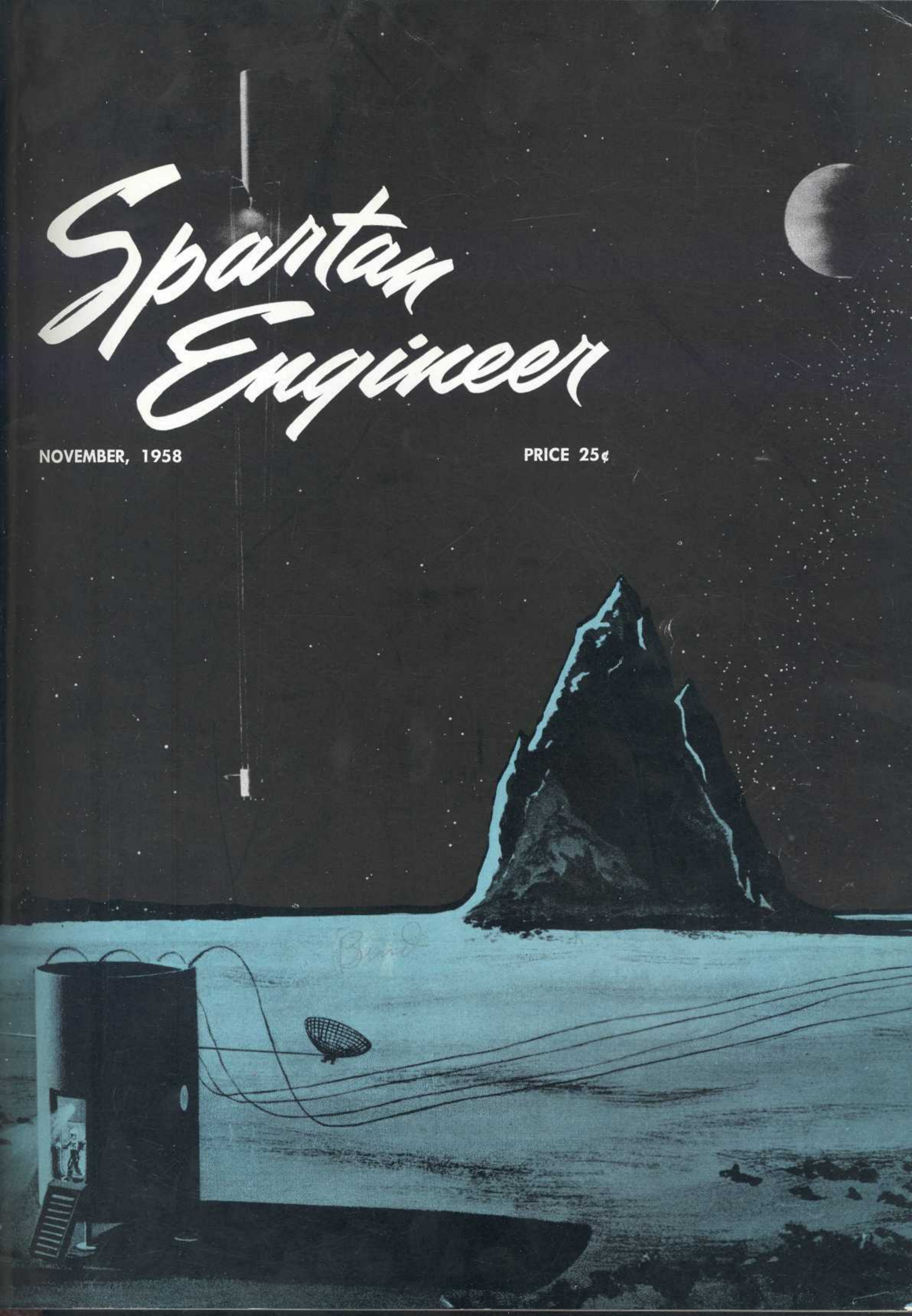
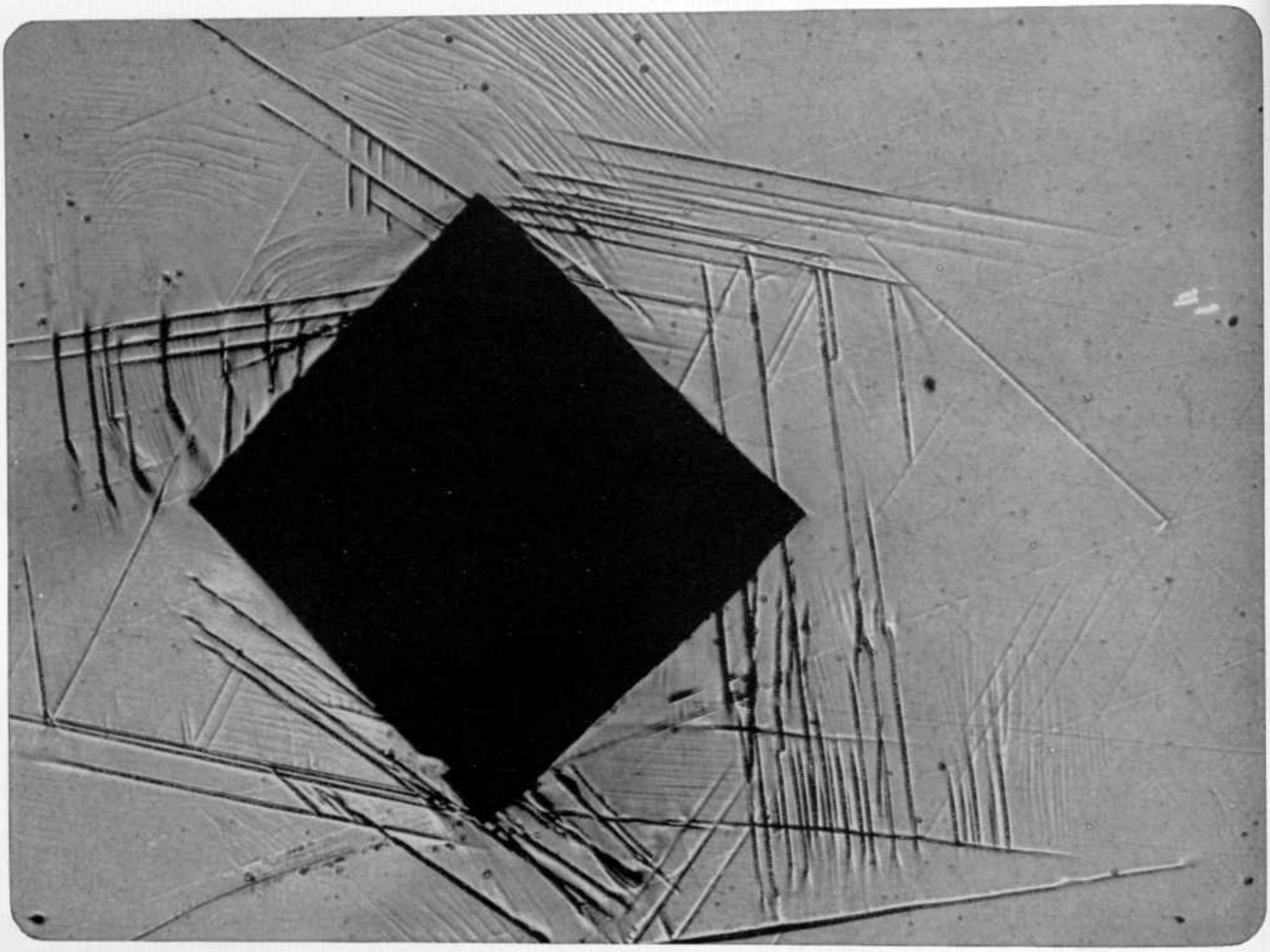
Spartan Engineer

NOVEMBER, 1958

PRICE 25¢





Did you ever hear atoms move?

"The physicist positions a single crystal of age-hardened steel under the sharp diamond penetrator. He touches a pedal, and the pyramidal tip of the diamond squeezes into the polished surface of the steel.

The instant that it touches, things begin to happen inside the crystal. Atoms begin to slip and slide, in layers. Some layers abruptly wrinkle and corrugate. If you listen hard when this happens, you hear a faint, sharp "click." This is the sound of atoms suddenly shifting within the crystal.

You can see the action, too — or, rather, the results of it. The photomicrograph above shows the characteristic ridges and ripples. The black diamond in the center is the depression made by the penetrator.

By studying these patterns, and correlating the information with other data, scientists at U. S. Steel are trying to learn what happens atomically when a steel is bent, flexed or broken. Secrets thus learned are helping us to develop new and better steels not only for everyday products, but also for missiles, rockets, submarines, and other intricate machines to explore the universe above and the world below us.

"Tomorrow" is an exciting word today— and never more so than at United States Steel where we are accepting the challenge of the future with energy, resourcefulness and confidence.

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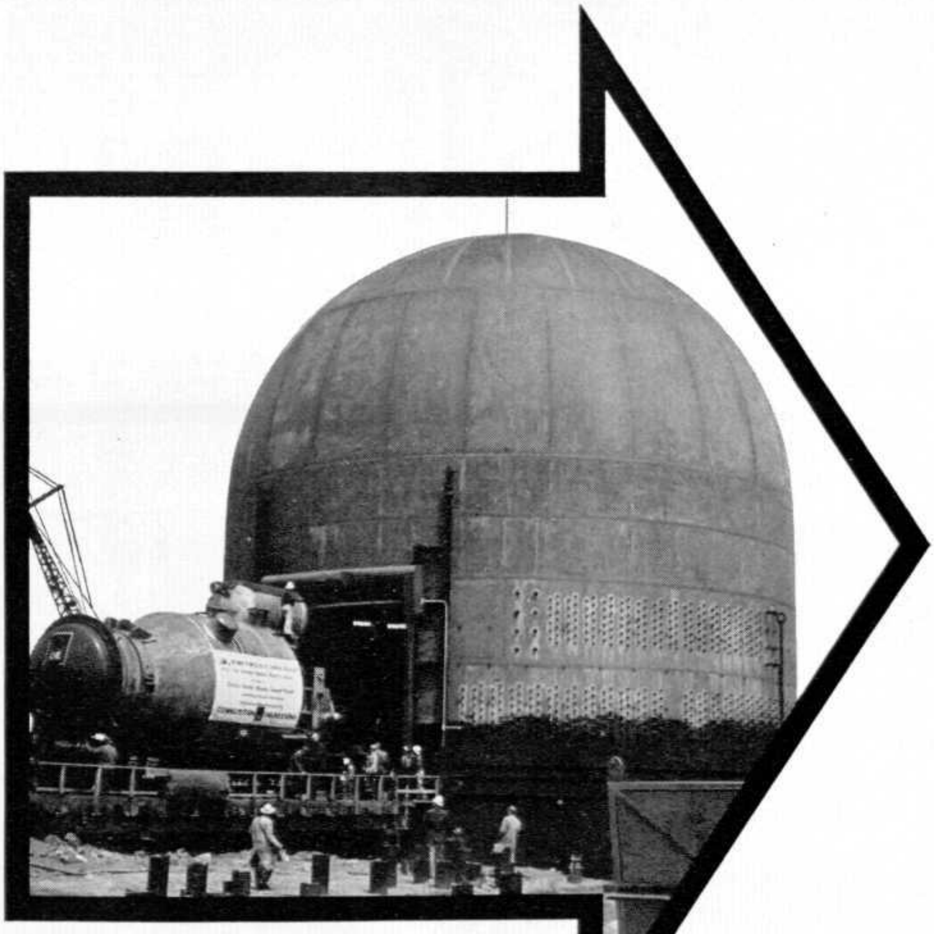
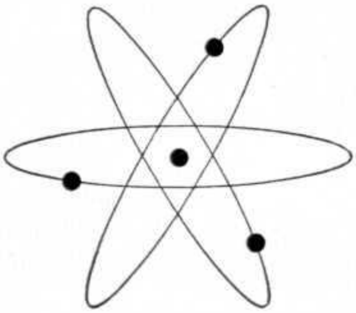
United States Steel

Into the atomic era of new engineering opportunities



The Enrico Fermi Atomic Power Plant under construction near Monroe, Michigan, will have the world's largest breeder reactor for the production of electric power.



