

The
COLORADO
Engineer

NOVEMBER, 1963

To Catch a Hummingbird

How the Gemini Spacecraft will find its target...

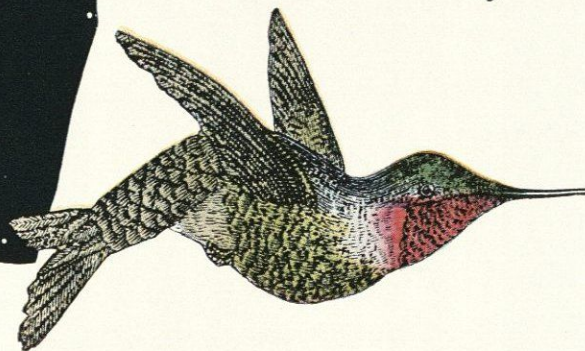
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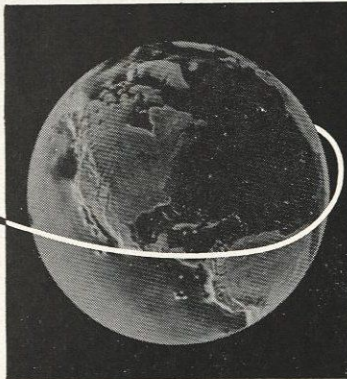
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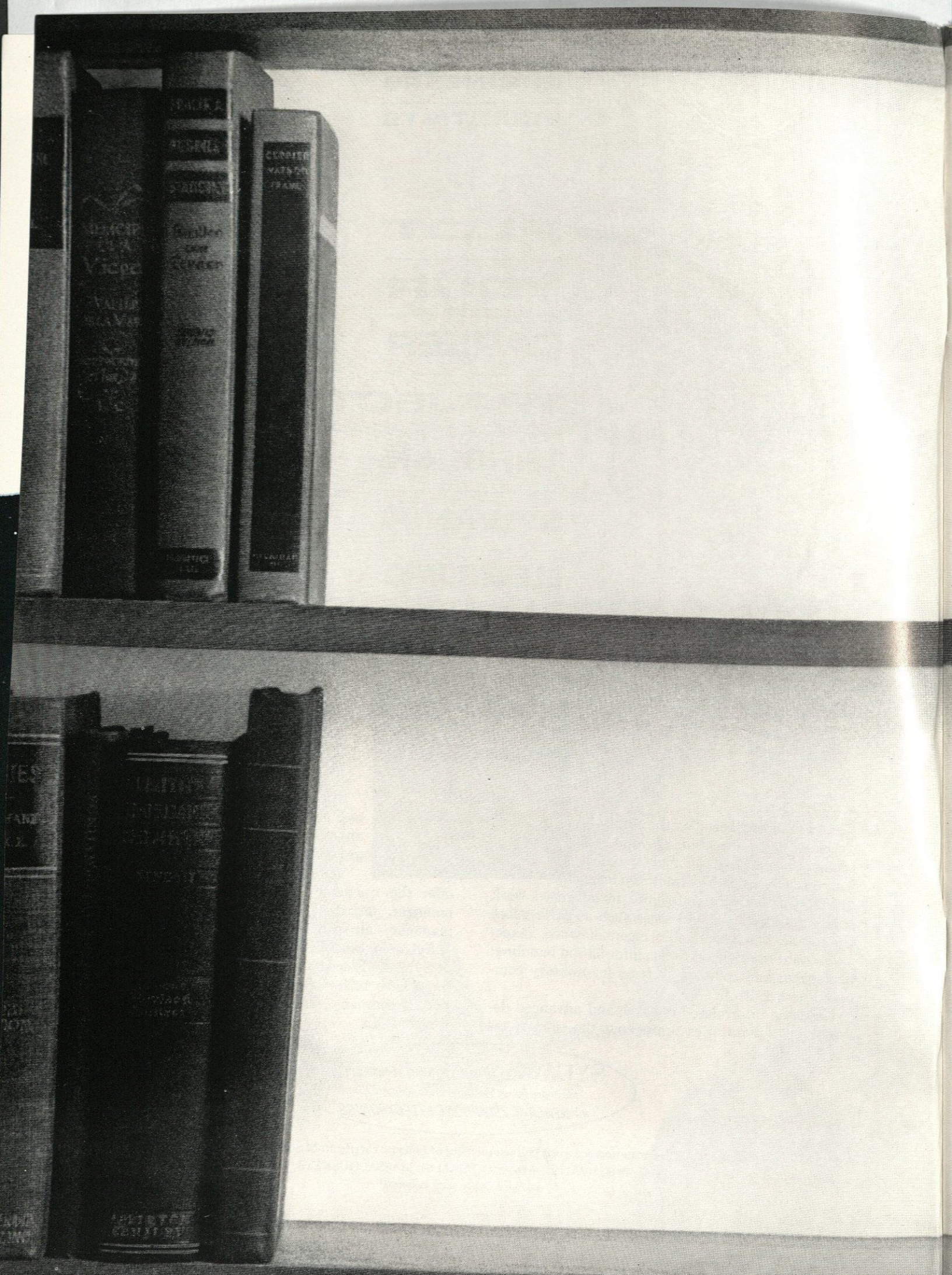
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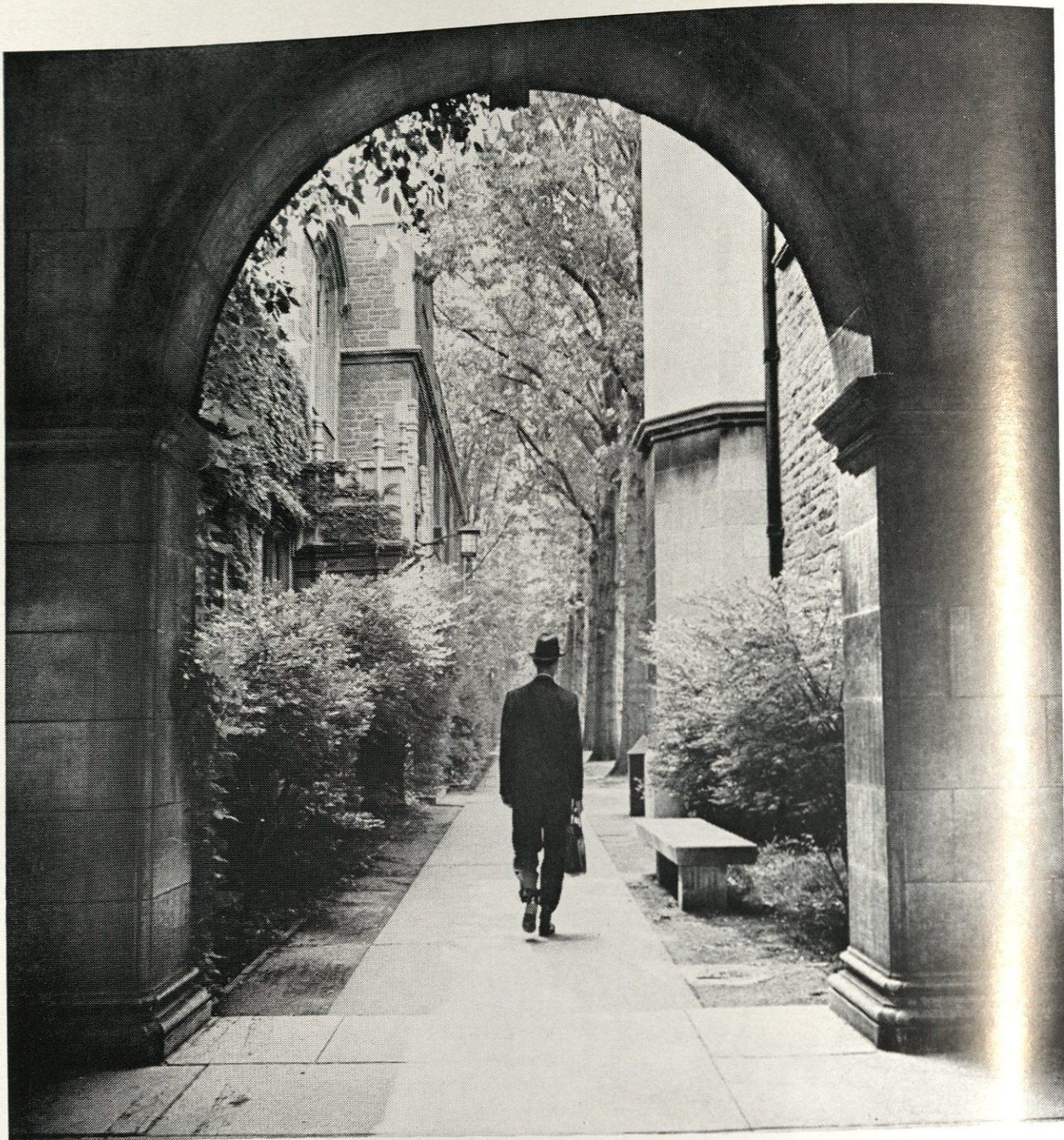
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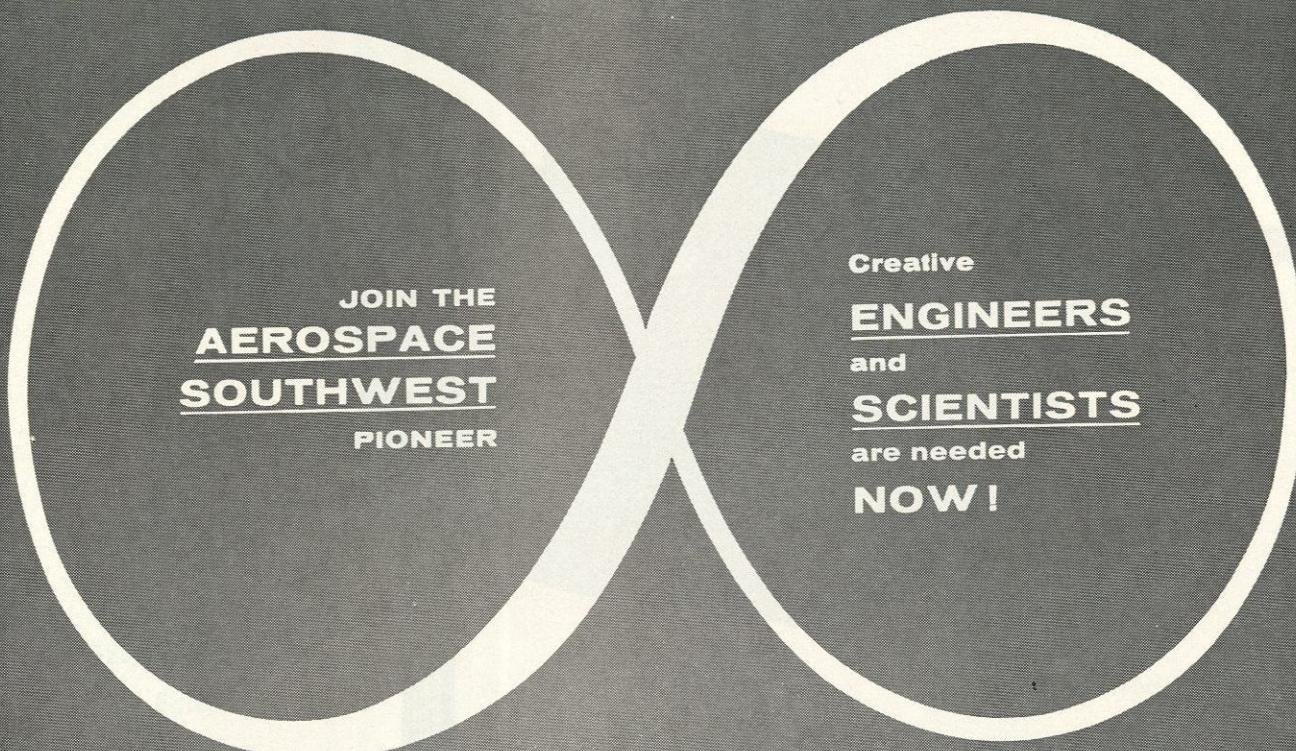
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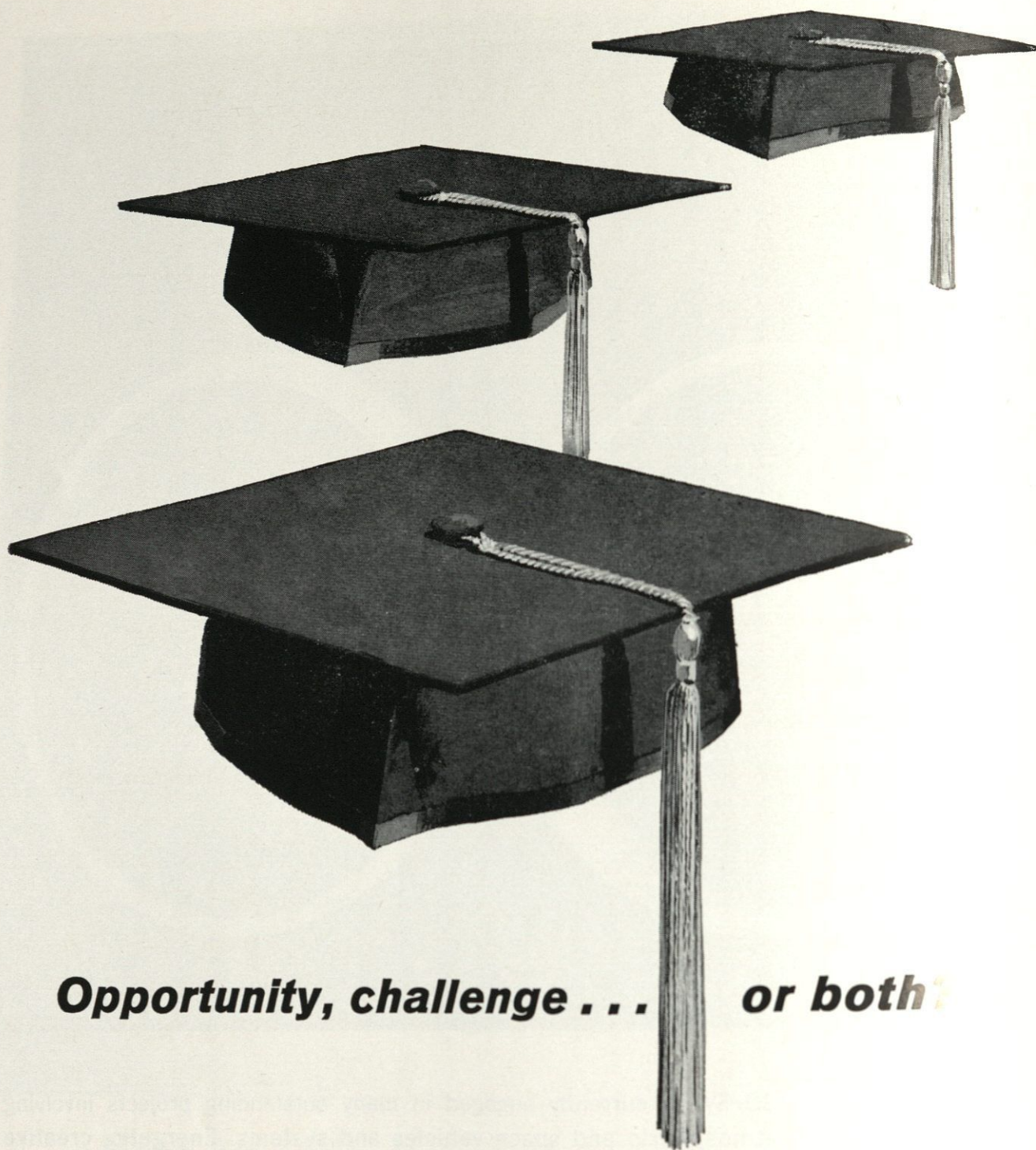
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VOLUME 60

NUMBER 1

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This month's cover by Mary Ann Miklich is titled "Space" and represents the cataclysmic theory of planetary and galactic formation.

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QUO VADIS?

Premier Khrushchev has said that Russia is not going to the moon this decade. Is he afraid Russia will lose the race, or is he trying to throw us off guard? Does he have some plan to conquer the United States before 1970 and thereby render the race meaningless, or has he decided that the idea of landing a man on the moon is itself meaningless?

Proponents of the moon flight contend that it would have many significant values. Some scientists believe that the knowledge gained as a side effect of the trip should indeed be the purpose of the entire trip. Some militarists argue that a moonbase has some peculiar advantage over orbital bases. Proaganda-minded politicians contend that the real reason for the trip is to increase our national prestige, a potent weapon in the battle for the world's empty stomachs. Other scientists believe that the knowledge gained from the trip would be comparatively small. A few militarists argue that a moon-launched bomb would be no more accurate than an earth-launched moon rocket. And as always, election-minded politicians cry about the prohibitive cost of a moon flight.

The contending factions do agree that *some* technical knowledge would be gained, that the cost would be as high as the objective, that any country would be proud to land the first man on the moon *alive*, and finally, they do agree that everyone wants it to happen. In spite of all questions and arguments, feelings and finances, our race wants to go to the moon and beyond. Why?

The flights are not necessary militarily. The majority of the military uses of space probes and satellites have been fulfilled. We have sky-spies looking down, looking out, and probably looking at each other. Even granting the military necessity of a moonbase, what prompted the flight to Venus and talk of one to Mars? The propaganda from the Mariner flight increased our prestige momentarily, but the general knowledge gained from the flight was small compared to the cost. The specific knowledge gained from Venus was large, but empty. Are we exploring space to provide an outlet for the population explosion? The twin fallacies in that thought are all too obvious. Are we going to mine the moon's resources? It would be cheaper to bring asteroids in from the asteroid belt.

The United States and Russia, when Khrushchev changes his mind again, are going to the moon because their people are curious about what really is on the moon, because people somehow believe that man will find the key to peace on the moon, or that the world will be better off if Man can build a tower to the moon. It is folklore, but it will put Man on the moon. What then?

—LARRY L. HUSTON.

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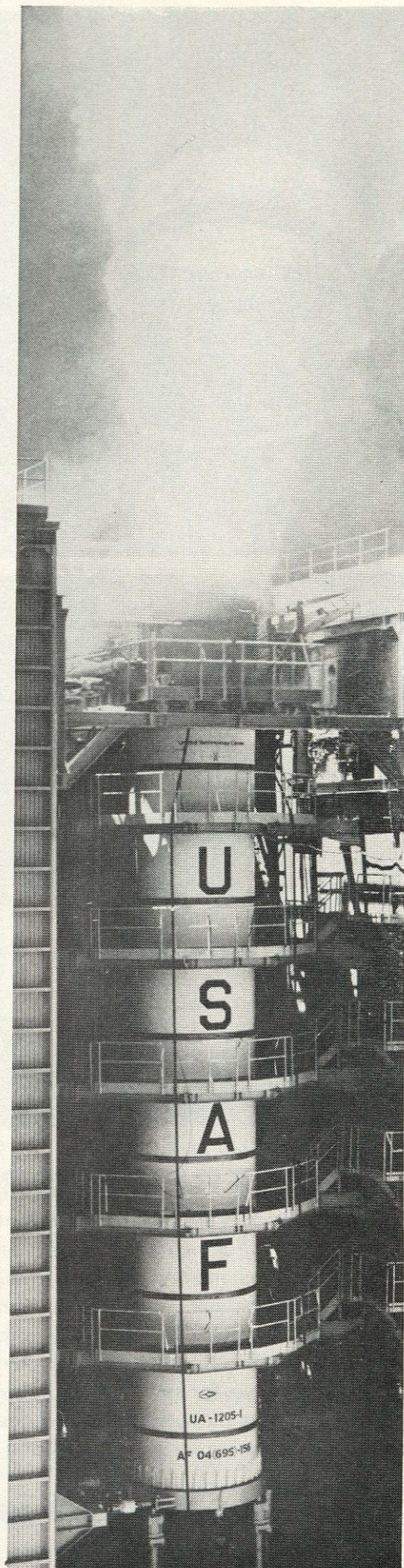
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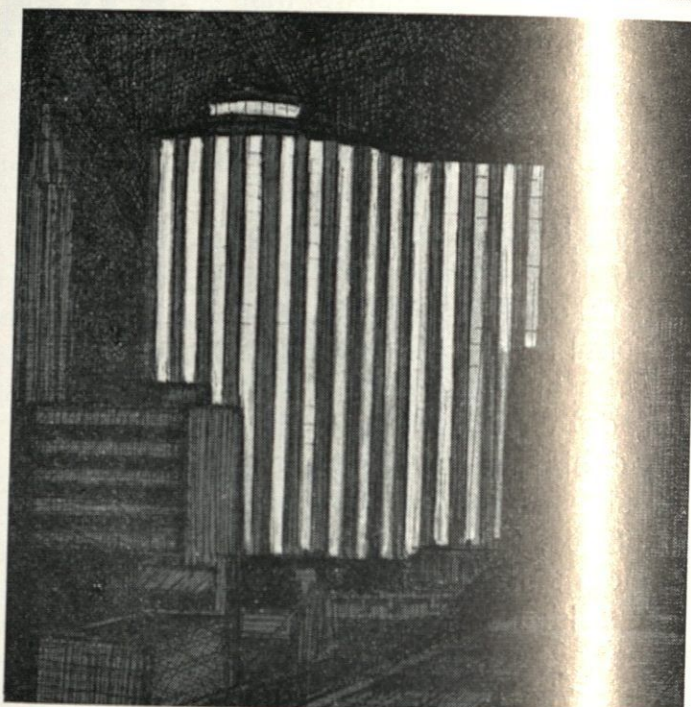
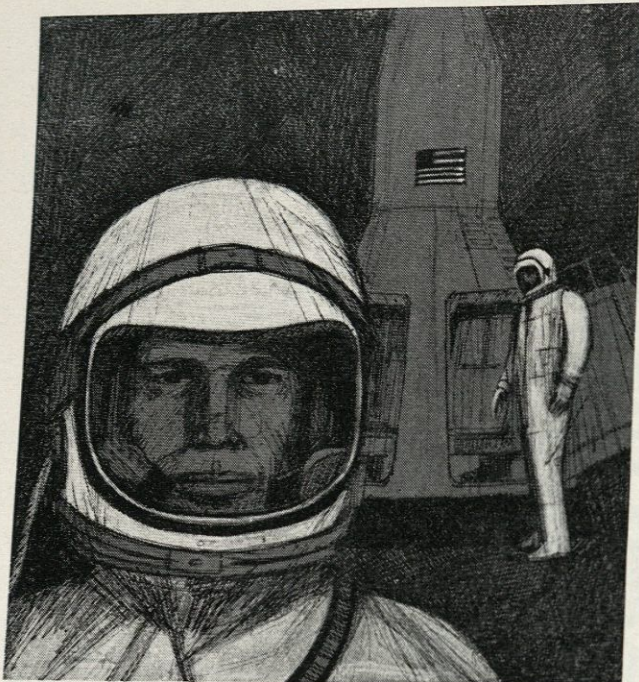
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COLORADO ENGINEER—November, 1963

ARE WE

ALONE?

