of the world about him. He must be alert in time (reality; the present) if he is to conquer time.

The third section of "Burnt Norton" turns back to the philosophy of the heat-death. Eliot talks of a region that is before time and after time. It has neither the permanence suggested by the slow, regular motion of a heavenly body nor the feeling of time standing still that sometimes accompanies us in darkness. It is here that the future desolation of a dead universe enters the human spirit that is alive in the present. The rest of the section continues in this spirit:

"Descend lower, descend only  
Into the world of perpetual solitude,  
World not world, but that which is not  
world,  
Internal darkness, deprivation  
And destitution of all property,  
Desiccation of the world of sense,  
Evacuation of the world of fancy,  
Inoperancy of the world of spirit;  
This is the one way, and the other  
Is the same, not in movement  
But absence from movement; while the  
world moves  
In appency, on its metalled ways  
Of time past and time future.

Finally, the last section of the poem describes the permanence of art. Poetry and music cannot live as individual words and notes, but can continue to exist only as verse and melody. This again is something physically intangible and also outside of time. Eliot says that the only moments of beauty man can achieve are the fleeting moments that are outside and above space and time.

The "Hollow Men" is more obscure than "Burnt Norton," but it contains many of the same implications. In the first stanza, Eliot again expresses the desolate, meaningless human spirit. He introduces "death's other Kingdom," in which man is not remembered for the deeds of his violent soul. He is remembered, if at all, as a hollow shell, a straw-

(Continued on page 49)

# DEAN'S COLUMN

DEAN PETERS



Our major Engineering event of the year will occur on May 3 and 4 when we hold our annual Engineers' Days. The speaker for the Convocation on May 3 will be Dr. William L. Eceritt, Dean of Engineering at the University of Illinois. Dr. Everitt will speak to us on the subject of "Maybe We Talk Too Much" with an interesting interpretation on information theory and demonstration of a Speech Compressor which Dr. Everitt, as an Electrical Engineer, has developed. I hope our students and faculty will make plans to attend all of the events during this important weekend for our Engineering College.

Among other honors and awards to be presented at Engineers' Days will be our Engineering Development Foundation Scholarships. The support we receive in the Engineering College through donations from Alumni and friends to the Engineering Development Foundation fund the an invaluable aid to our College. This year, we have had an unusually fine response from our faculty, and I think it is quite significant to note that almost all of our Engineering faculty dig into their own pockets to make donations to support our Engineering activities. The money supplied to us through the donations to the Engineering Development Foundation fund are used for many beneficial purposes such as printing costs for the Engineering Center brochure, mailing expenses for announcing the event honoring Professor Eastom on his retirement, expenses for bringing outstanding speakers to our campus, printing of a new Engineering Alumnae Directory, and other special activities for which regular University funds are not available. Will Fowler is doing a fine job in handling the Development Foundation for the Uni-

versity, and I hope all of us in Engineering will give the Foundation our complete support.

Another significant step forward has occurred in our College of Engineering with Dr. Mahinder Uberoi joining us on February 1 as Chairman of our Aeronautical Engineering Department. Dr. Uberoi comes to us from the University of Michigan with a national reputation in the areas of fluid physics and gas dynamics, and his presence here will mean a rapid and significant development in our teaching and research activities in Aeronautical Engineering.

A special course has been started this semester for interested faculty in the College of Engineering dealing with the use of the digital computer and the MAD programming system with particular emphasis on effective methods for including digital computer experience in teaching programs. The course is being handled by Dr. Paul Hultquist of our Applied Mathematics Department. Based on the experience obtained in this course, we shall be making definite plans on methods for including required instruction and experience on the digital computer for our undergraduate Engineers.

I have been following our undergraduate and graduate activities closely since I came to our campus last summer, and I want to report to you that I am delighted with the attitude I find among our students. In Engineering, our students take their education seriously with an ideal balance of appropriate outside activities. This matter of taking Engineering at the University of Colorado is serious business, and I am pleased with the dedicated way our students are approaching their education. Keep up the good work!

# Engineers! Are You Interested in a

# Summer Training Program

FRED LOVE

First hand knowledge of applied engineering can be a great help, both in choosing a particular area of emphasis within a major field, and in showing any prospective employers that a student has been exposed to the real world of engineering. For this reason, the college strongly recommends at least one summer of engineering-capacity work before graduation. Unfortunately, such jobs are not easily found. To help job-seeking undergraduates, Professor Scott, of the Department of Aeronautical Engineering, and Dean Stahl are working together as a link between students and various engineering firms around the Denver area. This service is open to any engineering student who is interested and qualified.

As part of their jobs, the students will learn to solve "live" engineering problems that occur in their daily assignments. In most cases, supervisors will be around to double-check the students' solutions and to help them students placed through the college, with their work. The students par-

---

Fred Love is a Sophomore Chemical Engineering and Business Major. He currently is participating in the Honors program and has maintained a 3.2 average.

ticipating in last year's program felt that the jobs were rewarding, both educationally and monetarily, and the companies also were happy with the results and interested in continuing the program.

As of yet, this summer's program is not completely set. The college has commitments from Martin Company for six student engineers and two more offers from Sunstrand. Summer jobs are pending at Stanley Aviation, Beech Aircraft, and Ball Brothers Research, all of whom participated in last year's program. The availability and number of the latter jobs will be known when contract negotiations are completed. Salaries for the various jobs are also not yet definite, although last year, they ranged up to \$400 per month.

The college will provide applications, which the students may fill out at their own convenience. The applicants will then be interviewed by faculty members, and those who, in the opinion of the interviewers, are qualified will be recommended to the companies for placement. Selections will be based primarily on grades and extracurricular work. The purpose of this screening before the applications are sent to the companies is to maintain the quality of

Thus, if the college has a reputation for recommending only the best prospective employees, employers will be willing to continue and expand the program.

This program is not intended to discourage students from seeking summer work on their own. The participating companies will accept individual applications through their own personnel offices in the usual manner. However, this program does insure that those placed (almost 20% of last year's applicants were hired by the various companies) will be doing engineering-level work. The program also is an aid to the busy student who might not find time to go to Denver to apply and then wait for an interview.

For the present, the program only includes aerospace industries, but ALL majors, preferably juniors and graduate students, may apply. In order for a student to have the best possible chance, applications should be in no later than April 1. Also, by getting the applications in early, the student will know where he stands before it is too late to find work elsewhere.

Applications and further information may be obtained from Mr. Scott in his office in Engineering I, Room 128 B.

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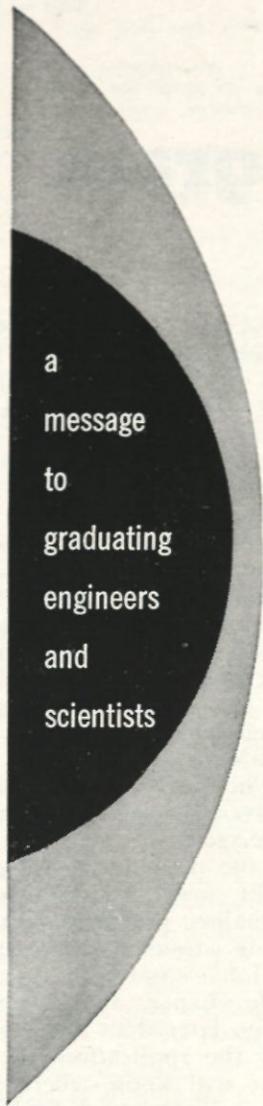
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to  
graduating  
engineers  
and  
scientists

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The glamour and excitement of space age programs often obscure a fundamental fact. It is simply that farsightedness must be coupled with sound, practical, down-to-earth engineering if goals are to be attained. This is the philosophy upon which Pratt & Whitney Aircraft's position as a world leader in flight propulsion systems has been built.

Almost four decades of solid engineering achievement at Pratt & Whitney Aircraft can be credited to management's conviction that basic and applied research is essential to healthy progress. In addition to concentrated research and development efforts on advanced gas turbine and rocket engines, new and exciting effects are being explored in every field of aerospace, marine and industrial power application.

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If you have interests in common with us, if you look to the future but desire to take a down-to-earth approach to get there, investigate career opportunities at Pratt & Whitney Aircraft.

To help move tomorrow closer to today, we continually seek ambitious young engineers and scientists. Your degree? It can be a B.S., M.S. or Ph.D. in: **MECHANICAL • AERONAUTICAL • ELECTRICAL • CHEMICAL and NUCLEAR ENGINEERING • PHYSICS • CHEMISTRY • METALLURGY • CERAMICS • MATHEMATICS • ENGINEERING SCIENCE or APPLIED MECHANICS.** The field still broadens. The challenge grows greater. And a future of recognition and advancement may be here for you.

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For further information regarding an engineering career at Pratt & Whitney Aircraft, consult your college placement officer or write to Mr. William L. Stoner, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.

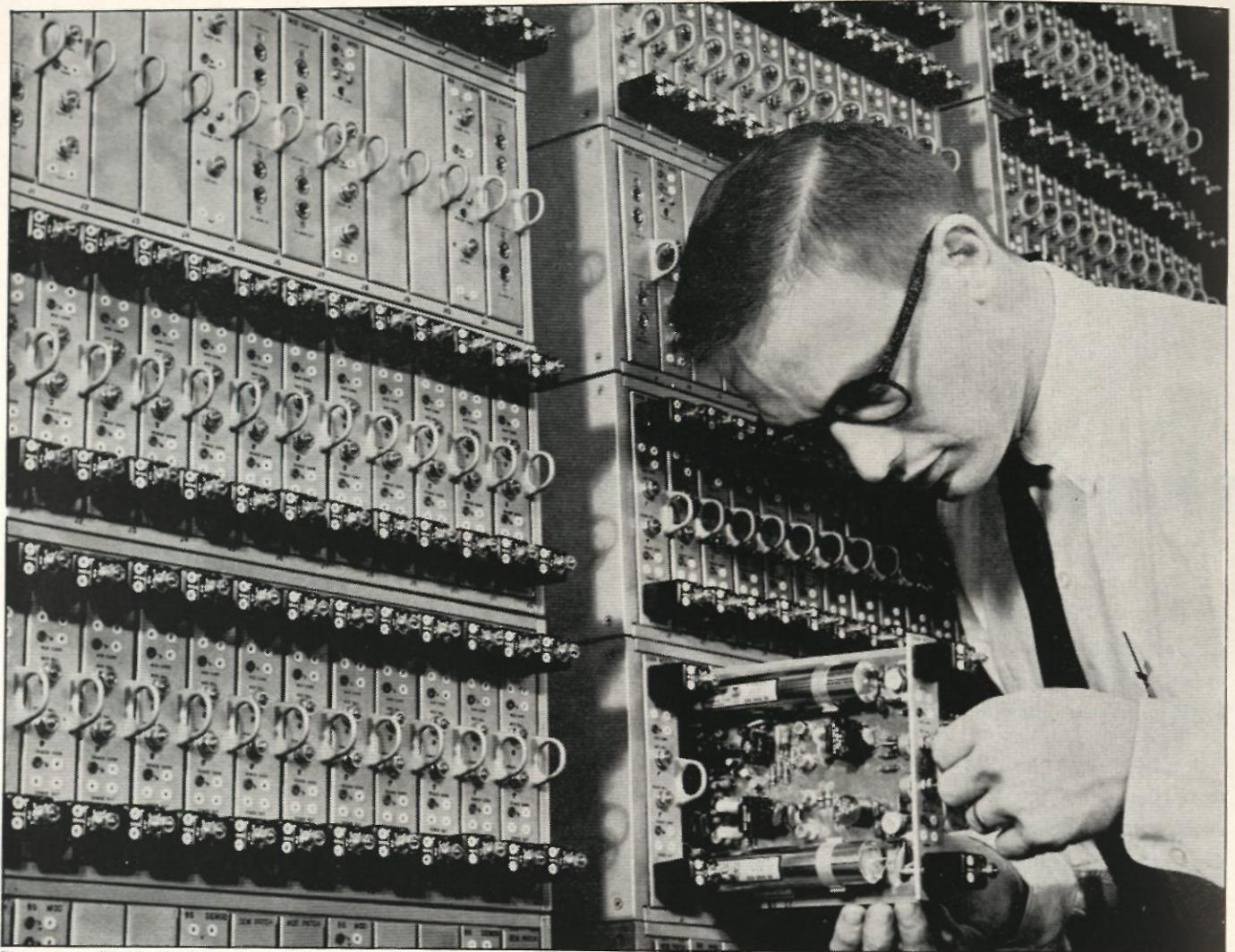
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WILLIAM W. SHIPLEY

# ALUMNI NEWS

CHUCK HANSEN

WILLIAM W. SHIPLEY, B.S. (A.Math) 1959; has been employed with the Computing and Controls Division of the Research Department at Caterpillar Tractor Co., Peoria, Illinois. Shipley has specialized in mathematical analysis of physical problems and digital computer programming since he joined the company in 1959.

He has made important contributions in the areas of vehicle stability and development of a general purpose digital computer program used to solve problems including heat flow, vibrations, and determination of residual stresses by X-ray diffraction.

Shipley is currently working on a monitoring routine for Caterpillar's new Bendix G-20 computer.

EMMET H. HEITLER, V.S. (M.E.) 1930; vice president of Shwayer Brothers, Denver luggage firm, has been elected an honorary member of the University chapter of Beta Gamma Sigma, national honor society in business administration.

ROBERT C. MAUER, B.S. (E.Phys.) 1950; was honored for an invention by the Lockheed-California Aircraft Co. in Burbank, California, where he works. Mauer received the award for developing a voltage relay detector, which is valuable in detecting minute errors in aircraft electrical systems.

HARVEY A. PROCTOR, B.S. (M.E.) 1939; was named a Director of the Southern California Gas Company.

Proctor has been Vice President in charge of engineering and trans-

mission operations of the gas company since 1958. He joined the company in 1939. He has been concerned with engineering and gas transmission of the company, serving since 1948 as Manager of Engineering Services and later as Manager of Engineering when the department name was changed.