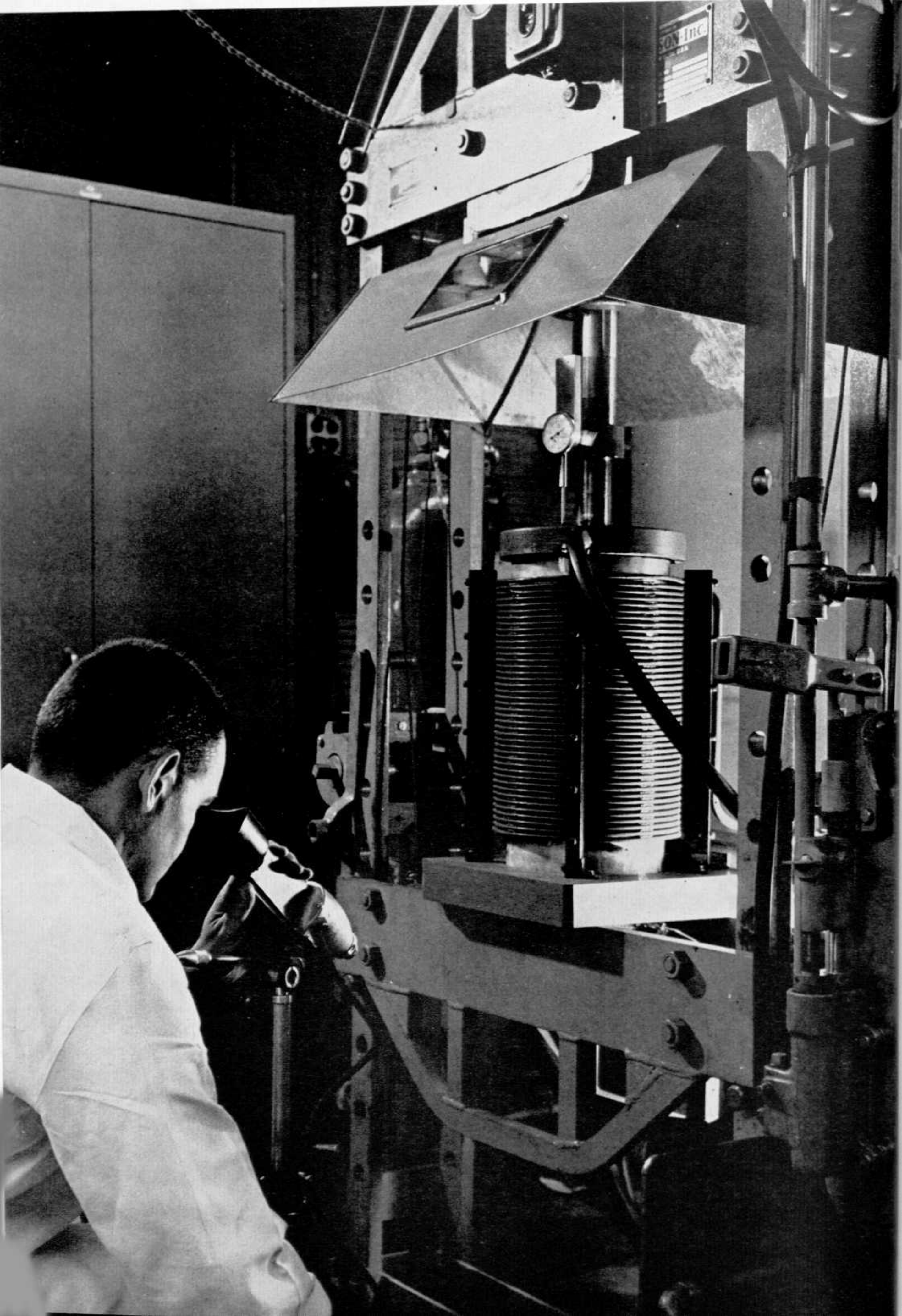
To the young engineers of America's electric power systems, the hope and promise of the peaceful atom grows clearer day by day. In laboratories and on construction projects these young men are serving our nation's new atomic-electric power industry.

Research and design, development and testing of new equipment, building of special structures and operation of reactor plants—for the more efficient production of electric power — offer opportunities for doing things that have never been done before.

A Detroit Edison representative will visit your campus in the near future to tell you of the job opportunities in the electric power industry. Check your placement office for appointments.

DETROIT EDISON

Detroit 26, Michigan



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Spartan Engineer

of michigan state university

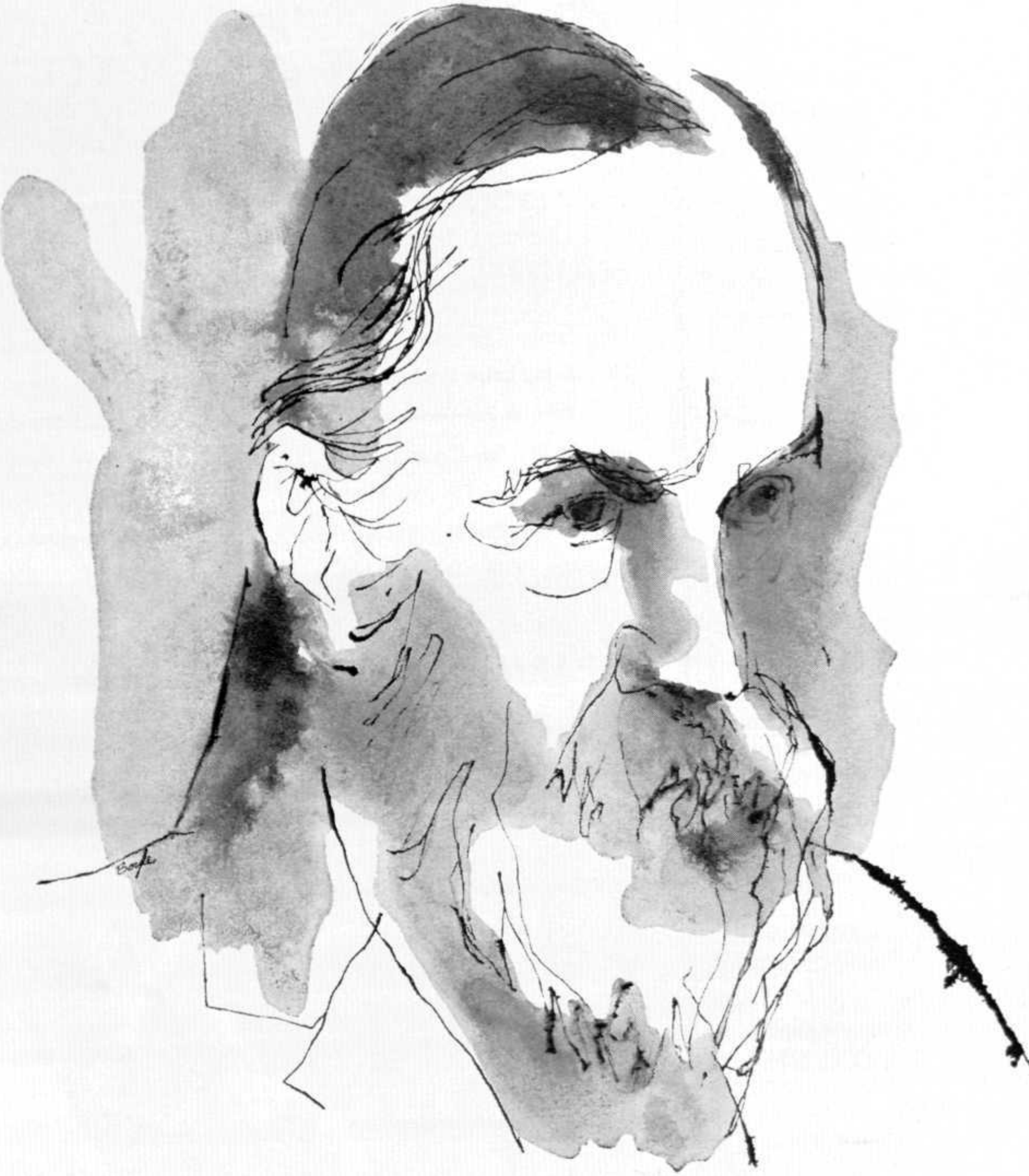
VOLUME 12 NO. 1 NOVEMBER, 1958

FEATURES

DEPARTMENTS

FRONTISPIECE: An engineer checks the temperature inside the hot press at the Westinghouse ceramcis development laboratory. Forming and sintering are performed simultaneously on this press which has a 60-ton capacity. (See page 57.)

COVER: To avoid expensive and hazardous landing of supply ships on the moon, a cargo drop technique can be used to deliver food and material to lunar bases. Vehicle in foreground is approaching moon tail first, so that rocket thrust pushes against weak lunar gravity. Supplies are carried in a case at top, protected by pair of inflated dome-shaped tubes. In background, ship has dropped the supply package from height of several hundred feet; it bounces and rolls toward buildings housing lunar base at edge of mountains. This method of lunar logistic supply is possible because moon gravity is only a sixth that of the earth.
(Courtesy, Convair)



Ernst Mach...on absolutes

"No one is competent to assert things about absolute space and absolute motion; they are pure matters oF thought that cannot be produced in experience. All our principles of mechanics, as we have shown in detail, are experienced knowledge concerning the relative positions and motions of bodies. They could not be. and were not. admitted in the areas in which they are now recognized as valid, without previous testing. No one is warranted in extending these principles beyond the boundaries of experience. In fact, such an extension is meaningless, as no one would possess the knowledge to make use of it."

~~*Die Meclxanik in ihrer Entwicklung,* 1912

WE WANT MEN TO CREATE TOMORROW'S HEADLINES!

The new, dynamic and diversified Northrop Aircraft, Inc., creates an ideal work climate for forward-thinking scientists and engineers. Our three autonomous divisions are all in Southern California - are all headed by progressive management eager to examine and try new ideas.

Let's assume that you are a man who can qualify for one of our engineering teams - a man who can create history!

You'll earn what you're worth, get increases as often as you earn them - based on your own individual achievements. Our salary structure is unique in the industry; our vacation policy extra-liberal, as are all of our other fringe benefits.

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You'll Work with men who are acknowledged leaders in their fields - men chosen for their own capabilities *and* for skills in guiding and developing the creative talents of younger men. And, these are men who delegate authority, assuring your fair share of credit for engineering triumphs.

You'll be flexible - able to apply your talents to the work you enjoy, in the field best suited to your own inclination and ability. Northrop Aircraft and its divisions offer wide diversity, with over 30 operational fields to choose from. All offer challenge aplenty - opportunity unlimited!

Now choose! See what each division of Northrop Aircraft has done and is doing. Then choose the division that offers *you* the most challenge. Write today to reserve your spot where news is *happening* - for your *own* chance to create tomorrow's headlines!

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Pioneers in celestial and inertial guidance. At Hawthorne: exploring infrared applications, airborne digital computers and interplanetary navigation. At Anaheim: developing ground support, optical and electro-mechanical equipment, and data processing devices.

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Creators of the USAF Snark SM-62, now operational with SAC. Currently active in programs for the ballistic recovery of orbiting man; readying the USAF-Northrop T-38 supersonic twin-jet trainer and the Northrop N-156F counterair fighter for flight tests.

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Creator of the world's first drone family; has produced and delivered tens of thousands of drones for all the U.S. Armed Forces. Now developing ultra-advanced target drone systems for weapon evaluation, surveillance drone systems, and guided missile systems.

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...NEWS IS HAPPENING AT NORTHROP

NORTHROP AIRCRAFT, INC., Beverly Hills, California

You're on the right road...

The biggest construction job in history is under way It's the building of a vast new network of Interstate Highways. Miles and miles of highway. For trucking. For travel. For defense. Some 41,000 miles in all. In addition, many thousands of miles of primary and secondary roads are being built in a greatly expanded "ABC" Highway Program.

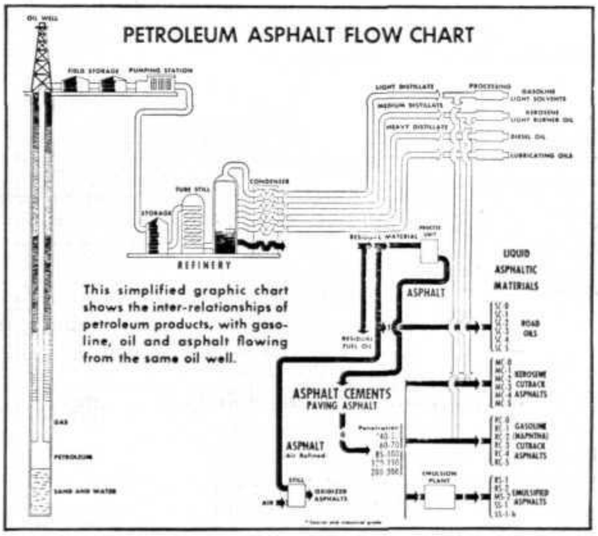
With these new highways will come new industries ... new communities ... a greater share in national life for everyone.