MARK SHERIDAN

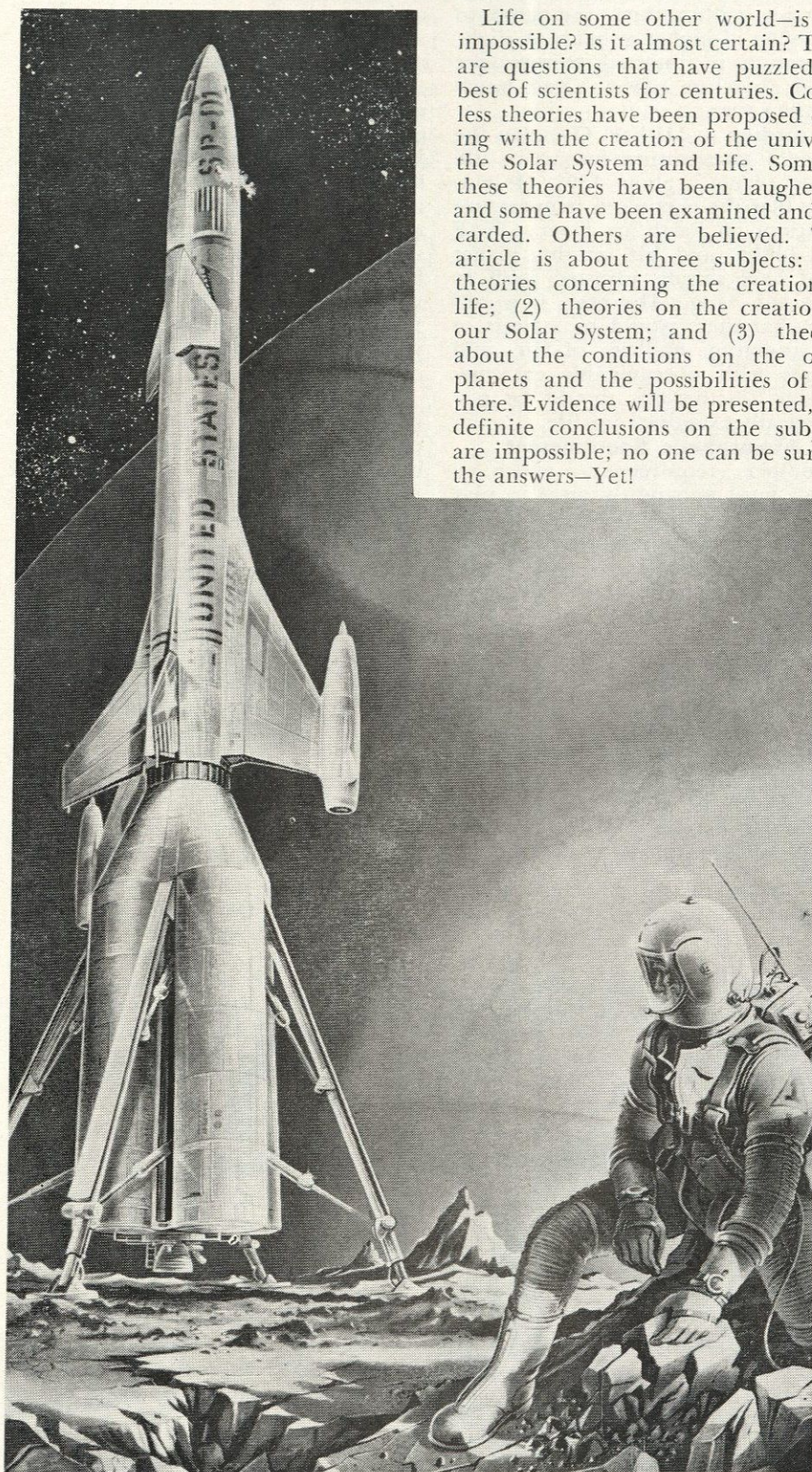
Life on some other world—is this impossible? Is it almost certain? These are questions that have puzzled the best of scientists for centuries. Countless theories have been proposed dealing with the creation of the universe, the Solar System and life. Some of these theories have been laughed at and some have been examined and discarded. Others are believed. This article is about three subjects: (1) theories concerning the creation of life; (2) theories on the creation of our Solar System; and (3) theories about the conditions on the other planets and the possibilities of life there. Evidence will be presented, but definite conclusions on the subjects are impossible; no one can be sure of the answers—Yet!

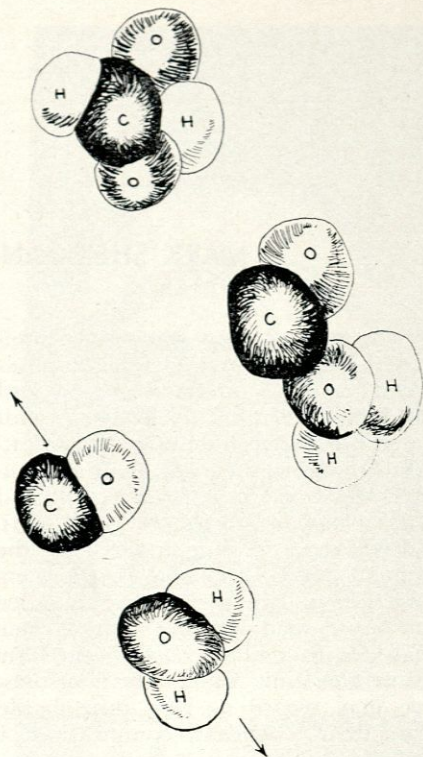
The idea of man contacting intelligent life from another world amuses some people, interests others and frightens most. This contact with alien life has been described in countless situations; the assortment of monsters described in science fiction and science horror stories serves as a tribute to the unceasing creativity of the human mind. Clay men, plastic men, metal men, little green men, big green men and medium sized purple men have all invaded the Earth in the form of printer's ink. The majority of these we may regard as very improbable, for their chemical composition is wrong.

What does it take to manufacture living organisms? Severe limitations can be put on the biochemical composition of life as we know it. We believe that carbon chains are the only possible building blocks for life, although man does not know enough about alternative systems to say definitely that there could be no basis other than our organic system. Assuming for the moment that there are many other planetary systems, there could be innumerable variations in temperatures, atmospheric conditions and planet compositions. At present our chemical knowledge does not allow us to say "No" to all of these variables, but we do have knowledge of some rather fundamental chemical facts which we should consider.

First, and most important, we know that chemical elements are the same and react the same throughout the Universe. If we were studying physics or chemistry in another galaxy, we would be haunted by the same confusing first law of thermodynamics as we are here on Earth. Similarly, we would have the same periodic chart with the same groups of elements.

Also, the tetra-valent carbon atoms are best suited to form complex molecules necessary for life. Silicon, similar to carbon in that it also has four valence electrons, does not form chains as long nor as stable as those of carbon. The reason for this is found in the outer electron shell of each. Carbon's outer shell can contain a maximum of eight electrons, while silicon's outer shell, although most stable containing eight, can accomo-





date more electrons under the right conditions. The silicon chain compounds are less stable and may be attacked by water to change the Si-Si form to Si-O-Si. Also, silicon dioxide is a solid compound below 2500°C rather than a gas like CO₂. Therefore the essential contributions that CO₂ makes to life could probably not be furnished by SiO₂.

In a like manner, sulfur atoms are probably incapable of replacing oxygen in the complex molecules of living matter since the sulfur atom's outer electron shell can also contain more than eight electrons whereas oxygen's outer shell cannot.

As far as we know, water is essential to all stages of life containing cells, but they depend on cells to multiply. All cellular organisms depend on water to transport material, fill the cells and serve many other functions. The idea of life at low temperatures using liquid ammonia as a substitute for water, although seemingly possible, will not be considered since little is known of the idea.

For these reasons life will only be considered as probable in a form elementally similar to that on Earth—carbon chains utilized as the basis for complex molecular structures, and water as the basic liquid of the organism.

Having set these limitations, we encounter others. Water freezes at 32°F and the complex carbon chains of our world begin decomposing around 140°F. This, of course, does not mean that life is limited to this range of temperature, for effective insulation is exhibited by all warm-blooded animals and many plants.

These two temperatures can nevertheless serve as a rough guideline to life's tolerable environment. We generally find that the more complex the life we observe, the more sensitive is that life to internal temperature variations. The reason for this is the effect of temperature on chemical kinetics; as temperature increases, the rates of chemical reactions increase—but not all to the same degree. Simple forms of life have relatively few reactions occurring within them compared to the bodies of higher animals. A slight fluctuation in internal temperature would therefore affect algae much less than man.

According to Michael Ovenden the range of temperature for active life on our planet is about 120°. He also states that the maximum temperature variations on Earth are from -75°F to +140°F, and life on this planet could have simply adjusted itself to fit in this range. However, it would seem that there would be a limit to the insulation abilities of life, and planets with unreasonable extremes or high fluctuations should be pessimistically examined for life.

Atmospheric Requirement

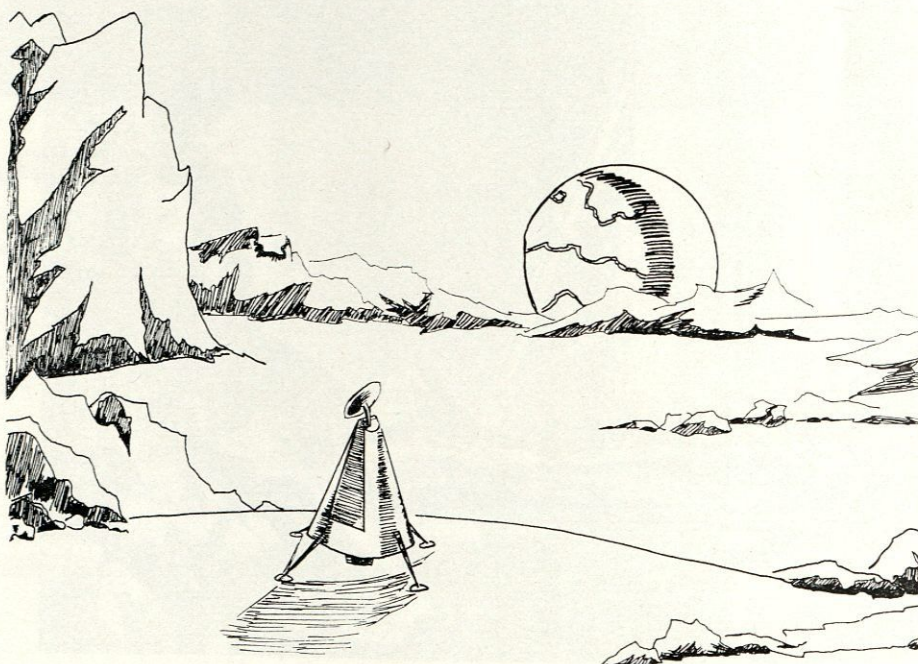
Another requirement which a planet must apparently meet to play host to life is some sort of atmosphere. An atmosphere is important for several reasons. Any liquid with a substantial vapor pressure will boil when in a vacuum. At normal sea level pressure, water boils at 212°F; at lower pressures the boiling temperature drops. Thus, we would expect to find no H₂O liquid on a hot planet with little atmosphere. Of course, water's existence in a gaseous state does not necessarily mean that it is useless to any form of life. It is easy to visualize plants that extract their water supply from the atmosphere. Still, any life

that had a water-based circulatory system would have to develop its own natural pressure suit, or its liquid would boil in its veins.

It is believed that the Earth originally had an atmosphere composed primarily of ammonia and gases containing carbon—carbon monoxide, carbon dioxide and/or methane—with little or no oxygen. Scientists have shown that these gases, in the absence of oxygen, can combine to form amino acids when energized by ultraviolet light, alpha particle bombardment or electric discharge.

These amino acids are the main component of the giant protein molecules which are the basis of animal life. We believe that amino acids were formed in the atmosphere by reactions of the gases. They then floated to Earth and became trapped on sticky, clay-like surfaces where they had time to react with one another in a long trial and error process. Eventually they formed molecules which could produce protein molecules.

Reproduction by molecules does not occur, of course, in the usual manner. Their reproduction occurs in a much less exciting manner—selective reactions. Long-chained, complex molecules of nucleic acid have special groups of atoms attached to them. These groups attract and hold certain specific amino acids to their surfaces in an exact sequence until these amino acids can join together to form the complete protein molecules. The protein molecules then break away from the nucleic-acid molecules. As Michael Ovenden describes the process, "the nucleic-acid molecules act as a template on which protein molecules are built, and the pattern of the template determines the pattern of the resulting protein molecule." Dif-



ferent nucleic acids will produce different proteins, but each type of nucleic acid will produce only one type of protein molecule.

This nucleic acid-protein system might be considered the simplest form of life. Although only single molecules, they establish a system of creation or reproduction. From this point, higher stages of life are simply stages of higher complexity.

Now, with the fundamental restrictions of molecular composition and environmental conditions, and with a popular theory on the evolution of life on Earth, we can look at the planets of the Solar System and see whether their physical conditions would be conducive to our form of life.

Pluto

Pluto, the most remote planet in our Solar System, seems to be one of the most remote in its chances for life. Its surface temperature is expected to be about -400°F . If a gaseous atmosphere surrounds the planet, it must be made of very light gases—hydrogen and helium. Oxygen and nitrogen both freeze above this temperature. Any thorough examination of this small planet is impossible at present because of its distance; nevertheless, its low temperature, calculated from the sun's radiation and its distance, would undoubtedly eliminate it as a planet having life. One puzzling fact about Pluto is its orbit. All of the planets in the Solar System except Pluto orbit in approximately the same plane and in approximately circular orbits. Pluto, a non-conformist, revolves in a completely different plane and a much more elliptical orbit. It is believed that Pluto could possibly have once been a moon of Neptune.

Neptune and Uranus are believed to be quite similar in surface physical conditions. They both probably have surface temperatures of about -300°F . Their masses are both about 16 times that of the Earth, and they are believed to have thick, gaseous atmosphere. At this time we do not know if they have solid, hard cores. Although oxygen and nitrogen could exist in gaseous stages, active life would again be unthinkable.

Saturn's surface temperature is about -240°F . Little is known of its inner composition. One theory states that it has a rocky core; another states that its core is mainly compressed hydrogen. The outer atmosphere has been analyzed by spectroscopic methods and found to be rich in hydrogen with some ammonia and methane. The surface is believed to be so cold that liquid ammonia could not exist to any extent.

Jupiter, the "Big Daddy" of all the Sun's planets, has a surface tempera-

ture about -200°F . Telescopic pictures show that Jupiter has large "cloud belts" on its surface, possibly ammonia clouds similar to our water clouds. There is one particularly interesting phenomenon on this planet's surface called the "Great Red Spot". This has been observed ever since 1631 and has been explained as possibly a huge mass of solid helium.

Jupiter does not rotate as a solid body; its equator has a period of rotation which is a few minutes faster than those of the poles. The Great Red Spot has a period different from any of these. This has confused astronomers to the point that no one is sure that there is a solid surface below Jupiter's atmosphere.

A scientist has suggested that there might be an organic system on Jupiter that uses liquid ammonia as a replacement for water. He believes that reddish-brown colors which appear every so often on Jupiter could be organic-ammonia compounds which are formed by electrical discharges and fade away as they react with hydrogen in the atmosphere.

Skipping over Mars and Venus for the moment we come to Mercury. This small planet has one side that always faces the Sun. On this side the temperature must exceed 700°F . On the shielded side the temperature probably approaches absolute zero, -460°F . The atmosphere of Mercury is negligible—less than 1% of ours. These conditions would be enough to make any life that had ever been there leave.

Venus

Venus has proved to be a disappointment. Until last December little was known about this planet that would help us decide on its chances of hosting life, for its surface is perpetually covered by thick clouds. Since that time Jet Propulsion Laboratory scientists have been decoding and evaluating facts sent back by Mariner II.

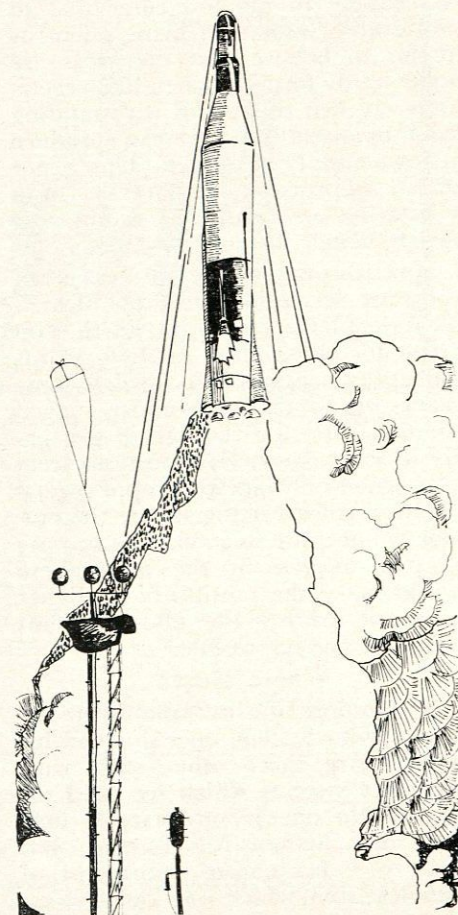
This space probe, by far the most successful of all probe attempts, gave scientists some very important information about the Morning Star. For example, the satellite scanned the dark and light sides of the planet and found that the temperature of both sides is about the same—a scorching 800°F . Oddly enough, Venus rotates very slowly. Quite possibly she keeps one side facing the sun at all times or doesn't rotate at all, thereby having a day and night period equal to one of her years. A thick atmosphere surrounds Venus; it is possibly ten to twenty times as great as ours. This atmosphere is probably what carries heat to her dark side. The atmosphere contains approximately 10% carbon dioxide and traces of nitrogen. No water vapor has been detect-

ed, so the amount present would be very small, if any. The clouds are still a mystery. Many scientists believe they are clouds of dust kicked up by the turbulent atmosphere. In an analysis of Venus for life, we find only one improvement over Mercury—an atmosphere. Our form of life would be impossible on Venus.

Mars

This leaves us with one chance. Mars has always been scientists' "ace in the hole". Many men, looking at Mars and its "canals" through telescopes, have seen barren deserts with some faint blue-green areas and have decided that the planet had a form of life that was on its way out. Scientists now believe that life, if really on Mars, could very well be on its way in. Since chemical reaction rates increase with temperature, the rate of evolution should do the same. The temperature on Mars is colder than that on Earth; over a 24.5 hour Martian day it ranges from -100°F to 80°F along the equator. The temperature difference between Mars and Earth and the absence of a thick atmosphere might have slowed down the trail and error evolution system on that planet.

If life is beginning on Mars, it is beginning under very difficult conditions. The polar ice caps are known to be solid ice by spectroscopic analysis, but they are not nearly the size of those on Earth. At most they are



only a few inches thick in the winter and are probably all frost.

The atmosphere of Mars at the surface is equal in density to ours at eleven miles. This atmosphere contains a very small percentage of oxygen.

Most scientists today believe that the network of canals "seen" on Mars is nonexistent. These narrow lines cannot be photographed by time exposures because our atmosphere distorts photographs. The canals have only been shown in drawings made by men viewing the planet through telescopes. It is a known fact that the human eye tends to connect random markings at the limit of visibility with straight lines. The organized network of double lines seen by the astronomer that drew them is generally believed to be an error in his sight. These lines would have to be over one hundred miles wide to be seen on Earth.

Plants

Although the major portion of Mars' surface is covered with red deserts (possibly iron oxide), it has blue-green areas which appear during the summer seasons and disappear during the winter seasons. Simultaneously the polar ice caps appear during the winters and disappear during the summers. The appearance of the blue-green areas clearly seems to be dependent on the melting of the ice caps. The areas have been explained as changes in mineral color due to water absorption, but many scientists prefer to believe that the areas are some hardy form of lichen-like vegetation which is capable of withstanding cold temperatures and can produce its own supply of oxygen. This is not at all improbable—in fact we have vegetation on Earth that would very nearly match these requirements.

Spectroscopic analyses of these green spots are very similar to those of high altitude plants found on Earth. Analyses for chlorophyll in these plants have proven negative so far, but some plants on Earth living under rugged conditions do not respond to this analysis either. In short, conditions seem quite good on Mars for simple vegetable life. As for intelligent life the outlook is not quite so good. The scarcity of free oxygen in the atmosphere would make the possibility of higher forms of animal life doubtful, but certainly not impossible.

Where Next?

If man does not find intelligent life in our Solar System, does this end his search? Are there other stars with planetary systems which we need examine? No one is sure exactly how our Solar System was formed, but there is a fascinating assortment of theories from which one can choose.

Before we examine theories on the Solar System we should understand it in perspective to the whole universe. Donald Menzel describes a model of the Universe very clearly in his book, *The Universe in Action*. In this model, one light year is one-sixteenth of an inch; one-hundredth of an inch is the equivalent of one million million miles.

The stars are in clusters several hundred feet in diameter "like giant swarms of gnats". These groups, representing galaxies, contain billions of stars, each separated by a few tenths of an inch. Millions of these clusters exist. Our Milky Way is a disk-shaped pinwheel about one hundred feet in diameter and ten feet thick.

Now, we expand the model so that the Sun is the size of a basketball. The Earth, the size of a large grain of wheat, has an orbital radius of one hundred feet (Mercury's orbital radius is forty feet and Pluto's is just under a mile). The nearest star is four thousand miles away, and the Milky Way occupies an area the size of the actual orbit of Venus.

Although this model makes man, his Earth and his Solar System seem very insignificant, we may find some day that they are the most significant creations in the entire Universe. For if our planetary system is unique, we are the only living creatures in the Universe.

When a Greek astronomer first proposed the theory that the heavens did not rotate around Earth, people laughed at him. Eventually man had to concede that he was not the center of the Universe. Since then astronomers have sought to find our relation to our Sun and other stars. One prime question has disturbed scientists ever since—How was the Solar System created?

Life Theories

There are two categories of theories on the creation of planetary systems; I will call them the "dependent theories" and the "independent theories". The dependent theories all state that it took some outside influence in Solar System. The independent theories propose that the Sun could form its own planetary system without any sort of outside influence.

One independent theory proposed by Laplace, a French astronomer, visualized the Sun as originally "an enormous mass of cold gas that grew warm as it contracted". This gaseous mass was rotating and, because of the conservation of angular momentum, increased its rate of spin as it contracted. As the mass contracted, the spinning grew so great that centrifugal forces occasionally threw out rings of matter. These rings condensed to form planets; and, as they did, they

created moons in a similar manner. This theory explained the facts that all planets orbit in the same direction, and all orbited in nearly the same plane [Pluto had not yet been discovered]. In 1898 William Pickering discovered a satellite of Saturn, Phoebe, which was revolving upstream—counter to all other known matter in the Solar System. Astronomers were so dejected over this discovery, they wrote a poem to Phoebe.