He is a member of the California Natural Gasoline Association, the American Society of Mechanical Engineers, the Pacific Coast Gas Association and the American Gas Association, and is a Director of PSGA.

DONALD E. WAGSTAFF, B.S. (Ch.E.) 1952; won the George F. Smith Award given by Johnson & Johnson annually to the most outstanding department manager selected from four of the company's plants. Wagstaff received an inscribed ring and a cash award.

CLYDE P. ELLIOTT, B.S. (E.E.), owner of the Clyde P. Elliott Company, has been appointed Denver representative for the Barkeley Electric Manufacturing Company of Middletown, Ohio. Mr. Elliott will be responsible for Barkeley sales in Colorado, Wyoming, Western South Dakota and Western Nebraska.

Elliott has been active in the manufacture of electrical switches since 1904. The company manufactures a high quality line of dead front, rotary tap, open knife, and Bolt-Loc pressure contact switches.

CHARLES V. SCHELKE, B.S. (M.E.) 1924; has resigned as general manager of General Electric Company be-

cause of partial impairment of his eyesight. Schelke is a Vice President of the Company.

LT. FRANK ELLIS (B.S. (C.E.) 1956; is doing well after suffering severe injuries last July in a low altitude ejection from his disabled jet fighter. Lt. Ellis, a naval aviator, ejected at an altitude of 75 feet, after piloting the jet clear of residential areas. His parachute failed to open in time and he suffered back, rib and severe leg injuries. His back and rib injuries healed well, but portions of both legs required amputation.

Lt. Ellis was ferrying the F9F Cougar jet from Norfolk, Va., to NAS Pt. Mugu Missile Range, California. The aircraft developed trouble during the landing approach and finally went completely out of control. Ellis did not eject until he was sure the jet would miss all houses and trailers in the area.

He remained at a civilian hospital at Oxnard, California, for two weeks and was then transferred to Balboa Naval Hospital at San Diego, where he was fitted with artificial legs after a series of operations.

In a recent letter Ellis wrote: "All in all it has been a most educational, thought provoking, time consuming and painful experience thus far. I still plan to return to flying (USN permitting), but I'll certainly be prepared to accept a new life if necessary. Finally, I'll say that two lower legs are a mighty small price to pay for a 75-foot above the ground ejection.

(Continued on page 37)

## THESE GRADUATES THRIVE ON CREATIVE CHALLENGES...THEY'RE



**PROJECT MANAGEMENT**  
R. J. Hayes  
Indiana Tech—BSME—1956



**SALES ENGINEERING**  
R. J. Hummer  
University of Toledo—BSEE—1961



**DEVELOPMENT ENGINEERING**  
J. H. Trumble  
University of Dayton—BSEE—1960

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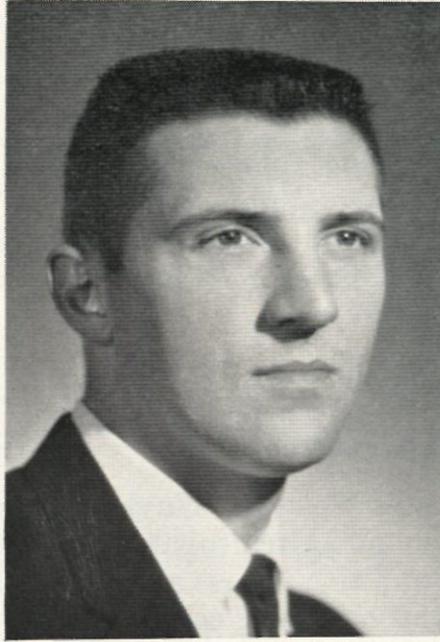
### **What is your opportunity?**

What are the advantages to you

## AUTOMATION PROBLEM SOLVERS



**MANUFACTURING ENGINEERING**  
R. H. Menzel  
Michigan Tech—BSME—1955



**CONTROL ENGINEERING**  
L. Gall  
University of Illinois—BSEE—1960



**ANALYTICAL ACCOUNTING**  
A. E. Morgan  
University of Wisconsin—BA—1960

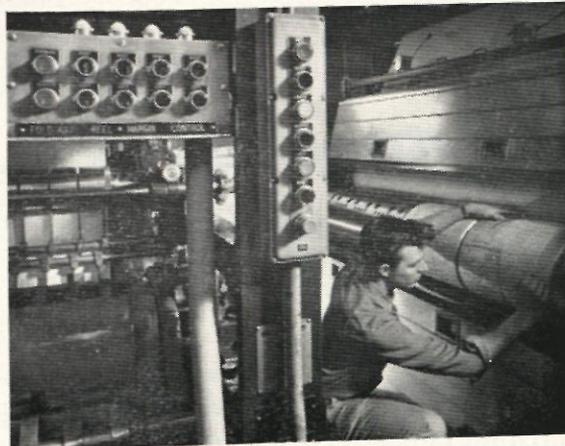
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Olin is a world-wide company with 39,000 employees developing, producing and marketing products from seven divisions: Packaging, Squibb, Winchester-Western, Chemicals, International, Metals and Organics. With corporate offices in New York City, the firm operates 56 plants in 30 states with plants and affiliates in 37 foreign countries.

## **WHAT DOES OLIN MAKE?**

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## **WHAT ARE THE OPPORTUNITIES AT OLIN?**

Olin recognizes its people as its greatest asset. Your future growth and career is as important to the company as it is to you. Beginning with corporate and divisional orientations, you will be given thorough on-the-job training in your first job. You will learn and progress, according to your ability, working with skilled and experienced men in various assignments with Olin.

For additional information about **Olin** please contact your Placement Office or write Mr. M. H. Jacoby, College Relations Officer, Olin, 460 Park Avenue, New York 22, N. Y.

O L I N M A T H I E S O N C H E M I C A L C O R P O R A T I O N

# BRAINWASHING

Winning Tau Beta Pi Pledge Essay

PAUL C. TURNER

A lot has been written about brainwashing and how the United States soldier succumbed to it, without the writers really understanding what it is and how it is applied, or the benefits that were derived from it. Many confuse brainwashing with breaking under interrogation. The police and intelligence agents know that, given a number of suspects, some of them will talk. The observations I made as a Prisoner of War of the Communists agree. Some men have the ability to resist interrogation for longer periods of time than others. After the Chinese "broke" a man, their questioning techniques produced some odd results. Some men were mentally deranged or confused and, in many cases, invented stories they thought the Chinese wanted to hear. Some others broke down emotionally, and some men spun tales that would have made Hemingway green with envy. The interrogation centers resembled mental institutions more than military camps and the hodge-podge of verbal garbage that emanated would

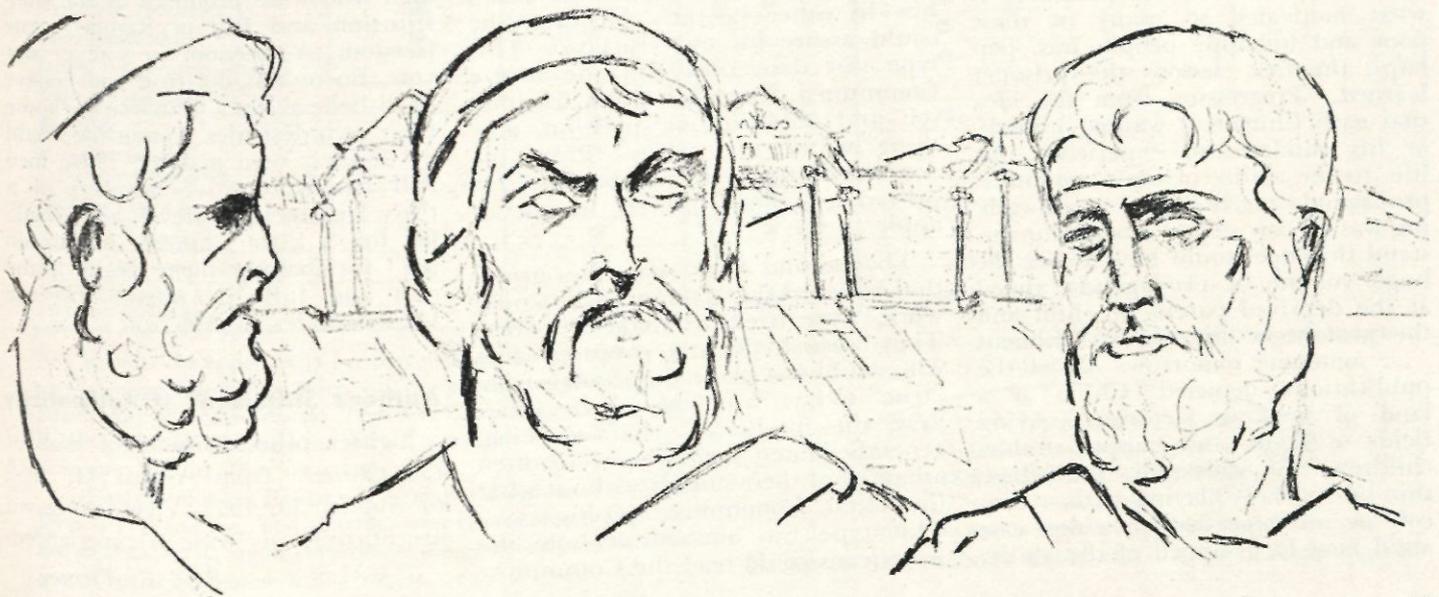
defy the imagination. The Chinese Intelligence Service probably possesses the greatest collection of American folk literature ever assembled. Some of this made it into print where it was picked up by the U. S. press, who thought its authors had capitulated.

Military information is dynamic and has only the benefit of the moment; radio channels are frequently changed, units are deployed differently, etc. It gets old quickly. But the Chinese Peoples' Volunteers wanted different information, for instance, all about germ bombs, atomic bombs, rocket ships, etc. To get it, they made fiction writers out of otherwise plain people.

There is nothing strange in the Chinese interrogation technique. Several months in solitary confinement, forced to live and smell in one's own filth, short rations or bread and water, no relief in sight, being taken out to be shot because of non-cooperation. . . . Some broke under the treatment, but those who got through

the experience while keeping their wits about them became better men. Presumably, the reason for the future conduct of some can be attributed to the deep-seated fear of death or continued imprisonment that was instilled by the Chinese during this intensive interrogation. This phase of POW life is frequently and erroneously thought of as a period of brainwashing.

Eternity eventually arrived and the man was released from the "hole" and sent to a camp, where he was told . . . "It was only a part of war." "Don't hold it against the Chinese." "Your side did it also, etc." But by now, the sight of zombies that were once fighting men was burned too deeply into the retina of many ever to leave and they had learned to hate, not an individual interrogator, but a system—Communism. These men had developed the cunning of the cave men and instincts of animals. They understood survival in the Communist jungle better than many of their Chinese captors. They understood



passive resistance, their own limitations and had faith in the U.S. These are the men who benefit from the subsequent brainwashing, or Communist education, or "Red Think," or political indoctrination.

When first exposed to brainwashing, many soldiers found that their political education had been rather limited, or, for many, nonexistent. The textbooks covered the topics of Socialism and Communism, Democracy and Totalitarianism in a rather clinical fashion. The men could define these words to their own satisfaction, and use them for communication, but words like "Truth" and "Freedom" were so twisted as to be unrecognizable. The G.I. needed a new education. "Freedom" meant unlimited freedom to follow the Communist dictates and party line—rather an interesting viewpoint. Free discussion—unlimited freedom to discuss the wise and proper path that the Communist hierarchy had chosen to take on some point. "Truth"—whatever agreed with the Communist plan of the moment. Cooperative ownership meant ownership by a ruling class to divide among the peasants as they saw fit. The American student found that a liberal education glossed over these fine points. So, the Chinese attempted to fill the educational gap. They did a good job.

The American student was free to read many authors: Marx, Lenin, Engels, Stalin, Mark Twain, Foster, Jack London, et al. It was most interesting to discover that the Chinese themselves could not understand the subtle differences in many of these writings, the reason being that the common Chinaman visualized everything in terms of a Communist-owned, green, water-tinkling park, full of laughing, jumping children, with full stomachs and many toys; the life they never knew. The realization that this desire for the simplest pleasures is what motivated so many of these poor and unhappy people was, perhaps, the first lesson the prisoner learned. Progressing from the idea that each Chinaman wanted himself, or his children, to experience this life, to the reality of the Communist propaganda machine and brainwashing was an easy step. To better understand this, one would have to see the huge volume of propaganda aimed at the deprived parent or child and the promise of his life's fulfillment . . . sometime tomorrow. All of the publications depicted China as a land of smoking factories, waving fields of grain, and happy, chubby children, not wide-eyed, fat-bellied, thin-limbed kids playing with a corn cob or an expended cartridge case amid land long sapped of the ability

to produce. The Communist hierarchy, a body politic worthy of support of historic reformers? No! A bunch of liars frosting their cake while cutting and crushing the fundamental ideas of a free productive society with the hammer and sickle. They were creating a dictatorial state, void of basic morals, and worshipping Mao Tse—"Dung". (The Americans were not the only ones being brainwashed, the Chinese people were getting a double dose.)

The U.N. POW's were prisoners of a race of old children. "Suffer little children . . ." was written for the Orient, then translated and smeared red by the Communists.

Another lesson was "commie-talk." The American had been thinking along the wrong lines. Only the Communists could use Dialectical Material correctly; the American prisoner could only emulate them. Everyone was considered a student learning what those in Peking had already learned, presumably were born with. The Chinese people were being given an inferiority complex. They were being taught to "realize" they needed a "Daddy" to spank them when they did wrong. "Confess your wrong thoughts," "admit your political errors," "be cleansed of Imperialistic tendencies," . . . until such time as we decide to use it to hang you or you find yourself bound to us by fear. They were being taught to be puppets and have all the freedom the strings would give them.