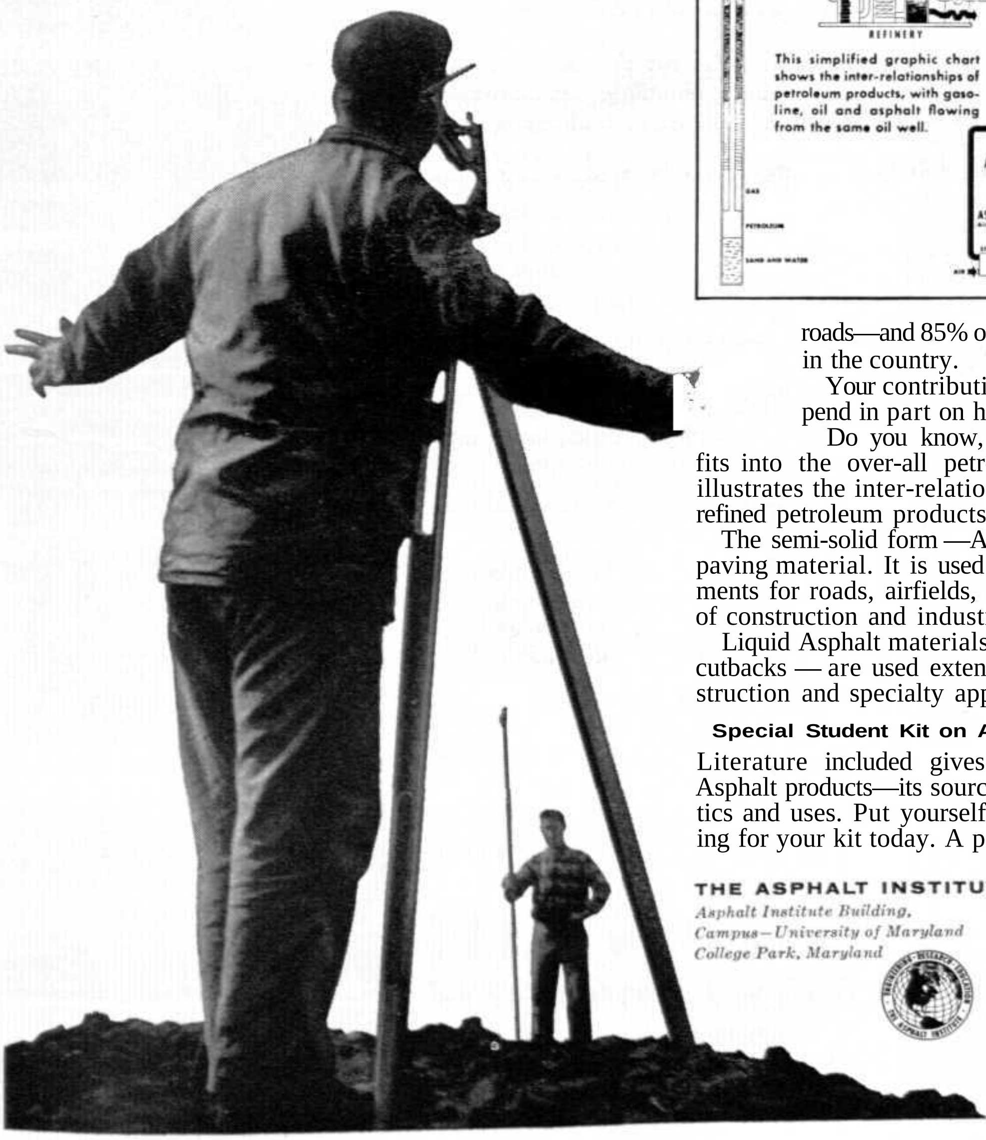
It's a big Job . . . an Important |ob!

And you're on the right road when you study asphalt technology . . . asphalt's characteristics and its applications in pavement construction.

Asphalt pavement is playing a leading role in the construction of the Interstate System.

It now surfaces 81% of State Primary and Municipal Extensions — the nation's most heavily traveled roads—and 85% of all paved roads and streets in the country.





Your contribution — and reward — will depend in part on how much you know about it.

Do you know, for example, how Asphalt fits into the over-all petroleum family? This chart illustrates the inter-relationship of Asphalt with other refined petroleum products.

The semi-solid form —Asphalt cement —is the basic paving material. It is used in hot-mix Asphaltic pavements for roads, airfields, parking lots and thousands of construction and industrial applications.

Liquid Asphalt materials — road oils, emulsions and cutbacks — are used extensively for a variety of construction and specialty applications.

Special Student Kit on Asphalt Technology Free!

Literature included gives you a broad concept of Asphalt products—its sources, production, characteristics and uses. Put yourself on the right road by sending for your kit today. A postcard will do.

THE ASPHALT INSTITUTE
Asphalt Institute Building,
Campus—University of Maryland
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Ribbons of velvet smoothness...
ASPHALT-paved Interstate Highways

The huge Convair-Fort Worth plant is located on the western edge of Fort Worth, and is connected to all parts of the city by a system of limited access freeways.

Nearing completion at Convair-Fort Worth — the world's largest Altitude Chamber of its kind.

Bonded sandwich paneling-pioneered by Convair-Fort Worth — is fabricated in an almost unlimited variety of shapes and sizes.

Final checkout of B-58 is performed with special 50-ton refrigeration unit to cool electronic equipment, and an electric-power generator.

Vital statistics for the engineer and scientist interested in a position affording a high potential for professional growth:

America's largest and most complete air craft manufacturing facility located in the nation's 12th market area

Nearly half-a-hundred highly advanced Air Force contracts now on hand

Extensive research and development equipment and facilities

Broad educational and employee benefits

First to employ the weapons system management concept

Latest achievement . . . America's first supersonic bomber . . . the all new B-58

A resume of your training and experience will be evaluated by engineers in the department best suited to your particular qualifications.

CONVAIR

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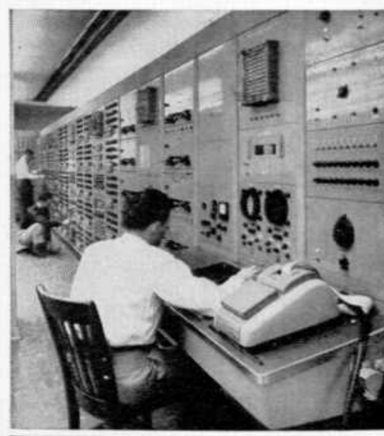
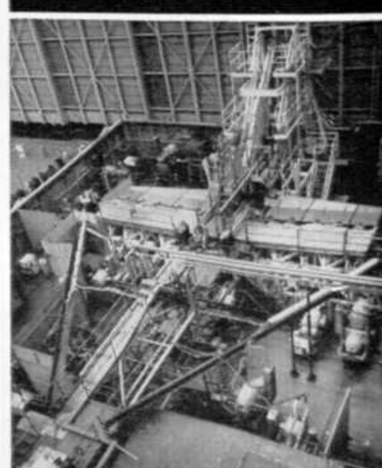
CONVAIR IS A DIVISION OF GENERAL DYNAMICS CORPORATION

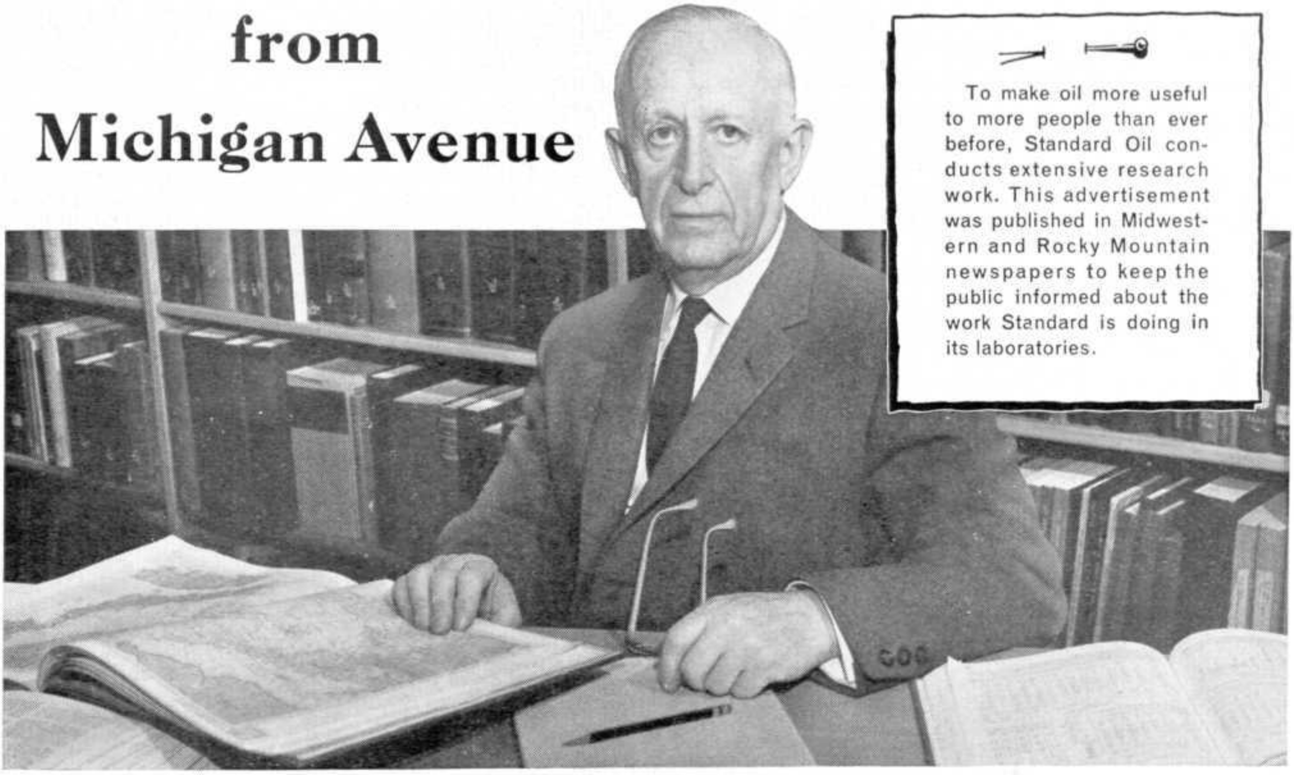


DAEAC — newest and most advanced facility — permits static, dynamic, flutter and steady-state areoelastic testing of the complete airplane by means of direct electrical analog.



Full scale mock-up and test stand for B-58 hydraulic powered flight control system.

Meet the man who watches Moscow from Michigan Avenue



To make oil more useful to more people than ever before, Standard Oil conducts extensive research work. This advertisement was published in Midwestern and Rocky Mountain newspapers to keep the public informed about the work Standard is doing in its laboratories.

Jacob G. Tolpin, expert in the field of foreign scientific developments, often is consulted by leaders in academic, government and industrial enterprises.

He keeps tab on Russian scientific moves

WHAT are Russian scientists up to now?

Few people in America are better able to answer this question than a mild-mannered, unobtrusive man dressed like other business executives on Chicago's Michigan Avenue.

There is no cloak-and-dagger atmosphere surrounding Jacob G. Tolpin.

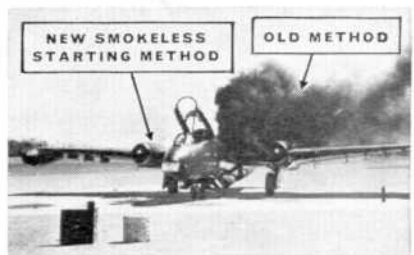
It has been the daily job of Mr. Tolpin since 1937 to keep track of Russian scientific advances. He is a key man on the staff of specialists at Standard Oil who analyze foreign technical journals and patents.

The primary purpose of this work is to keep Standard Oil research scientists informed of developments throughout the world. But the work has broader significance. Standard Oil furnishes important foreign technical data to nationally important bodies and to libraries, such as the Library of Congress. The knowledge gained from the foreign periodicals thus is made available to all.

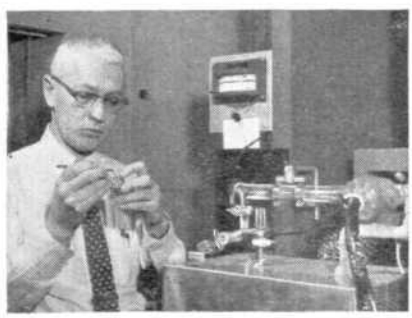
Even the Russians admit, says Mr. Tolpin, that American knowledge of petroleum technology is superior to their own. Standard's research at Whiting and other centers has resulted in many important discoveries which have helped to make America supreme in the field of petroleum and to strengthen its defenses. In the last few years alone, Standard scientists have made outstanding contributions that have advanced America's missile program and its jet air defense.

Since our first laboratory opened 68 years ago, we have spent hundreds of millions of dollars to learn more about oil—how to find it, produce it, refine it and make it *more useful to more people* than ever before.

What makes a company a good citizen? One measure is the contribution a company makes to the economic and physical strength of its country. Through constant and intensive research, we at Standard have tried to make oil yield its maximum usefulness—both for civilian and military purposes. Steadily mounting efficiency also has helped to keep the price of oil and gasoline down.



America's jets now have a new, improved smokeless starter cartridge (being used in the engine above, left) as the result of a Standard Oil research development. The old method, on the right, was so smoky it made concealment impossible and also blocked fliers' views of the field.



Radiation-resistant lubricants for atomic power plants are under study in Standard's research laboratories. Seymour Meyerson, above, is engaged in pioneering work in this new field. He is an authority on the controlled shattering of molecules by electron bombardment.

STANDARD OIL COMPANY

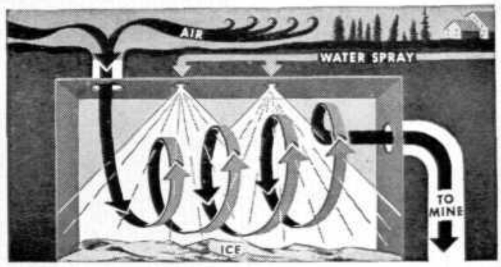
THE SIGN OF PROGRESS... THROUGH RESEARCH

Freezing water to warm a mine

Inco shows a king-size operation that helps mine more Nickel

The bigger the mine, the more men at work, the more air they need. Gales of air. Warmed in winter. Cooled in summer. That's the reason for this mammoth "air conditioner" in an Inco-Canada mine.

In winter it raises the temperature of cold air from outside *by making ice.* In summer it uses the ice to cool air that's too hot! (See diagram below)



In winter, cold air is blown through sprays of warmer water. The water loses its heat, freezes into mountains of solid ice. In the process, the latent heat of freezing is transferred to the air, warms it up for use inside the mine.