Phoebe, Phoebe, whirling high
In our neatly plotted sky.
Phoebe, listen to my lay,
Won't you whirl the other way?

All the other stars are good
And revolve the way they should.
You alone, of that bright throng,
Still persist in going wrong.

Never mind what God has said,
We have made a law instead.
Have you never heard of this
Nebular hypothesis?

It prescribes in terms exact
Just how every star should act,
Tells each little satellite
Where to go and whirl at night.

Disobedience incurs
Anger of astronomers
Who, (you mustn't think it odd)
Are more finicky than God.

So, my dear, you'd better change
Really we can't rearrange
All our charts from Mars to Hebe
Just to fit a chit like Phoebe.

Phoebe was not the only reason that this theory was discarded. It was found that the angular momentum requirements were not what they had to be for this theory to be true. If the Sun expanded so that its mass encompassed the orbit of Mercury, its rotational period would slow from the present twenty-five days to over five hundred years. The subsequent addition of Mercury's mass would slow down this period by only one hour—hardly a stabilizing change.

Menzel's Theory

Menzel has proposed an independent theory which considers electromotive forces. He suggests that solar electric currents and their magnetic fields, which are believed to be the cause of solar surface disturbances, could be slowly weakening. If they were stronger in the early period of our Sun's life, Menzel reasons that the forces of such currents flowing about the equator could have caused a giant surface bulge. The current then tore itself away from the "carrying with it a doughnut ring of matter". This doughnut, held together by electric currents, was still connected to its creator by electromagnetic

forces and thereby gained angular momentum which speeded up the doughnut's rotation and slowed down the Sun's. The ring then broke up, condensing into planetesimals and then planets.

Although I have not run across this theory, it seems that this electromagnetic binding of two physically disconnected masses and the resulting transfer of momentum could bring a variation of Laplace's theory back into consideration.

Dependent theories involve the Sun and some foreign body—another star, meteors or a cloud of dust and gas. The dependent theories leave out the simple gravitational capture of matter flying through space, because this capture does not produce angular momentum unless some kind of friction is involved. Writers of popular dependent theories realize this and have introduced forces in their theories which result in the creation of angular momentum.

Chamberlain and Moulton introduced their "planetesimal hypothesis" about 1900. They theorized that the Solar System was created when a foreign star passed close to our Sun, causing tremendous swells on the

Sun's surface until huge streams of gas squirted into space. These streams were set whirling about our Sun by the attraction of the passing star as it flashed by. Over a period of time the gas collected into many clusters and cooled into planetesimals. These planetesimals served as magnets to collect the smaller matter into planets. The planetesimal formation of planets is popular with many geologists because it explains the composition of the Earth quite well.

Other Theories

Various other theories involving our Sun and other matter have been proposed, including theories which describe our Sun as originally part of a double star.

C. F. von Weizsäcker suggests that the Sun could have been surrounded by a disk-shaped nebula in violent movement. This nebula eventually collected into planets. This theory is popular among some astronomers.

Collisions among stars are very, very rare. If planetary formation is dependent on the collision of stars we would probably find only about one hundred stars with planets in our galaxy. If, on the other hand,

stars can create planets by themselves in the process of their natural formation, we could expect to find billions of stars with their own Solar Systems in our galaxy.

Within the last decade we have discovered encouraging evidence of extraterrestrial life from the examination of meteorites. Carbonaceous chondrites, a particularly fragile type of meteorite, have been analyzed using the most modern instruments. Hydrocarbons like those of decayed organic matter have been found in these meteorites. These hydrocarbons could have been produced in manners other than organic decomposition, but other forms of matter similar to Earth life have been found. Microfossils have also been found which resemble algae of the Earth. One type of algae is different from any species known on Earth.

Confirmation of life outside of our Earth would be of tremendous scientific value, but it would also be of unequalled sociological and philosophical significance. The realization that the life created on Earth is not unique would have a profound effect on man's attitude toward himself and the heavens.

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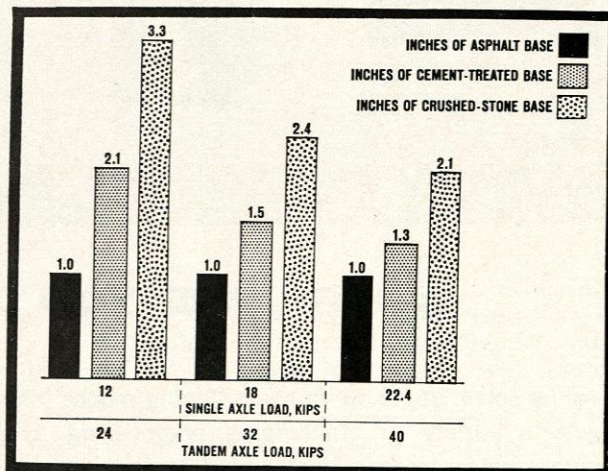


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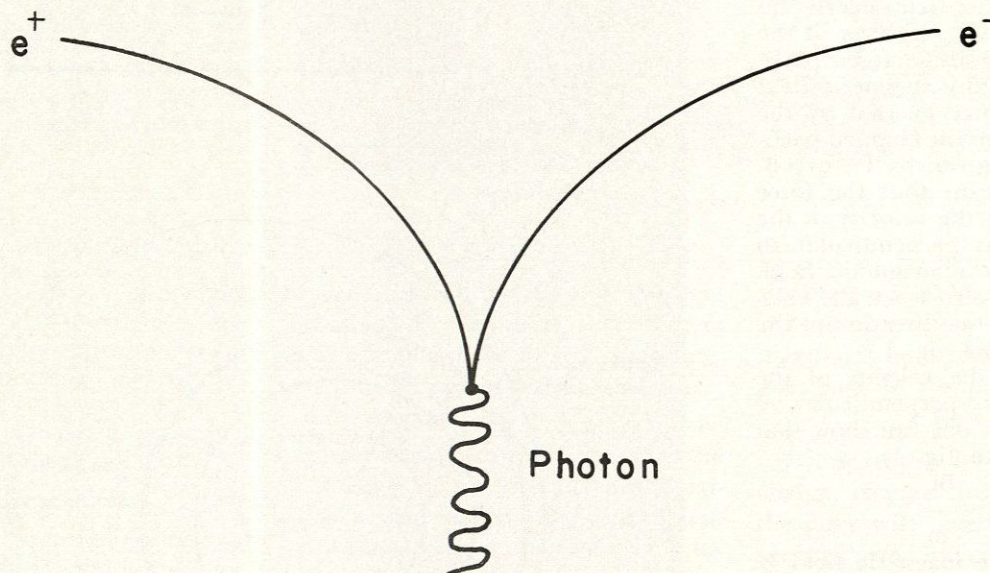
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SPECTROMETER

SILAS GONZALES



This past summer the National Science Foundation in conjunction with the Superior Student Program in the College of Engineering sponsored the building of a beta-ray spectrometer for use in undergraduate laboratory courses in physics. The research grant was given to two participants of the Superior Student Program, and a faculty member was named to advise and help the students.* The following describes the theory and construction of the spectrometer.

Among the many instruments that have been built to study the nucleus and radioactive decay the beta-ray spectrometer is rapidly becoming very important. The primary purpose of the beta-spectrometer is to sort the electrons emitted by radioactive substances. A glass prism splits a light beam into its color components, similarly the beta-spectrometer splits an electron beam into electron beams whose electrons have the same energy.

The first beta-spectrometer of sig-

nificant use as a scientific tool was built around 1915 by Ernest Rutherford. This spectrometer was of the type having electrons orbiting in the plane perpendicular to the magnetic field and passing through the source of beta rays. Since then there has been a concentration on building beta-spectrometers capable of very precise energy measurements of closely spaced electron groups. Essentially this amounts to designing spectrometers with an extremely high resolving power.

Field Design

Because of this research many types of beta-spectrometers have been designed. The prime difference between these spectrometers is the shape of the magnetic fields and hence the shape of the orbit of the electrons. Some fields (magnetic) are uniform; others non-uniform. The spectrometer which was built here at the University of Colorado last summer was designed and modeled after the much larger University beta-spectrometer

designed and built by Professor A. A. Bartlett, R. Ristinen, and R. Bird. The properties of this model shall be discussed later, along with those of the small beta-spectrometer which was built this last summer. The large beta-spectrometer is of the type having a non-uniform magnetic field. Professor Bartlett used a model magnet to determine the exact shape of the magnetic field needed for the large spectrometer. This magnet was used to produce the magnetic field in the small spectrometer.

Electromagnetic forces are of two basic types, the electric force and the magnetic force. Both of these forces play a very important part in the theory of a beta-ray spectrometer. Coulomb's law gives us the electric force F_e between two electronic charges q_1 and q_2 (mutually attractive or repel-

*The Faculty member was N. Ashby and the students were Charles Nelson and Silas Gonzales.

lent, according as they are of like or unlike signs) separated by a distance as:

$$F_e = \frac{q_1 q_2}{4 \pi \epsilon_0 r^2} = \frac{k q_1 q_2}{r^2}$$

This equation applies for charges in free space, where ϵ_0 , the electric permittivity for free space, is

$$8.85 \times 10^{-12} \frac{\text{coulomb}^2}{\text{newton-m}^2}$$

$$\text{and } k = \frac{1}{4 \pi \epsilon_0}$$

is $8.99 \times 10^9 \text{ newton-m}^2/\text{coulomb}^2$.

If there is an electron, stationary with respect to a present magnetic field, the magnetic field exerts no force on the electron. However, if the electron (or any other charged particle) is moving in this magnetic field there will be a force exerted by the magnetic field upon the charged particle. This force is given by $\vec{F} = q\vec{v} \times \vec{B}$. This equation means that the force is maximum when the velocity of the charged particle is perpendicular to the direction of the magnetic field. The force will be zero when the velocity is parallel to the direction of the magnetic field. (See fig. 1.)

Assuming that the velocity of the charged particle is perpendicular to the magnetic field, one can show that (again referring to fig. 1)

$$V = \frac{q}{m} \frac{Br}{\sqrt{2\pi}}$$

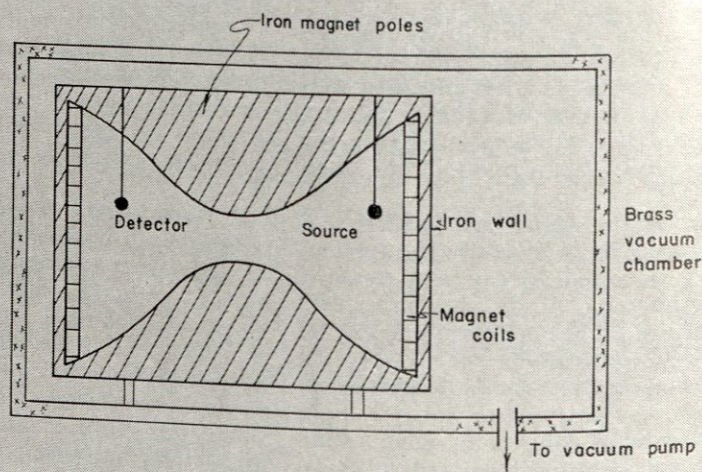
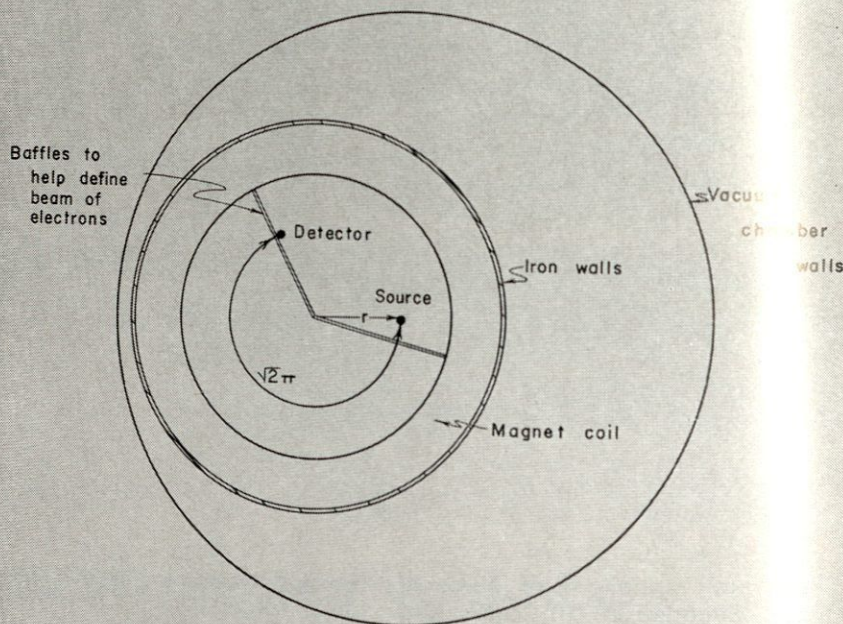
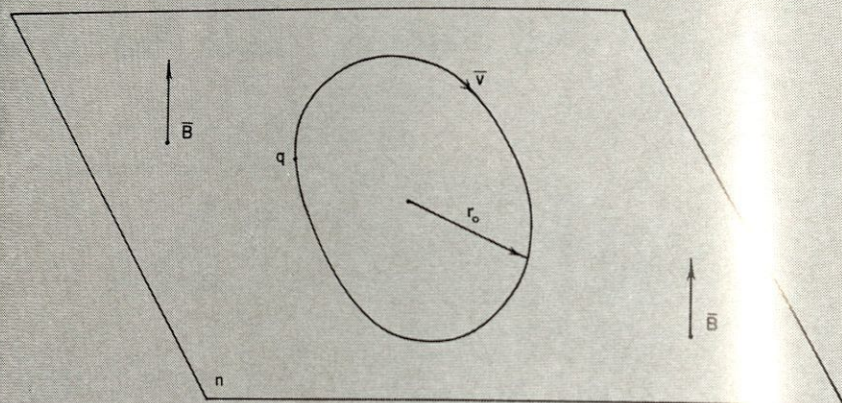
Thus knowing the magnetic field B , the charge q , and r the constant radius of the orbiting charged particle, one can readily calculate the velocity. Furthermore, since the energy of the particle depends upon the velocity, Kinetic Energy $= \frac{1}{2} mv^2$,* the energy can be calculated.

These basic principles are the foundations for the theory and construction of the beta-spectrometer. The small spectrometer consists of a magnetic field surrounded and contained inside an iron alloy chamber. Figure 2 is a drawing of the beta-spectrometer. The entire magnetic chamber must be in a vacuum to allow the orbiting electrons unimpeded motion.

It can be shown that for the shape of the magnetic field in the beta-spectrometer, a beam of electrons of height z emerging from the source will be focused at the detector if the detector is $\sqrt{2\pi}$ radians from the source. The focused electrons must of course, be of the same energy. Also the magnetic field will have to correspond to both r , the radius, and the energy of the electrons.

The ability of a beta-spectrometer to focus a beam of electrons at a

*Corrections can be made if the particle is moving fast enough not to warrant ignoring relativistic effects.



radius r and of height z is called the double focusing property. The large University spectrometer is of this type; consequently, the small spectrometer is also of this type.

Every radioactive isotope which emits beta rays emits beta rays of a certain energy or energies. Thus all the atoms of Cesium 137 will emit beta rays of certain energies only. If one desires to study a beta-ray emitting isotope, one merely varies the magnetic field until the counting system registers a pronounced peak in the number of beta rays being emitted. The magnetic field is varied because the radius of the orbit of the moving electrons is fixed by the geometry of the spectrometer. Also the velocity and energy of the beta ray is fixed by the isotope. Thus the precise energy or energies of the beta ray can be readily calculated (See Figure 4.)

Atomic and nuclear physicists are avidly seeking information which would help establish more understanding of nuclear decay and other phenomenon of the nucleus. Since the knowledge of the emitted particle plays a very important part in the study of such phenomenon, the beta-spectrometer also plays a very important role in this study.

Planned Experiments

Two specific experiments being planned for under-graduates to perform on the beta-spectrometer are studying the beta ray spectra of specific isotopes and studying positron-electron pair production. Conceivably, many other experiments could be performed, all involving other nuclear phenomenon. Among these other experiments is one involving the study of the probability of occurrence of intra-atomic electron scattering by gamma rays. This phenomenon occurs when a gamma ray energy; then by chance the photon strikes an electron of the same atom before it has a chance to get away from the atom. When this occurs very sharp peaks appear in a graph of the number of electrons counted versus the energy of the electron.

Studying beta ray spectra of a specific beta-emitting isotope involves gathering the number of counts. (The counting system must, of course, only count electrons rather than all types of radiation.) Plotting this data against the energy of the beta rays, or something proportional to the energy yields the beta spectrum. The data can be readily obtained by placing the source in the spectrometer, then taking counts as the magnetic field is varied. The magnetic field is varied



THE DETECTING APPARATUS AND THE BRASS VACUUM.

because of the already mentioned equation, $F = qv \times B$. The student will then be required to interpret various phenomena in the spectrum, which are frequently quite complex.

The second experiment, positron-electron pair production, involves the production of particle and anti-particle, since the positron is the anti-particle of the electron. The famous Curies were one of the first teams to demonstrate that a gamma-ray photon of sufficient energy may lead to the emission of electron and positron pairs when passed through a plate of matter. They were able to obtain a photograph showing an electron and a positron originating from the same point. (Fig. 5.) The energy corresponding to the mass m_0 , of either an electron or positron is, according to Einstein's relation, $mc^2 = 510$ Kev. Therefore, to create two electrons a minimum energy $2m_0c^2 = 1.02$ million electron volts is needed. If the energy of the photon is greater than $2m_0c^2 = 1.02$ Mev, it can give rise to an e^+ and e^- pair, with the extra energy being converted into the kinetic energy of the two electrons.

Clearly, then, to study electron pair production in the beta-spectrometer, one must have a gamma ray source embedded in a material capable of giving rise to the pair production. Generally, lead is used for this purpose. The spectrum of the emitted electrons can be plotted. Then the spectrum of the positrons can be

plotted by reversing the direction of the magnetic field and thereby counting the positrons. The reason the magnetic field has to be reversed goes back to the basic equation

$$F = qv \times B.$$

It can readily be seen that if q , the charge, changes from minus to plus, the force will reverse direction. Thus the electron and positron will each reverse their direction of motion. From this data one can study the conservation of momentum, the conservation of mass-energy, and learn precisely what occurs in electron-positron production.

Needless to say the beta-spectrometer will help enrich students' study of physics. It is therefore a valuable addition to the physics laboratory equipment.

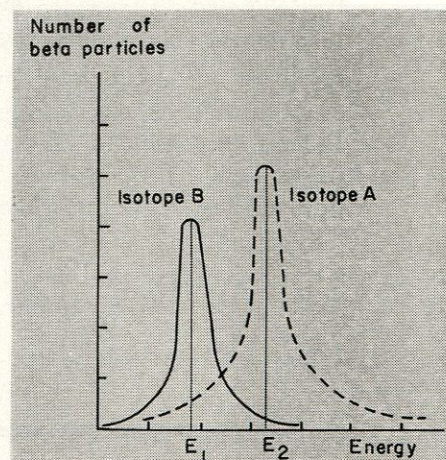
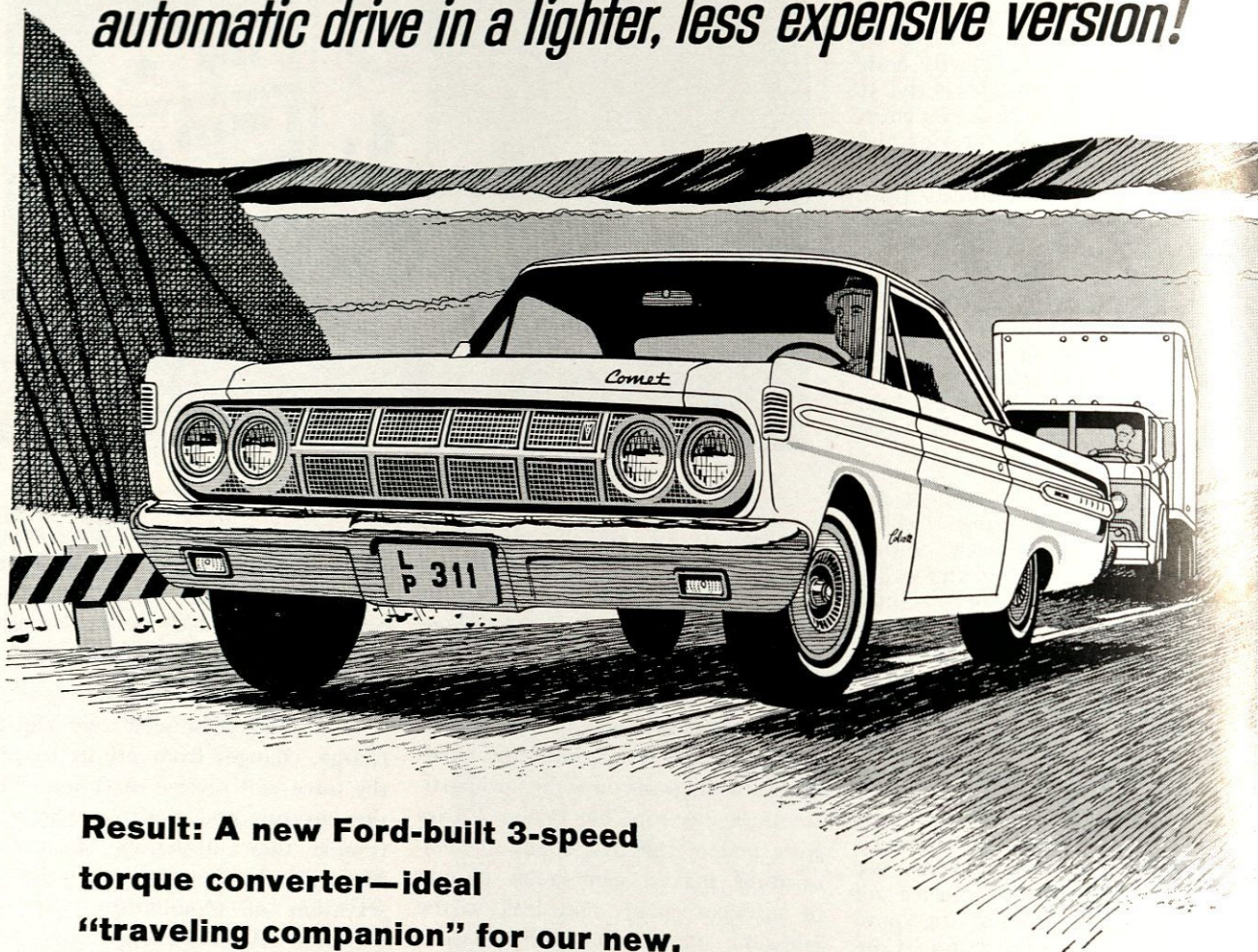


FIGURE 4

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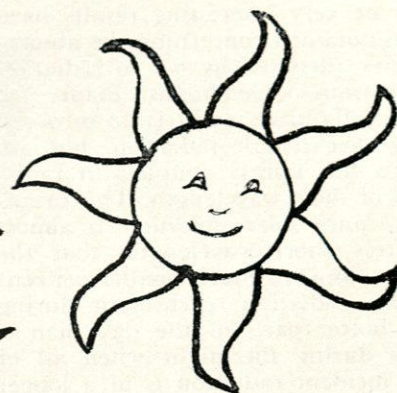
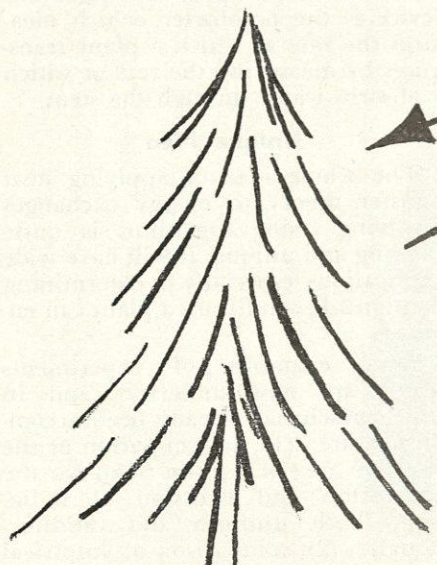
Another assignment completed; another case of engineering leadership at Ford providing fresh ideas for the American Road.