The last horrible lesson was, with many Chinese, it was working. They were dividing into three classes. There was one class of people who knew that all of this was a chance for personal advancement, that if he followed the party line and sang the patriotic songs a little louder, recited his Communist catechism a bit louder, and kept his political nose clean, but in other people's business, he could assure his own survival. This type was dangerous and the future Communist. He didn't think for himself and did, without question, anything he was told to do. "Prove the Americans dropped germ bombs." He proved it; others suffered, he got an apple.

The second class was the group that believed that Communism would work, that tried to make it work. They were frequently confused men who could not make the change from "true" today, "a lie" tomorrow. They were the intellectual, hard-working, generally honest men who were often ashamed of their stupidity about what the latest Communist piping was. This type was amazed at how the Americans could read the Communist

newspaper and, for instance, predict the downfall of Beria long before it happened. The propaganda machine prepared them well; they just didn't quite understand what was going on. Like rats, they got in line behind the flutist, not knowing where they were being led.

The third type was the citizen who didn't give a damn as long as he got two meals and was left alone. It was all too confusing to him. He hollered when hurt and smiled when petted. The others described him as a peasant in one breath and the "leader of the revolution" in the next. Give this man some education and a little freedom and he will revolt, as they do, a few at a time, because the hurts seem to come more often than the pats.

The grandstand seat occupied by the POW's was front row, center for one of the plays of the century, and the lessons brought home by most will be a valuable asset to our country. Sure, the Chinese captured some American Communists and made some Americans Communists, but only a few. Some came home and talked loudly and, when no one listened, they calmed down and began to think, and re-evaluated. They were no different than some of the children who now play with the Red toys on the campuses of some of our universities, and aren't yet men enough to take the individual responsibility imposed by a free society. Perhaps they should be crushed whenever they are found out, or given a little Communist "freedom", or better, be allowed to grow up.

The majority of G.I.'s came home to a new and different America, a much richer America. They were no longer merely citizens born and raised in a free society, embarrassed by a little flag waving, but individual men who were promised by the Constitution and Bill of Rights a true freedom. A freedom to vote or not vote, do or not do, read and believe or disbelieve; they were free to choose their own destinies. Tomorrow would be of their own making. These men will be appreciative members of a truly free society forever, and thankful for a little Chinese "brainwashing" for making them aware of the rich and full life offered by the United States of America.

#### **Author's Statement of Authenticity**

Fighter pilot, Prisoner of War of the Chinese from August 14, 1952 to August 30, 1953. Views expressed are entirely my own as experienced.

*Paul C. Turner*

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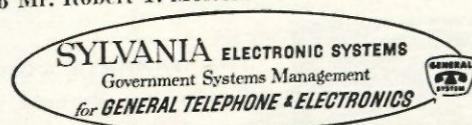
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ECM & ECCM Techniques	●		●	●
Electronic Tactical Warfare Systems				●
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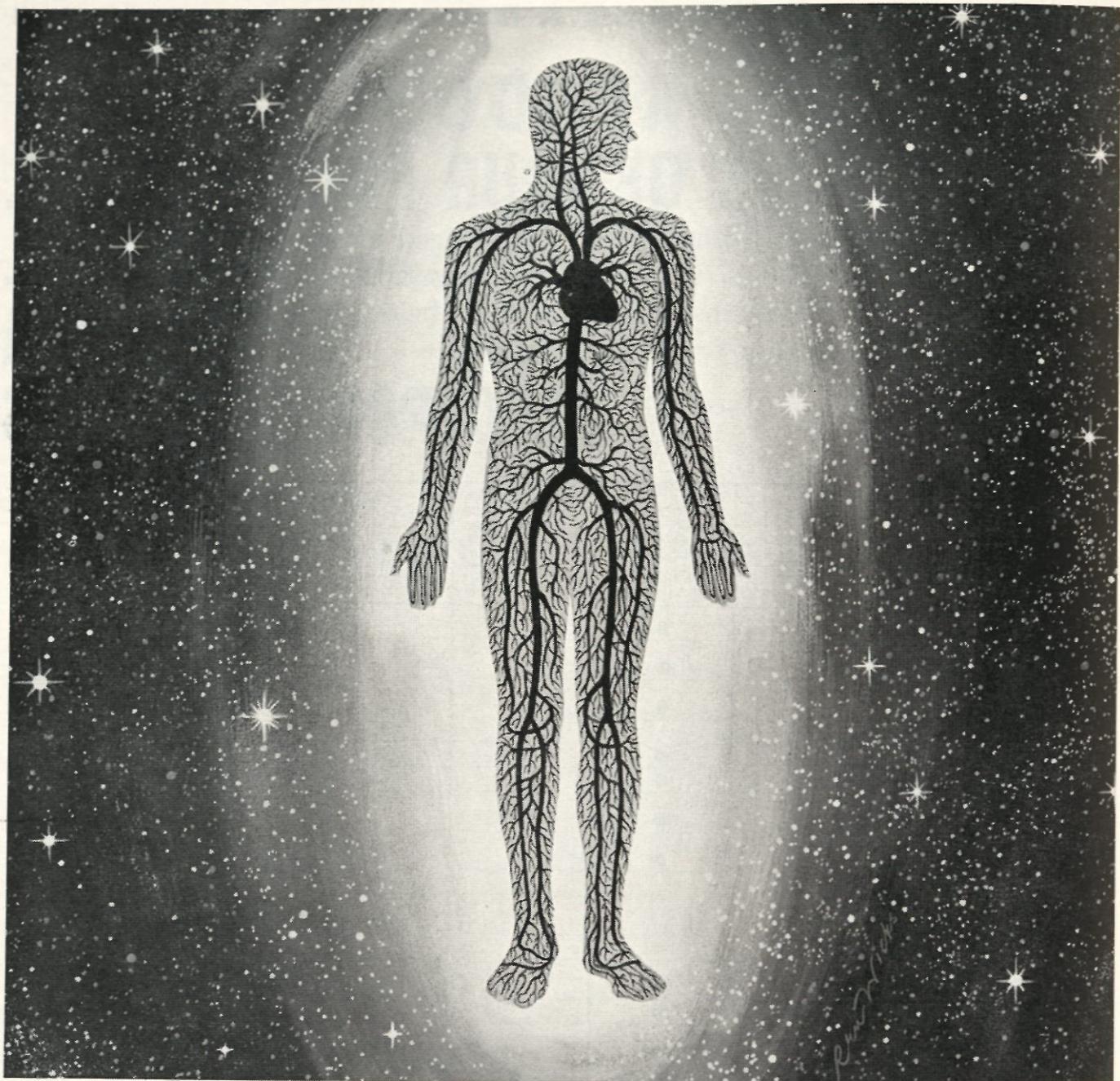
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**ULTIMATE STRENGTH . . .**

(Continued from page 20)

The moment curvature graph was recorded automatically by an electronic recorder.

**Comparison and Conclusion**

The theoretical and experimental results were reasonably close. Use of the idealized stress-strain diagram of concrete also gave fairly good results. It was concluded that unloading and reloading curves of moment curvature relation could be approximated by straight lines. It was also found that there was no incremental collapse in statically determinative structure; and possibly some of existing shakedown theorems could be applied to find out the shakedown load.

Experiments are now being conducted to verify the above inference.

**Acknowledgments**

The research mentioned above is being carried out at the University of Colorado under the direction of Prof. K. H. Gerstle and Prof. L. G. Tulin. A pilot project was started by Mr. B. P. Sinha who finished his Ph.D. thesis on this subject. Present work is being done by M/S S. W. Jones, Shao-Chien Chang and myself.

**ALUMNI NEWS . . .**

(Continued from page 29)

tion where the parachute didn't have time to blossom. I'm just quite delighted my rib and back injuries healed as they did, and that God spared by life for a reason or reasons that time may disclose."

Lt. Ellis is now on a half day basis duty with his squadron and hopes to be flying soon.

R. HUGH TAYLOR, JR., B.S. (C.E.) 1957; is an engineer with the Los Angeles consulting firm of Leeds, Hill & Jewett. He won an award at the 1962 annual meeting of the American Society of Civil Engineers for his discussion on a paper, "Roll Waves and Slug Flows in Inclined Open Channels."

CAPTAIN ARTHUR M. CASBEER, B.S. (M.E.) 1958; is a missile combat crew officer. He recently participated in special ceremonies at Tinker AFB, Oklahoma, in which the nation's first operational complex for launching the Minuteman Intercontinental Ballistic Missile was turned over to the Strategic Air Command and placed on alert.

ROBERT F. BLANKS, B.S. (Ch.E.) B. S. (Bus. Admin.) 1959; is currently employed with Union Carbide Plastics Company in Bound Brook, New Jersey. He received his Ph.D. in Chemical Engineering from the University of California, Berkeley, in 1962.

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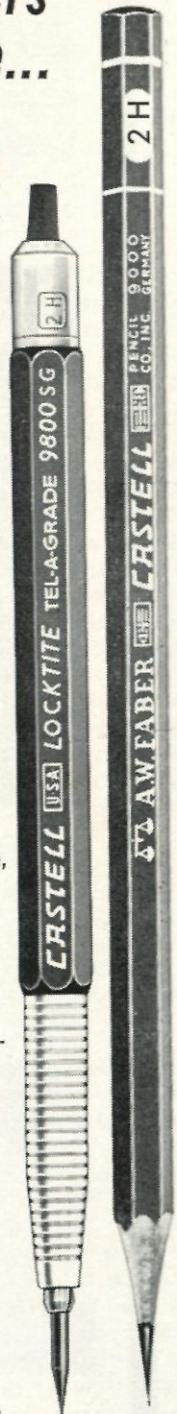
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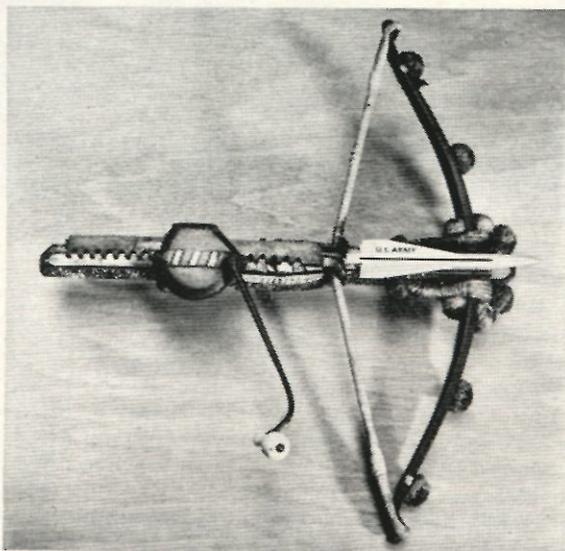
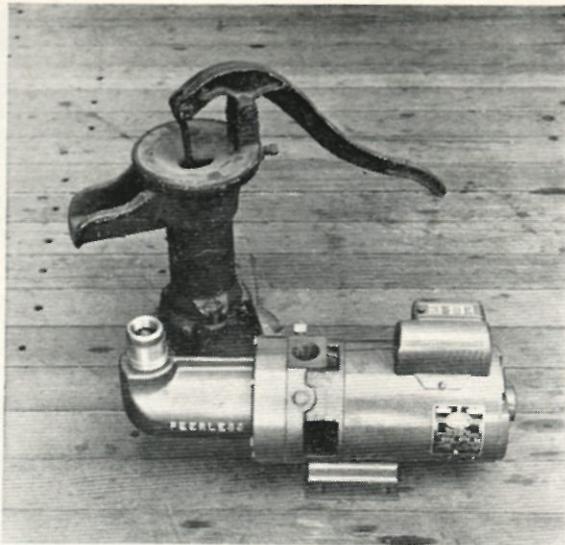
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Putting Ideas to Work in Machinery, Chemicals, Defense

## Shape and Flow, the Fluid Dynamics of Drag

Ascher H. Shapiro, Anchor Books, Doubleday and Company, Garden City, New York, 1961, 186 pp. \$95.

This book, part of Doubleday's Science Study Series, is written for those without a great deal of scientific background and thus is extremely readable and enjoyable.

It provides a clear and intuitively plausible explanation of the basic concepts and terms of aerodynamics, e.g., viscosity, boundary layer separation, Bernoulli's principle, Reynold's Number.

The book is organized around four simple experiments: 1) the change of a sphere's drag with speed; 2) the drag of a smooth sphere as compared with that of a rough one; 3) the effect of streamlining in a slightly viscous fluid; 4) the effect of streamlining in a very viscous fluid.

The author shows through these experiments what, at first glance, seem to be paradoxes in the behavior of bodies in fluids. He then goes into a study of the principles of fluid dynamics, including the various forces involved, dynamic similarity, the derivation and significance of the Reynold's Number.

Next he shows the differences in the laws of flow at low and high Reynold's Numbers. This in turn leads to a discussion of the viscous boundary layer, and then to the study of laminar and turbulent flow.

Streamlining is discussed in some detail. Results of experiments comparing the drag of various shapes in air are given in a quantitative form, showing quite dramatically the advantage of streamlined objects. Bernoulli's principle is stated and explained, as is the effect of viscosity on the pressure distribution. Boundary layer stall and backflow and discussed and dramatically illustrated using visible smoke as the fluid and showing pictures of the objects passing through it.

Dr. Shapiro concludes his book by returning to the opening set of four experiments and showing how their seemingly paradoxical behavior follows logically from the concepts of fluid dynamics which have been developed.

A very important and favorable characteristic of this book is its abundance of illustrations. As well as adding to the readers enjoyment, they make statements easy to understand. The fact that the book was adapted from a motion picture produced by Educational Services, Inc., partially explains why so many illustrations have been used.

Dr. Shapiro is a professor of Engi-

# BOOK REVIEWS

ELLEN CARR

neering at M. I. T. and, in 1960 was recipient of the Richards Memorial Award of A. S. M. E. "for outstanding achievement in engineering."

## Rocket Development

Robert H. Goddard, Ed Esther C. Goddard and G. Edward Pendray, Prentice-Hall, Inc., 1948, 222 pp., \$2.45.