At full capacity in a winter season, this system alone can generate as much heat as 350,000 gallons of fuel oil. During this period, 150,000 tons of ice may form. (See photo at left)

Installations like this are expensive in time and money. Such outlays are typical of many made by Inco-Canada. Their cost adds up to millions. Results are-to continue the increased production of Nickel.

Mining for Nickel is a 45-minute color film loaned to high school science groups, college engineering classes and technical societies. Write to Educational Service, Development and Research Division,

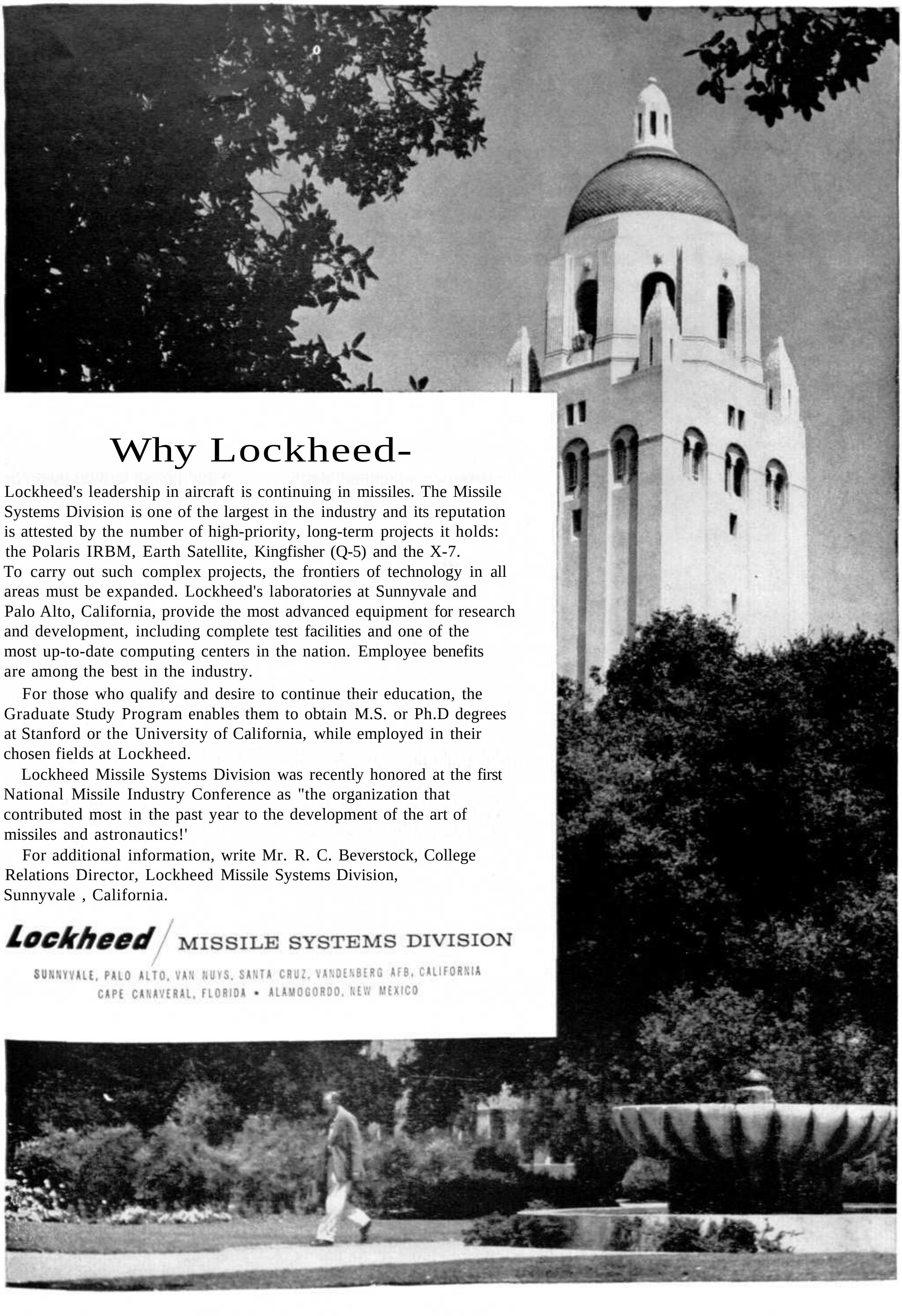
The International Nickel Company, Inc.
New York 5, N. Y.

INCO

International Nickel

The International Nickel Company, Inc., is the U. S. affiliate of The International Nickel Company of Canada, Limited (Inco-Canada) — producer of Inco Nickel, Copper, Cobalt, Iron Ore, Tellurium, Selenium and Platinum, Palladium and Other Precious Metals.

A mountain of ice, built up in this inside-a-mine "air conditioner." The rock chambers, or "stopes," where the ice forms, are high as a 23-story apartment, big enough to house 300 families. Things have to be done in a big way to get Nickel in the tremendous amounts used by industry to make metals that perform better, longer.


Why Lockheed-
Lockheed's leadership in aircraft is continuing in missiles. The Missile Systems Division is one of the largest in the industry and its reputation is attested by the number of high-priority, long-term projects it holds: the Polaris IRBM, Earth Satellite, Kingfisher (Q-5) and the X-7.
To carry out such complex projects, the frontiers of technology in all areas must be expanded. Lockheed's laboratories at Sunnyvale and Palo Alto, California, provide the most advanced equipment for research and development, including complete test facilities and one of the most up-to-date computing centers in the nation. Employee benefits are among the best in the industry.
For those who qualify and desire to continue their education, the Graduate Study Program enables them to obtain M.S. or Ph.D degrees at Stanford or the University of California, while employed in their chosen fields at Lockheed.
Lockheed Missile Systems Division was recently honored at the first National Missile Industry Conference as "the organization that contributed most in the past year to the development of the art of missiles and astronautics!'
For additional information, write Mr. R. C. Beverstock, College Relations Director, Lockheed Missile Systems Division, Sunnyvale , California.
Lockheed MISSILE SYSTEMS DIVISION
SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, VANDENBERG AFB, CALIFORNIA
CAPE CANAVERAL, FLORIDA • ALAMOGORDO, NEW MEXICO

Dean's Letter

Our Greetings to our new students! Those transferring from other institutions will become acquainted with us rapidly, but to the Freshmen we can only say: do a good job in that mathematics and we will look forward to seeing you in engineering classes next year.

To other students we would like also to point out the importance of mathematics. It provides the tools with which you are going to work in your more advanced courses, and a good workman has good tools. Being friends with your mathematics book is a necessity in the more advanced engineering courses such as dynamics, hydraulics, thermodynamics, or electric circuit theory.

All engineering curricula are composed of sequence courses, courses which in turn depend on one or more earlier subjects, as well as on mathematics. This in part explains why it is not often possible to double up or accelerate an engineering program-first we wait for completion of the mathematics sequence and then the engineering sequence must follow.

Good work is thus required in all elementary areas if it is to be possible to do good work in the advanced subjects. In this connection may we point out the fallacy of high school thinking which regards "C" as an average grade—in college "C" happens to be the lowest passing grade; a "C" average is the lowest grade with which you can graduate.

May we also mention our advisor system for upper classmen. Each student is alphabetically assigned to an advisor in his major department and these advisors are available for counseling in regard to scholarship and curricular problems. You should get acquainted if you have not already done so since these men can be of aid in selecting courses suited to your particular need, although the maintenance of a good point average is your best ally since preference is given to good students. By now you may have drawn the impression that we like our good students. This conclusion is excellent engineering deduction—we do like them!

John D. Ryder

Dean, College of Engineering

Here is a reply to . . .

Three Challenging Questions

by Robert W. Slade, E.E., '59

. . . about a frontier which is captivating the imagination of millions of people throughout the world.

North of the Lake of Dreams and east of **the** Sea of Serenity desolate **mountains** rise **three** and one-half miles to **dominate** a **windless** world. Silence is total; and only shadows move, spreading like black, frigid death over the barren land. But death has no **meaning** here, for there is no life . . .

Such a **scene** is not a fantasy. The mountains are as real as the Roekies, and the shadows are deeper than **any** on earth. The land described has been charted in minute detail for centuries, and maps are still being drawn and redrawn. Yet no man has climbed the stark peaks or navigated the waterless seas.

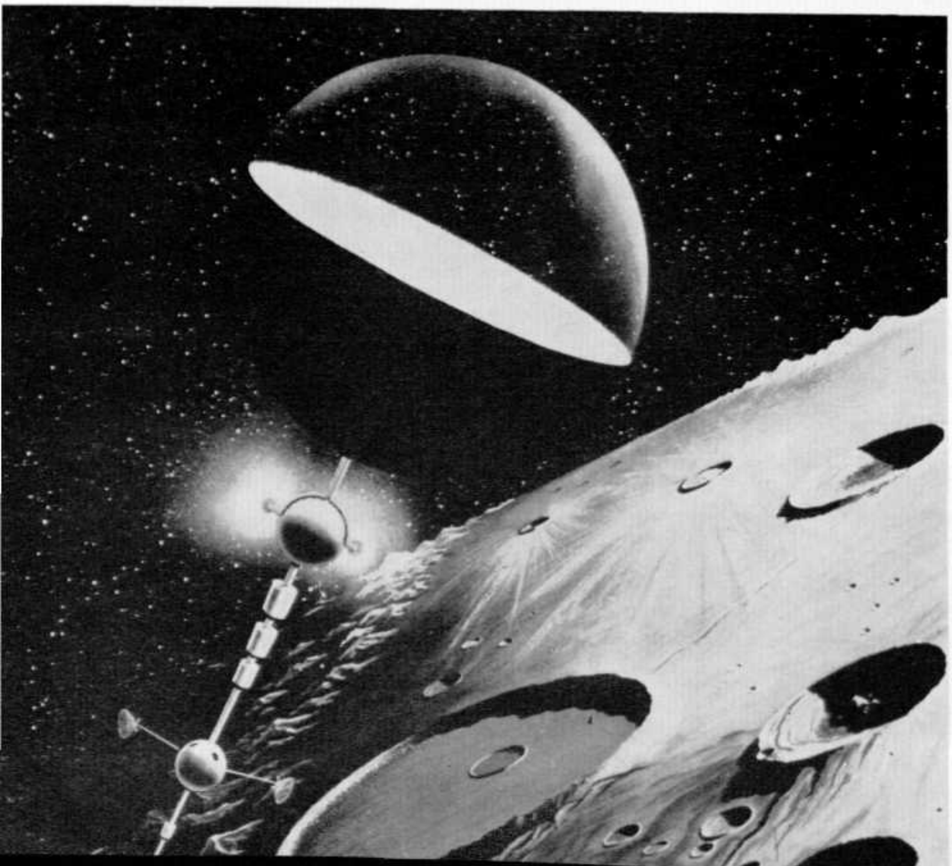
The land is 239,000 miles away from any place on earth. We will be traveling there sooner than many realize. It is the surface of the moon.

The questions posed by such a project are not lightly or briefly answered. **Basically,** these are "How?" "Why?" and "When?"

The question, "How?" has been almost entirely answered. In fact, more has been written on this than on any other aspect of man's projected penetration into outer space.

The idea of space travel has appeared in fiction with increasing frequency since the last century. As might be expected, the first of these fanciful adventures were far more imaginative than scientific. Edgar Allan Poe, for instance, had one of his heroes fly to the moon in a balloon. As the years passed, however, writers and readers of science fiction became more sophisticated. True, many inconsistencies and doubtful devices appeared in their stories, but the basic concept of a sealed spaceship traveling through the vacuum of space by rocket propulsion was used, and could successfully meet the challenge of "impossible!" Still, the segment of the general public imaginative enough to study and accept the idea was small.

When the first German V-2 rocket crashed into the heart of bomb-battered London near the end of World



Sunlight captured by the large plastic sphere of this solar ship is used to heat liquid hydrogen carried in the three tanks at the center of the structure. The gaseous hydrogen is expelled through two rockets between the sphere and the tanks. One half of the sphere—the half facing the sun—is transparent. The other half is coated with silver or aluminum to form a mirror-like surface which collects solar radiation and concentrates it on a heat exchanger along the focal line of the reflector. A crew gondola with attached radar antennas is shown at the opposite end of the vehicle.

—(Courtesy-Convair)

War II, public indifference vanished. The rocket was no longer confined to pulp magazine pages. It had burst into dramatic reality and few could ignore the implications of the event.