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PLANTS



AND THEIR ENVIRONMENT

ELLEN CARR

Dr. David M. Gates, Senior Research Associate of the Institute of Arctic and Alpine Research of the University of Colorado and consultant for atmosphere physics at the National Bureau of Standards, has been supervising numerous projects concerned with understanding quantitatively and with precision, the physical processes which relate plants to their environment. Collaborators with Dr. Gates in supervising these projects are Professor Frank Kreith, Chairman of the Superior Student Program at the University of Colorado, and Professor John Marr, Director of the Institute of Arctic and Alpine Research.

As Dr. Gates points out, an animal can transfer itself from searing sun to cooler shade, and similarly from freezing exposure to a sheltered enclosure, while a plant, being rooted to its environment, must endure the extremes of its surrounding climate. How a plant is able to cope with these conditions is the question in point.

Although meteorological parameters (temperature, humidity, wind,

sunshine, average rainfall) are most frequently used to describe a plant's environment, a more meaningful description can be given by expressions which relate these parameters to the energy exchange between the plant and its surroundings.

A plant exchanges energy with its environment in various ways. It is warmed by solar (short-wave) radiation and by long-wave radiation from the atmosphere and from its terrestrial surroundings. It can be either cooled or warmed by convection to or from the fluid (air) in which it is immersed. It is cooled by transpiration (heat loss by evaporation) and by reradiation to its surroundings.

Radiation

The expression relating the meteorological parameter, temperature, to energy exchange by radiation is

$$R = \epsilon \sigma T^4$$

where R is the rate of energy transfer per unit area, σ is the Stefan-Boltzmann constant, T is the temperature of the radiating body and ϵ is an emissivity constant, determined by the efficiency with which the body radi-

ates. Many readers will recognize this as the basic equation of radiation heat transfer. All bodies above a temperature of absolute zero radiate energy according to the above relationship.

Radiation is relatively simple to describe, since the only meteorological parameter involved is temperature. The rate of convection energy transfer depends on the density, velocity, humidity, and temperature of the air, as well as on such nonmeteorological parameters as the geometry (size, shape, and orientation) of the plant. The rate of transpiration depends on the vapor pressure gradient from the interior to the surface of the leaf, on the humidity, and on countless other characteristics of the leaf itself.

In order to describe a plant's relation to its environment in an intuitively meaningful way, Dr. Gates has introduced the concept which he calls "coupling." For radiation, the coupling factor is simply the absorptivity of the plant, i.e., the ratio of the energy being absorbed by the plant to that which a black body (perfect absorber) would absorb under similar conditions.

Some very interesting results have been obtained concerning the absorptivities (denoted by α) to radiation of various wave-lengths. Plants are essentially black ($\alpha \cong 1$) to infra-red long-wave length radiation, but are much less tightly coupled to radiation of short wavelength. This means that, since solar radiation is almost entirely short wavelength, that the plant absorbs a much smaller per cent of the radiation reaching it during the hotter parts of the day than it does during the night when all of the incident radiation is of a longer wavelength. This enables the plant to compensate to a certain extent for the wide variation in temperature from day to night. Carbon dioxide and water vapor, while making up only a small fraction of the total atmosphere, are also extremely effective in providing a protective shield for the earth during the day, because their absorptivities to certain solar radiation is quite high.

Convection

The convection coupling factor is the convective heat transfer coefficient (denoted by h_c), and the equation relating it to energy exchange per unit area is

$$C = h_c \Delta T$$

where ΔT is the difference in temperature between the plant and the surrounding fluid. The coefficient h_c is quite complex and can only be determined experimentally, except in very specialized cases. As is to be expected, a small object, such as a pine needle, for which the ratio of surface area to mass is very large, is much more tightly coupled, convectively, to its environment than is a larger object, such as a broad leaf. This effect is enhanced by the fact

that a small object has a thinner boundary layer than a broad object, and also by the fact that, as heat is transferred to the air passing over a broad leaf, the temperature difference changes.

Transpiration is also quite a complex process in which water molecules diffuse into the air from saturated intercellular spaces beneath the surface of the leaf. Transpiration is controlled by the leaf—the regulatory mechanism being stomata (pores) which open or close depending on such factors as sunlight, water availability, temperature, etc. Transpiration is indispensable to a plant on a still, clear day, when the amount of radiant energy being received is much greater than the amount of energy being lost by convection and reradiation.

The essential purpose of the projects now underway is to determine the coupling coefficients: the absorptivities α , the convection coefficient h_c , and the transpiration heat loss for different plants.

The convection experiments are being done in a wind tunnel designed by Cam Tibbals in the Mechanical Engineering department. Cam's work in the field of heat transfer from plants was also the basis for his master's thesis, which he received in August, 1963. Radiation experiments are being done in a vacuum to eliminate convection.

Silver Castings

Another technique initiated by Cam Tibbals and subsequently adopted by others is the use of silver castings and copper replicas of the actual plants to determine the radiation and convection aspects of the total energy transfer. Since the total energy exchange

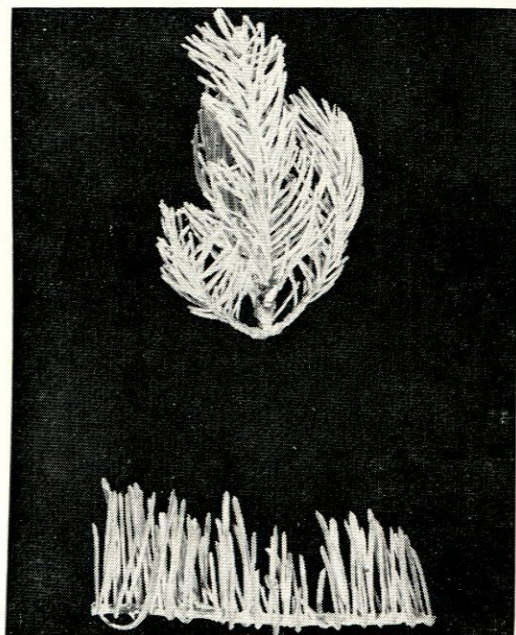
can be observed for both the non-transpiring castings and the live leaf, the transpiration aspect can be determined by a process of elimination.

Several new measuring devices have been developed which are extremely useful; for example, a pyrliometer which measures incident solar radiant heat flux, and radiometers which measure the long wave infrared radiant flux from the ground or from the sky. Another simple, yet ingenious device is the potometer, which measures the rate at which a plant transpires by measuring the rate at which it absorbs water through the stem.

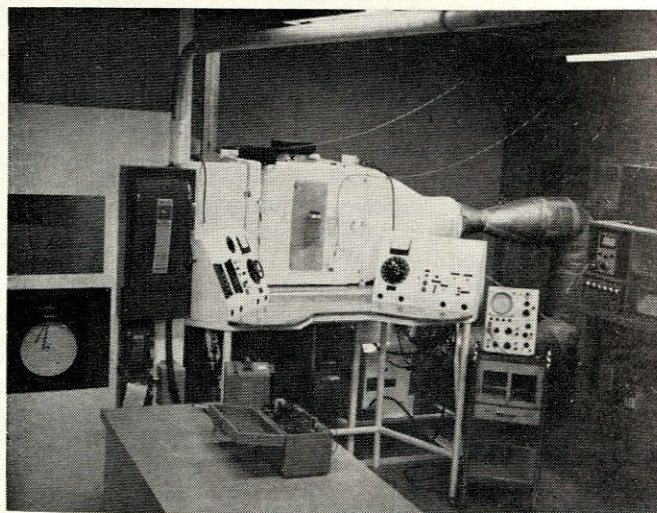
Unique Idea

The whole idea of applying heat transfer theory to energy exchanges involving living organisms is quite exciting and unique. It will have wide applications, especially in determining the limiting conditions a plant can endure.

Some examples of experiments which are now underway and in which much has already been accomplished are: (1) determination of the effective area of a given plant for the absorption and emission of radiation (both uniform and unidirectional); (2) comparison of empirical results for broad leaves with that predicted by heat transfer theory for a flat plate; (3) examination of the variation of temperature at the interior of a tree trunk during a twenty-four hour day, as compared with the variation at the surface; and (4) determination of the effects of changing the spectral distribution of the radiation to which a plant is subjected on the number and kind of mutations which the plant undergoes.



LEFT:
SILVER
CASTINGS
OF
SPRUCE
TWIG
(TOP)
AND
FIT
TWIG



ABOVE: WIND TUNNEL FOR STUDY OF HEAT TRANSFER COEFFICIENTS OF PLANTS.



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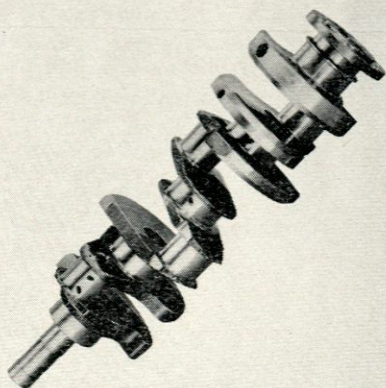
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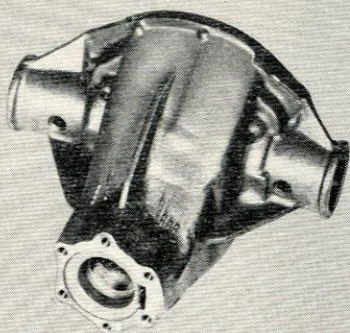
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KEEPERS OF THE PEACE

JIM TOEVS

EDITOR'S NOTE: This article won first prize in both the General and Better Government categories of the Tau Beta Pi pledge essay contest.

This paper is a brief discussion of the prevention of war under the existing world conditions. The title represents the four factions that I feel play the largest roles in controlling the world situation: the United States, Russia, other countries as a group, and the United Nations. The title also implies that peace is being kept—which refers to my confidence in the deterrent system.

Russia and the United States occupy prominent positions in this theme because they are the strongest nuclear powers, together posing the strongest, if not the only, threat of nuclear war. Therefore, the concept of nuclear deterrence primarily involves only these two countries, and will be so discussed in this paper.

Speaking before a student group last fall, Professor of Sociology Alex Garber outlined his thoughts concerning the world situation. Two of his main points were that we must follow a plan of action, and that we must learn to redefine the enemy. My discussion of Russia and the United States will primarily be the development of these two ideas.

To prevent mutual destruction by war, we must either alleviate or balance those forces of destruction at play

in the world today. We cannot stand idle, letting the forces act without restraint. Pacifism is not a plan of action. The deterrent system is, for it seeks always to maintain a balance, adjusting continually to bigger bombs and faster delivery systems. In our deterrent system, many precautions are taken against accidental war. The success of the precautions is demonstrated by several well-known incidents in the history of our continental defense system, an example being the near-crisis that developed when radar was stronger than expected, and picked up the rising moon as an unknown object. War by escalation is a possibility, but the deterrent threat exists there also, in that neither the U.S. nor Russia will jeopardize the motherland for the sake of another country. This was demonstrated by the Cuban crisis.

Russia is now as afraid of war as we are. This was not true when Russia was still far behind us industrially. There was too much dispersion of the Russian population for a nuclear war to be as effective against them as it would have been against us. Now, however she is raising her living standard and enjoying it. This leads to centralization of the population around industrial centers, giving Russia much more to lose in all-out war, and she knows it. This is the only situation in which the deterrent can

work — neither side willing to lose its way of life in order to get rid of the enemy.

Sociologically, there are the three primary definitions of the enemy. The first is the "annihilative" definition—the "only good Indian is a dead Indian" point of view. An example of the definition of a people in annihilative terms was Hitler's attitude towards the Jews. The second type is the "instrumental" definition, in which the second party is the first party's enemy because it has something that the first party wants. An example is China's definition of India in the recent border disputes. The third definition is in "agonistic" terms. This definition creates enemies for honor alone, such as the jousting tournaments in the days of knight-hood.

Russia and the United States need to maintain the deterrent balance and the arms race until we can redefine each other in less annihilative terms, since each redefinition brings about more rules of war, and therefore more control of the means and extent of destruction. The process of redefinition must take many small steps until eventually an understanding will exist that neither side will try to completely destroy the weapons balance. Perhaps both sides can develop an unwritten agreement to inform the other of what research is being done to

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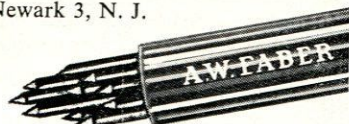
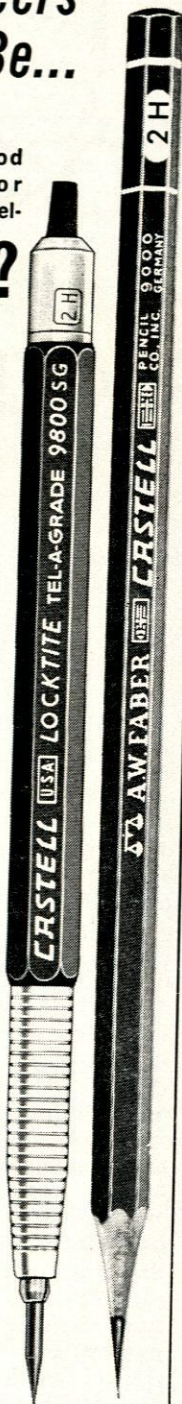
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break the deterrent. Even now, many ideas are being exchanged, such as general statements concerning the development of the laser as a weapon.

Eventually, reductions in arms could be made, along with increases in the time necessary to deliver nuclear weapons, which now stands at 15-20 minutes. If missiles were disarmed or defused, the delivery time might be increased to an hour, and so on. This is a plan of action. The Korean War was an example of redefinition. Many Americans wanted to drive the Red Chinese clear back into China, which would have been an annihilative definition of the ideology. But South Korea was returned (geographically, at least) to the South Koreans as it had been before the war. This was the purpose of the conflict as defined in instrumental terms.

These facts show that the deterrent is working. Every trouble spot, such as Berlin or Cuba, offers opportunities for negotiation, and therefore, opportunities to ease the tensions of the cold war. It seems that Mr. Khrushchev is also realizing the senselessness of nuclear destruction.

The Only Contenders

I feel that other nations cannot enter into the problem except as innocent bystanders in the event of nuclear war. The nuclear power of the world is essentially divided between the U.S. and Russia. We are the only two countries that could wage nuclear war with any hope of success, and we have only each other to fear. No other country could cause war between us unless one of us was directly behind the actions of the third country. At the same time, it is unlikely that either of us would ever find a third country worth the devastation of a nuclear war. This was illustrated quite well by the Cuban crisis. Russia was directly behind Cuba's actions, and we teetered on the brink of war. However, when the U.S. threatened direct attack on Russia if any missiles were fired from Cuba, Russia immediately withdrew.

Red China recently accused Khrushchev for being afraid of the "paper tiger" of the West. Actually, the paper tiger is Red China, with her 700 million people. Even if she develops the hydrogen bomb within a few months, as many physicists believe she will, she still will not have a delivery system capable of presenting a threat. Her only strength is in her cheapest commodity — the human being, who cannot overrun nuclear weapons with sheer numbers, even though China often sounds as if she would like to try.

One hears both praise and scorn for the United Nations. Some want to see

it turn into a world government, and others want to see it collapse. Still others, and I am among these, wish to see it continue its evolution, feeling that it plays an important role, but feeling also that the world community is far from being ready to unite under a single flag.

World Government

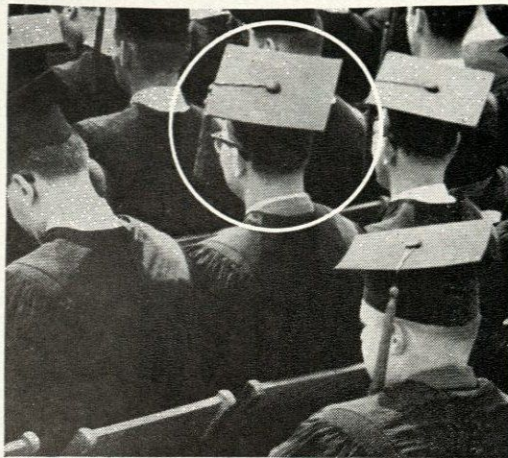
In its present state, the U.N. functions as a sounding board to hear the voice of every member country. It can give itself the power to keep most countries of the world in line, but can not enforce its will on either the U.S. or Russia. This is good, for if it could, it would be essentially a world government.

Before the U.N. could become a world government satisfactory to the majority, many problems would have to be solved. One of the main ones is the problem of law. What set of moral standards could serve as the basis for statutes that would please everyone? During a recent discussion, several students tried to find similarities in the moralities of different countries. The only common national moral standard was the idea that to try to survive is always morally ethical. We would expect to find great difference between the concepts of justice and the value of human life of a starving country like China and of a rich country like the United States. Yet how can one call the United States a highly moral nation when, world market or no world market, two-thirds of the world goes hungry while we let farm surpluses build up and rot.

Equality

I believe that there can never be moral equality between nations until there exists some semblance of economic equality. Whether or not it is morally right to try to force economic wealth and a higher standard of living on other people is a different question entirely, and perhaps an equally hard one to answer. The United Nations could, however, along with its other functions, do much more to act as a central agency to help countries that wish to help themselves. The funds, equipment (tractors, etc.), and people to perform this task must come from richer countries, and must come without a political price tag. The U.N., serving as the intermediary, could do much to remove the price tag.

Perhaps, far in the future, the world will be ready for an absolute sovereignty, but today there are no persons to whom we would be willing to entrust the authority and responsibility of world government. We have not yet learned to live with our fellow man.



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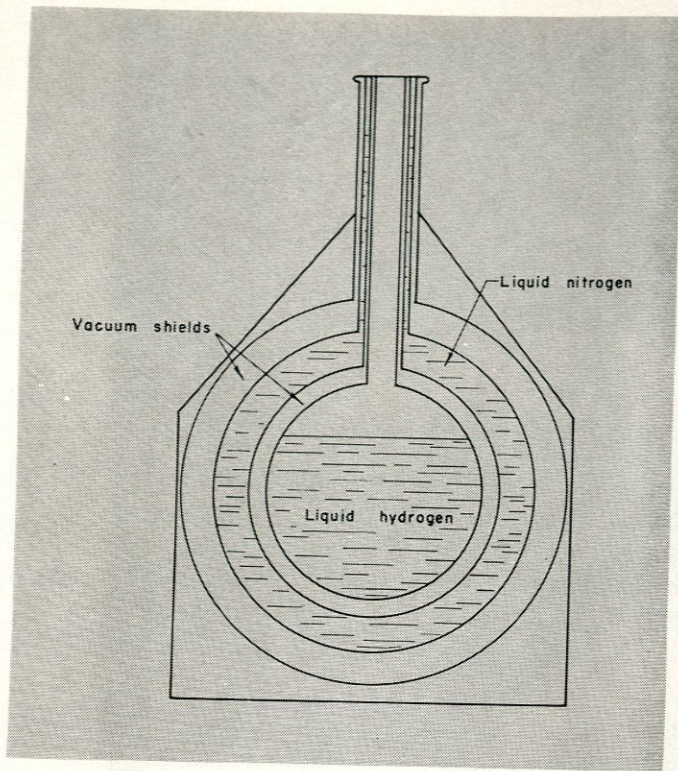
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THE "LITTLE BROWN JUG" — A STORAGE DEWAR FOR LIQUID HYDROGEN.

Did you know that Colorado University has the distinction of being one of six universities in the United States that is engaged in research in the field of Cryogenics? For those who aren't familiar with this field, definition of Cryogenics is "the study of properties of substances cooled to temperatures below 150 degrees Kelvin". When interest in this field first took a foothold among the faculty members in the department of Chemical Engineering, the Boulder Bureau of Standards donated facilities to these people so that they might work in conjunction with the Bureau staff on various phases of Cryogenics. Three years ago the Chemical Engineering Department decided to offer an undergraduate course in Cryogenics which would be available to all qualified seniors. In order to handle this new program effectively, a laboratory with very limited facilities was set up in the rear of the Chemical Engineering laboratory. Interest in this scientific field has increased so sharply that funds are currently being sought to add even more people to the list of personnel within this extremely important field. In fact plans for the new Engineering center include a unique laboratory with a "blowout wall". This lab will enable the research to expand at an even greater rate.

Why does the university have such an avid interest in this field? The answer to this question lies in a brief look at the actual scope of Cryogen-

ics. By far the most important phase of the subject is the study of liquid fuels for missiles and rockets. This problem is of vital importance to the rapidly advancing missile programs which constantly demand improvement. The discovery of a fuel which will give a large initial thrust to a rocket requires that a new container and refrigeration unit be designed for optimum performance in space, that a new method of combining fuels be developed for more efficient combustion, and that many more details be adjusted to the discovery, to insure the success of the entire project. So Cryogenics, even in this one phase, is not only an important science itself, but it encompasses many more industries as it progresses. This isn't the only area of importance in this field however. Things such as superconductors, infrared detectors, and plasma research are associated with Cryogenics. In fact a new type of digital computer utilizing these refrigerated products is currently being developed. These, then, are the reasons why the university should be interested in Cryogenics. Also, because of the convenient location of the Bureau of Standards and the cooperation of its staff, the problem of setting up facilities is lessened greatly.