When Dr. Robert Goddard died in 1945 he left behind voluminous photographs, records, ideas, and experimental data representing his total work on the practical use of rockets. *Rocket Development* is an almost day by day record of his most important years—those from 1929 to 1941. In this book Goddard's wife (also his photographer) and Edward Pendray, one of the founders of the American Rocket Society who also acted, along with Goddard, as co-director until the latter's death, have edited Goddard's notes on his experiments during these years. Actually, Goddard was such a precise man that few corrections had to be made to publish his notes.

In 1909 Goddard started developing his ideas on multistage rockets and on hydrogen and oxygen fuels for interplanetary flight. Out of his earliest work came his famous book *A Method of Reaching Extreme Altitudes*.

Early in the 1920's he learned that it is painful to be a pioneer, especially one with such a daring idea as going to the moon. A "New York Times" writer said that Goddard lacked "the knowledge ladled out daily in high schools." He was called the "moon man" when it became known that he thought it possible to shoot the moon. As late as 1945 Goddard was to write, "The subject of projection from the earth, and especially a mention of the moon, must still be avoided in dignified scientific

and engineering circles." Despite these obstacles, he was a happy man who was merely a seeker of the truth.

He did his early work in Massachusetts, leaving only when the State Fire Marshall forced him to stop work. He then moved to Roswell, New Mexico, where the majority of his work was done. By 1941 Goddard had eighty-three patents with such things as gyrocontrols, clustered rockets, turbopumps for propellants, and a prototype of the modern bazooka. Recently one hundred thirty-one more patents were granted to him after his executors looked over his notebooks and diaries. Today it is absolutely impossible to design, construct, or launch a rocket which does not use the ideas or devices covered by Dr. Goddard's patents.

## We Seven

Carpenter, Cooper, Glenn, Grissom, Schirra, Shepard, Slayton; Simon and Schuster, New York, 1962, 473 pp., available only through the Literary Guild.

*We Seven* is the story of our first seven astronauts written by themselves. In this truly exciting story one sees for the first time that the job of being America's first space heroes is not all seen in the glory, nor is it a job that consists of being just guinea pigs for the space scientists and engineers of NASA. It is more an important part of an all-out effort by the United States to keep in the space race and win. It is a united effort in which these seven men, as well as all the engineers, scientists, technicians, doctors, etc., who are connected with the program of manned space flight, are working as a team.

When Project Mercury first began, each astronaut was assigned a job in which he had done previous work. For example, Scott Carpenter worked on communications and navigation

aids, Alan Shepard worked on the tracking range and recovery teams, and Gordon Cooper concentrated on the Redstone booster while Donald Slayton studied the Atlas. They visited such places as McDonnell to watch the development of the capsule, and although they could not make any improvements of such things as the already operational Redstone and Atlas, they did learn all they could that might be useful, and each one reported what he had learned to the other six. In such areas as pressure suits and instrument panel layout they were able to make suggestions for improvements. For instance, in the astronauts survival kit one of the most valuable items is a knife. Several manufacturers submitted samples of their products; however, the astronauts were not completely satisfied with any of them. Finally a man by the name of Walter Randall, who had made knives for the commandos in World War II, was given the job. The finished knives were made of high-grade Swedish steel and hand-forged and hand-tempered so that they were able to cut through steel bolts. Their design even included a place to keep other survival equipment such as fish hooks and matches.

Another important point is illustrated by this example. When we

think of Project Mercury, we usually think of such big names as McDonnell, Boeing, and North American, to name just a very few who have been major contributors, but we see here that not all of the work is given to such large companies.

As seen from this one example, if this book illustrates nothing else, it does illustrate the tremendous amount of teamwork and coordination needed to keep us in the space race.

### Building Failures: Case Studies in Construction and Design

Thomas H. McKaig, McGraw-Hill, 1962, 256 pp., \$10.75.

Thomas McKaig is an architectural and structural engineer who now operates a thriving consulting engineering practice in Buffalo, New York. He has frequently been called upon to investigate building failures and to testify in court as an expert in this area.

This book was written in the hope that, as the result of the brief outlines included, some future failures might be avoided. In Mr. McKaig's words, "Building failures have occurred since man first started placing block upon block. The lessons learned from these failures have been

the foundation on which modern design and construction practice have been developed."

*Building Failures* contains an interesting account of case studies of over 200 of the most noteworthy failures of recent years, and also includes a few of the most remarkable failures of earlier date. The reasons for the failures and the way in which they could have been avoided are discussed.

All kinds of failures are covered: reinforced concrete structures which collapsed during construction (this is probably the most common type of failure), steel frame buildings, masonry and timber constructions.

There are also several chapters dealing with specific causes of failures: carelessness or ignorance; newly introduced designs with unforeseen weaknesses; deterioration due to over-loading or old-age; causes not directly related to design, such as wind, fire, or explosion.

This book is not intended to be used exclusively by those who are engineers or architects or it would be treated on a more technical level. It would make interesting study for anyone interested in this field.

Grateful acknowledgment is hereby made to Sandy Pyle, a sophomore in Aeronautical Engineering for reviewing *We Seven and Rocket Development*.

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# THIS TODAY

JOE CAYER

## REVOLUTION IN COMPUTER USE

The fact that computers direct the use of industrial machines is now accepted as common place. However, using computers to look into the future and correct manufacturing mistakes or drifts toward tolerance limits before they happen is revolutionary. This new concept, combining statistical quality control with fully mechanized processing under the guidance of a digital computer, is now producing electronic components at the North Carolina works of the Western Electric Co.

An array of eleven interconnected machines turns out flawless deposited carbon resistors, small electronic components that are used in immense quantities in a variety of electronic equipment including radar and missile control system. In some military systems the electrical requirements for the resistors are so severe that manual techniques of manufacturing them are rendered impractical. Since

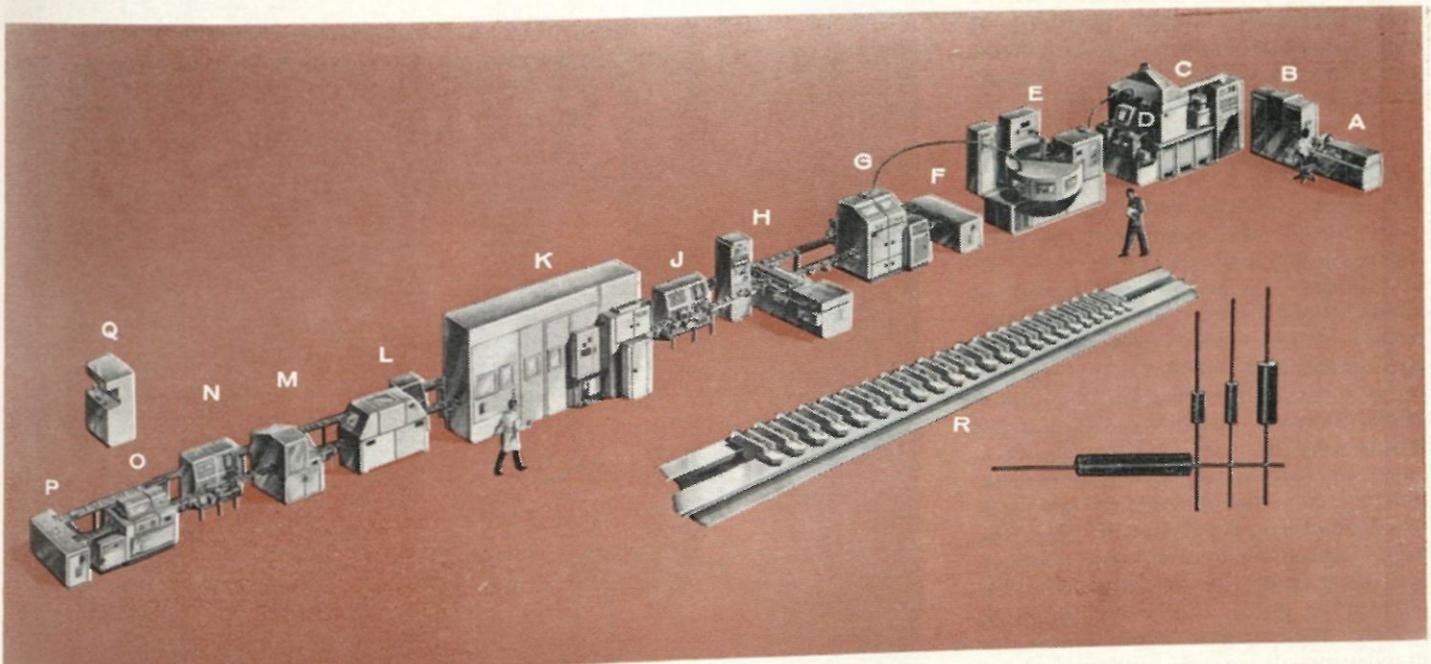
the resistors produced by the automated line are extremely reliable, there is only minimal need for costly final inspection and sorting procedures.

In addition to controlling step-by-step details of manufacture, the computer can accept a production schedule for a full month's output and thereafter automatically issue detailed instructions to the fabricating machines to make and package any or all of four power sizes of resistors in such quantities and resistance values as may be desired.

Sensing and measuring devices, installed at strategic stations along the line, detect trends in machine performance and tendencies on the part of the product to depart from specified values. Based on information relayed by the sensors, the computer continuously predicts future process trends and feeds correcting information to the automated line, heading off manufacturing errors before they occur.

The resistors look like tiny black firecrackers with copper wire "fuses" extending from the ends. Each consists of a short ceramic rod or core which is first coated with carbon. A conductive gold coating is applied to each end of the core for attaching a cap and wire terminal. Then a spiralled groove is cut into the carbon film, barber-pole fashion, to change the electrical path on the core and raise the resistance to the desired level. Finally, the resistor is encased in a cylindrical, epoxy plastic cover for protection. The machines work on a three second cycle, producing a resistor during each cycle. Maximum production rate is 1,200 finished resistors per hour.

By adopting advanced automation, contamination disappears as a problem, production is vastly increased and, most vital, a level of reliability is attained that manual methods cannot match, advantages that are reflected in low unit costs.



MACHINE STATIONS IN THE AUTOMATED PRODUCTION LINE FOR MANUFACTURING DEPOSITED CARBON RESISTORS

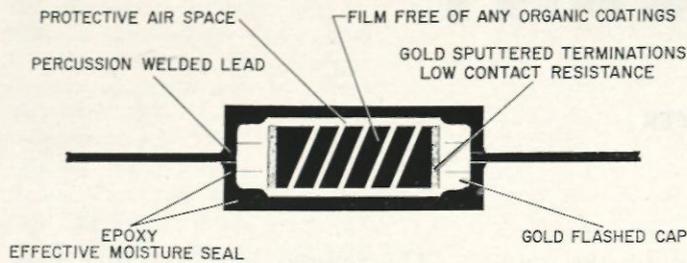
### LEGEND

- A. COMPUTER
- B. OUTPUT-INPUT CONTROL STATION
- C. COATING STATION
- D. FIRST INSPECTION STATION
- E. TERMINATING STATION

- F. CONVEYOR CONTROL EQUIPMENT
- G. CAPPING STATION
- H. HELIXING STATION
- J. SECOND INSPECTION STATION
- K. ENCAPSULATING STATION
- L. LEAK DETECTOR STATION

- M. MARKING STATION
- N. THIRD INSPECTION STATION
- O. PACKING STATION
- P. CONVEYOR CONTROL EQUIPMENT
- Q. CAP-LEAD WELDING MACHINE
- R. DETAIL OF CONVEYOR LINE

## EPOXY ENCAPSULATED RESISTOR



WESTERN ELECTRIC COMPANY'S NEW AUTOMATED PRODUCTION LINE AT THE NORTH CAROLINA WORKS IS FIRST OF ITS KIND—A COMPLETELY COMPUTER-CONTROLLED PROCESS FOR MAKING DEPOSITED CARBON RESISTORS. THE RESISTOR IS NOT TOUCHED BY HUMAN HANDS IN ITS JOURNEY THROUGH 11 DIFFERENT PROCESSES.

## REBIRTH OF THE CITY

Dr. Walter Gropius, Chairman Emeritus of Harvard University's Department of Architecture, believes that suburban Americans in the next few decades will be flocking back to the cities because of a more efficient use of air. The upsurge in urban living will be due to more extensive use of "air rights" — the privilege of putting up an apartment house over a site already in use.

Building over such places as over the approach to the George Washington bridge in New York is now possible because of a high-strength steel developed in recent years. The steel gives the same strength with ten per cent less weight than ordinary steel. Building codes have been revised in many cities to permit their use, with a savings in cost. Steel enables a building to be up quickly and is especially desirable in areas which are subject to earthquakes.

Gropius feels that the trend will be away from sprawling suburbs, where automobiles are needed, to living in high rise apartments again. More and more people will want to get close to centers of culture and commerce once again.

## DIAMOND-CUTTING LASER

General Electric engineers have recently used the high-energy light beam of a Laser to strike holes in diamonds. The holes were bored in 200-millionths of a second—the light beams striking with explosive force and generating temperatures in the order of 10,000 degrees F. The industrial diamonds used in the experiments were about 1/4 inch in diameter, and the holes drilled were approximately 20 thousandths of an inch in diameter. Analysis of the diamonds revealed no structural damage resulting from the drilling. The experiments point the way to high speed, inexpensive techniques for machining all sorts of extremely hard materials. Laser light has also been used by GE engineers to pierce stainless steel, tungsten and other tough metals. In all of these experiments the pencil-thin, coherent light beam was further concentrated by placing

a focusing lens between the Laser "gun" and the workpiece.

Diamonds and other materials can also be cut by an electron beam technique, but the Laser method promises a number of advantages, including lower cost and higher operating speed. The electron beam must be operated in a vacuum, which is not required for the Laser. The Laser experiments were conducted at room temperature, but even higher energies could be achieved by cooling the ruby crystal, heart of the device, with liquid nitrogen.