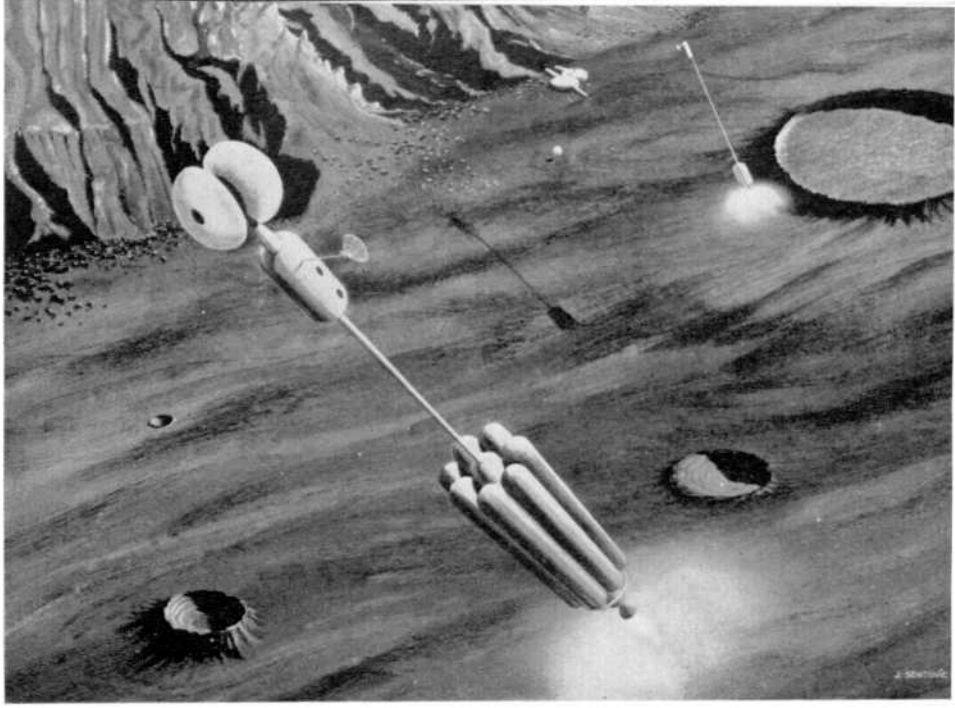
The German scientist primarily responsible for the V-2's development was Dr. Wernher Von Braun. In 1945 the U. S. Government brought Dr. Von Braun to this county, and the American rocket and missile program began in earnest.

In 1951 Dr. Von Braun together with a group of prominent scientists and laymen contributed to a series of scientific articles entitled "Will Man Conquer Space Soon?" It was here that, for the first time, a broad general public was informed of the principles and problems, the "how?" of space flight.

As a first step to the moon, the group proposed the construction in space of an artificial, manned satellite circling the earth every two hours at a distance of 1,075 miles. Unlike Sputnik and Explorer, which were launched in one piece, this satellite would be carried up to its orbit in parts by manned rockets, and constructed there. With such a base of operation the moon rocket could be built in space and launched from there to its destination. Recent findings from our satellites now in orbit indicate that due to intense radiation present, 1,075 miles may not be the best distance for a manned space station. This, however, is a minor detail, since an orbit of greater or less distance can be as easily achieved.

The question most often asked regarding artificial satellites is "What keeps them up?" This is a complex problem, and some confusion is understandable. Perhaps the best **way to** approach the problem without actually mastering the difficult **dynamic** system **involved** is to think of the satellite as a ball thrown at unusually high speed. All of us know that the faster we throw a ball parallel to the earth, the farther it will go before striking the ground. Normally, because of the relatively short distance covered, the curvature of the earth may be neglected. But if we think of **a** ball thrown much faster, and therefore, covering a far greater distance, this **curvature** becomes significant.

Just as an object thrown from a hilltop must fall farther before hitting the ground, and, therefore, travels a greater distance than if it were thrown on level ground, so must our high-speed ball go farther because of the earth's curve than if the earth were flat. If the speed is great enough.



Sunlight captured in two cylindrical plastic "collectors" would drive this spaceship. Each solar collector would be made of polyethylene 0.001 inches thick, and would retain its shape under a pressure of 0.01 pounds per square inch. The half of each cylinder nearest the sun would be transparent, the other half coated with silver or aluminum to provide a reflecting surface. Solar energy captured by the cylinders would be used to heat liquid hydrogen, which in turn would be expelled through a nozzle to produce thrust. A crew gondola and radar antenna are attached to the tank carrying liquid hydrogen.
—(Courtesy-Convair)

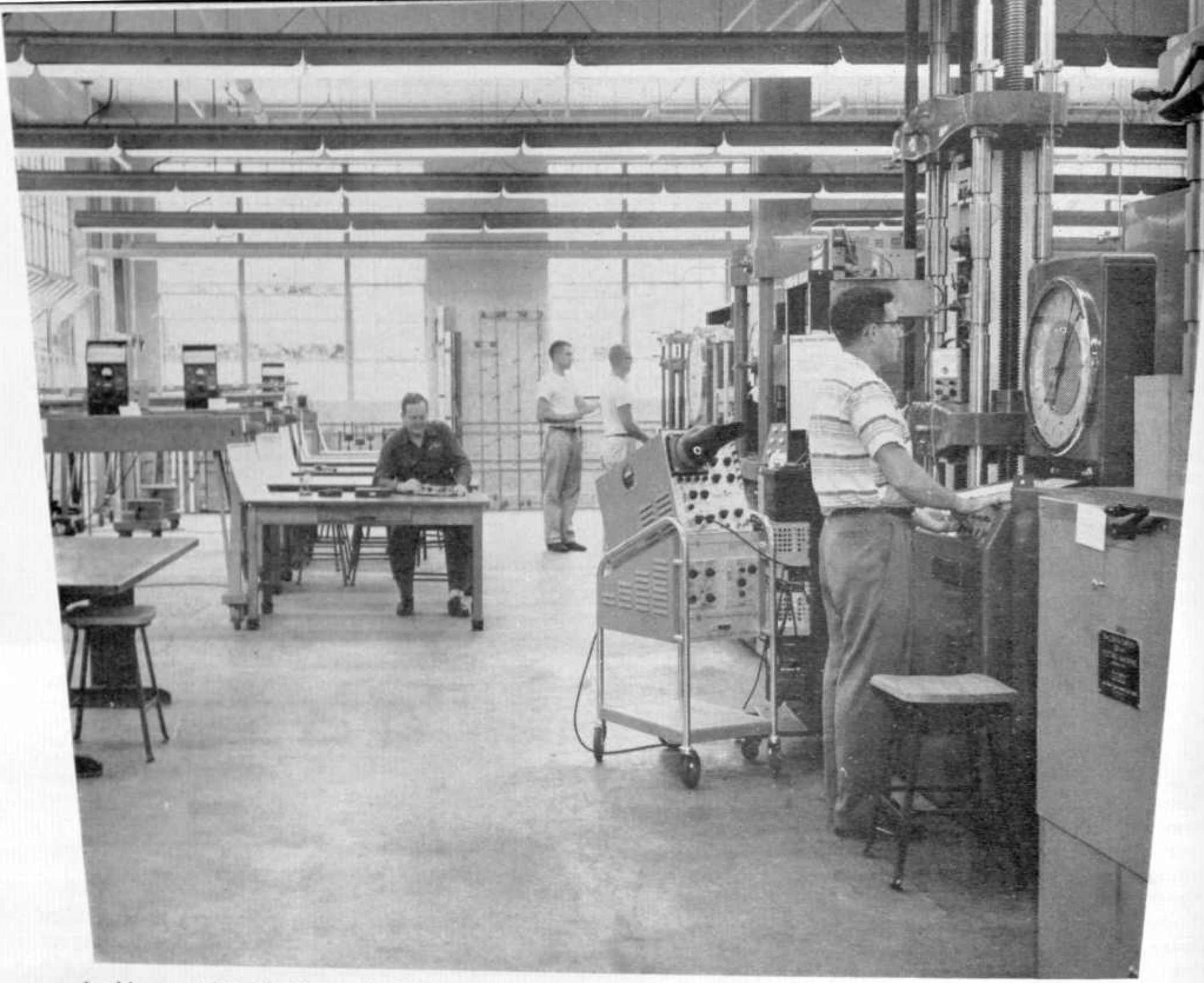
the arc of our falling ball will match the earth's curvature, and it will never strike the ground. Instead it will fall around the earth indefinitely. The orbiting body is now a satellite. A thrown ball will never stop in its course and drop abruptly to the ground. It would be just as unlikely for a satellite to drop from its orbit.

There are two main advantages to building a manned satellite first, rather than launching the moon rocket directly from the earth. The first is that the satellite would function as a frontier laboratory where the rigors of space travel could be closely studied, and both men and materials tested. The second is that the satellite, traveling at great speed, would furnish most of the 25,000 mph velocity necessary for a moon rocket to escape the earth's gravity. This would reduce greatly the amount of fuel needed, and correspondingly increase the ship's payload of men and equipment.

The problem of fuel has been one of the most difficult for rocket engineers. Rocket fuel of the type now used in ballistic missiles consists of two main ingredients. These are a highly combustible substance and an agent to furnish the oxygen for combustion. Such chemical fuels are used in both solid and liquid form. Solid fuels are often difficult to control. since once they begin to burn, they cannot be stopped. The burning of liquid fuels, on the other hand, can be controlled through the use of injection devices, but here the problems of storage and possible corrosion may arise. In spite of these problems and others, practical fuels have been developed, and both fuels and fuel systems are continually being improved. On top of this, research is now being done on a new system of propulsion, which utilizes ions, charged atoms, rather than the products of chemical combustion. Such a system may be used on the first manned moon rocket, but rockets of the immediate future will probably still depend on chemical fuel.

The concept of a rocket motor, which can use such fuels, is as old as fireworks. Operating on the fundamental physical law that every action results in an equal and opposite reaction, the rocket engine simply forces hot gases in one direction, and, as a result, moves itself in the opposite direction. This is not unlike the recoil of a rifle, a reaction force of the same kind, but one which results from the firing of a bullet, rather than hot gas molecules. Because this reaction is completely independent of its surroundings, a rifle or a rocket ship would have no difficulty moving in the vacuum of space.

(Continued on Page 61)



Looking east into the Strength of Materials lab., Dr. Clement A. Tatro is shown at the right with his research equipment. Technician Richard Jenkins is seated, adjusting a calibration fixture. In the background, students Sam De-Leeuw and Neall Schroeder are shown testing a piece of reinforcing steel.

A. M. Labs Vacate Olds

by Dr. C. O. Harris,
Head, Dept. of Appl. Mech.

. . . to expand facilities in the light, roomy MEL spaces.

JUST east of Olds Hall is MEL. The initials stand for Mechanical Engineering Laboratories, although at the present time part of the building is used for other purposes.

In June of 1958, the department of Applied Mechanics moved all of its laboratory equipment into the large front room on the ground floor of MEL—room 110. This room had been used for many years as a pattern and sheet metal shop in the department of Mechanical Engineering, but this work was abandoned due to the progressive tendency of MSU engineering currieulums to prepare students for scientific engineering. The College of Education took over the spaces for manual arts training, until the new education building was completed this year. When MEL was vacated, the facilities became available to the department of Applied Mechanics.

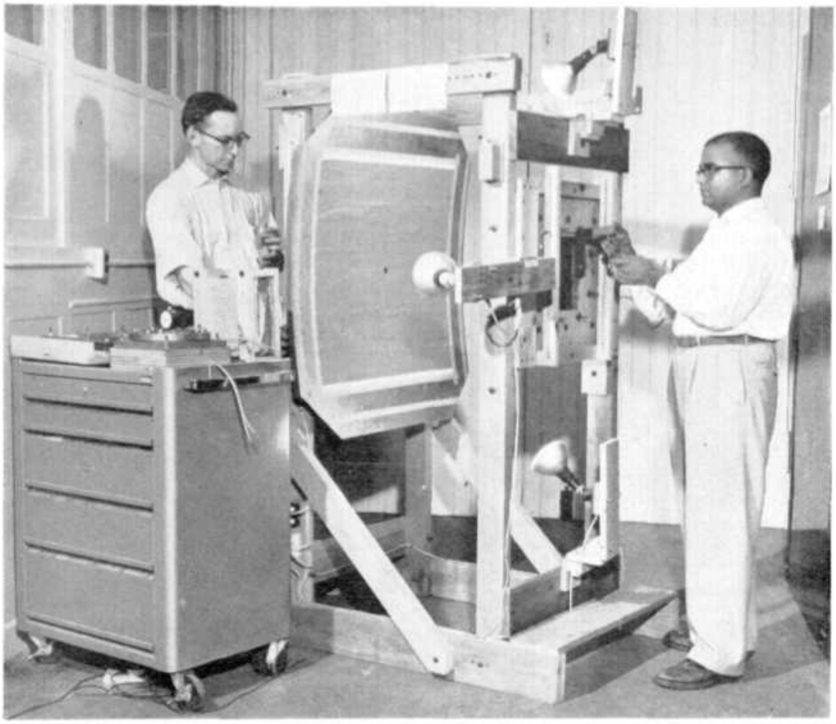
The room was cleaned and decorated. Miss Agnes McCann, assistant to the Dean of Engineering, served as the color consultant, and pastel colors were used on the walls. Now as a visitor enters the room, he is conscious of the area's spaciousness and light.

The **equipment** which was **moved into** 1 10 MEL had **been** crowded **into one-third as** much space **in** Olds Hall. Most of it had been in **three** small laboratories and sonic had had to **be crowded into** faculty offices **in order** to **permit important research** to **be** carried on.

Smaller rooms inside 110 MEL now provide office space for 15 stafl members.