In order to fully appreciate the scope of the present program, a look at portions of the current activity not directly concerned with academic study is in order. In 1960 and again in August of last Summer, the Nation-

al Cryogenic Engineering Conference was sponsored by the College of Engineering and the Bureau of Standards, and was held here on the CU campus. Over a thousand delegates attended the 1963 conference which lasted for three days. Also represented in the delegation were Japan and France whose representatives presented papers on various aspects of cryogenics. A total of sixty papers were presented which varied in subject matter from insulation and heat transfer to fluid chemistry and super conductivity. Dr. K. D. Timmerhaus represented the university on the planning committee and is himself working on a set of papers resulting from current research in the university and Bureau facilities for the tenth annual conference next year. It is through activities such as this one that the university will gain national prominence in Cryogenics and, subsequently, graduates having worked in this program at CU will be in greater demand.

Another project which is expanding the reputation of cryogenics is the Air Force contracts which are being coordinated by Dr. Barrick. These Air Force projects are university sponsored with the cooperation of the Bureau of Standards.

Hydrogen Study

One contract is for studying the catalytically promoted change for parahydrogen to orthohydrogen. (The terms ortho and para refer to the spins of the nuclei of the

hydrogen molecule; in orthohydrogen the nuclei of the two atoms are spinning in the same direction, and in parahydrogen the nuclei of the two atoms are spinning in opposite directions.) Ordinary hydrogen contains 75 percent orthohydrogen and 25 percent parahydrogen. When it is liquified, it changes to 99.8 percent parahydrogen. Without a catalyst, the reversing of the spin takes place slowly; in the presence of a suitable catalyst, it can take place very rapidly. The object of the current research is to find the comparative rates of the various steps in the catalytic reaction. This should give an insight into the reaction which will be helpful in controlling the entire reaction.

This reaction is important from two points of view. The first concerns the production of liquid hydrogen, which is in great demand as a fuel for the more advanced rockets. The change from orthohydrogen to parahydrogen is exothermic. Because of this, it is important that liquid hydrogen put into any type of storage be almost pure parahydrogen, since the gradual change of orthohydrogen to parahydrogen in storage would give off heat, which in turn would evaporate the liquid hydrogen. It has been estimated that if a mixture of 75 percent orthohydrogen and 25 percent parahydrogen were liquified and put into storage, 34 percent would evaporate the first day because of the heat given off by the ortho-para shift reaction. Because of this, the orthohydrogen must be converted to parahydrogen before it is placed in storage.

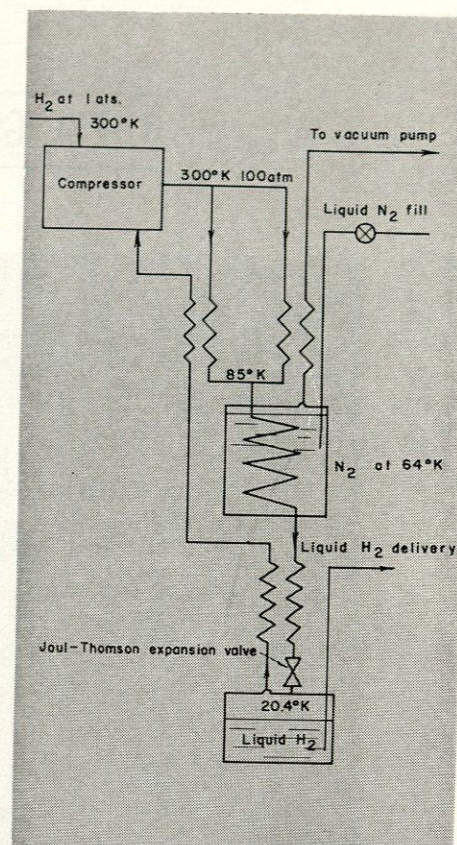
The other interest concerning this reaction stems from the idea of a space plane. If hydrogen were to be used as fuel, the change from parahydrogen to orthohydrogen could provide a

readily available source of refrigeration in the plane. For instance, if a condenser on a small distillation column were required, the para-ortho hydrogen shift reaction might give the needed cooling of the condenser.

The men who are involved with this project are Dr. Lee Brown, research associate and Ph.D. in Chemical Engineering; Harold Hutchinson, M.S. in Chemical Engineering and continuing on for a Ph.D. David Geddes, just having completed his M.S. in Chemical Engineering; Donald Page, laboratory technician; and Dick Cruse, a senior in Chemical Engineering.

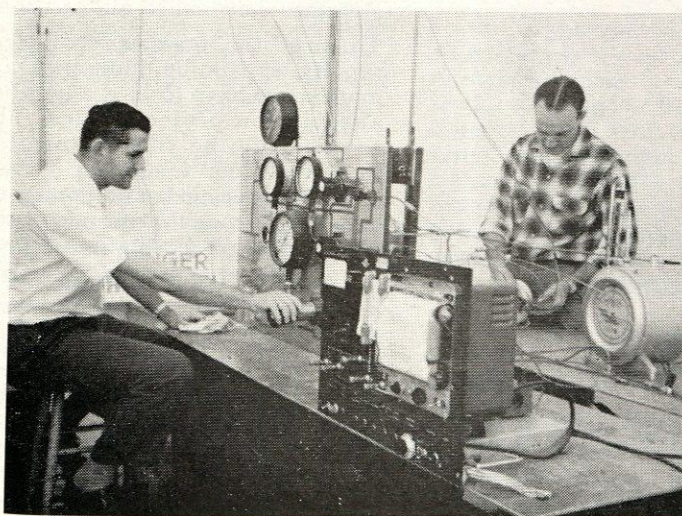
The second Air Force contract is an experiment to determine thermodynamic properties of solutions of liquefied light gases. The object of this experiment is simply to study phase equilibrium of Cryogenics systems in terms of the composition of the liquid phase and the gaseous phase at various temperatures. The significance of this type of study is in programs such as the Centaur and Rover-rift rocket project. Combinations of liquid hydrogen and liquid oxygen or fluorine are being considered as possible propellants for these rockets. These liquid fuels will give much greater specific impulse to the rocket and will enable it to break free of the earth's gravitation while using limited amounts of fuel. The less fuel used in taking off from the earth the farther the rocket will be able to travel. Richard V. Herring, a graduate student working on his Ph.D. in chemical engineering, is working on this contract with various faculty members and Bureau personnel.

From these observations it is obvious that Cryogenics is an important field in terms of the future of the United States, in the race for the

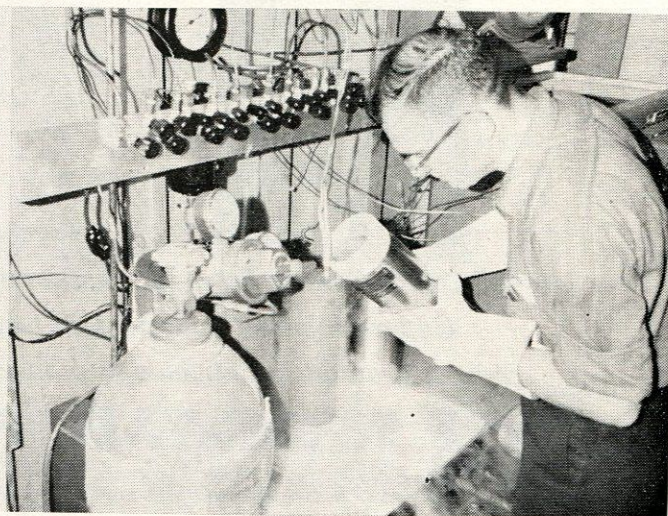


SCHEMATIC OF A HYDROGEN LIQUIFACTION CYCLE

moon and also for a great number of ordinary everyday products. The university has taken a leading position in this field and is striving to increase the facilities and course instruction for Cryogenics. Opportunities in this particular field are prolific and highly paid. Many companies throughout the country are interested in Cryogenic engineers to lead various research projects, so the appeal of the field is nearly as great as its importance.



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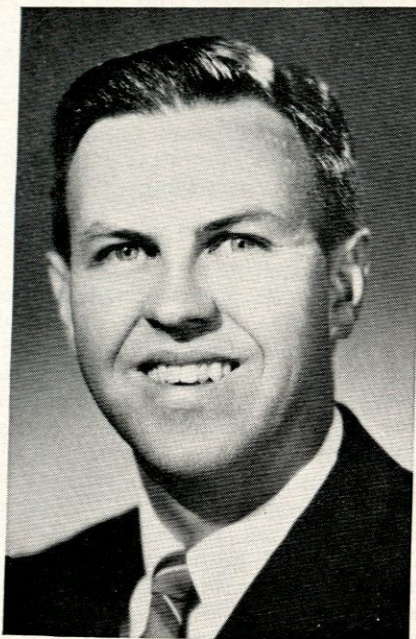


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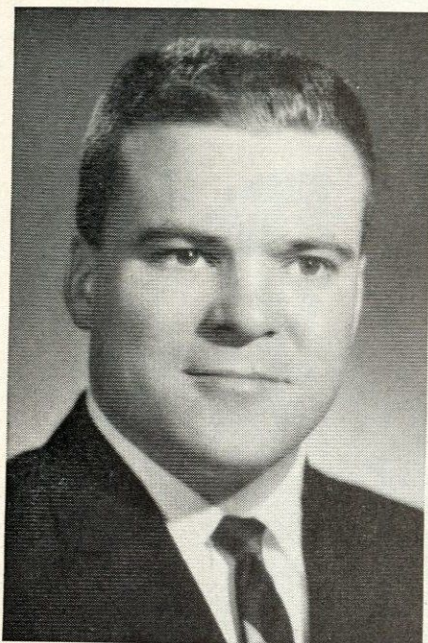
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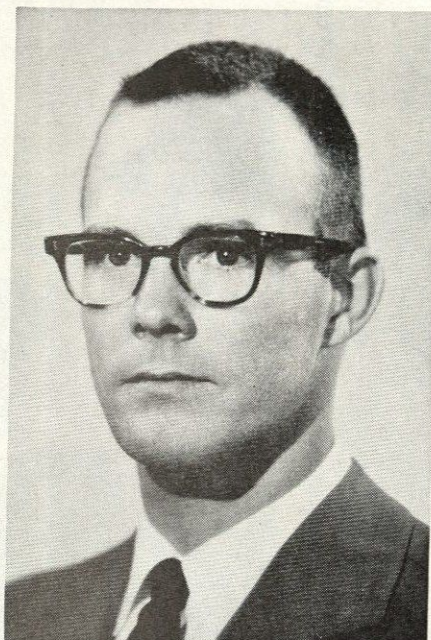
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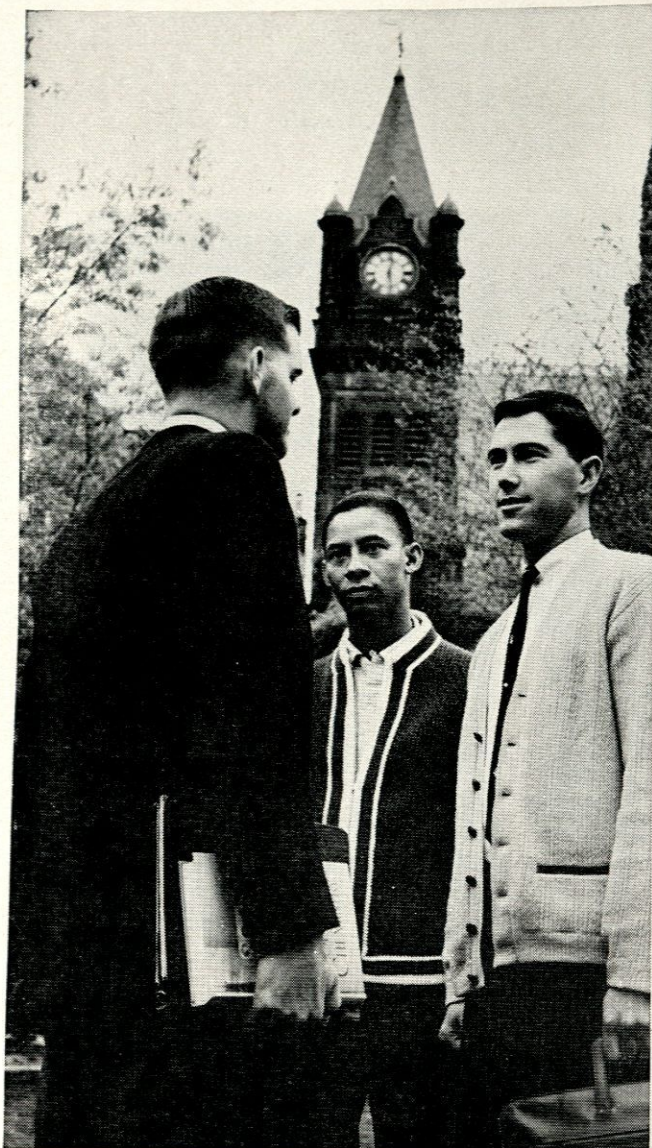
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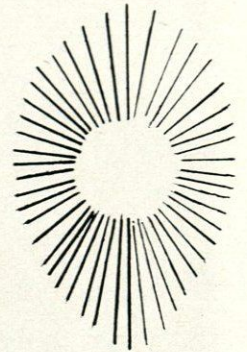
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TWINKLE TWINKLE LITTLE LIGHT

JIM TOEVS



As the door of the Ventura's control room opened, Wiley turned to see Ferris, his co-pilot, standing in the opening with a worried look on his face. "La Rosa's gang is in business again, Captain Wiley. Two more transports have been hijacked while forming flight patterns soon after blast-off." Occasional blips across the radar screens of patrol ships had recently created the rumor that the intergalactic criminal was headed towards the Ventura's convoy. The ships, in elliptical orbits around Zarris, the third member of a planetary system near Betelgeuse, the shining beacon of Orion. An introverted race, the Zarrians offered only hostility to outsiders in distress, leaving the convoy with the single alternative of flying in a security formation in deep space.

The speeding pirate ship was sighted while defense preparations were still under way. Since she was the only escort ship in the convoy, the Ventura moved out to intercept the attacker. The two ships approached each other at almost half the speed of light, due to the hijacker's great attack velocity. The ships closed dramatically, shooting conventional rockets, then suddenly passed, with neither scoring a hit. Immediately, the pirate moved towards the convoy. The Ventura's only chance of recovery lay in shifting to galactic drive, which transmits the complete wave pattern of ship and crew into hyperspace, from which the pattern can be re-emitted at any point in real space. The idea was to fire an armed rocket just as the transition was being made, so that when the ship was reimposed in real space between the hijacker and the convoy, the rocket would already be approaching the bandit, giving him less time to evade it.

Having been designed for long range transportation, the galactic drive was hard to use accurately in

such tight quarters. A slight error caused the weapons rocket to be re-emitted in the space already occupied by the pirate, resulting in a tremendous nuclear explosion which shook the whole convoy. The Ventura's instruments tried to reject the position of reemission with a force that shot her back into hyperspace. Before new coordinates could be established, she had all but burnt herself out of the magnetic "fuel" that powered the drive. Wiley knew it would take weeks for the ship to recharge her magnetic cells from the magnetic field of a planet, therefore he chose an earth-type planet for landing, hoping that a food supply could be found. The ship was designed to stay in space no longer than several days at a time, and therefore had only a two-week supply of rations.

The ship landed safely after the last transition, which extinguished the supply of magnetic potential. The chosen planet, the navigators discovered, was uninhabited R-3, of the fifth magnitude star, D-8, which was so distant from civilization that laser contact was inconceivable. Part of the crew organized a hunt while others worked on repairs, always casting an occasional glance at the control panel's potential indicator bulb, which would glow red when the magnetic cells had absorbed from the planet's magnetic field a potential adequate to sustain transitions into hyperspace.

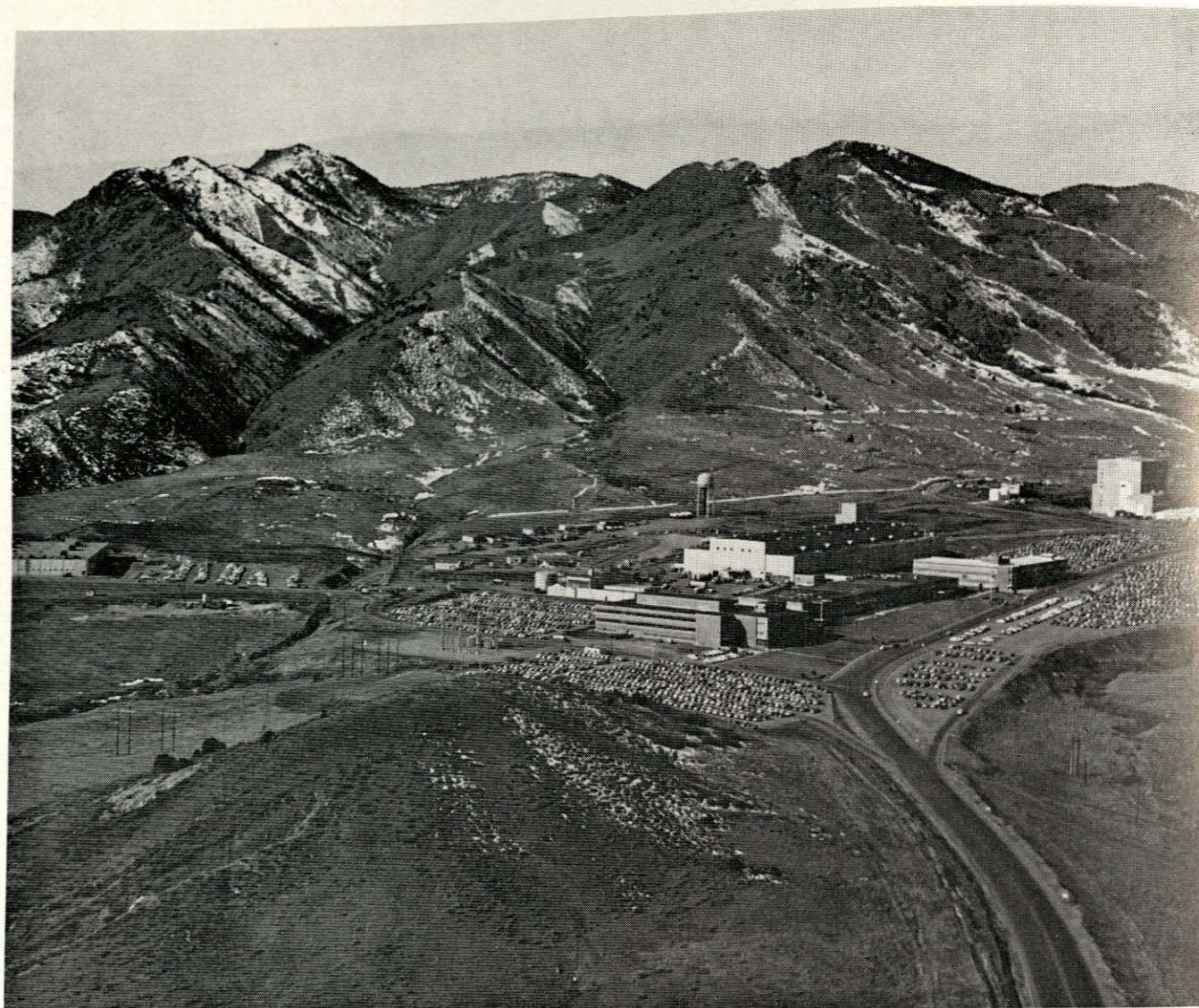
The hunt had proven fruitful, and all were overjoyed until Jaeger, the electrical engineer, ate heartily, then keeled over with a ghastly scream. He was dead! Wiley left strict orders that no one was to touch the game, and sent Carter, the biochemist, into the ship's laboratory to analyze the poisonous forage. He found that the planet's life structure was based on sodium cyanide, rather than sodium chloride. Further searches revealed

the same bitter fact. Carter tried to find a method of ion exchange to remove the cyanide from the food, but this also was in vain. One morning, Fitzhugh, unable to resist the innocent looking, smelling, and tasting game, was found in his bed; the grotesque mask of death was on his face. Eyes were constantly aimed at the small red bulb, as if they could cause it to stare back at them.

At last it seemed that death would win. Three men had starved in the last twenty-four hours. Then Carter heard the men talking among themselves, preparing to cast lots to see who would offer himself first for the others to devour. The thought appalled Carter. If only the potential would build up, all would be saved. But this seemed impossible; besides, death was at hand. The turmoil in Carter's mind was unbearable, as he pictured a crew of cannibals. As a human being, he could not let this take place.

The men were gulping the food down ravenously, their first nourishment in days, when Schneider asked, "Why aren't you eating, Carter?" "I just wanted to make sure everyone gets his full share," was the reply. Then, when all had finished except himself, Carter said, "I lied to you about removing the sodium cyanide. The food is just as lethal as when you first found it. I couldn't stand to see you eat each other like cannibals. It's better this way." And he began his own meal.

Most of the crew had ended their convulsions with the final spasm of peace. Carter, too, had cleaned his plate and was beginning to sense the reaction of his system to the poison. As he put his head on the table, he turned for one last look at the instrument panel. The little fuel indicator bulb was glowing red.



THE DENVER PLANT

COLORADO INDUSTRIES

LARRY FOWLER

Martin Company's Denver division, one of the largest defense contractors in the United States, is engaged in the research, development, testing and production of missile weapon systems, electronic equipment, and associated space age projects. Situated on 7,000 acres of land along the Front Range of the majestic Rocky Mountains some 22 miles southwest of Denver, the Air Force-industrial complex is composed of administrative-engineering and manufacturing buildings, laboratories, test fixtures and four giant captive-firing stands. The facility is a fully integrated missile plant

and has the capacity to transform an engineer's drawing into a complete weapon system.

Martin Company, the aerospace division of Martin-Marietta Corp., was selected by the Air Force in 1955 as the major associate contractor in developing an intercontinental ballistic missile system capable of delivering a warhead to a target more than 6,000 miles away. Martin Company is one of the nation's principal defense and space contractors. Since its inception in 1909, Martin's activities have revolved around the science and technology of flight. The Company built

some of the most distinguished military and commercial aircraft of the 20th Century. Its activities today span the spectrum of the modern flight sciences. Martin currently is engaged in the design, development and manufacture of missile systems; space vehicles for manned and unmanned missions; anti-missile and air defense systems; defense and space related electronic equipment; and specialized nuclear power systems. Martin also is engaged in a broad range of advanced space research involving manned flight and future space missions. Martin Company today is an operating

division of Martin-Marietta Corporation, which was formed in October, 1961, through the consolidation of The Martin Company and American-Marietta Company.