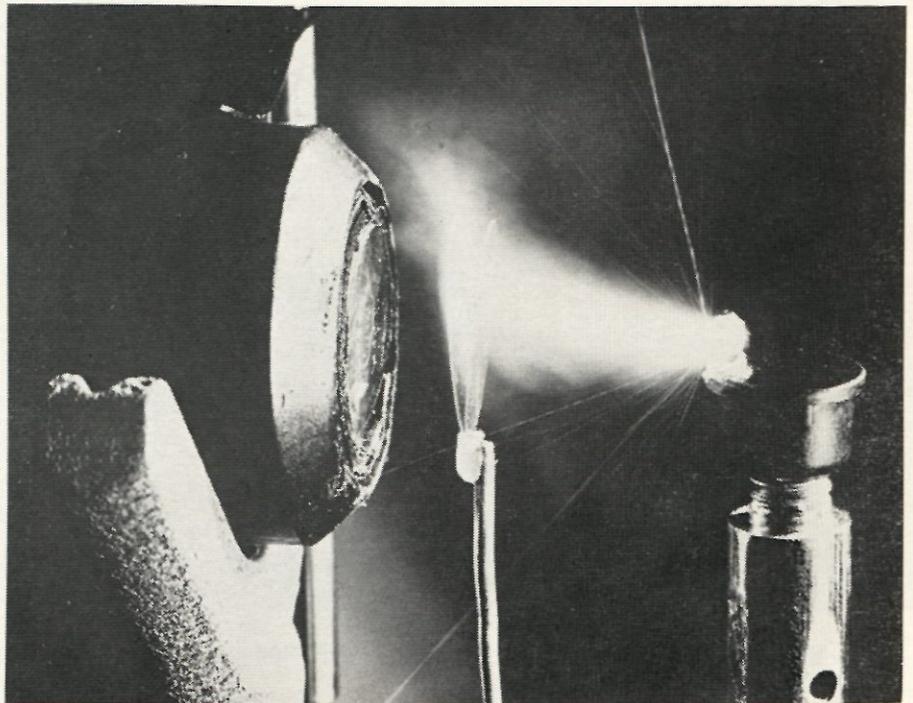
## PROGRESS ON THE FUEL CELL

A new fuel cell which will operate on inexpensive fuels such as natural gas is being worked on by General Electric Scientists. Fuel cells are devices that convert chemical energy directly into electrical energy without use of moving parts. Most earlier fuel cells have operated on hydrogen, a fuel substantially higher in cost than the common hydrocarbons. Hydrogen fuel cells will probably be limited to

specialty applications such as power sources for spacecraft and portable military communications systems because of the cost.

The novel cell has a solid electrolyte made of zirconia, a refractory oxide. Several of the cells have been stacked together in the form of a "fuel battery." The efficiency of this type of fuel battery is estimated to be about 30% using natural gas as the fuel. Other hydrocarbons could produce greater efficiency. By comparison, the typical internal-combustion auto engine is about 20% efficient and the hydrogen fuel cell is operating in the range of 50-80% efficiency.

In a fuel cell, electrons move from one electrode to another, then pass through a circuit in which they do useful work. Unlike the conventional battery, the fuel cell draws its energy from a fuel that is pumped in instead of consuming its own electrodes. In the new General Electric cell, the natural gas breaks down into carbon and hydrogen. Carbon builds up inside the cell to form one electrode and oxygen is obtained from the air which is introduced into the other electrode—molten silver. Oxide ions migrate through the zirconia electrolyte to the carbon electrode. The oxygen yields its electrons to the carbon and combines with part of the carbon to form carbon monoxide gas. The electrons are conducted out of the cell as an electric current. The left-over carbon monoxide and hydrogen gases are burned within the cell assembly to keep the cell going. It operates at high temperatures to keep



STARTLING EFFECT OF THE LASER LIGHT AS IT STRIKES A HOLE IN A DIAMOND. THE INTENSE LIGHT OBSCURES THE DIAMOND ITSELF ON TOP OF THE PEDESTAL AT RIGHT. LIGHT IS FOCUSED BY A LENS, IN FRONT OF WHICH IS A PROTECTIVE GLASS DISC. THE LASER IS OUT OF THE PICTURE TO THE LEFT.

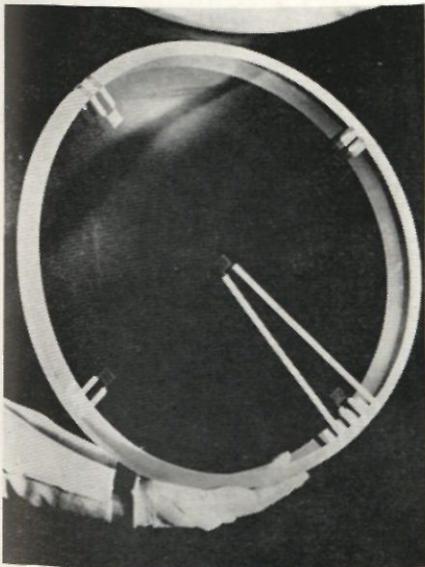
the cell going. It operates at high temperatures and is self-sustaining.

Among advantages of the new cell is the fact that it does not require significant quantities of expensive catalytic electrode material. The solid electrolyte also has great structural and chemical stability.

### SPACECRAFT WINDOW

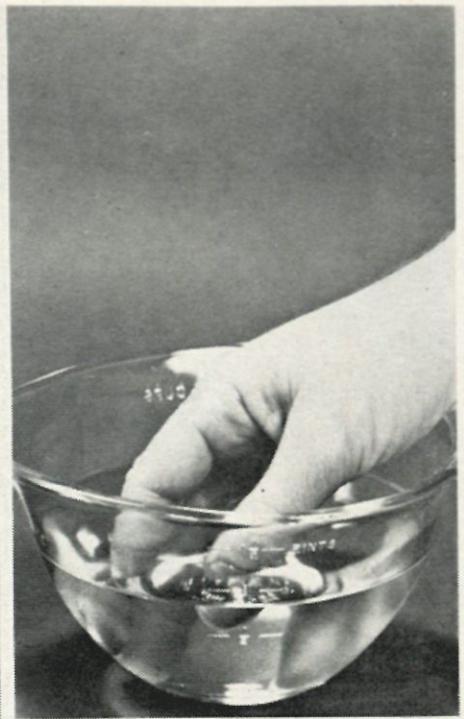
A fused silica camera window 19 inches in diameter and 1½ inches thick will be used soon in one of the X-15 research spacecraft. The window will be mounted aft of the cockpit in the bottom of the number 1 ship. Developed by Corning Glass Works, fused silica was chosen primarily because of its low temperature coefficient of linear expansion. The high temperature properties of the glass were also desired. Average temperature coefficient of fused silica is  $5.6 \times 10^{-7}$  degrees C between 0 and 300 degrees Centigrade. Normal service temperature is 900 degrees Centigrade, and the extreme service temperature is 1100 degrees Centigrade. Corning said the maximum temperature expected to play on the camera window is approximately 800 degrees Centigrade. Each window has five thin-film thermistors fired into its outer surface to determine heat distribution across the panel during flight.

Corning also makes the aluminosilicate glass outer thermal shields for the X-15 viewing windows. Some of these have been made with various thin-film thermistor designs for a number of missions seeking in-flight temperature data.



FUSED SILICA SPACECRAFT WINDOW DEVELOPED TO WITHSTAND 1100° HEAT.

COLORADO ENGINEER—March, 1963



ACID DOESN'T AFFECT THIS HAND DUE TO THE PROTECTIVE COAT OF A NEW ACID RESISTANT CREAM.

### NEW PROTECTION AGAINST ACID

A new cream called Kerodex that protects the skin from harmful effects of acid is produced by Ayerst Laboratories of New York City. In the accompanying photograph, a zinc plate fumes, boils and dissolves in pure hydrochloric acid while a bare hand protected only with a coating of Kerodex is immersed for a full minute without a later sign of burn or blister.

This carrier cream is now being used in major industries and, depending on the particular type of cream, routinely protects workers' hands, forearms, and faces from irritants such as acids, alkalis, epoxy resins, amine hardeners, fiber glass, cutting oils, solvents and thinners, adhesives, petrochemical agents, plating solutions, and many others. Kerodex is available in two types—one for dry or oily work and one for wet work. It protects against dermatitis from irritants, sensitization and allergy, and hand-staining by chemicals and tars.

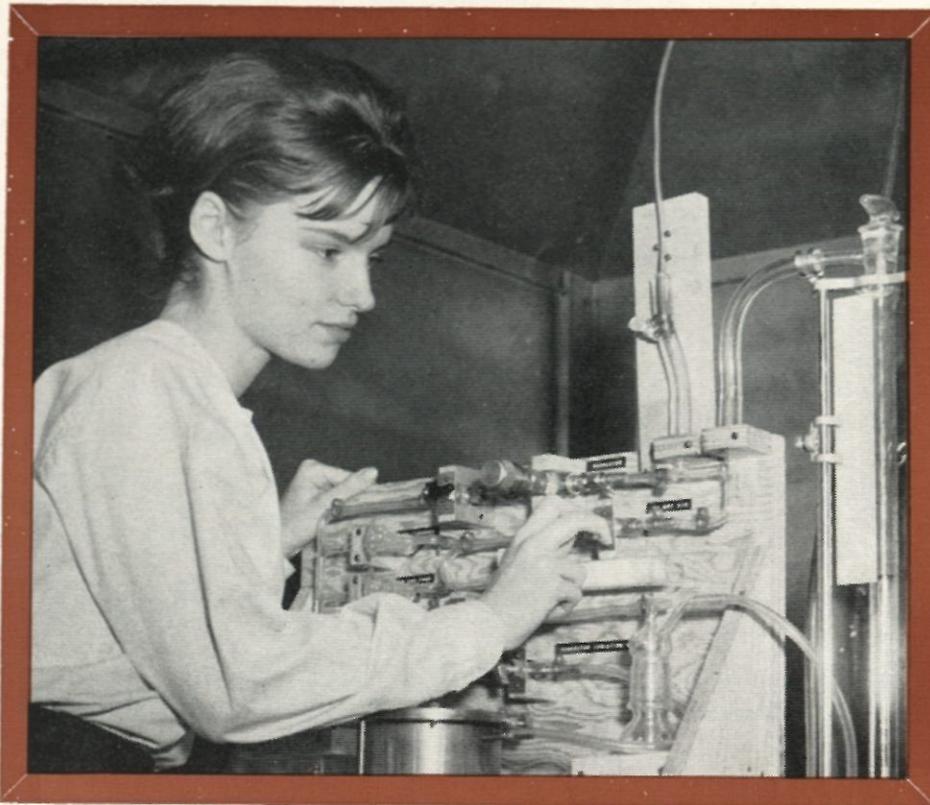
### NEW REPELLENT

Du Pont Company's Dye and Chemical Division has demonstrated a new flouride-based textile finish which makes fabrics water and oil repellent and resistant to oil and water-borne stains. The new product has been named "Zepel" fabric fluoridizer and is applied during the finishing process by the mill. The word "fluoridizer" was coined by Du Pont because no single term exists which describes the multi-purpose properties of the new chemical adequately. It indicates

the presence of fluorine in a chemical form which is extremely non-reactive. This fluoro-chemical is the key ingredient which provides resistance to liquids and stains.

Zepel is a white, odorless compound which is colorless after application and does not affect fabric or appearance. It remains effective after repeated washings and dry cleanings. It clings to each fiber in the fabric, forming a chemical shield which pushes away watery and oily substances and prevents them from being absorbed. Du Pont believes it can be applied successfully to fabrics of any fiber or fiber blend, natural or man-made. Staining agents such as coffee, ink, and salad oil roll off treated fabrics while untreated fabrics of identical construction soak them up like a sponge. Also, a great majority of stains applied to the surface of Zepel-treated fabrics can be removed completely by blotting with a cloth or by spot cleaning with standard household solvent. In the case of severe staining, where the substance has been allowed to dry and set, laundering or dry cleaning will remove it in almost all cases. Thorough rinsing is necessary to remove all soaps which may inhibit the performance of Zepel.

Articles treated with Zepel will be on the market in the fall of 1963. Included in these articles will be: men's and women's raincoats and outdoor wear, draperies and slip covers. Later, a wider variety of clothing and home furnishing will be available with the Zepel treatment.



JEAN DEXHEIMER IS THE THIRD WOMAN TO BE ELECTED INTO THE UNIVERSITY OF COLORADO CHAPTER OF SIGMA TAU, NATIONAL ENGINEERING HONORARY FRATERNITY. THE ELECTRICAL ENGINEERING JUNIOR IS THE DAUGHTER OF LT. COL. AND MRS. ROBERT DEXHEIMER OF (1300 ANDERSON) LEESVILLE, LA., FORMERLY OF FT. CARSON.

A University of Colorado coed who never considered an engineering career until after she entered college has become the third woman ever to be initiated into the CU chapter of Sigma Tau, a national engineering honorary fraternity.

Jean Dexheimer, an electrical engineering junior and a graduate of Fountain High School near Colorado Springs, originally had planned to major in Russian and German languages. She abruptly changed her plans in her freshman year while taking a mathematics course.

"Science all at once seemed so much more interesting and worthwhile to me," she explained. "Computers especially fascinated me."

Miss Dexheimer is the daughter of Lt. Col. and Mrs. Robert Dexheimer of (1300 Anderson) Leesville, La., formerly of Ft. Carson.

"It's difficult to be a woman engineer," she says, "but I definitely feel that the American female has a place in engineering."

"I believe the reason why there are so few women in the field is because so few are ever introduced to it. High school counselors tend to discourage it." There are only 30 girls enrolled this year in the College of Engineering out of a total enrollment of 1,539.

In addition to being an honor student, Miss Dexheimer is active in extracurricular activities. She is chairman of the CU chapter of the Society

of Women Engineers, treasurer of the CU student branch of the Institute of Electrical and Electronic Engineers and an honorary cadet captain of Castle Belles, a CU Army ROTC women's organization.