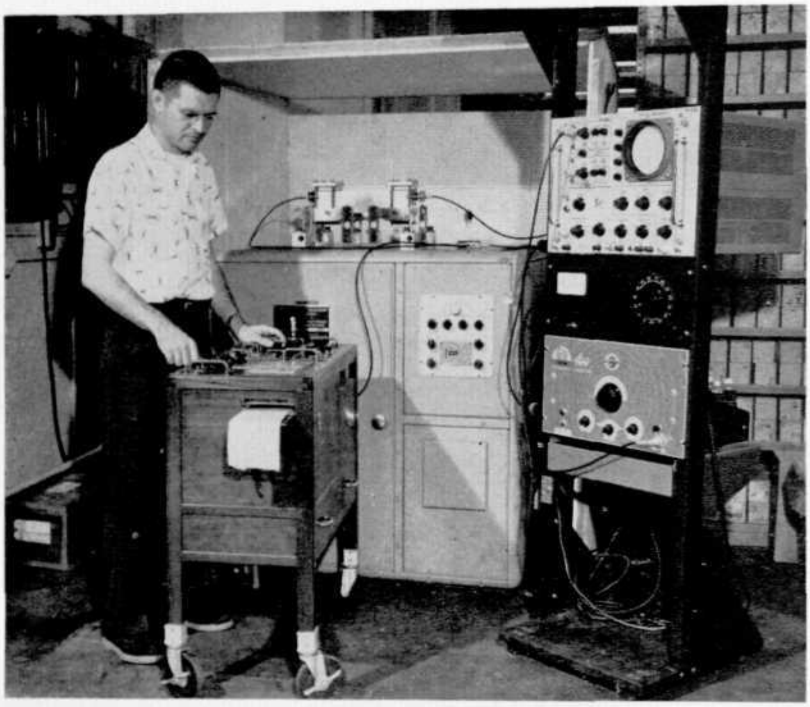
The entrance to IK) MEL is from the north, at the center of the room. To the east of the entrance is **the Strength** of Materials **laboratory. Along** the right hand side of this area are the five universal testing machines, and on the left are six straining frames, which were designed and built at MSU. About half of the experiments are performed on the testing machines, and half on the straining frames. Six parallel experiments will be underway simultaneously with the class divided into six groups. Another testing machine is badly needed.

(Continued on Next Page)



Dr. William A. Bradley and Mr. B. Basava Raju are posing with the apparatus which they built for studying the behavior of plates by an optical interference method.

Dr. Samuel Mercer answers a question about the components in the problem board of the analog computer for Maurice Rich, while Dick Larder is preparing another problem on a second plug-in problem board. The scene is in one corner of the computing lab.

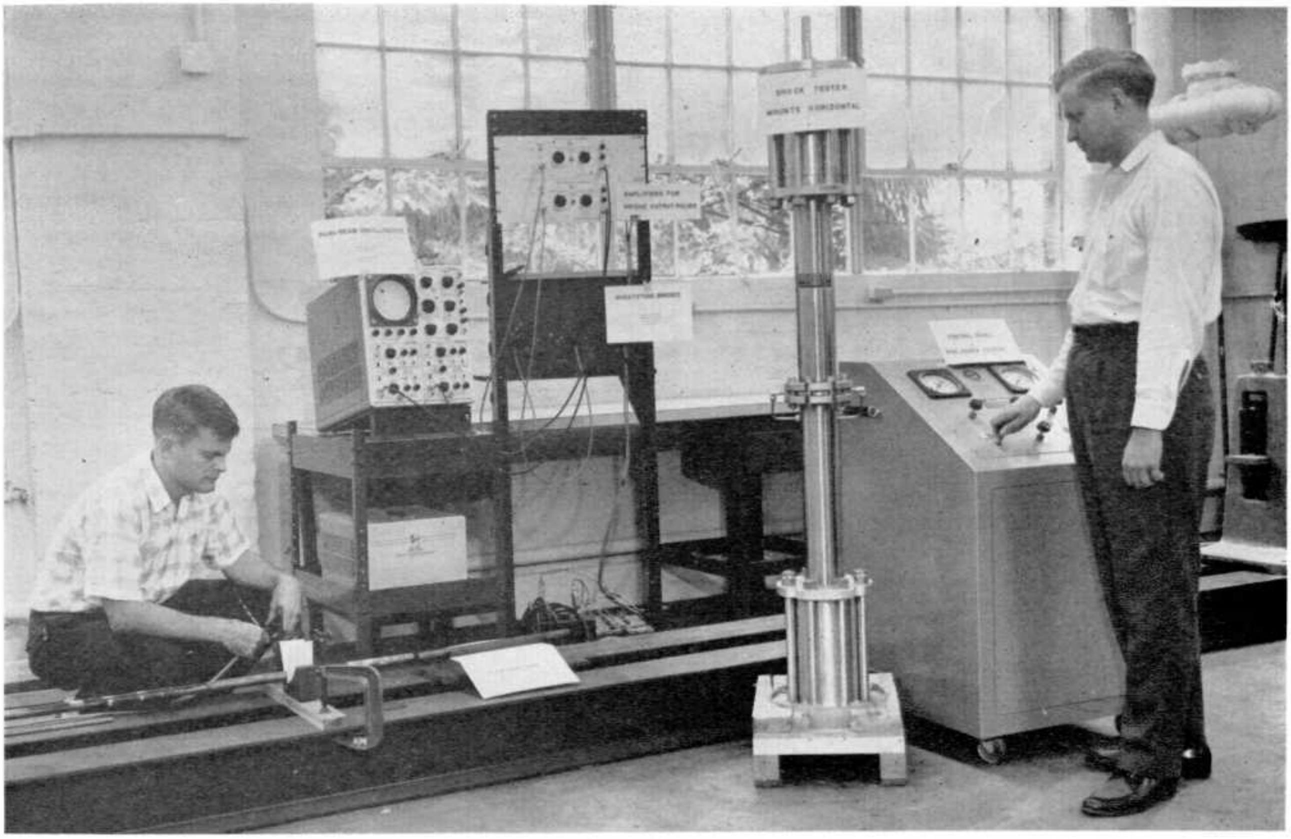


Jean Dalrymple, part-time instructor and graduate student, is shown with the equipment which he and Dr. John T. McCall are using for their research in the fatigue of concrete.

Next to the Strength of Materials laboratory is the Experimental Stress Analysis lab. Experimental Stress Analysis began as a field of knowledge in 1938 with the invention of the SR-4 electric resistance wire strain gage, and has since been carried to a high point of development. It is a field which has become of tremendous interest to industry.

The west end of 110 MEL is used for research by the faculty and graduate students in Applied Mechanics. **Typically,** a faculty member acts as the leader of **a** research team with one or more graduate students to help him. The equipment used in several of the research projects is shown in the pictures on these pages. Other research projects which might be mentioned are the work of Dr. Karl Brenkert and Mr. Kuang Min Lin in turbulence in fluid flow, Dr. George Mase and Mr. Richard Larder in the study of visco-elastic plates, and my own work with Mr. Rao in studies of birefringence.

Dr. Tatro and John Campbell study and work in Dr. Tatro's combination office-laboratory.



Dr. Lawrence E. Malvern is at the control cabinet of the Hygee shock loader and Ulric Lindholm is checking a connection. Their research is into the propagation of plastic waves.

The department of Applied Mechanics was established **in** December of 1951 by action of the State Board of Agriculture, the governing body of MSU. Before that time, some work in Mechanics had been given in the Department of Civil Engineering and some in the Department of Mechanical Engineering. Since then, there has been a considerable correlation and expansion, especially in graduate work and research. A Master's program was started in September of 1952 and a Doctor's program in September of 1956. Most of the graduates of these programs **have** entered work in research and **development.**

The department offers undergraduate courses in Statics, Dynamics, Strength of Materials, and Fluid Mechanics, and every undergraduate student must take two or more of these courses in order to complete degree requirements. With our expanded facilities, we are now able to continue **instructing** the growing engineering student **body** in the concepts of Applied **Mechanics,** and **carry** on many research **programs.**

Just inside the front door is a small Sonntag fatigue machine. A strain gage is mounted on the fatigue specimen, and the gage output is fed to an oscilloscope via the amplifier adjusted by T.V. Kameswara Rao of India.

You, A Publications Engineer?

by Herb Harman, E.E., '59

Don't discount the unlimited opportunities available to you in this rapidly growing profession.

STRIVING to keep pace with the increasing complexity of modern research and development, industry today has recognized the necessity of a new type of engineer. This graduate must have the ability to cope with the problems of translating productive thoughts and technical advancements into various levels of comprehension, most of which are on the level of the ordinary layman. This unending task has been assigned to a technical writer or publications engineer-one with the ability to express what the scientist has designed or developed.

Without a true translation or record of productive research, there would be little progress in the field of science or engineering. How often does the engineer today use the Laws of Newton or Maxwell's equations? Would our civilization today be making its present advances had not someone taken the time to record these achievements? Translation of these laws and principles into basic terms that the common man could understand, was perhaps as great an achievement as the discovery itself. Our progress can be traced back to such discoveries through various writings. Technical progress can be interpreted in terms of what is recognized as being the true results of scientific research and technical advancement, only after such advancements have been thoroughly defined by a technical author.

In addition to general writing skills, a technical writer must have ability as an engineer in his particular field. He must have a thorough knowledge and understanding of this field in order that he might recognize the significance of a new development. His facility as a writer is equally important, for he must be able to handle words and express ideas clearly and concisely. In order for his explanations to be logical, he must put himself in the reader's place as well as that of the research scientist.

Personality and salesmanship abilities play an important role in the career of a publications engineer, as he is frequently in contact with fellow engineers and the public. The engineer-writer must sell his ideas and himself to gain confidence and respect for this new profession.

One of the qualifications of a technical writer which must be stressed most heavily is the desire to be a good writer. Without desire, the engineer-writer will soon find that he is not able to express himself properly, and not capable of benig a success in this field.

Where a good engineer will fit into the wide area covering technical writing depends mainly upon the interest of the writer and his particular employer's objectives.

The engineer with visions of success in editing a technical publication within industry itself, may find himself within training programs with such large corporations as Westinghouse, General Electric, International Business Machines, and Sperry-Rand. There are 1,500 periodicals published by industry to broaden the scope of customer service, and to interest various industrial employees and business readers. Excellent community relations are sometimes established through these publications.

Nearly 2,000 different periodicals are published annually in this country-covering a range of 150 different fields of business. All are related to technical writing. Included in this portion of the field is technical advertising, scientific reports and surveys. Editorships and management positions await publication engineers who want high salaries and responsibilities.

Script writing opportunities for technical and industrial movies is rapidly growing. In cooperation with Public Relation Divisions, technical writers are called in as advisors to help communicate scientific concepts to the layman.

The United States government offers unlimited opportunities to writers of technical manuals and instruction handbooks. These publications are produced for the armed forces training programs and maintainance divisions. Since approximately 20 per cent of the armed forces members have not graduated from high schools, and

only 3 per cent have graduated from accredited colleges and universities, the presentation level of these manuals must be reduced in complexity. This is a challenge to any technical writer.

The specification writer must be adept in his field, therefore his knowledge must be on par with that of the research engineer to accurately describe the subject. These men are needed in all stages of our industry. One must consider that every product, especially concerning our national defense, must have these specifications for future modifications and development of the product.

The technical writer is not limited in his field for he may assist in the presentation of symposiums and demonstrations for technical and non-technical personnel. His responsibilities often put him in the role as a coordinator between various departments of industry, and help to bridge the gap between research and production. The publications engineer, or technical writer often is the ideal choice for executive duties due to his versatility.

The demand for technical writing abilities can be found in almost **any** newspaper want-ad today. Industry **and** commercial publishing companies such as McGraw-Hill, the Heyden Publishing Company, and the Pe'nton publishing Company constitute the largest group hiring technical writers, some of the magazines in need of writers are *Electronic Design, Machinery, Product Engineering,* and *Electronics,* and magazines such as *Mechanics Illustrated, Scientific American,* and *Popular Mechanics* have a very large circulation and wide appeal. Various handbooks and publications edited by engineering societies-A.I.E.E., A.S.M.E., I.R.E., A.S.C.E., etc.—are rated tops as specialized publications. These articles are written mainly by engineers, and must be edited accurately by personnel familiar with technical terms—the publications' engineers.

The demand for engineers with the required abilities have been recognized by many universities throughout the country. Graduate and undergraduate programs have been established in many colleges. Rensselaer Polytechnic Institute established the first such curriculum in 1953 awarding a graduate degree in technical writing to engineers. The results have proved very satisfactory for these engineers are placed in the field long before they graduate. Purdue University now offers a Bachelor of Science Degree in which various options such as chemistry, physics and the biological sciences are included. Programs of varied length, but similar in nature, are now established at Massachusetts Institute of Technology, University of Pennsylvania, and Penn State. These are leaders in this relatively new field, and the trend is rapidly growing.

Probably the most common question which arises from undergraduate engineers interested in technical writing is how they can prepare themselves for such a career. This depends mainly upon the individual's personal initiative and his college curriculum. Perhaps one of the best methods is to become proficient in English. Proficiency can be accomplished by taking various courses, and constantly practicing learned techniques. Some of these methods include the careful gathering of information and specific data, with a complete outline of the subject before starting to write. This will save precious minutes and minimize the time spent rewriting. Every technical author must be as brief as possible without sacrificing clarity of the subject, and consideration must be taken to insure that the reader is not going to be insulted through various definitions which would be expected to be known. Care and good judgment must be taken when mathematical formulas and technical terms are involved, especially to the non-technical reader.

Experience is the best method of attaining good writing methods. There are generally technical publications on every campus which the undergraduate engineer will find to be most helpful in preparing himself, for technical writing and publications procedures. Any creative writing will be to the writers advantage and is an aid in gaining experience. Many engineering societies sponsor annual

(Continued on Page 53)

Digits Are Your Tools

by Robert W. Slade, E.E., '59

In the first of three parts, the author presents the background and the significance of the numbers evolution.