To handle the multi-million-dollar assignment of developing and manufacturing the TITAN weapon system, Martin established its Denver Division. The system was to be produced by a team of industry contractors located from coast to coast and coordinated by Martin-Denver. Other members of the team were Space Technology Laboratories, Inc.; Aerojet-General; Arthur D. Little, Inc.; Western Electric Company; Remington Rand Univac; American Machine & Foundry Company; General Dynamics Telecommunication and the Avco Corporation.

In 1962, TITAN I became an operational weapon system—and the keystone of the nation's heavy-duty ICBM force. The final TITAN I launching at Cape Canaveral, Fla., closed out the research and development flight program with a record of 34 successes, nine partial successes and only four failures.

In April of that year a squadron of TITAN I's was declared operational at Lowry AFB, Denver. Thus, TITAN I became the Free World's first, hard-base ICBM, capable of surviving nuclear attack and then striking back. By the end of August, the last of six squadrons was turned over to the Air Force—thus meeting a deadline set several years before. Martin-Denver, as integration contractor, had the key role in the extremely complex equipment installation and systems check-out phase of TITAN I base construction.

TITAN is the nation's first missile to use a pump-fed second stage engine which ignites at high altitude, an engineering feat many once thought impractical. The twin-barrel first stage engine develops 300,000 pounds of thrust to lift the 110-ton TITAN I from the launch site. The single-barrel second stage produces 80,000 pounds of thrust. Both burn a combination of RP-1, a form of kerosene, and liquid oxygen. To feed these huge engines, Arthur D. Little, Inc. of Cambridge, Mass. developed the automatic ultra high-speed propellant loading system. This system—a maze of vessels, piping, valves and controls—incorporates extremely high flow rates in order to accommodate the comparatively short countdown time for TITAN I. Contained within three underground, tunnel-connected structures, the loading system is designed for storage and rapid transfer of liquid oxygen, liquid nitrogen, gaseous nitrogen and helium.

Computer

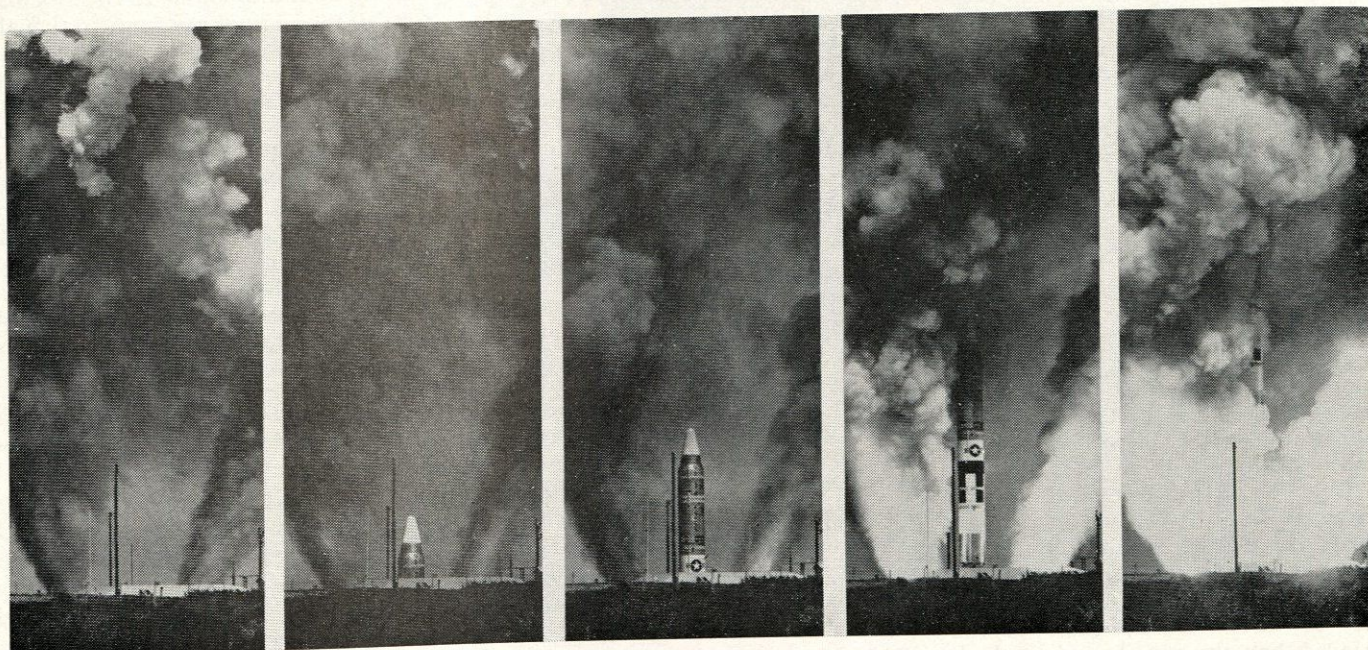
The brains of the mighty Martin-built TITAN I stay on the ground when the missile is launched. A very precise guidance radar and a high-speed digital computer think for and talk to the speeding TITAN while it is under power. The heart of this ground-control guidance system—a super-computer called Athena—was designed and developed by Remington Rand Univac Division of Sperry Rand Corporation. Entirely automatic, the computer's 100,000-plus components guide the TITAN into free flight. Athena has no trouble in matching the speed of the missile in receiving and delaying information. It

is capable of operating at the speed of light. Given a task, it could add a million billion-size figures in 17 seconds—filling an adding machine tape two miles long with the total. Such accuracy is essential. If the TITAN drifts off course as much as three inches for ten minutes in its flight of thousands of miles, the target would be missed by hundreds of miles.

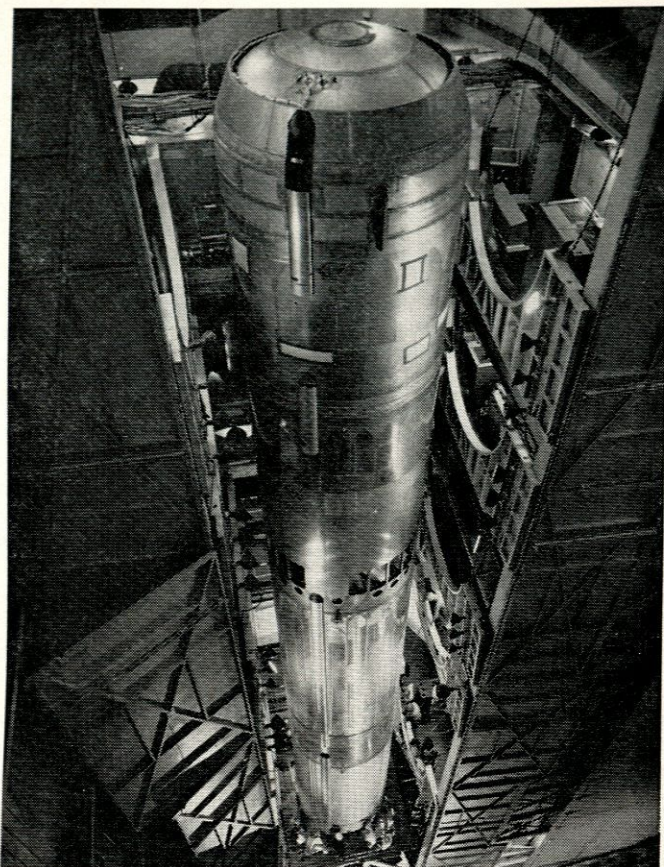
To aid in launch accuracy, The American Machine and Foundry Company of New York developed and constructed a completely automatic launcher system. The objective of the system is to protect the missile and launching equipment from shock (in case of an enemy salvo of nuclear weapons) and automatically prepare for the launch. To do this a unique design was conceived, utilizing a suspension system consisting of compression spring capsules, which isolate the missile and the entire launching system from violent ground shock.

As the "business end" of the TITAN, the nose cone's mission is to protect the vehicle payload—either a warhead or delicate instrumentation—during the tremendous shock and heating of re-entry into the earth's atmosphere.

At the time of re-entry the vehicle is traveling at speeds up to 15,000 miles an hour as it arches back from its high point of 600 to 800 miles above the earth. At these speeds air friction generates heat up to 15,000 degrees F. The re-entry vehicle survives because of its aerodynamic design and its special heat-protective coating of quartz ceramic reinforced with a metal honeycomb structure.



GROUND VIEW OF TITAN II LAUNCHING



103' TITAN II
IN VERTICAL
TEST FACILITY.

NOTE
TECHNICIANS
IN LOWER
CENTER.

The TITAN II Weapon System, an outgrowth of TITAN I, represents increased deterrent strength at an early operational date. Because of the basic design similarity, it has been possible to dovetail the TITAN II program with the TITAN I utilizing existing TITAN I manufacturing and test facilities. The Denver Division is the integrating contractor responsible for design and development of the airframe and for test of the complete weapon system. Martin is also responsible for testing and activation of the TITAN II Weapon System operational bases. Associated with the Martin Company in the TITAN II program are Aerojet-General Corp., propulsion; AC Spark Plug, Division of General Motors, guidance; General Electric Company, Missile and Space Vehicle Division, re-entry vehicle, and Ralph M. Parsons Company, facilities. TITAN II incorporates many major advances including more powerful engines; storable propellants; in-silo launch; reduced vulnerability; inertial guidance, completely airborne; and automated, simplified countdown. The operational base for TITAN II is a silo-type installation hardened for protection against enemy attack. The missile silos in the completely underground base are cylindrical and have ducts on opposite sides to carry exhaust gases to the surface when the missile is launched.

The substantial simplification in the missile has resulted in greatly reduced ground equipment — both in quantity and complexity. The order to launch initiates a brief countdown which includes the command to open the multi-ton sliding silo door at the surface. TITAN II is launched directly from within the silo.

Martin is also integrating contractor for the Air Force TITAN III Standard Space Launch System — and it builds the three liquid-propellant stages of the huge TITAN III vehicle, as well. The TITAN III consists of a two-stage storable propellant booster evolved from the TITAN II Intercontinental Ballistic Missile, a new upper stage, a control module, and twin "strap-on" solid propellant rocket motors.

Martin Company will be responsible for airframe modifications to USAF TITAN II core, strengthening it to accommodate the "strap-on" solid booster engines as well as providing the structure for the upper stage and control module. The airborne system relies heavily on the development philosophy, systems, components and reliability established in the TITAN II program. It utilizes the same structural design features, propellants, propulsion system and guidance as TITAN II.

The TITAN III will be flown in two configurations. These are: Configuration A, consisting of the two-stage modified TITAN II, a new upper stage and control module, and Configuration C, consisting of Configuration A and two, 5-segment 120-inch diameter solid propellant rocket motors strapped on both sides of Configuration A for additional lift capacity.

The new upper stage and control module, to be constructed at the Denver plant, is a restartable propulsion unit located on top and separable from the second stage of the core. It provides vernier propulsion (which permits roll control and velocity adjustment) and attitude control functions for orbit injection of payloads. The control module houses the guidance system and portions of the flight control, vehicle safety and instrumentation systems for the entire booster. The equipment is an integral part of all vehicles, permitting them to be self-sufficient and independent of varying payload requirements. All three stages of Configuration A use storable, liquid propellants. On May 9, 1962, the Air Force started negotiations with United Technology Corporation of Sunnyvale, Calif., for development of solid fuel motors to be used on the TITAN III. These solid propellant rocket motors are 10 feet in diameter. Each of the 5-segment solid rocket motors will develop an average thrust in excess of one million pounds. The solid rocket motors are jettisoned after burnout.

Laboratories

Like any other weapon, to be entirely reliable, TITAN must be capable of functioning under a wide variety of climatic and environmental conditions. The Environmental Laboratory, a part of the General Purpose Laboratory complex, is equipped to duplicate any conditions to which TITAN may be exposed during its operational life. The laboratory is furnished with equipment to produce, in controlled variables, conditions of vibration, acceleration, and shock. The laboratories are capable of simulating conditions of high altitude, intense heat or cold, sand and dust, salt fog or rain, explosion, and extreme acoustical conditions.

The Propulsion Laboratory engages in research and development and in environmental testing of propulsion system components and sub-systems. Much early development of such propulsion system units as the gas generator, the accessory power supply, the liquid-level sensors, and the helium heat exchanger was conducted here. Mockups, including everything

from the tanks to the propellant piping are built in order to test the missile's propellant system, under simulated flight conditions, without actually operating the engines. Such tests were necessary before the commencement of the captive test firing program and are still being conducted on a continuing basis in order to maintain and improve the reliability of the propellant system.

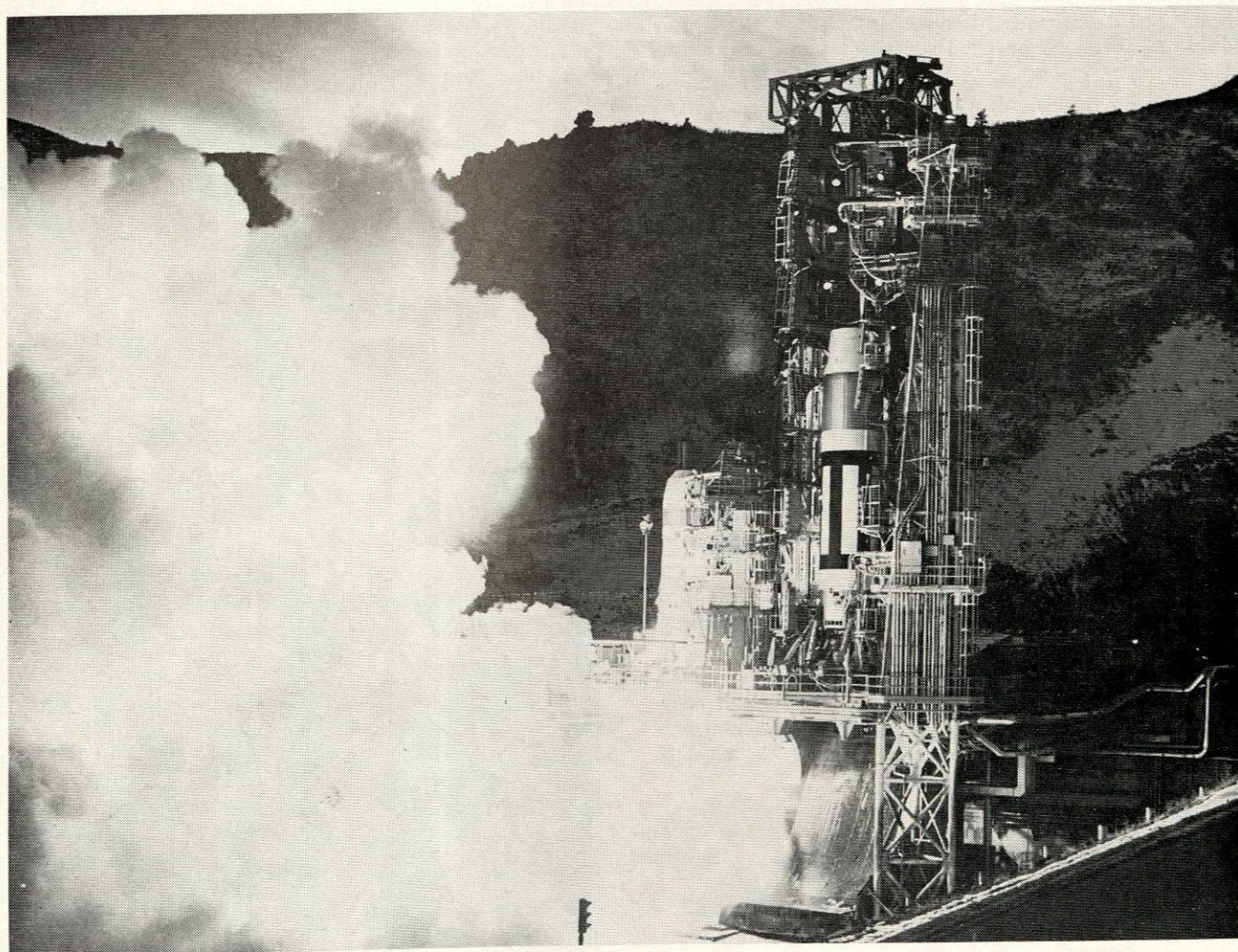
The four test stands are the site of two types of tests that are by far the most spectacular of the operations carried out at The Martin Company's Denver facility. Both involve firing the missile engines with all the noise, flame, smoke, and steam that accompany an actual launch. The first of these, the so-called "battleship" firing tests, involved the operation of the propulsion system with the use of heavy-gauge stainless-steel propellant tanks instead of the thinner aluminum tanks used in the actual missile. The internal configuration of the propellant tanks, the plumbing, and other components of the propulsion system exactly duplicates the arrange-

ment in the missile. The use of the heavy-duty tanks permits the evaluation of the propulsion system under actual engine-firing conditions without exposing the relatively thin flight-missile tanks to the uncertainties of operation when the various components are combined for the first time. The additional strength and tolerance of the "battleship" test provides ideal conditions for the training of test crews.

The second type of testing conducted at the test stands is the verification of the production missiles through sequence firings. In the sequence firing, the two stages of the missile are mounted side by side in their assigned positions on the stand. The firing of the Stage I engine is followed in proper sequence by the automatic firing of the Stage II engine. All functions of actual flight are performed without the missile leaving the stand. Also simulated here are the numerous flight conditions of static wind loads, thrust, cryogenic cooling, aerodynamic heating, shift of center of gravity due to propellant

outflow, and varying acceleration. Other cells, completely shielded from external radio interference, test electrical and electronic equipment and their compatibility with ground support equipment.

Unless the information resulting from the test program is made available for permanent use and study, much of the time and effort expended in testing would be wasted. The gathering of data is accomplished by an elaborate system of wiring and connection facilities that tie the different parts of the test area together. As far as possible, the data-acquisition systems of the various test installations are standardized to permit their output to be readily coordinated. A total of several thousand recording channels is available at the various locations. The collected data are recorded by photographic methods, on magnetic tape, in the form of punched IBM cards, or by automatic tabulation. Once recorded, the information may be reduced for visual inspection or it may be put into a form suitable for processing by one of Martin's



SEQUENCE TESTING ON TITAN ICBM

electronic brains, the IBM 7090 Digital Computer or the Reeves Analog Computer 400.

The need for Martin's intensive testing program becomes evident when it is learned that each TITAN consists of hundreds of separate parts. The failure of one of these parts whether a vacuum tube, a valve, or even a strategically placed rivet might cause the failure of a missile mission and expose the free world to an undefended attack. "For want of a nail the shoe was lost . . ." has as much application today as it did in the old jingle — but this time it will not be a mythical kingdom but the free world that may be lost.

Other Research

Research and testing are of vital importance in preventing missile failure, but their application is by no means confined to that field. Soon after the TITAN project got under way, it was decided that a particular copper-rich aluminum alloy had the desired characteristics for structural use in the missile. It was found, however, that this material was commercially considered to be unweldable. Manufacturing research and development soon worked out a system of heliarc-fusion welding that solved the problem and permitted this once unweldable material to be used successfully.

After testing, redesigning, and testing again the missiles are ready for installation. Some are earmarked for missile bases, others will go to the Gemini project. Project Gemini is the second step in this nation's manned space exploration. Unlike earlier space projects, Gemini — sometimes referred to as a second generation spacecraft — will be entirely man controlled. Its capabilities will include rendezvous and docking — the ability to meet and attach to another orbiting object.

Pilot and co-pilot have specific duties during each mission. They are cross-trained and can handle the mission alone if necessary. Status and control of the spacecraft are general responsibilities of the pilot. The co-pilot monitors all spacecraft systems.

During boost phase the pilot is concerned with the trajectory of the spacecraft and booster performance. He monitors burning time and booster staging to insure the spacecraft's proper height and speed to attain a satisfactory orbit. If spacecraft instruments indicate a possible failure anytime during powered flight he must decide when and how to abort the mission. Although the decision to abort is primarily the pilot's, the co-pilot also can initiate the sequence.

The manual abort system provides

pilot control of the mission and increases mission reliability. Since man's reaction to an abort situation is comparatively slower than automatic devices, it would seem a pilot might not escape any catastrophic failure. However, with hypergolic fuels a malfunction will produce a rapid and intense burning rather than a violent explosion, thus giving time to eject safely.

In event of launch vehicle malfunction above 70,000 feet, the pilot can use a second mode of escape. He shuts down the TITAN II engine, detaches the spacecraft from the booster and deploys the paraglider at proper altitude to a landing without ejection.

The Gemini center of gravity has been offset slightly giving the craft a slight lifting action. Lift vector direction can be controlled by rolling the spacecraft. This allows the pilot to deviate laterally from his flight path and to increase or decrease his range. Any landing point within 50 miles on either side of the line of flight or up to 450 miles downrange can be achieved.

After passing the maximum heating area, a drogue chute deploys to stabilize the spacecraft. Then the pilot deploys the paraglider at about 70,000 feet. The paraglider, a lift-producing wing with a span of 43 feet and a length of 30 feet, is deployed in flights

using it, by slowly reeling it out on five connector cables. Three booms that support the wing are inflated and the pilot flies to a normal landing at a prepared site.

Should the paraglider only partly deploy, or a boom lose pressure, the pilot can simultaneously activate five cable cutters to release the spacecraft from the paraglider. Descent is then by individual parachute after the crew has ejected.

In orbit the Gemini spacecraft will operate somewhat similarly to its predecessor, Mercury, but will have some unique features of its own. It will rendezvous and dock with an Air Force Agena D satellite vehicle previously orbited. Following docking maneuvers, the Gemini spacecraft — using the Agena's engine for power — will be able to extend its apogee (highest point of the orbit from the Earth) or change to another orbit entirely. The Agena will be launched by an Air Force Atlas booster.

Project Gemini will provide an early means of experimenting with long-duration, Earth-orbital manned flights of up to two weeks to determine man's capabilities in space. Martin Company, as coordinator and developer for this, the basic TITAN, and other systems is thus playing a conspicuous leading part in our nation's and in Colorado's space industries.

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OF SEPARATION
OF TWO
STAGES AND
IGNITION
OF THE
LAST STAGE
OF
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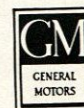
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FRANK A. EASTOM

ALUMNI NEWS

CHUCK HANSEN

Frank A. Eastom, B.S. (E.E.) 1921, M.S. '26; retired June 30 from his position of Professor of Electrical Engineering at CU. His retirement concludes forty-two years on the engineering faculty staff.

Eastom began his career as Instructor of Electrical Engineering in 1921 after graduation. He became assistant professor in 1926, associate professor in 1930, and professor in 1935. He has been a consultant or engineer with the Denver Tramway Corporation, Westinghouse Electric and Manufacturing Company, Public Service Company of Colorado, and Zero Hour Torpedo Company. Most of this work has been in the area of high voltage transmission and testing.