Miss Dexheimer also is doing research work under Assoc. Prof. Frank S. Barnes of the electrical engineering department. The project, financed by a National Science Foundation grant, is to improve the accuracy of the Pirani gauge, a temperature-sensitive gauge.

She is attending CU with the aid of a Joint Honor Scholarship. Her plans are to earn a doctorate and eventually to teach.

## New Fellowship Announced

Boulder, Colorado — A graduate fellowship program in the atmospheric sciences will be started this coming summer by the University Corporation for Atmospheric Research (UCAR), utilizing a \$20,000 grant from the Charles F. Kettering Foundation. Dr. Walter Orr Roberts, director of UCAR, announced today. The grant was made to the University Corporation for Atmospheric Research, the 14-university non-profit corporation that operates the National Center for Atmospheric Research (NCAR) in Boulder.

The fellowships, the first two of which will be awarded this summer, will cover a year's graduate study in any accredited institution, and in any geophysical or fundamental discipline broadly related to the atmospheric sciences. This includes disciplines extending well beyond the usually defined borders of meteorology, Dr. Roberts said.

Along with the fellowship awards will go an automatic summer research appointment at NCAR, during the summer preceding the fellowship year. Grants will be renewable.

The fellowship program is being started in order to attract potentially outstanding students into the atmospheric sciences, and thus to help remedy a severe shortage of top-flight doctoral candidates in meteorology and allied fields, Dr. Roberts said.

Many students with brilliant potential in mathematics and physics are turning away from the atmospheric sciences because of what Dr. Roberts described as an "erroneous public and professional image of the character and research potential of the atmospheric sciences."

"This view is now obsolete," he said. "The application of rigorous physical analysis and mathematical techniques to the atmospheric sci-

# CAMPUS NEWS

ences has in recent years become an important road to progress in the field."

At the same time, graduate departments in the atmospheric sciences at various universities have greatly improved, and now offer opportunities of high scientific promise.

The program, which will have a trial period of three years, is designed to help fulfill NCAR's mission to augment and supplement basic research and educational efforts in universities and research groups on a national basis. Ultimate goal of the program is to offer a significant number of fellowships each year, with the fellowships continuing, where appropriate, throughout a student's graduate career.

For further information please call: Edwin L. Wolff, Phone 443-1960, Ext. 234.

### New Director

The appointment of Prof. Klaus D. Timmerhaus as acting director of the Engineering Experiment Station and acting associate dean of engineering for graduate and research programs was approved by the University of Colorado Board of Regents.

Timmerhaus will continue as professor of chemical engineering. He has been a member of the CU faculty nine years. He succeeds Assoc. Dean Charles A. Hutchinson as acting director of the experiment station.

"Dr. Timmerhaus will have the major responsibility of not only coordinating the entire engineering graduate and research program, but also of coordinating our plans for research and graduate facilities in the new Engineering Sciences Center," Dr. Max S. Peters, engineering dean said.

Currently there is about \$800,000 worth of research underway in the College of Engineering, with 250 engineering graduate students on the Boulder campus and 390 graduate students in engineering at the Denver Extension Center.

"With the steadily increasing activities of the graduate and research program in engineering, it is essential we have a man of Dr. Timmerhaus' ability to help direct our efforts. I know he will give invaluable service for the progress of our engineering college," Peters said.

Timmerhaus received degrees in chemical engineering from the University of Illinois. He is a specialist in the field of cryogenic engineering and is a member of the CU-National Bureau of Standards Joint Council sub-committee in cryogenics. He has been director of the National Cryo-

genic Engineering Conference since 1956.

Timmerhaus is coauthor of four books in cryogenics and has edited and contributed to seven volumes on "Advances in Cryogenic Engineering."

### Undergraduate Research

The University of Colorado has received a \$21,600 National Science Foundation grant to continue a research program for undergraduates in the College of Engineering.

The program, begun four years ago, is conducted mostly during summers under the direction of Prof. Frank Kreith of the mechanical engineering department. Twenty-one students took part in the program last summer.

The purpose of the program is to give exceptionally bright and creative engineering undergraduates an opportunity to try out their own ideas, to take part in research conducted by the faculty and to become acquainted with methods of creative work in engineering sciences.

A by-product of the program has been the publication in national journals of the results of some of the undergraduate work. Also, some of the projects are being continued by graduate students as the basis for theses.

### New Center Receives Award

The design of the Engineering Sciences Center for the University of Colorado has won the Education Citation Award in the 10th annual Design Awards Program sponsored by Progressive Architecture, national architectural magazine.

A town house design by Marvin Hatami, a 1958 graduate of CU, won the Residential Citation Award in the program.

The two awards were among 20 other award-winning projects chosen from more than 500 entries.

The Engineering Sciences Center was designed by Architectural Associates of Colorado, composed of William C. Muchow Associates; Hobart D. Wagener & Associates; Fisher & Davis; and Ketchum, Konkel & Hastings.

Other designers cited by the magazine include Pietro Belluchi, architectural consultant to CU, Hideo Sasaki, CU cite planner and landscape architect, and Swanson, Rink & Associates, electrical engineers.

CU is requesting \$3.5 million from the 1963 Colorado Legislature in order to complete financing the first phase of the \$10 million center.

Though the present campus is composed of many individual buildings

loosely grouped around open courtyards and malls, the need for closely integrated and academic research spaces, and the limited building site, necessitated a compact, high-density structure. The new structure is architecturally compatible with existing buildings on the campus.

### Soil Study

Engineers from the University of Colorado and the State Highway Department are trying to solve two problems that have plagued highway designers for many years.

They want to find a low-cost way to strengthen paving with chemical or other additives and a method to prevent roads from crumbling because of swelling soils.

What they find could have millions of dollars in road construction, decrease highway maintenance and lead to longer lasting highways.

The project is supported by a \$33,000 contract awarded by the CU civil engineering department by the State Highway Department. Cosponsor is the U.S. Bureau of Public Roads.

Prof. Roland C. Rautenstrauss, department chairman, Assoc. Prof. Charles V. Hallenbeck and Asst. Prof. William R. Eager are studying various materials suitable for mixing with asphalt or cement-treated paving materials. They also are studying chemical and mechanical means for strengthening the material.

Their research is centered in eastern Colorado, near Eads, Holyoke and Strasburg, where there is no sand or gravel adequate for highway construction.

This lack has caused highway builders to import better mixes from other parts of the state or to strengthen chemically, at high cost, existing material.

The stability of road building material is greatly affected by moisture variation. Lack of moisture turns the material brittle. Too much moisture weakens it.

The engineers are seeking to identify various types of soil, study what has been done before with poor materials, prepare an economic analysis for mixing chemicals or other additives with poor materials and attempt to formulate guidelines highway engineers can use. Much of the analysis is being done in highway department laboratories.

In a related project, Associate Professors Edward Sampson, Jr. and Robert L. Schuster are looking for what causes roads to rise, ripple, crack and crumble—in some cases only a few years after they have been built.

(Continued on page 49)

**\$60 Million Outlay in Few Years Expected**

By CHARLES VAUGHAN, Business Editor  
 The Atomic Energy Commission (AEC) today awarded a contract for construction of a mobile military reactor to Allison Division of General Motors. The contract puts Allison in the nuclear field as a prime contractor, a matter of utmost significance to the Midwest and Indianapolis, Allison officials said. The contract is expected to involve an expenditure of at least \$60 million over the next few years.

Allison earlier had disclosed negotiations with the AEC for development of the reactor. Preliminary studies to which the most promising approach were completed last year by Allison and General Motors.

Picture on Page 10

**Allison Will Build Mobile Atom Plant**

**Allison Awarded Atomic Contract**

**Allison Expands For Nuclear Work**

Allison Division of the General Motors Corporation has expanded its nuclear engineering staff yesterday for the production of a mobile nuclear reactor for the Atomic Energy Commission. The AEC, which awarded the contract yesterday, estimated that expenditures for the reactor might run as high as \$60,000,000. The reactor, which was designed for military use, is being built at Allison's Indianapolis plant.

**\$60 Million Is Estimated for A-Power Generator Production**

The Atomic Energy Commission today awarded Allison Division of General Motors a contract which may amount to \$60 million for building mobile atomic power generators. Allison spokesman described the award, which makes the division a prime contractor in the nuclear field on its first major attempt, as an important advance in the horsepower race to bring more nuclear and space reactors to Midwest industry.

**A Widening Circle**

The success of Allison Division in Indianapolis in winning a multimillion-dollar defense contract will have an impact in Indiana much like a stone dropped into a pool of water. The immediate splash is the prospect that the Atomic Energy Commission will spend up to \$60,000,000 with the General Motors Corporation division. Indiana University already has received a grant of \$10,000,000 in the program when it came about directly because of this research project. Allison is presently recruiting men with advanced degrees in science to work on the project. Such men will not only fill its contracts, but will also be contributing to the community.

**In Step With the Times**

Allison's \$60 million contract to develop small atomic generators is an irrigating boon for Indianapolis and Indiana. In addition to its obvious impact on jobs, it adds further diversity to an industrial base which already is rich in electrical energy, here which already is remarkably and successfully marketed. It also provides a vital outlet for the the gloomy prophets who industries of the atom in the Midwest. This project is right in the existing times, and more surely will bring to us many some of the most and research experts.

**GM gets Army contract to develop mobile nuclear reactor for field use**

The Army is expanding its effort to develop a mobile compact nuclear power reactor for field use. With one such reactor cranking up a long string of successful tests, Army has just given General Motors Corp. the \$60-million to \$80-million job of developing an even more powerful lightweight field nuclear power plant. The new reactor will be built by GM's Allison Div. in Indianapolis. It will use a liquid-metal coolant and operate with a power plant generating 3,000 kw. of electricity. That's seven times the output of the M-1, the Army's closed-cycle gas-cooled reactor already being built. Allison's new project has the same goal: to develop what is known as a mobile nuclear generator.

**Allison Lands Key Nuclear Contract**

● Award of a multimillion-dollar contract to Allison by the Atomic Energy Commission for construction of a mobile Military Compact Reactor highlights the progress Allison is making in energy conversion programs.

Objective of the high priority project is the design, construction and operation of an extremely mobile, lightweight powerplant capable of generating 3000 kw. of electricity. The plant will have a high temperature, liquid metal-cooled reactor coupled to a power conversion system. In addition to its military field use, the MCR could serve as a power source in civilian defense and power failure emergencies. Allison, the energy conversion Division of General Motors, was selected by the AEC as prime contractor on the basis of company capability to act as systems manager for the complete project.

In other fields, first and second stage rocket motor cases designed and produced by Allison for Minuteman have achieved a 100 per cent reliability record. Too, Allison research has made significant progress in the development of cases from lighter weight materials, titanium and plastics, and now is in position to meet the case needs of the future . . . whatever they may be.

Allison also maintains its position as foremost designer, developer and producer of turboprops. Current emphasis is directed toward developing engines of greater power with maximum fuel economy, and without increasing engine size.

Acceptance by the Army of the Allison 250-horsepower T63 turbo-shaft engine for Light Observation Helicopters is further evidence of Allison capability in the gas turbine areas.

Perhaps there's a challenging opportunity for you in one of the diversified areas at Allison. Talk to our representative when he visits your campus. Let him tell you first-hand what it's like at Allison where "Energy Conversion Is Our Business."

*An equal opportunity employer*



# The New Engineering Building

C. L. ECKEL<sup>1</sup>

Contracts have been let and work on the construction of the new Engineering Building is now well under way. This building and the two wings of the Liberal Arts Building which are also under construction are the first projects in the ten-year building program which was authorized at the last session of the Legislature. Construction of both buildings at this time is made possible by P. W. A. grants of approximately 45 per cent of the cost of the building.

The cost of this building, including furniture, will be about \$205,000\*. Not including furniture, the cubic foot cost of the building is 29 cents. This is considerably under the engineer's estimate and may be attributed to the condition of the materials market at the time the contract was let.

The new building is located on the site of the old tennis courts, and the tower sections are 50 ft. from the front of the Engineering Buildings I and II. It is I-shaped, 243 feet long, 95 feet wide at the towers and 51 feet wide between the towers. The ground, first and second floors, and the middle section of the third floor conform with the foundation plan. In the tower sections, at both ends, the third and fourth floors are set back.

Accommodations for the Dean's office, the Engineering Library, the service departments now quartered in Engineering Building III, and class rooms will be provided in the new building. Laboratories will remain in their present locations in Engineering Buildings I and II.

A usable floor area of 38,500 sq. ft., which is about two and one-half times the capacity of Engineering III, will provide 6,400 sq. ft. for the Engineering Library, twenty-five class rooms of 445 Sq. ft., and three freshman drawing rooms of 1,800 sq. ft. Dean Evans estimates that these rooms will accommodate 1,100 students at one time; consequently, it is believed that reasonable class-room

provision has been made for future growth. The Dean's office suite will occupy 1,300 sq. ft. There are twenty-eight other offices, each with approximately 225 sq. ft. of floor space.

The Engineering Library will occupy the east half of the ground floor. The Dean's office, a record storage vault, a faculty conference room, and the two offices are located in the west tower section on the first floor. The second floor will be used for class rooms and offices. Most of the third floor is planned to accommodate classes in freshman drawing. One room on the fourth floor will be used for blue-printing, while another will provide for photostat equipment. Toilets for men are located on the ground and second floors, and for women and faculty on the first floor. Other room assignments have not been made. Drafting rooms will be lighted from the north. A typical class room has a width equal to approximately twice its window height and a window area equal to 25 per cent of its floor area.

## Architectural Treatment

The building follows the "University of Colorado" style of architecture, which is Mr. Charles Z. Klauder's adaptation of countryside architecture in northern Italy to meet the University's needs. This style has proven flexible in meeting requirements of buildings for numerous University functions. The treatment of mass and form in the Engineering Building conforms with other campus buildings, but the fenestration and the unbalanced gable treatment give it an individuality of its own. Architecturally, the treatment of this building is undoubtedly the best on the campus.