Part I: A Matter of Digits

What is **the 16th** power of 8?

In the year 1812 Zerah **Colburn,** a **boy of** 8 years and the son of a **Vermont** tanner, worked out the **correct** answer in only a few seconds before an **amazed** London audience.[1] **Amazed** response to such a feat is, of course, no surprise to any of us. So rare is such a talent that were a Zerah Colburn to appear on our television sets today, few of us would turn him off.

Yet countless problems of even greater difficulty are solved daily all over the world by persons who have no more and perhaps less mathematical ability than you and I. The equalizer between them and the incredible Vermont farm boy is nothing more than a machine capable of extremely rapid counting: a common desk calculator.

Counting was man's first form of computation, and his first calculator came ready-made; it was his fingers. Even today the word "digit" can mean either a finger or an integer from 0 to 9, and our system of tens, or denary system, is directly related to our number of fingers.

An interesting side light to this evolution of numbers is found in several primitive Brazilian Indian tribes. These people, rather than count on separate fingers, make their tallies on their finger joints. As a result, they have developed a system of threes, or ternary system, for counting.

It is only by a whim of nature, then, and a prehistoric penchant for counting on our fingers that we have our scale of tens, a notation which is by no means the easiest or best, but one which, because of its almost universal use, is probably impossible to change.

With the beginnings of civilization finger counting soon became inadequate and substitutes appeared in the manipulation of sticks, pebbles, and piles of sand. These devices eventually evolved into the abacus, a counter developed over 3000 years ago and still widely used today.[2]

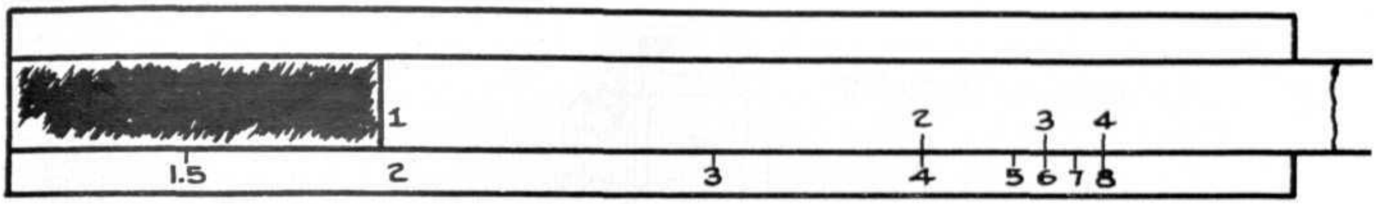
As opposed to the ten digits of the decimal or denary scale, binary notation employs only two, 1 and 0. Translation from one system to the other is a relatively simple matter. A study of the table below reveals an interesting correlation between the two scales. In the binary system the number 2 appears as 1-0, just as does 10 in the denary system. Going further, 2 squared, or 4, appears as 1-0-0, and 2 cubed, or 8, as 1-0-0-0. A general statement of this characteristic says that in a scale based on any integer the respective powers of that integer will be expressed as 1-0, 1-0-0, 1-0-0-0, and so on. Thus if we

Binary	Denary	Binary	Denary	Binary	Denary
0	0	1011	11	10110	22
1	1	1100	12	10111	23
10	2	1101	13	11000	24
11	3	1110	14	11001	25
100	4	1111	15	11010	26
101	5	10000	16	11011	27
110	6	10001	17	11100	28
111	7	10010	18	11101	29
1000	8	10011	19	11110	30
1001	9	10100	20	11111	31
1010	10	10101	21	100000	32

see the number 100,000 in a binary notation we recognize it immediately as 2 to the fifth power, or 32, in the denary scale. By way of example, the denary number 1254 can be translated into its binary equivalent, 10, 011, 100, 110, by breaking it down into powers of 2, expressing these powers in binary form, then adding them up:

1024		2^{10}		10,000,000,000
128		2^7		10,000,000
64	=	2^6	=	1,000,000
32		2^5		100,000
4		2^2		100
2		2		10
1254 (denary)				10,011,100,110 (binary)

1. 8i« = 281,474,976,710,656
2. The abacus is also called the soroban (Japanese), the suan pan (Chinese), the s'choty (Russian) and the coulba (Turkish). All or these may take somewhat different forms from one another, but they are operated in the same way.



The slide rule above multiplies 2 x 4 for the answer 8. Vertical lines on both scales represent the logarithmic values of numbers but are marked by the numbers themselves. In this way transition of a number to or from its logarithm is done without notation of the logarithm itself.

In fact, contests between **an** abacus and a modern adding machine, both in the hands of **a** skilled operator, are almost always won by the abacus.

The abacus remained the only important mechanical aid to computation **until** the middle of the 17th century. In 1642 the great French mathematician, Blaise Pascal, though not yet 20, invented the first modern adding machine. This device consisted of numbered wheels and gears not unlike those found in today's machines. Its most distinctive feature was that it automatically carried tens **to** the next highest decimal place. Less than 30 years later the German mathematician and philosopher, Gottfried Wilhelm von Leibniz, invented **a** more versatile machine capable of multiplication and division through rapid addition and subtraction.

The inventions of both Pascal and Leibniz were limited, not only by the crude machine tooling of their day, but by the fact that both machines were hand-powered. Today, however, the same principles embodied in these early computers are used in the skilled construction of our modern, electrically-driven adding machines and desk calculators.

Limitations imposed by relatively crude tooling were felt even more strongly **in** 1812, when Charles Bab**bage** conceived his "analytical engine." Though financed by the British government far beyond the cost originally expected, Babbage's machine was never completed. Even with greater financial support, it probably never could have been, for, although Babbage's planning and design were sound, the tools of his day apparently were not.

In spite of its failure in construction, the analytic engine itself was no folly. Had it been completed, it would have been the first digital computer, or, as better known in popular lore, the first "mechanical brain."

The basic principle behind all such "brains" from Babbage's engine **to** the massive digital computers of today lies in each machine's "memory." Each such computer has storage devices, either electronic or mechanical, which contain information upon which it can draw in the solution of a problem. They are also capable of storing temporarily the answers to interim calculations in the process of the solution, and using them when needed later. Because of this capacity the computer can be given complete **instructions** for the solution of a complex problem before hand, and the operator need do no more before receiving his answer. This procedure is called "programming."

An analogy to this kind of problem-solving might be found in a mother's shopping instructions to her son.

"When you get to the store," she might say, "price the apples. If they're ten cents a pound or less, get a dozen, but if they're more, only get eight. If they haven't got them all out yet, do the rest of the shopping first, then come back later for a better choice."

With these instructions the boy's mother has finished her part in the problem of the apples. The boy has been "programmed," and, like a computer, is equipped to solve the problem on his own. Of course, should the boy deviate in any way from his specific instruction, for instance, buy peaches instead of apples, or go to another store, the analogy would no longer hold. Machines capable ot original thought still only exist in theory.

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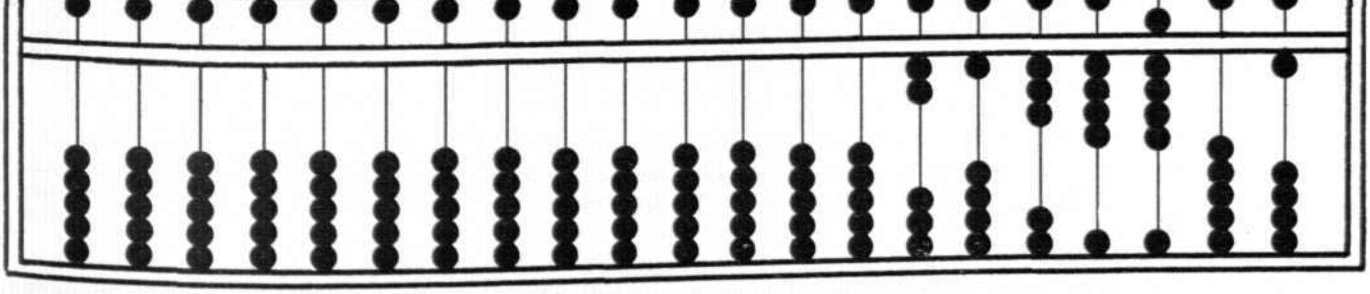
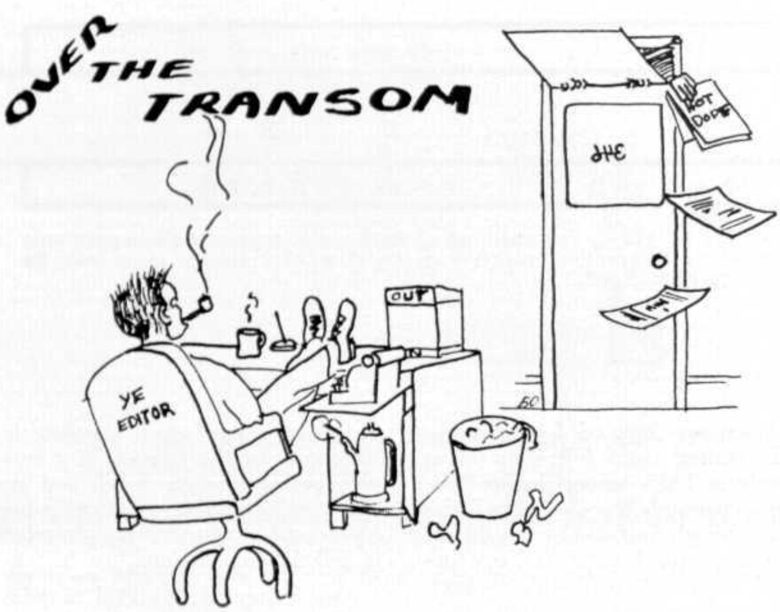


A Japanese Soroban

The abacus pictured above shows the number 2134901. Each column of beads from right to left represents a successive decimal order. That is, the right hand column is units, the next column tens, the next hundreds, and so on. The one bead on top of each column represents five units in its order, while the five beads below each represent one unit in the order.



In a speech to the MSU engineering alumni, Chrysler Vice-President James Zeder, said that missile development is providing a strong stimulus to engineering creativeness and accomplishment.

"I am convinced that scientific and engineering brainpower will be the force that propels us into a brighter future. In the long run, the great thrust of technical creativity will be far more exciting and far more significant than the thrust which takes a missile off the launching pad."

The facilities of a major television network have been turned into a three million **square** mile classroom for a full credit college course in atomic age physics.

The course is being offered for credit by more than 300 colleges and universities and will cover two semesters of physics review—from a discussion of experimental method to a lecture on inertial guidance systems.

It is the first time in the history of television that a full year course in any field of education has been offered to the general public on a nation-wide basis.

Conducted by Dr. Harvey E. White, Professor of Physics at the University of California at Berkeley and consultant to the Atomic Energy Commission, the course started October 6 and will run through June 5, 1959. Occasionally during the class year guest experts, drawn from the ranks of the nation's leading physicists, will conduct special lectures.

CONGRATULATIONS - Robert Joseph Warrick, 302 Fulton St., Homer, Michigan, has been named as one of eight 1958 recipients of Wheelabrator Corporation Fellowships by the Foundry Educational Foundation.

Warrick, a 1958 graduate of Michigan State University will continue his studies here in the field of metallurgical engineering. As an undergraduate, he was awarded five scholarships.

The fellowships are valued at $1,500 each. During the ten-year period of the program, fifty awards will be made.

B. C. Ringo of the Civil Engineering Dept. is studying for his doctorate at the University of Michigan.

J. Hemmye, Mechanical Engineering, left for Saigon this month to spend two years with the MSU delegation working on the Viet Nam Project.

W. P. Smith, Mechanical Engineering, is studying for his doctorate at the Case School of Applied Science.

Engineering alumni were welcome guests at the Engineer's editorial office last month. We hope to see more of "ye grads" when you are on the campus.

The new facilities of the Placement Center are the finest in the country according to interviewing employers. Eight hundred different companies will set up 1,600 interviewing schedules. Fifty to 60 percent of the senior class is expected to take advantage of the Placement Center services. Between 7,500 and 8,000 interviews will take place this year. The overall demand for college seniors is much higher than a year ago. Salaries paid to engineers and scientific persons will be higher than **a** year ago.

In spite of talk of recession, depression, and layoffs, there has been no material change in industry's demand for qualified engineers holding a bachelor's degree.

Companies are becoming more and more selective. They want engineers who suit their needs—whether or not the graduates are draft-exempt or in the top quarter of their class.

College recruiting still remains the most effective way for American industry to secure much-needed engineering personnel.

The loss of engineering talent at the senior level in college has reached serious proportion according to President John T. Rettaliata of Illinois Institute of Technology.

He expressed alarm over the fact that in 1957 on a national basis less than 85 per cent of senior engineering students received degrees. "This is a loss the nation can ill afford, particularly in engineering and science," Rettaliata said, "for our very survival in future years will depend upon our scientific and technological competence."