Eastom was a pioneer in the field of air-blast circuit breakers. He is believed to be the first to construct, test and operate such a circuit breaker in the United States. The device is still used by CU engineering students.

Because of his interest in high voltage applications the General Electric Company donated to the electrical engineering laboratories a 1,000,000-volt surge generator and a cathode ray oscillograph. Using this generator and a 200,000-volt transformer, Eastom conducted an extensive study of lightning and corona at an elevation of 5,280 feet.

Eastom made an exhaustive study of the lightning-caused burning of wood poles and recommended protective measures to the Public Service Company of Colorado. He also did extensive breakdown tests on electrical porcelain.

Among his numerous publications is his book, *Experimental Practice in Electrical Engineering* (1932). This text was supplanted in 1946 by *Electric Power Apparatus*. This treatise on the operation and testing of electrical apparatus has been adopted by

several universities and was also used by the Navy.

Eastom has directed more than two dozen student research projects leading to technical papers. Six of these papers have won top prizes in national technical-paper contests sponsored by the American Institute of Electrical Engineers.

Eastom is a fellow and life member of AIEE and contributor in the Rocky Mountain Area to the unity program of the Engineers Joint Council. He was chairman of the Denver section of the AIEE in 1949-50 and has served on several national committees of the organization.

In appreciation for his services to the University of Colorado, the Engineering Development Foundation has established the Frank A. Eastom Fund to provide teaching and research equipment for the College of Engineering.

Frank E. Spindler

Frank E. Spindler, B.S. (E.E.) 1948; has been appointed general manager of the Westinghouse General Control Division in Buffalo, New York. Mr. Spindler was formerly director of province planning for the Westinghouse Industrial Group in Pittsburgh.

Following his studies at the University of Colorado, Spindler completed his master's degree (E.E.) at the University of Pittsburgh and his master's degree in business administration at Harvard University.

He joined the Westinghouse graduate student course in 1948 and later was assigned to the Industry Engineering Department at the East Pittsburgh plant. In 1956, he was transferred to Buffalo as manager of d-c motor apparatus sales and held that position until 1960 when he transferred to company headquarters in Pittsburgh.

Thomas E. Dalby, B.S. (Arch. E.) 1940; has been appointed Manager of Structural Shapes Sales Division for Bethlehem Steel Company. He joined Bethlehem Steel as a member of the 1940 Loop Course and was assigned to the sales department. In 1942 he was named a clerk in structural shape sales, remaining in that position until 1944 when he enlisted in the Navy. Following two years active service in the Navy where he attained the rank of Lieutenant, Junior Grade, he returned to Bethlehem as a salesman for structural shapes. In 1957 he was made assistant manager of that division, and in 1960 he was named Manager of Sales Engineering.

Mr. Dalby is a member of the American Iron and Steel Institute. He served as Chief of the Structural Section, Iron and Steel Division, National Production Authority, from March through July, 1951, and from September, 1957, to September, 1961, was in the Department of Commerce, National Defense Executive Reserve.



THOMAS E. DALBY

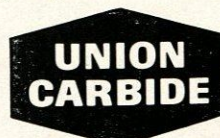


TOP ROW (left to right): Australia, Switzerland, Great Britain, India, Mexico, New Caledonia, Venezuela, Panama, Italy, Japan, Puerto Rico, British Guiana, Canada, France, Ghana. MIDDLE ROW: Thailand, Malaya, Philippines, South Africa, Brazil, Pakistan, Hong Kong. BOTTOM ROW: Argentina, Norway, Indonesia, Greece, Sweden, New Zealand, Colombia, Nigeria.

Meet the ambassadors

Around the world, Union Carbide is making friends for America. Its 50 affiliated companies abroad serve growing markets in some 135 countries, and employ about 30,000 local people. ► Many expressions of friendship have come from the countries in which Union Carbide is active. One of the most appealing is this collection of dolls. They were sent here by Union Carbide employees for a Christmas display, and show some of the folklore, customs, and crafts of the lands they represent. "We hope you like our contingent," said a letter with one group, "for they come as ambassadors from our country." ► To Union Carbide, they also signify a thriving partnership based on science and technology, an exchange of knowledge and skills, and the vital raw materials that are turned into things that the whole world needs.

A HAND IN THINGS TO COME



WRITE for the booklet, "International Products and Processes," which tells about Union Carbide's activities around the globe. Union Carbide Corporation, 270 Park Avenue, New York, N. Y. 10017.

THIS TODAY

ROBERT BARRY

NEW DATING TECHNIQUE

Drs. P. B. Price and R. M. Walker of the General Electric Research Laboratory have developed a rapid, low cost method for geological dating. The key to this method was the discovery of tiny, permanent, fossil tracks left in minerals by the natural fission of uranium atoms. Because many minerals do not contain enough of the radioactive elements on which older dating methods are based, it is often impossible to ascertain their age. However, almost all rocks contain enough uranium to be dated by means of the fossil tracks found in them.

The new dating technique relies on the fact that the uranium atoms are radioactive and decay into more stable atoms at a known rate. Some uranium decays by undergoing fission. As the fission fragments move apart in a piece of mica, for instance, they permanently damage a region about 0.0005 inch long and a few atoms wide. This damaged area can be studied only with the aid of an electron microscope. If the mineral sample is dipped into hydrofluoric acid, however, the acid will etch out the damaged region to form a track visible through an ordinary optical microscope. After the sample has been

etched the tracks are counted. The sample is then irradiated in a nuclear reactor to artificially split some of the remaining uranium atoms. The mineral is again etched and a second count of the fossil tracks is made. The age of the rock is calculated from the ratio of old tracks to new.

To test the accuracy of the new method, a number of rock samples were dated by other methods as well as the new technique and the results were compared. For samples up to a billion years old the new method produced the same results and was much faster and less expensive than other techniques. If the age of the rock sample is more than a billion years however, the technique becomes unreliable, apparently because of slow fading of the tracks.

FIREPROOF CARBON

Carbon, important as the basic element of most fuels here on earth, may become an important structural material in space. Scientists at the Westinghouse Research Laboratories have found that under some conditions encountered in space flight carbon is more fireproof than such common space-age metals as molybdenum and tungsten. This apparent paradox was discovered during a study of how oxygen combines with high-tempera-

ture structural materials at temperature and pressure conditions similar to those encountered during space vehicle re-entry into the earth's atmosphere.

Conducting precise experiments, Dr. Earl A. Gulbransen and two associates, Kenneth Z. Andrew and Fred A. Brassart, investigated the theoretical and actual oxidation rates of structural carbon, tungsten, and molybdenum at temperature ranges of about 3000 degrees Fahrenheit and pressures down to 1/40th that of the atmosphere at sea level. Under these conditions carbon theoretically should burn three times faster than tungsten or molybdenum. However, during the experiments it was found that the theoretical oxidation rate of carbon is 22,000 times its measured rate; tungsten, however, has a measured rate which comes within 590 times of its calculated value. This means that the rate of combustion of tungsten is 12 times as great as that of carbon under the conditions of temperature and pressure used. By using exceptionally pure materials and carefully controlled conditions, the scientists reduced the oxidation reactions to their simplest forms and were able to study the basic mechanisms involved. They found that the rate of the

reaction between carbon and oxygen builds up to a point and then levels off far below the theoretical rate. At 2750 degrees Fahrenheit and under pressure equal to 1/20th atmosphere pressure, the rate of reaction of carbon with oxygen increases to three billion (3×10^9) atoms per second per square inch of exposed surface. The reaction then exhibits a sort of self-control which prevents the reaction from increasing to its theoretical value, more than 20,000 times faster. Under identical conditions tungsten and molybdenum are not equally self-controlled and burn at rates much nearer the theoretical maximum.

The speed with which oxygen atoms can diffuse through the reaction products which surround the burning material is believed to be the factor which makes these reactions self-limiting. The gases produced by burning carbon interfere with the diffusion of oxygen to a greater degree than do the gases and smoke from burning metals. Therefore, from the standpoint of oxidation resistance, structural carbon is better suited for space conditions than are certain metals, such as tungsten and molybdenum, which are commonly regarded as space materials. However, it must be emphasized that oxidation resistance is only one of the many properties which such materials must possess.

COMPUTER-MADE MOVIES

Scientists at the Bell Telephone Laboratories are employing perspective movies, computed and drawn by an electronic data processing system, to aid them in visualizing the complex motions of an orbiting satellite. Dr. E. E. Zajac, who pioneered the new technique, has been using it to study the angular motions of a communications satellite, which is oriented by gravity-gradient torques and contains an attitude-control system

made up of two single-axis gyros. Control of a satellite's attitude is desirable in order to keep the satellite's antenna pointed towards the earth. It is much easier to visualize how the satellite control system works by studying the movies than by plotting the satellite axis-angles against time.

In addition to depicting satellite motions, the computer-made animated movies communicate, with far greater clarity than can be achieved in a written report, the results of mathematical research. They can also be used to depict other sequential events, such as simulation of shock waves and explosions, and missile trajectories.

A movie is made by programing an IBM 7090 digital computer to generate a magnetic tape which contains the data needed to describe sequential perspective drawings of the satellite's position and attitude. A General Dynamics/Electronics SC 4020 Recorder converts this binary data into line drawings on the screen of a special cathode-ray tube. A motion picture camera mounted directly opposite the tube photographs these images on the screen. Valuable computer time is saved by using a slide projector to superimpose over the frame standard drawings which do not change from frame to frame. Thus, in a movie of satellite motion, a figure representing the earth could be superimposed by the slide projector.

The cost of the computer-made movies depends on how difficult it is to mathematically describe the object being depicted. Complex shapes require more complicated programming. A simple movie, representing an orbiting satellite by a rectangular block which yaws and turns over in orbit, requires from three to eight minutes of computer time per minute of movie time.

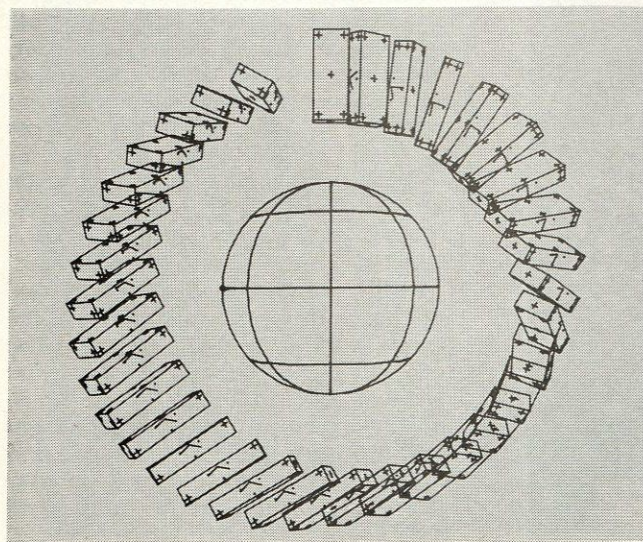


THE NEW FUEL CELL USING DIESEL OIL TO POWER MOTOR ON RIGHT.

IMPROVED HYDROCARBON FUEL CELL

For the first time a fuel cell has been developed which can operate efficiently at moderate temperatures on a variety of inexpensive hydrocarbon fuels. Fuel cells are devices which convert the chemical energy of fuels and oxygen into electrical energy without combustion or the use of moving parts.

The new fuel cell, developed by Drs. Thomas Grubb and Leonard Niedrach of General Electric Research Laboratories, eliminates a number of the undesirable characteristics found in previous cells. The most important advance is that the cell can run on hydrocarbon fuels such as propane, natural gas, and to some extent even gasoline and diesel fuel. The simple hydrocarbon fuels, such as propane or methane, appear to form carbon dioxide and water while producing power with an efficiency of up to 50 per cent. Gasoline, diesel oil, and kerosene, more complicated hydrocarbons, have all worked unexpectedly well as fuels, but certain additives in these fuels are detrimental to the operating life and efficiency of the present cells. A second improvement contained in the new cell is that previous hydrocarbon fuel cells generally operated at temperatures in the range of 1000 - 2000 degrees Fahrenheit; the new cell requires only 250 - 400 degrees Fahrenheit for efficient operation. The energy of the fuel which is not released as usable electricity results in waste heat which is used to maintain the cell at its required temperature. Among the cell's other attributes are its ability to function at atmospheric pressure and to utilize the oxygen from the air rather than



AN EXAMPLE
OF SATELLITE
MOVEMENT
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SYSTEM

pure oxygen from a special source.

According to its developers, the new cell is a "remarkably simple device," which depends on a novel electrode structure and a liquid electrolyte for its operation. The cell has achieved efficiencies in the range of 40 - 50% at reasonable current densities. These figures compare very favorably with those for internal combustion engines which have efficiencies of about 25%.

Although the new cell is much closer to being a practical power supply than earlier cells, much more development will be necessary before fuel cells can be used in general military or industrial applications. The greatest obstacle to their wide industrial use is the cost of some of the materials. Platinum, for example, is used in the electrodes of the new cell. If, however, their cost can be reduced, fuel cells will probably become a major source of power for military, scientific, and industrial purposes.

CROSSWIND SIMULATOR

Engineers at the General Motors Research Laboratories have recently developed a new technique for simulating crosswind forces on a moving automobile. The technique utilizes a rocket engine which can be mounted anywhere on the side of the vehicle.

A number of uses have been found for this new rocket crosswind simulator. Experiments with the rocket engine have verified the equations of lateral motions which are used for computer simulation of automobile handling. By recording the effect of the rocket thrust on vehicle motions, engineers have proved that the computer method accurately simulates

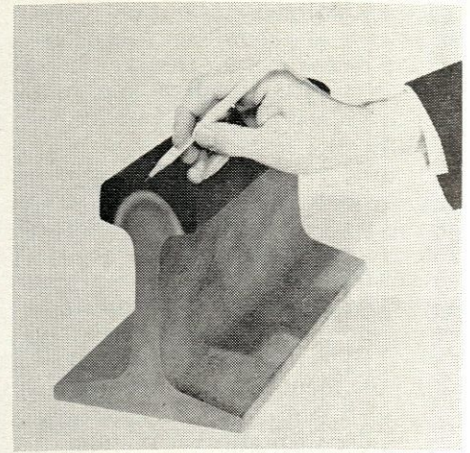
crosswind effects. The rocket engines also provide a relatively easy method of checking the crosswind stability of actual automobiles and, since the rocket engine can be mounted almost anywhere on the vehicle, it furnishes a means for predicting the effects of crosswind forces that would result with different body shapes.

Because the force of the rocket thrust and the "force-time" curve of each test run can be accurately controlled, the new technique is much more successful than previous attempts to study crosswind effects. The previous attempts to simulate crosswind had usually involved propeller-driven wind blasts directed against the moving vehicle from the roadside. The disadvantage of this arrangement was that the vehicle was not in the crosswind for a long enough period of time. Other attempts to test automobiles in actual crosswinds were unsuccessful because winds were too variable and could not be measured accurately.

WEAR RESISTANT RAILROAD RAIL

Last July the United States Steel Corporation introduced a new, heat-treated steel rail designed specifically for use on railroad main lines where wheel abrasion at curves causes severe rail wear. Conventional rails at such curves and similar locations must be transposed or replaced at frequent intervals. The new rails, trademarked "curvemaster," are specially heat-treated to stand up to this type of use and will cut maintenance costs.

The new rails are heat treated on a special induction hardening line, using high frequency alternating cur-



U.S. STEEL'S CURVEMASTER RAIL WITH HEAT-TREATED HEAD

rent. Since the head is the only rail surface which must withstand the abrasive action of car wheels, it is the only part treated. The remainder of the rail receives no special treatment.

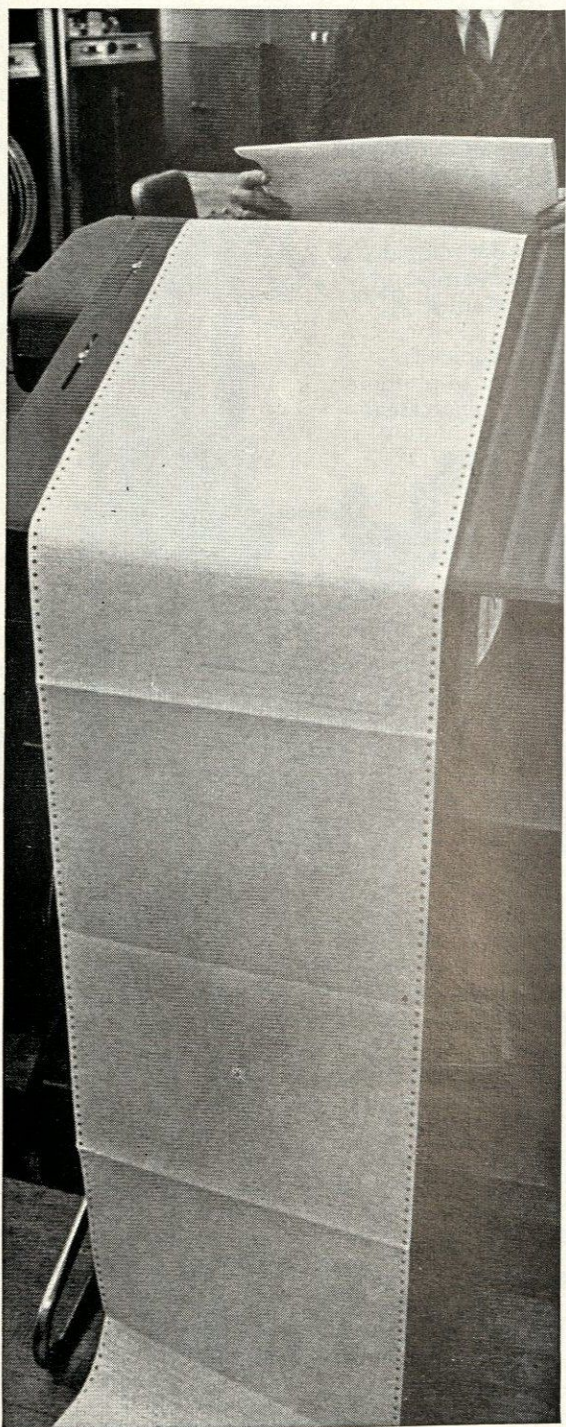
The actual heat-treating process is continuous and completely mechanized. The rails are first arched over a shuttle platform and anchored at both ends. The induction units with coils in the shape of an inverted "U" are then lowered onto the rails. As the induction unit moves along the rail it heats the rail head to a precise hardening temperature. As the heated section passes from under the induction coil it enters an air quench where it develops the proper hardness and microstructure. The air-quenched portion is tempered by residual heat within the rail. Final cooling is accomplished through the use of a carefully controlled water spray which aids in preventing rail distortion. A mechanical rail handling procedure also helps to minimize distortion and the need for subsequent straightening. Such straightening after heat treatment may result in nonuniform or excessive residual stresses.

For nine months before the new rail became commercially available last July, it was tested in actual service on a section of the Baltimore and Ohio main line where freight traffic is particularly heavy. At the end of the test period the test-rail showed only moderate wear, while conventional rails in the same place would have been in need of replacement.

Although designed primarily for use on main line track curves, the heat-treated rails will probably be used on spurs connecting heavy-industry plants to main lines and in mining operations where heavy cargos tend to cause rail surfaces to wear quickly. In the future these rails may also find application on high-speed mass transit systems.



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BOOK REVIEWS

JOANN CRAM

In a rough course, a good reference book can sometimes literally save the day by including another diagram or one more example. Up until now, finding a reference involved either a dusty, time-consuming search through Norlin Library, or buying what amounts to another textbook, with the usual astronomical price tag attached. But the paperback book has done it again and now offers excellent reference material at a reasonable price. (If only this could happen to textbooks!) The following reviews are all of paperback books.

A Servo-Mechanism Primer: An Introduction to the Theory and Design of Automatic Controls

By Ira Ritow, 148 pp., Dolphin Books, Doubleday & Company, Inc., Garden City, New York, 1963, \$1.95

This book is an introduction to servomechanisms (automatic controls) written for readers with a high school physics background and a limited knowledge of mathematics. The book is divided into three parts:

Part I is a survey course in servomechanisms for readers with no calculus training.

Part II explains how to design simple (linear) servomechanisms for readers with a slight knowledge of calculus.

Part III describes how to design more complex (nonlinear) servomechanisms and also requires a slight knowledge of calculus.

"The word *servomechanism* means 'slave machine'. Basically, the closed-loop servomechanisms in wide use today are just that: they are machines whose output follows the instructions of the input. To qualify as a servomechanism they must also have the feature of 'errorsensing'. This means that the system which causes the output to follow the input is not sensitive directly to the magnitude of the input but, rather, to the difference or error between the values of input and output. Because of this error-sensing feature, servos duplicates somewhat the mode of control characteristic of a human being. For example, when someone reaches for a pencil on a

desk, his eyes guide his hand by watching the difference between the position of his hand and the position of the pencil. By so doing, the human is sensing and reacting to the 'error'."

Mr. Ritow has written a readable book with many figures and diagrams, and the emphasis throughout is on explaining basic principles in simple terms rather than presenting detailed proofs of accepted rules.

Chess for Fun and Chess for Blood

By Edward Lasker, 224 pp., Dover Publications, Inc., 180 Varick St., N.Y. 14, N.Y., Corrected republication of second, 1942, edition, \$1.25

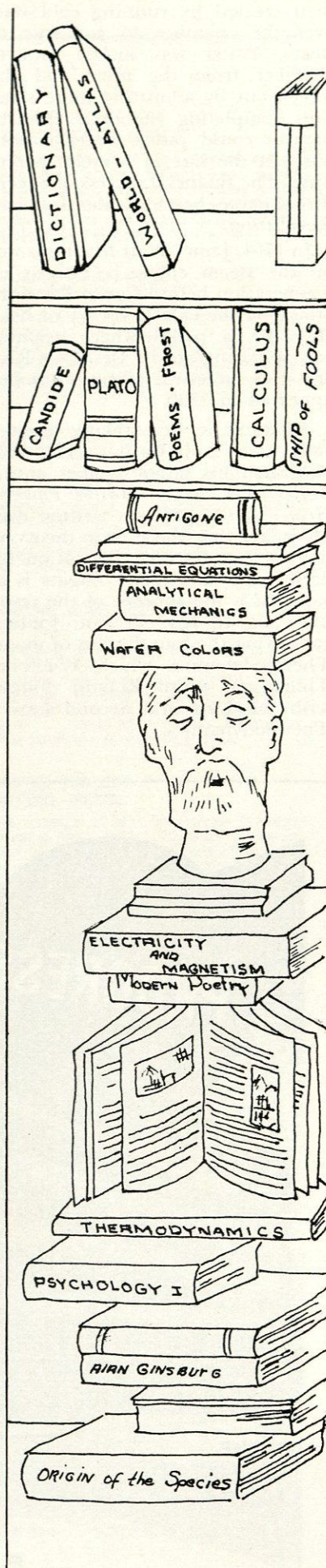
In need of recreation after so much studying? Edward Lasker is unique in the literature of chess. He is a first rate player who has a remarkable eye for seeing basic processes behind complex move-sequences. He discusses such questions as: Is chess a defensible use of time? Does a chess player have any use except as a chess player? What are the qualities of a good chess player? How good does one have to be?