The building is faced with local Lyons sandstone. Individual stones do not exceed five inches in thickness and thirty-six inches in length. Care is taken to select colors and size to obtain the desired effects. Outside walls are backed with "jumbo" hollow tile with vertical webs. Variegated buff and gray Bedford (Indiana) oolitic limestone is used to trim the building.

## Structural Features

The outside walls of the building

are of the bearing type, but the interior of the building is of reinforced concrete beams and columns with pan floor construction. In addition to dead load, the building is designed for a live load of 50 lb. per sq. ft. in class rooms and offices, and 100 lb. per sq. ft. on the corridors and stairways. The design of the reinforced is in conformity with the 1936 tentative standards of the American Concrete Institute. The concrete in the footings is designed to develop a minimum compressive strength of 2,000 lb. per sq. in. in 28 days; that in the columns 3,500 lb. per sq. in. in 28 days; and in all other parts of the building, 3,000 lb. per sq. in. in 28 days.

The roof framing in the tower sections will be of select structural rough-sawn old growth wood free from heart centers. Ceilings will be furred and plastered. In the middle section of the building, light C.B. sections with a 2 in. x 4 in. nailing strip on the top flange of the beam are used. These beams are exposed; however, the ceiling will be insulated. Straight Barrel Mission tile in four colors will be used on the roof.

All exterior doors are of hollow metal. Interior door frames are of metal, but doors are of birch. Steel window sash is used throughout the building. The floor covering is 12 in. x 12 in. x 1/8 in. gray asphalt tile. A 6-inch cement base is used. Stairs are of reinforced concrete construction with metal safety nosings and 3/16 in. asphalt tile on treads and landings. Green Optex blackboards 48 inches high and trimmed with birch will be used.

## Electrical Requirements

All electrical design conforms to the National Electric Code as revised in 1935, and all wiring is in accordance with the recommendations of the National Board of Fire Underwriters. On runs less than 50 feet long, No. 12 wire is used, while No. 10 wire is used for longer runs. In general, circuits do not have more than 1,200 watts connected load. A typical class room of 445 sq. ft. has four ceiling

<sup>1</sup>Head, Department of Civil Engineering, University of Colorado.

\*Surprise! He's not talking about the New Engineering Sciences Center; he's talking about Ketchum. We thought you might be interested in what people were excited about 25 years ago. Times do change, particularly the price. This was first printed in the COLORADO ENGINEER in January, 1938.

outlets and the offices have two ceiling outlets. Wall telephone outlets are provided in all offices. Lighting fixtures are of the semi-indirect type with glass shades.

### Heating and Plumbing

Preliminary investigations were made to determine the feasibility of using a hot-air heating system with humidification and air washing during the summer season. Inasmuch as there is no waste space in the building, large air ducts would occupy otherwise useful space and seriously interfere with the interior arrangement of the building. The added cost of providing duct space was not thought justifiable; consequently, steam heat will be used. All radiators are supported on the walls. In addition to individual thermostats in the class rooms, duostat temperature with day and night clock control is provided for the whole building.

Copper water pipes are used throughout the building. Plumbing fixtures such as water closets, urinals, lavatories, drinking fountains, and slop sinks are white. They are bolted to wall or floor in accordance with the manufacturer's specifications.

### Personnel

All construction at the University of Colorado is under the direction of W. E. Rockway, c. '17, Supervising Engineer. Charles Z. Klauder of Philadelphia, Pennsylvania, is Consulting Architect and Glenn Huntington, c. '12, of Boulder, is Associate Architect. Newstrom and Davis of Denver, Colorado, are the general contractors. The structural plans were prepared by Warren Raeder, Associate Professor of Civil Engineering, and by the writer.

Freshman: "I'd like to meet a girl who doesn't flirt, giggle, smoke, drink, pet, use make-up, or go up Flagstaff."

Junior: "Why?"

A Long Island Potato married an Idaho Potato and eventually the two became the proud parents of a little Sweet Potato. Sweet Potato grew up and one day announced her intention of marrying Gabriel Heatter. "But you can't marry him," her shocked parents wailed. "He's only a commentator."

I serve one purpose in this school  
On which no man can frown.  
I quietly sit in every class,  
And keep the average down.

An engineer is said to be a man who knows a great deal about very little and who goes along knowing more and more about less and less until finally he knows practically everything about nothing; whereas,

A salesman, on the other hand, is a man who knows very little about a great deal, and keeps knowing less and less about more and more until he knows practically nothing about everything.

A purchasing agent starts out knowing practically everything about everything, but ends up knowing nothing about anything, due to his association with salesmen and engineers.

"Drink?"

"No."

"Neck?"

"No."

"Well, do you eat hay?"

"Of course not!"

"Gad, you're not fit company for man or beast."

## WORLD'S LARGEST LABORATORIES FOR RESEARCH ON PORTLAND CEMENT AND CONCRETE

**How PCA helps keep you up-to-date on concrete after you leave engineering school.** At the \$10,000,000 Research and Development Laboratories of the Portland Cement Association is the world's largest assembly of scientists, engineers and equipment devoted solely to the study of portland cement and concrete. The findings benefit all.

Technical literature, prepared by other PCA engineers and specialists is made freely available. PCA field engineers regularly inform project engineers on advances in concrete construction.

These services of the Portland Cement Association are made possible by the voluntary support of its more than 75 member cement companies.

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A national organization to improve and extend the uses of portland cement and concrete



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## ANGKOR WHAT? . . .

(Continued from page 17)

A few saffron robed monks ring gongs and chant. Incense rises. Candles flicker. With the exception of the restoration crews these remain about the only signs of life and the former glory that was Angkor. Angkor where are you now? Angkor what?

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## T. S. ELIOT . . .

(Continued from page 24)

filled scarecrow. In death's other kingdom, there are no nightmares, only pleasant scenes and sounds, distant like a "fading star." Perhaps death's other kingdom is the region outside of time in "Burnt Norton." The kingdom seems to be instants in between events, when time stands still.

"Between the idea  
 And the reality  
 Between the motion  
 And the act  
 Falls the shadow  
 For Thine is the Kingdom.

Between the conception  
 And the creation  
 Between the emotion  
 And the response  
 Falls the Shadow  
 Life is very long.

Between the desire  
 And the spasm  
 Between the potency  
 And the existence  
 Between the essence  
 And the descent  
 Falls the Shadow  
 For Thine is the Kingdom."<sup>2</sup>

The final stanza of the "Hollow Men" again refers to the desolate end of the world with a perfect summation of the poem and the concept:

This is the way the world ends  
 This is the way the world ends  
 This is the way the world ends  
 Not with a bang but a whimper.

In conclusion, Eliot seems to have been influenced by modern scientific philosophy in these two poems. To Eliot, mankind has no purpose or meaning when he is trying to carry out his will, because all his actions have been prescribed since the beginning of time. Man's only salvation lies in the ability to exist outside of time, in fleeting moments of appre-

ciation of the beauty in life. If man has no appreciation, then there can be no beauty, and he is indeed one of the Hollow Men.

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2. Eliot, T. S., "The Hollow Men," same collection.

## CAMPUS NEWS . . .

(Continued from page 45)

Swelling soils transform a smooth 70-mile-an-hour highway into, first, an uncomfortable "tilt-a-whirl," then into cracking clabs of concrete that become a death trap at 30 miles an hour.

The study is centered on a section of U.S. Highway 40 about 10 miles northwest of Limon.

"The roads we're studying were laid down by conscientious builders using the best knowledge available. These are not cases of faulty construction," Sampson said.

"The problem is," Schuster added, "there isn't a great deal of accurate, helpful information about swelling soils."

They explained that Colorado's eastern slope is dotted with wide areas of clay-mineral type soils having a tendency to expand when absorbing moisture. These areas are too wide to avoid in road building.

Changing the environment of the soil with a road changes the soil's behavior. In winter an envelope of warm soil rests under the pavement. Cold ground on either side of the road forces water to form under the road, especially where sponge-like soil exists.

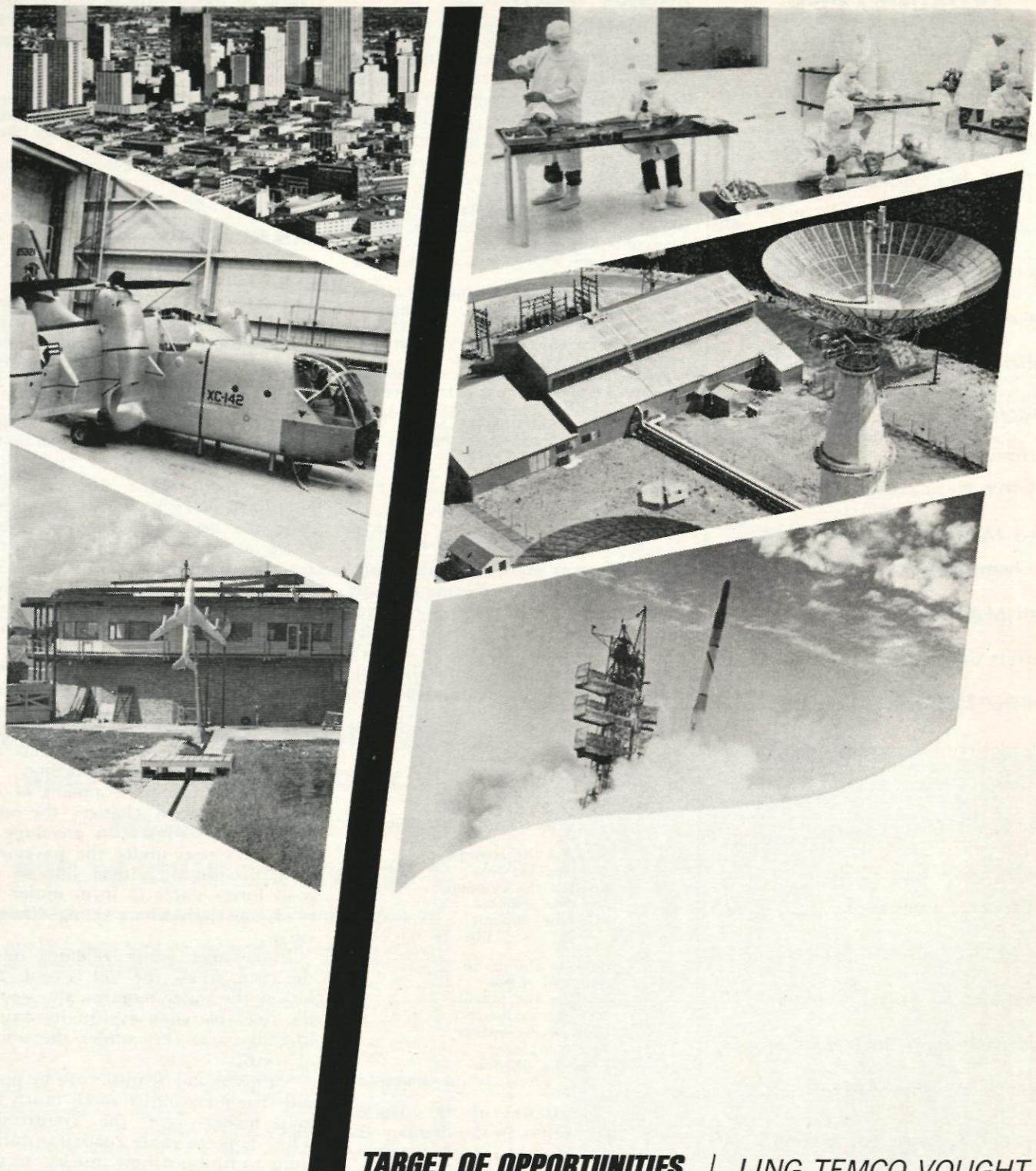
In summer water remains under the road, where the soil is cool. The longer the water remains, the weaker the road becomes, eventually crumbling like a cracker under the weight of traffic.

Sampson and Schuster are mapping soil structures under roads much like map makers plot the countryside. They hope to chart road transformations to find out how much a section of road rises in a year and to learn the swelling capacity of different soils.

Eventually they hope to pinpoint why soils swell and determine if swelling can be predicted.

Their work should develop a method for constructing roads over swelling soil with greater assurance they won't crumble soon after completion.

Then there was the ill-humored civil engineer who built cross roads.



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# PUZZLE PAGE

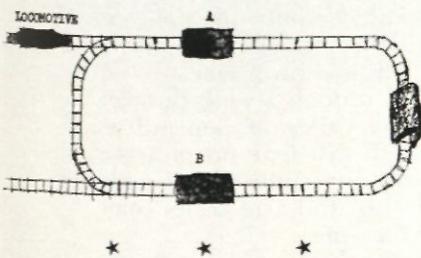
MITCHELL ALLIES



The efficient switching of railroad cars often poses frustrating problems in the field of operations research. The switching puzzle depicted on this page combines simplicity with surprising difficulty.

The tunnel is wide enough to accommodate the locomotive but not wide enough for either car. The problem is to use the locomotive for switching the positions of cars *A* and *B*, then return the locomotive to its original spot. Each end of the locomotive can be used for pushing or pulling, and the two cars may, if desired, be coupled together.

The best solution is the one requiring the fewest operations. An operation is here defined as any movement of the locomotive between stops, assuming it stops when it reverses directions, meets a car to push it, or unhooks from a car it has been pulling. Movements of the two switches are not counted as operations.



Imagine a large cube formed by gluing together 27 smaller wooden cubes of uniform size. A termite starts at the center of the face of any one of the outside cubes and bores a path that takes him once through every cube. His movement is always parallel to a side of the large cube, never diagonal.

Is it possible for the termite to bore through each of the 26 outside cubes once and only once, then finish his trip by entering the central cube for

the first time? Show how it is either possible or impossible.

\* \* \*



The monad, pictured above, is constructed of two small semi-circles drawn as shown inside of a larger circle. It is probably one of the oldest political or religious symbols because it has the quality of depicting graphically the abstract, complementary polarities that exist in human development.

There is one particularly easy way to bisect both areas of the monad. See if you can find it.