Or, if chess isn't your idea of recreation, try Charles Goren's game. Four people are twice as interesting as two.

Heat Engines: Thermodynamics in Theory and Practice

By John F. Sandfort, 282 pp., one of the Science Study Series published by Anchor Books, Doubleday & Company, Inc. Garden City, New York, 1962 \$0.95.

While Thermodynamics is only about 100 years old, heat engines have been 'known' and in use since ancient times. But until the 1700's, the use was for entertainment: our all important heat engines were nothing but toys because steam and the pressure it exerts were not understood. The first practical engine was patented in 1698 by Thomas Savery, an English engineer. His machine was designed to drain water from mines and was called a 'fire engine' because fire generated the steam for its operation. The steam generated was admitted into a chamber which forced most of the air out. A partial vacuum was



then created by running cold water over the chamber to condense the steam. Water was sucked into the chamber from the mine and then forced out by admitting more steam, thus completing the cycle. The apparatus could pump water continuously at the rate of 5 cycles per minute. The financial success of Savery's Fire Engine heralded the Industrial Revolution.

In 1764, James Watt began his work on the steam engine. (This is still a generation before Count Rumford's attack on the caloric theory of heat.) By 1787, a paddle-wheel steamboat was operating on the Delaware River, and the successful steam locomotive appeared in 1829.

Advances in heat theory began in 1824 when Sadi Carnot (1796-1832) published his famous paper entitled *Reflections on the Motive Power of Heat*. This paper was written under the belief that the caloric theory was correct, but Carnot's definition of a perfect thermodynamic engine is still valid, as is the concept of the reversible cycle. In 1842 Prescott Joule began laying the foundations of modern Thermodynamics which William Thompson (Lord Kelvin) followed with the First and Second Laws of Thermodynamics.

The book goes on to explain thermodynamic properties and processes with a great deal of clarity and a minimum of mathematics. This is followed by a development of the heat pump and heat engine cycles and efficiency. The Otto and Diesel cycles are discussed and complete sections on the steam turbine, gas turbine, and jet propulsion are presented.

This book is a good introduction to the regular course in Thermodynamics, as well as being a reference.

Mathematics and the Physical World

By Morris Kline, 537 pp., Anchor Books, Doubleday & Company, Inc., Garden City, New York, 1963, \$1.95

Mathematics and the Physical World is a good supplement to classical physics, as well as all four semesters of required mathematics. After an entertaining first chapter in which Dr. Kline reveals that he is on our side, the author presents two good chapters on basic arithmetic, one algebra and one chapter on geometry. He then talks about astronomy, throws in a little philosophy of science, and forges into practical physics problems with contagious courage and enthusiasm. Dr. Kline finishes up

with a discussion of differential calculus, non-Euclidian geometries, and the personal nature of Mathematicians themselves. This book is my favorite, but then I'm a math major, and therefore prejudiced.

Advanced Servo Mechanism Design: A Detail Study of the Theory and Practical Application of the Principles of Automatic Control

By Ira Ritow, 203 pp., Dolphin Books, Doubleday & Company, Inc., Garden City, New York, 1963, \$1.95

In this follow-up to his beginning book, Mr. Ritow is indeed more detailed and technical. Again, the book is divided into three parts:

Part I discusses the transfer-function approach to servomechanism design.

Part II explains design techniques that are based on the pole and zero concepts of operational calculus.

Part III describes how to extend the techniques of Parts I and II to design complex servomechanisms.

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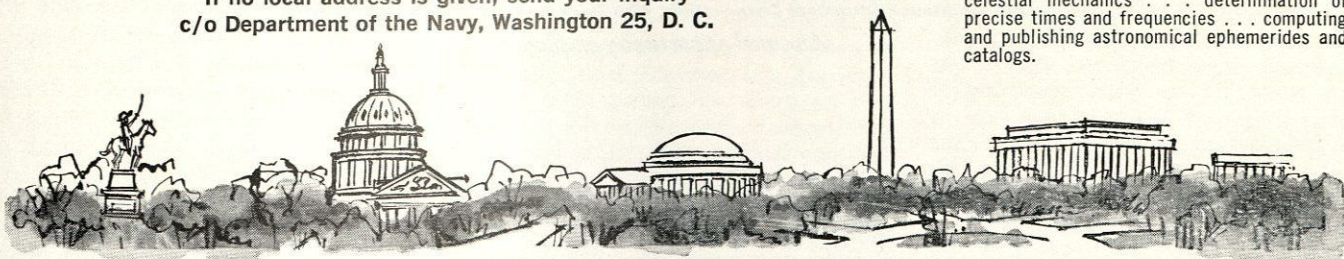
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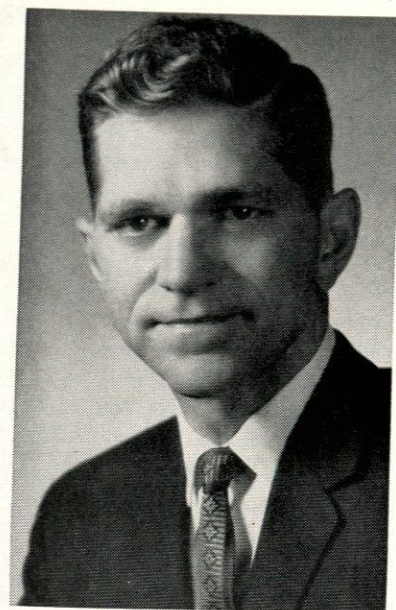
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Our 1963-64 academic year is off to a good start with the architectural plans being completed for our new Engineering Center and preparations being made to put the plans out for bid. We have had unusually good success in adding highly qualified new members to our Engineering faculty. The following new faculty members have joined us in the College of Engineering this Fall:

- Dr. Adolf Busemann — coming from the National Aeronautics and Space Administration. Professor in the Department of Aerospace Engineering Sciences.
- Dr. C. Forbes Dewey, Jr. — coming from the California Institute of Technology where he received his Ph.D. Assistant Professor in the Department of Aerospace Engineering Sciences.
- Dr. George C. Vlases — coming from the California Institute of Technology where he received his Ph.D. Assistant Professor in the Department of Aerospace Engineering Sciences.
- Dr. Watson Bryan Fulks — coming from Oregon State University. Professor in the Department of Applied Mathematics.
- Dr. E. Rex Krueger — coming from the Army Mathematics Research Center, Madison, Wisconsin. Assistant Professor in the Department of Applied Mathematics.
- Dr. Gary H. Meisters — coming from the University of Nebraska. Associate Professor in the Department of Applied Mathematics.
- Dr. Larry James Feeser — coming from Carnegie Institute of Technology where he received his Ph.D. Assistant Professor in the Department of Civil Engineering.
- Dr. Chuan Chung Feng — coming

from the University of Mississippi. Associate Professor in the Department of Civil Engineering, Denver Extension Center.

Dr. Petr Beckmann — coming from the Institute of Radio Engineering, Czechoslovak Academy of Sciences, Prague. Visiting Professor in the Department of Electrical Engineering.

Dr. Warren L. Flock — coming in February from the University of Alaska. Professor in the Department of Electrical Engineering.

Dr. Russell E. Hayes — coming from Stanford University where he received his Ph.D. Assistant Professor in the Department of Electrical Engineering.

Dr. Jerrold H. Krenz — coming from Stanford University where he received his Ph.D. Assistant Professor in the Department of Electrical Engineering.

Professor Vincent C. Rideout — coming from the University of Wisconsin. Visiting Professor in the Department of Electrical Engineering.

Dr. William G. Gottenberg — coming from the Space Technology Laboratory. Assistant Professor of Mechanics in the Department of Mechanical Engineering.

I would like to ask each of you who are undergraduates in Engineering to give special consideration to the advantages of being a member of the Associated Engineering Students' group. This group has done an outstanding job in the past of organizing Engineering activities on our campus; however, to carry out these activities in our past tradition, the majority of our undergraduates must be regular members. If you have not already joined the AES, I would suggest you

take the appropriate steps to become a member.

Improvements continue to be made in our undergraduate program with the development of a special undergraduate laboratory in Electrical Engineering dealing with automatic controls, a new Superior Students measurements laboratory, continued experimentation with TV instruction in Applied Mathematics, an improved undergraduate curriculum for Mechanical Engineering, increase in undergraduate project and research activities, additional use of computers in our undergraduate courses, and plans for a careful evaluation of our entire undergraduate program during the coming year. The serious limitation we have had on expanding our undergraduate laboratory activities has been compounded this year by an increase of more than 30% in the number of our on-campus graduate students. With the number of Ph.D. candidates in Engineering increasing from 36 last year to 89 this year, our space situation is now critical, and the great importance of completing the new Engineering Center as soon as possible is obvious. In the meantime, however, we plan to continue up-dating and improving our undergraduate and graduate programs in as effective manner as possible with our present critical space shortage.

I wish each of you the best of success during the coming year. You are going to find our faculty full of new ideas and increased enthusiasm for Engineering activities. I hope each of you will respond by participating fully in all of the Engineering activities on campus this year and by concentration on your academic subjects.

Max S. Peters
Dean

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ABOUT THE AUTHORS

ARE WE ALONE?

Mark Sheridan is a senior in the combined five year chemical engineering and business program. He is planning to graduate in 1965. Besides writing, he participates in the student chapter of A.I.Ch.E. and is a member of Alpha Chi Sigma, professional chemical-chemical engineering fraternity. On the weekends he enjoys skiing or water skiing, depending on the season.

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Plants And Their Environment

Ellen Carr, a member of the Superior Student Program, is a junior in Mechanical Engineering. During the summer, she worked on an undergraduate research project attempting to discover the effective surface areas of certain plant specimens for the absorption of unidirectional radiation. Her home is near Falcon, Colorado, where her family ranches.

SPECTROMETER

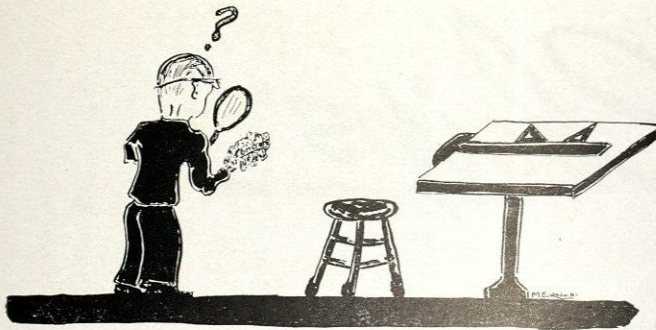
Silas Gonzales, a member of the Superior Student Program, is majoring in applied mathematics and physics. He is attending college with the aid of a four year Gates Company Scholarship. Silas is a member of SIAM and his outside interests include tennis, bridge, and skiing.

LITTLE BROWN JUG

Rick Cys is a sophomore in the combined chemical engineering and business curriculum. He is house manager of Phi Kappa Tau fraternity and a member of Phi Epsilon Phi, sophomore men's honorary. Skiing, intramural sports, and carpentry take up Rick's leisure time.

KEEPERS OF THE PEACE

Jim Toevs, a senior in Engineering Physics, is a fourth-year participant in the Superior Student Program. He is a member of Sigma Tau, Tau Beta Pi, Sigma Pi Sigma, and Kappa Kappa Psi, and plays trumpet in the University Band. He spent the last two summers doing research under an NSF undergraduate grant, and is presently engaged in high-energy negative ion research at the University's cyclotron. Outside interests include music, tennis, mountain climbing, and a pretty medical student at the University of California. Jim plans to do graduate work in Physics.



PUZZLE PAGE

MITCHELL ALLIES

Being an old country boy of sorts, I was rather interested in the following blacksmith's puzzle when it was related to me. Perhaps some economy-minded engineers will also find it amusing.

A young man has five pieces of straight chain of three links each. He wishes to have them made into one long, straight chain, so he takes them to the blacksmith. The blacksmith says he charges five cents to cut a link and ten cents to weld it back together. What is the cheapest price for which the job can be done?

For you budding topologists, here's a twist concerning the torus, which (as you know) has this property: it can be turned inside out by pulling

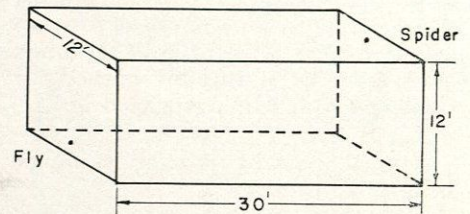
it through a hole in its side. (The uninitiated reader is left to attempt to picture this in his own mind.)

Now imagine an inner tube lying on the floor. Near the upper side and around the larger circumference draw a circle on the inside of the inner tube. Next, on the outside and around the tube as in cross section, draw another circle. The two circles will be interlinked in space. What will these curves look like if the inner tube is now pulled through a hole in itself?

One of Dudeney's great puzzles concerned a spider and a fly shown in the rectangular room below. The fly is at the left center one foot above the floor. The spider is at the right

center one foot below the ceiling.

The spider advances on the fly which is paralyzed with fear. What is the shortest route that the spider can take to get to the fly? The problem can be solved by unfolding the room into a flat plane and then drawing a straight line from the spider to the fly. The problem is how to unfold the room.



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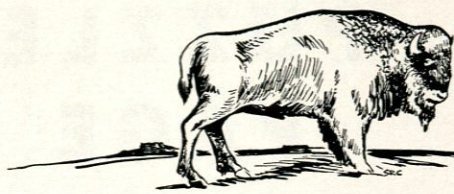
A national organization to improve and extend the uses of portland cement and concrete



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Chips

LARRY HUSTON

Guests in a London hotel, hearing a scream in the corridor, discovered a damsel in a negligee being pursued by a gentleman who was, to be blunt, nude. Later it developed that the impetuous Romeo was an English army officer, who was promptly court-martialled. His lawyer won him an acquittal, however, by virtue of the following paragraph in the army manual: "It is not compulsory for an officer to wear a uniform at all times, as long as he is suitably garbed for the sport which he is engaged in."

Tom: "She said that she would be faithful to the end."

Jack: "That sounds good."

Tom: "Yes, but I'm the quarter-back."

The following advertisement appeared in a physical culture magazine: "Here's a good test for your stomach muscles. Clasp your hands over your head and place your feet together on the floor. Now bend to the right at the waist as you sit down to the left of your feet. Now bend to the left at the waist as you sit down to the right of your feet. Now by sheer muscular control, haul yourself up, bend to the left and sit down on the floor to the right of your feet. Keep this up and let us know the result."

The first letter received said: "Hernia."

Customer to bank teller: "May I see the loan arranger?"

Teller: "He's out to lunch. Would Tonto do?"

Daffynitions:

Conceit: A form of I-strain.

Cocktail party: A place where alcohol removes the polish from the furniture and people.

Hangover: What you go through after you've been through too much.

Bachelor: A man who has thought seriously about getting married.

Assets: Baby donkeys.

Happiness: When your earning capacity balanced your yearning capacity.

Learning that several of his employees were tanking up on no-trace vodka martinis during lunch hours, a wise company president issued the following notice:

Re: All employees

If you must drink during lunch hour, please drink whiskey.

It is much better for our customers to know you're drunk than to think you're stupid.

Psychiatrist to patient: "Your problem is you had a happy childhood and you've got a guilt complex about it."

Psalm 1963

The government is my shepherd
Therefore I will not work.

It alloweth me to lie down on a good job—

It leadeth me beside the still factories—

It destroyeth my initiative.

It leadeth me in the path of a parasite for politics' sake.

Yea, tho' I walk thru the valley of darkness and deficit spending

I will fear no evil for the government is with me.

It prepareth an economic Utopia for me by appropriation of the earnings of my own grandchildren.

It filleth my head with false security—
My inefficiency runneth over.

Surely the government should care for me all the days of my life,
And I shall dwell in a fool's Paradise forever.

Leader of a flock of geese to a bird following: "Stop that infernal honking; if you want to pass, pass!"

Chivalry is the attitude of a man towards a strange woman.

Dean: "I have a report here that says coke, soda and whisky were found in your room. What do you make of that."

Student: "Highballs, sir."

Hard work is an accumulation of easy things you didn't have time to do when you should have.

During the aircraft carrier *Princeton's* 1958 Far East cruise, the consumption of fresh water was greater than the evaporators could keep pace with. The executive officer, trying every means to curb consumption, put the following in the plan-of-the-day:

"The *U.S.S. Constitution* (old Iron-Sides) as a combat vessel carried 48,600 gallons of fresh water for her crew of 475 men. This was sufficient to last six months of sustained operations. Total evaporators installed: None."

The next day the *Princeton's* daily newsletter quoted the statement, adding this "historical" note:

"On 23 August, 1779, the *U.S.S. Constitution* set sail from Boston. She left with 475 officers and men, 48,600 gallons of fresh water, 7400 cannon shot, 11,600 rounds of black powder and 79,400 gallons of rum. Her mission-to destroy and harass English shipping.

"Making Jamaica on 6 October, she took 826 pounds of flour and 68,300 gallons of rum. Then she headed for the Azores, arriving there on 12 November. She provisioned with 550 pounds of beef and 64,300 gallons of Portuguese wine. On 18 November, she set sail for England.

"In the ensuing days she defeated five British men-of-war and captured and scuttled twelve English merchantmen, salvaging only the rum. By 27 January, her powder and shot were exhausted.

"Unarmed, she made a night raid up the Firth of Clyde. Her landing party captured a whiskey distillery and transferred 40,000 gallons aboard by dawn. Then she returned home.

"*U.S.S. Constitution* arrived in Boston on 20 February, 1870 with no cannon, no shot, no food, no powder, no rum, no whisky, and 48,600 gallons of stagnant water."

A modern country is one which bans fireworks and produces H-bombs.



This kind of chemical engineering is not as easy as it looks

An outmoded stereotype should not scare a good Ch.E. off from a highly satisfactory career in marketing. We are proud to say that the job calls for more than a collection of shaggy dog stories plus a convincing manner of taking two more strokes than the customer on that dogleg 14th hole.

Often a marketing career in our non-photographic operations starts out much like the traditional concept of chemical engineering, except that you work on the *customers'* production problems instead of our own. Then you get to meet a few live customers who come to see what you are up to. Maybe you are sent to a trade convention where you meet more than a few customers. To your amazement, they seem to regard you as a fountainhead of valuable technical infor-

mation in a given area. To your further amazement you realize it's true—they do badly need to know exactly what you are being paid to tell them and show them. (Willy Loman never had it so good.) By and by, you may do a tour of duty in one of our field sales offices, or even get into the advertising end. As another course, you may settle down into liaison with manufacturers of equipment that needs to be fed with our plastics, fibers, solvents, chemical intermediates, or fine chemicals.

We define the chemical marketer as a chemical engineer who forges the most rational links between what we can most efficiently turn out and what other companies can most efficiently use. He is a hero of the chemical industry today.

As for the chemical engineer of

different personality bent who, early in his career, prefers to put down roots in one of the three communities where we manufacture—Rochester, N. Y., Kingsport, Tenn., Longview, Tex.—we need him too. And of course, diversified as we are, we also need engineers of other than chemical persuasion, to say nothing of scholarly chemists and physicists to lay down good, solid foundations for all that engineering and creative salesmanship.

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**An Interview
with G.E.'s
J. S. Smith,
Vice President,
Marketing and
Public Relations**



Mr. Smith is a member of General Electric's Executive Office and is in charge of Marketing and Public Relations Services. Activities reporting to Mr. Smith include marketing consultation, sales and distribution, marketing research, marketing personnel development, and public relations as well as General Electric's participation in the forthcoming New York World's Fair. In his career with the Company, he has had a wide variety of assignments in finance, relations, and marketing, and was General Manager of the Company's Outdoor Lighting Department prior to his present appointment in 1961.

For more information on a career in Technical Marketing, write General Electric Company, Section 699-08, Schenectady, New York 12305.

COULD YOU OUT-THINK A COMPETITOR?

Consider a Career in Technical Marketing

Q. Mr. Smith, I know engineering plays a role in the design and manufacture of General Electric products, but what place is there for an engineer in marketing?

A. For certain exceptionally talented individuals, a career in technical marketing offers extraordinary opportunity. You learn fast what the real needs of customers are, under actual industrial conditions. You are brought face-to-face with the economic realities of business. You participate in some of the most exciting strategic work in the world: planning how to out-engineer and out-sell competitors for a major installation.

Q. Sounds exciting. But I've worked hard for my technical degree. I'm worried that if I go into marketing, I won't use it.

A. Don't worry—you'll use all the engineering you've learned, and you'll go on learning for the rest of your life. In fact, you'll have to. You see, the basic purpose of business is to sense changing customer needs, and then marshal resources to meet them profitably. That means that you must learn to know each customer's operations and needs almost as well as he understands them himself. And with competitors trying their best to outdo you, believe me—every bit of knowledge and skill you've got will be called into play.

Q. Is that why you said you wanted "exceptionally talented people"?

A. Technical marketing is not everybody's dish of tea. It takes great personal drive and energy, and a talent for managing the work of others in concert with your own. It takes flexibility . . . imagination . . . ingenuity . . . quick reflexes . . . leadership qualities. If you're nervous with people or upset by quick-changing situations, I don't think technical marketing's for you. But if you are excited by competition, like to help others solve technical problems, and enjoy seeing your technical work put to the test of real operation—then you may be one of the ambitious men we're looking for.

Q. Now what, actually, does a man do in technical marketing?

A. Let me describe a typical situation in General Electric. A field sales engineer is in regular contact with his customers. Let's say one of them makes an inquiry, or the sales engineer senses that the time is right for a proposition. With his field application engineer, he determines the basic equipment needed. Then he contacts the marketing sales specialist in the G-E department that manufactures that equipment. The sales specialist, working closely with his department's product engineers, specifies an exact design—realistic in function and cost. Then the sales engineer and his supporting team try to make the sale, changing and improving the proposition as they get cues from the competitive situation. If the sale is made—a very satisfying moment—then the installation and service engineers install the equipment and are responsible for its operation and repair. With the exception of the product design engineers, all these people are in technical marketing. Exciting work, all of it.

Q. In college we learn engineering theory. How do we get the sales and business knowledge you mentioned?

A. At General Electric, a solid, well tested program of educational courses will quickly advance both your engineering knowledge and your sales capacities. But perhaps even more important, you'll be assigned to work with some of the crack sales engineers and application and installation men in the world, and that's no exaggeration. A man grows fast when he's on the sales firing line. As a FORTUNE writer once put it, the industrial sales engineer needs "that prime combination of technical savvy, tactical agility, and unruffled persuasiveness." Have you got what it takes?

699-08

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