## SOLUTIONS TO THE PUZZLES IN THE JANUARY ISSUE

There is a point besides the North Pole from which you can walk a mile south, a mile east, and a mile north and find yourself back at the starting point. In fact, there are an infinite number of points. You could start from any point on a circle drawn around the South Pole at a distance slightly more than  $1 + 2\pi$  miles from the Pole—the distance is slightly more to take into account the curvature of the earth. After walking a mile south, your next walk of one mile east will take you on a complete circle around the Pole, and the walk one mile north from there will then return you to the starting point. Thus your starting point could be any one of the infinite number of points on the circle with a radius of about 1.16 miles from the South Pole. But this is not all. You could also start at points closer to the Pole, so that the walk east would carry you just twice

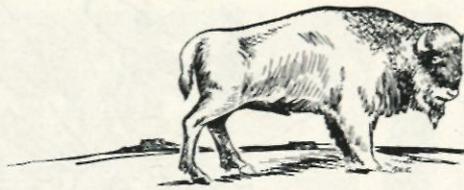
around the Pole, or three times, or more, toward an infinite number of circlings of the Pole.

\* \* \*

The logician points to one of the roads and says to the native, "If I were to ask you if this road leads to the village, would you say 'yes'?" The native is forced to give the right answer, even if he is a liar! If the road does lead to the village, the liar would say "no" to the direct question, but as the question is put, he lies and says he would respond "yes." Thus the logician can be certain that the road does lead to the village, whether the respondent is a truth-teller or a liar. On the other hand, if the road actually does not go to the village, the liar is forced in the same way to reply "no" to the inquirer's question. More complicated forms of the question to the native can be devised, but they all hinge on the same logical principle: namely, that a double negative equals an affirmative.

\* \* \*

You can learn the contents of all three boxes by drawing just one marble. The key to the solution is your knowledge that the labels on all three of the boxes are incorrect. You must draw a marble from the box labeled "black-white." Assume that the marble drawn is black. You know then that the other marble in this box must be black also, otherwise the label would be correct. Since you have now identified the box containing two black marbles, you can at once tell the contents of the box marked "white-white": you know it cannot contain two white marbles, because its label has to be wrong; it cannot contain two black marbles, for you have identified that box; therefore it must contain one black and one white marble. The third box, of course, must then be the one holding two white marbles.



# Chips

LARRY HUSTON

*Into every life let there come humor.*

Chemical Analysis of Women:

**ATOMIC WEIGHT:** Reputed to be 120. Isotopes are known through 90 to 180.

**OCCURRENCE:** Found both free and combined. In combined state it is found with man.

**PHYSICAL PROPERTIES:** All colors, sizes and shapes. Seldom found in pure state. Boils at nothing and will freeze without reason. Surface is usually covered with film of paint of oxide in various colors and depths. Unpolished specimen turns green in presence of highly polished one. All varieties melt if used correctly. Density is not so great as generally supposed.

**CHEMICAL PROPERTIES:** Highly explosive and dangerous in inexperienced hands. Extremely active in the presence of men. Possesses great affinity for gold, silver, platinum and all precious stones. Has the ability to absorb great quantities of expensive food and drink. May explode spontaneously when left alone with man. Sometimes yields to pressure. Fresh variety has great magnetic attraction, but ages rapidly.

**USE:** Chiefly experimental. Efficient cleaning agent. Acts as a positive or negative catalyst in the production of fevers.

**UNSOLVED PROBLEM:** The thing that mystifies many engineers is the fact that the most streamlined specimens offer the most resistance.

The mama broom and the pappa broom had a little whisk broom and they could not understand it because they had never swept together.

When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute — and it's longer than an hour. That's relativity.—Albert Einstein.

Robert Welch is now represented among the campus youth movements. The new group is called "The Sons of Birches."

Connect 20,000 volts across a pint. If the current jumps it, the product is poor. If the current causes a precipitation of lye, tin, arsenic, iron, slag, or alum, the whiskey is fair. If the liquor chases the current back into the generator, you've got good whiskey.

Little girl: "Mother, are there skyscrapers in heaven?"

Mother: "No, dear, it takes engineers to build skyscrapers."

In case you find a mistake in this magazine, please remember it was put there for someone's benefit. We try to please everyone and some people are always looking for mistakes.

Anyone who thinks he is indispensable should stick his finger in a bowl of water and notice the hole it makes when he pulls it out.

Golf is a game in which a ball 1½ inches in diameter is placed on another ball 8,000 miles in diameter. The object of the game is to hit the small ball and not the big one.

A lion ate a bull. He felt so good he roared and roared. A hunter heard the roar and killed the lion.

The moral of the story is: When you're full of bull, keep your mouth shut.

Pilot to tower, pilot to tower: "Plane out of gas; am one thousand feet and thirty miles over ocean. What shall I do?"

Tower to pilot, tower to pilot: "Repeat after me— 'Our Father, who art in heaven'—."

Two young sisters had been given parts in a Christmas play at school. At dinner that night they got into an argument as to who had the most important role. Jody, aged 11, was very superior.

"Why, of course mine's the biggest part," she told five-year old Lucy. "Anybody'll tell you it's much harder to be a virgin than an angel."

Chemical Engineer (moaning at the bar): "It's terrible, the cost of living has gone up to \$4.18 a quart."

Probably the reason God made woman last was that he didn't want any advice while creating man.

My slide rule is my shepard,  
I shall not want.  
It maketh me set down to the  
third decimal place  
And leadeth me to interpolate  
to the fourth.

It restoreth my average  
and leadeth me along the  
paths of correct answers  
for my own sake.

Yea, though I walk through  
the valley of pop quizzes,  
I will fear no professor,  
for my slide rule is with me.  
Its log and trig scales comfort  
me.

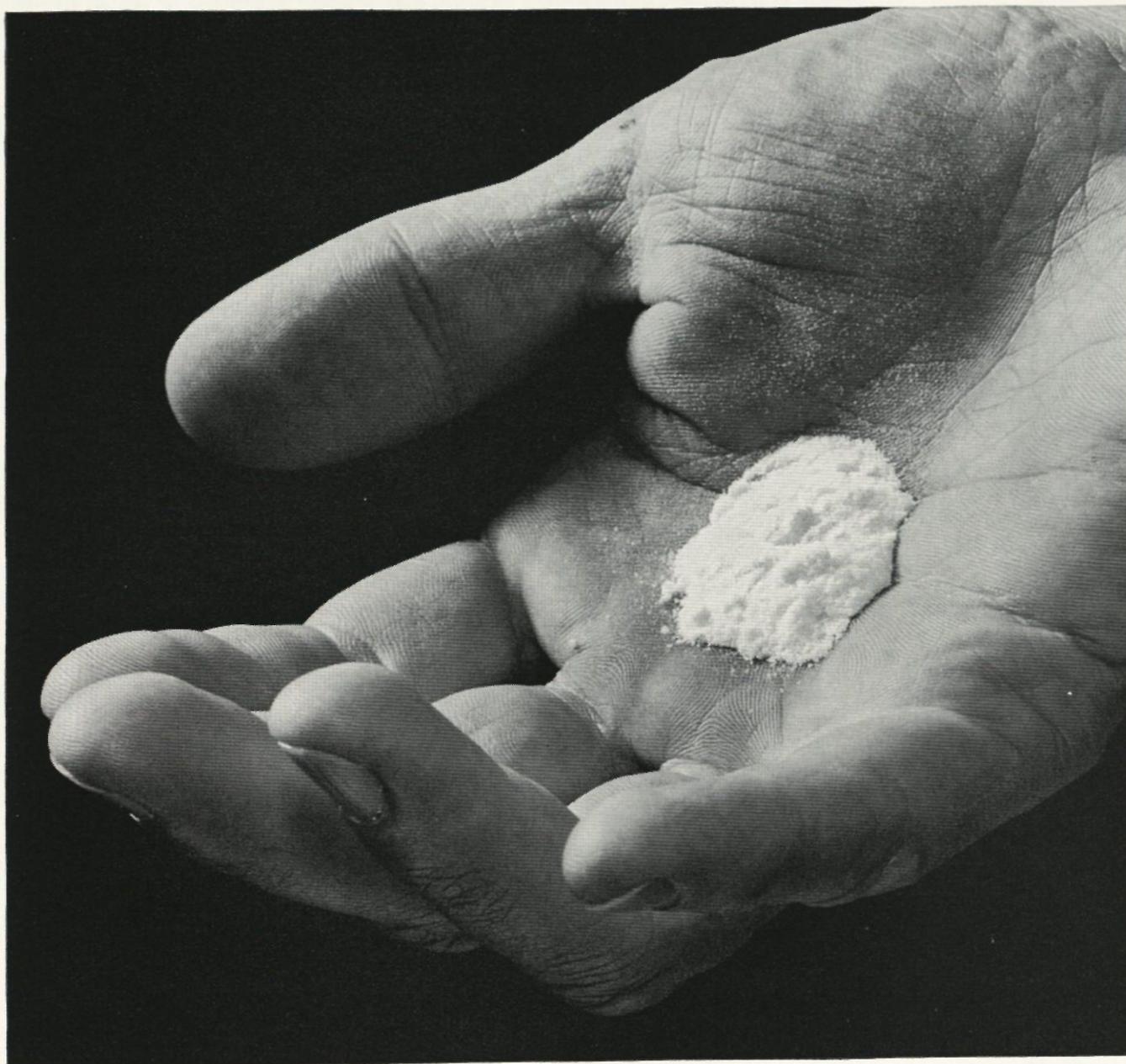
It preparast an answer for  
me in the presence of my  
instructors.

It annoints my paper with  
answers and by brain relaxes.

Surely quality and accuracy  
shall follow me all the days  
of my life, and I shall dwell  
in the House of Dietzgen  
forever.

The editor of this page points with pride to the clean, white spaces between the jokes.

## Kodak beyond the snapshot...



**The powder is vitamin E.** Vitamin E is essential to human life. Also to poultry and livestock. This much is enough for about 200 multivitamin tablets. We make so much of it for the pharmaceutical manufacturers that the operation long ago entered the domain of chemical engineering.

It's an especially interesting kind of chemical engineering, related to the kind we have been developing over the years in our basic business of manufacturing photographic materials.

Vitamin E is in no way a by-product of photographic manufacturing. Only the engineering skills behind it are a by-product. They come out of the maddeningly sensitive nature of sensitized film and paper. Now they are available for the thousands of other fascinating things we make besides vitamin E.

We need more chemical engineers to indoctrinate in our ways. The snapshot business is excellent, but photography has gone far beyond the snapshot and we have gone far beyond photography. *Please drop us a note asking for an explanation of what all this has to do with you.*

**EASTMAN KODAK COMPANY** • Business & Technical Personnel Department  
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# Manufacturing Careers Offer Diversity, Challenge and Opportunity

## An Interview with G.E.'s H. B. Miller, Vice President, Manufacturing Services



Halbert B. Miller has managerial responsibility for General Electric's Manufacturing Services. This responsibility includes performing services work for the Company in the areas of manufacturing engineering; manufacturing operations and organization; quality control; personnel development; education, training and communications; materials management; purchasing and systems as well as the Real Estate and Construction Operation. Mr. Miller holds a degree in mechanical engineering and began his General Electric career as a student engineer on the Company's Test Course

For complete information about General Electric's Manufacturing Training Program and for a copy of G.E.'s Annual Report, write to: Personalized Career Planning, General Electric Company, Section 699-06, Schenectady 5, New York.

### **Q. Mr. Miller, what do engineers do in manufacturing?**

A. Engineers design, build, equip, and operate our General Electric plants throughout the world. In General Electric, this is manufacturing work, and it sub-divides into categories, such as quality control engineering, materials management, shop management, manufacturing engineering, and plant engineering. All of these jobs require technical men for many reasons. First, the complexity of our products is on the increase. Today's devices—involving mechanical, electrical, hydraulic, electronic, chemical, and even atomic components—call for a high degree of technical knowhow. Then there's the progressive trend toward mechanization and automation that demands engineering skills. And finally, the rapid development of new tools and techniques has opened new doors of technical opportunity—electronic data processing, computers, numerically programmed machine tools, automatic processing, feedback control, and a host of others. In short, the requirements of complex products of more exacting quality, of advanced processes and techniques of manufacture, and of industry's need for higher productivity add up to an opportunity and a challenge in which the role of engineers is vital.

### **Q. How do opportunities for technical graduates in manufacturing stack up with other areas?**

A. Manufacturing holds great promise for the creative technical man with leadership ability. Over 60 percent of the 250,000 men and women in General Electric are in manufacturing. You, as an engineer, will become part of the small technical core that leads this large force, and your opportunity for growth, therefore, is unexcelled. Technical graduates in manufacturing are teamed with those in marketing who assess customer needs; those in research and development who conceive new products; and those in engineering who create new product designs. I sincerely believe that the role of technical graduates of high competence in the manufacturing function is one of the major opportunities for progress in industry.

### **Q. What technical disciplines are best suited to a career in manufacturing?**

A. We need men with Doctor's, Master's, and Bachelor's degrees in *all* the technical disciplines, including engineering, mathematics, chemistry and physics. We need M.B.A.'s also. General Electric's broad diversification plus the demands of modern manufacturing call for a wide range of first-class technical talent. For one example: outside of the Federal Government, we're the largest user of computers in the United States. Just think of the challenge to mathematicians and business-systems men.

### **Q. My school work has emphasized fundamentals. Will General Electric train me in the specifics I need to be effective?**

A. Yes, the Manufacturing Training Program is designed to do just that. Seminars which cover the sub-functions of manufacturing will expose you to both the theoretical and practical approaches to operating problems. Each of the succeeding jobs you have will train you further in the important work areas of manufacturing.

### **Q. After the Program—what?**

A. From that point, your ability and initiative will determine your direction. Graduates of the Manufacturing Training Program have Company-wide opportunities and they continue to advance to positions of greater responsibility.

*Progress Is Our Most Important Product*

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