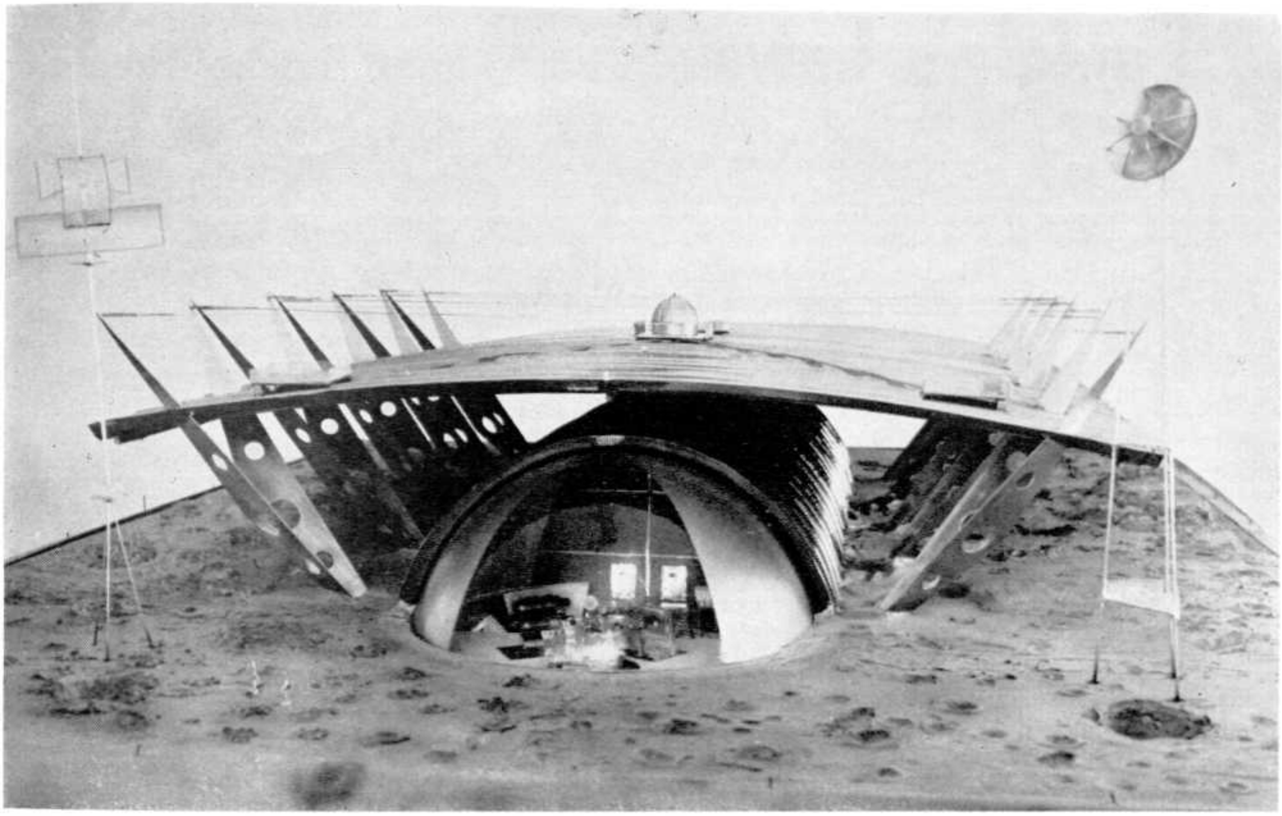
Engineering student apathy for campus activities has been charged by many on the campus. However, let's list a few "active" engineers. Our list is not exhausted here.

John Drabelle, E.E., '59
- V-Pres., AIEE
- Pres., Knights of St. Patrick
- Pres., Engineering Council
- Pledge, Eta Kappa Nu
- Pledge, Sigma Phi Delta
- Asst. Editor, Spartan Engineer

Fran Weihl, E.E., '59
- Business Manager, Spartan Engineer
- Pledge, Eta Kappa Nu
- Secretary, Engineering Council
- V-Pres.,'Knights of St. Patrick
- Pledge, Theta Sigma Phi

Lowell Brigham, E.E., '59
- Tau Beta Pi
- Eta Kappa Nu
- V-Pres., Student Govt.
- Phi Kappa Phi

Let's hear from more of you "actives."



Courtesy Wonder Bldg. Corp.

The "moon building" will be a permanent structure to house living quarters for moon explorers, laboratories for scientific research, maintenance shops for space vehicles and stations for earth-moon communications. Plastic bubble observatory in foreground is protected by sliding metal doors from intense ultra-violet radiation. Upper section over structure is a protective meteoric shield, designed to ward off gnatlike rain of interplanetary meteoric dust which descends with great velocity on the barren surface of the moon.

"At Home On The Moon"

A truss-less building has been designed to house visitors to the moon.

PLANS are being made for a permanent "moon building" to house living quarters for moon explorers, laboratories for scientific research, maintenance shops for space vehicles and stations for earth-moon communications.

A detailed 5 by 6 foot scale model of the structure-a cigar shaped corrugated metal cylinder covered by a Protective metal "meteoric shield"-was recently unveiled to military and federal government officials at a presentation in Washington, D.C.

Because of the present lack of knowledge and great divergence of opinion concerning the moon's surface, the moon building has been designed for the worst condition anticipated—a sea of dust upon which the building would float, anchored by heavy weights suspended by cables from the body of the structure. If the moon's surface proves to be sufficiently solid, it could then provide normal support for the building.

In actual size, the moon building would be 340 feet long, 160 feet wide and 65 feet high. Including air lock and plastic observation bubble, it would measure 520 feet in length. The building would be fabricated of aluminum alloys which combine high strength and low weight with ease of fabrication. Aluminum also provides a good reflecting surface which aids cooling problems.

Above and separated from the roof of the building is a slightly curved umbrella-shaped protective meteoric shield, designed to ward off the gnat-

(Continued on Page 56)

Finagle's Laws. . . . .

Ever since the first **scientific experiment,** men have been **plagued** by the **unceasing antagonism** of Nature. Only **his** patience, adaptability and **Eorebearance have permited the** scientist **to** learn **a** few minor facts **about the operation of the** universe.

We still **do** not really know why this should be so. It's only natural that Nature should he **logical** and neat—but it isn't, and the best teacher **of** all, **Experience,** turns out **to be just the** gradual acceptance of Nature's **pigheadedness.**

Over the **years** a series of laws have **evolved.** The laws **actually** represent a distillation of experience of thousands of experimenters, but (until Dr. **Finagle** came along) they were never recorded for the study and edification of **younger** members of our profession because they had no **derivation—no** proof. **They** are true because they have always been true. Look into **your** own experience and see if this is not so.

We are grateful to John W. Campbell, editor of *Astounding Science **fiction*** and the *IRE Student Quarterly,* for bringing **this** work to our attention, and to **the** many readers of these magazines who collected and **contributed samples** so **that** others might share in their experience.

ON EXPERIMENTS

***The first** four **laws** arc **the** only ones dignified by number. Note the beauty and simplicity of the **First Law.** Also note that the remaining three laws refer **to men's** reactions **to** Nature—not to Nature itself.*

First Law: If **anything** can go wrong with an experiment, it will.

Second Law: No matter what result is anticipated, there is always someone willing to fake it.

Third Law: No matter what the result, there is **always** someone eager to misinterpret it.

Fourth Law: No matter what occurs, there is always someone who believes it happened according to his pet theory.

The Law of the Too Solid Goof:

In any collection of data, the figure that is most obviously correct—beyond all need of checking—is the mistake.

Corollary I—No one whom you ask for help will see it, either.

Corollary **II—Everyone** who stops by with unsought advice will see it **immediately.**

*A further series of rules—or really adviee to experimenters—has been formulated. They are a natural **consequence** of the first four laws reduced to **day-to-day** practice.*

Experiments must be reproducible—they should all fail in the same way.

First draw **your** curves—then plot the readings.

Experience is directly proportional to equipment ruined.

A record of data is useful—it indicates you've been working.

To study a subject best, understand it thoroughly before you start.

In case of doubt, make it sound convincing.

Do not believe in miracles—rely on them.

Always leave room to add an explanation when it doesn't work. (This open door policy is also known as the Rule of the Way Out.)

HUMAN FOIBLES

The remaining rules outline the human problems that follow from the above. To some extent they represent man's reaction to Nature and, even more aptly, man's reaction to man.

Laws of **Revision** *(Often lumped into the Now They Tell Us! Law)*

First Law: Information necessitating a change of design will be conveyed to the designer after-and only after-the plans are complete.

Corollary I-In simple cases, where one obvious right way is opposed to one obvious wrong way, it is often wiser to choose the wrong way

(Continued on Page 42)

"Make The Most Of It"

by Harry M. Gage
President,
Coe College, Iowa

Have a business and mind your own business. College is your main business.

In "Letters of a Self-Made Merchant to His Son" old Gorgon Graham wrote, "Boy, go after your job just like I went after your ma when I was a-courtin' her—go early, stay late, and set close."

If being a good student in college is not your main job, then decide what your main job is, go after it and get on it. College life is life, not just preparation for life. Your main business does not rule out other businesses and interests related to college life and work.

College has nothing to give you. It is an organized opportunity to get something. After awhile you will have to organize your own opportunity and get along without teachers.

Be free. You cannot be free from debt but you can be free from debts or obligations you cannot or will not discharge. Be responsible. The free man incurs debts freely on his own responsibility and pays his debts in the same way. This is clear evidence that one is truly free.

Give all you have to your main job here and now, not after awhile. Then you will get much in return. Don't be a sponger, a leach, a parasite. Don't try to get something for nothing.

Keep your record clear. It is on file permanently and available for inspection in registrar's, treasurer's and personnel offices. Maybe in future years your record in the treasurer's office will be as important as your record elsewhere.

Considering the cost of your education, including money cost to the college, plus the money value of your time, how much in dollars and cents does loafing cost you each day? Each year?

Railways, factories, and businesses run on schedule. What is your production schedule?

Learn to live 24 hours a day. Time is the stuff of which life is made.

(Continued on Page 57)

Power On The Moon

(Courtesy of Westinghouse)

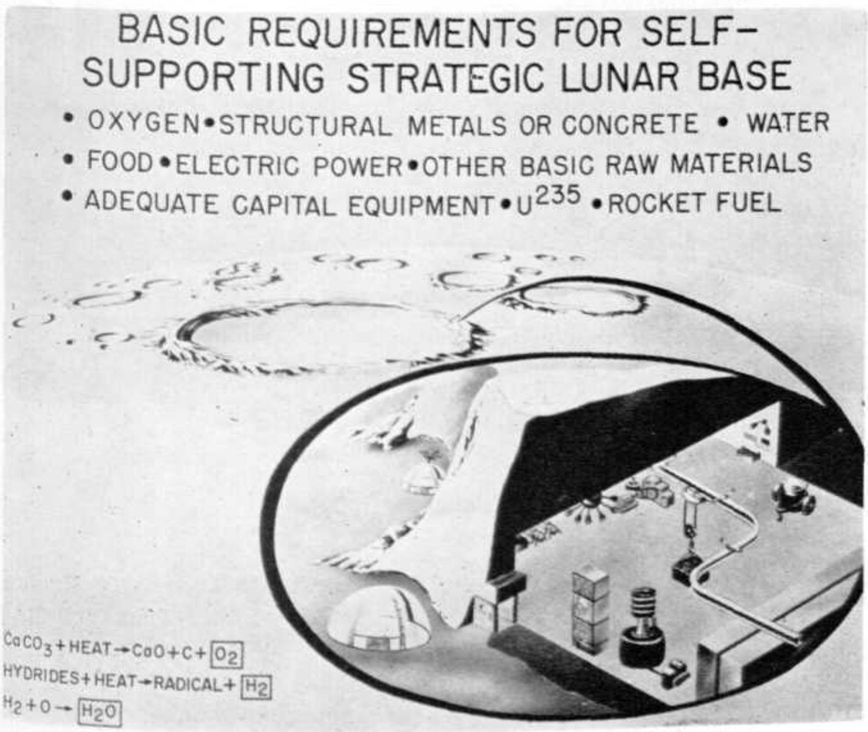
To be self-sufficient on the moon, a lunar base must provide ample electric power.

ELEMENTS of an electric power station designed for use on the moon have been demonstrated recently by scientists of the newly-formed Astronautics Institute.

A working model of the moon power station was operated to show how the revolutionary generating unit would be powered by light from the sun. A modified vacuum tube, containing the same elements that would be used in a full scale station on the moon, absorbed a beam of light from a nearby sun lamp generating enough power to drive a small motor.

Guiding the space technology work is the newly formed Astronautics Institute, headed by Dr. Peter Castruecio.

Major General Albert Boyd (USAF, Ret.), vice-president of Westinghouse and general manager of its defense products divisions, said the lunar electric power plant is just one of several space projects for which scientists have developed plans. He said work also is being done in the fields of space propulsion, communications, and guidance.



Boyd said the importance of the lunar electric power plant project is dictated by the fact that a United States space base on the moon must, first of all, be self-sufficient.

"Electric power is a must for self-sufficiency on the moon," he stated, "and to subsequent technological exploitation of not only the moon itself but later to its use as a jumping-off point for exploration of our solar system."

Top-level Westinghouse scientists and consultants from divisions throughout the company make up the Astronautics Institute. The group is located in Baltimore, but members have access to all corporate activities touching on the space effort, and can draw on the talents of main specialists.

Scientists at the applied research laboratory of the electronic tube division were responsible for the successful work in the theory, design and construction of the operating model of the moon station.

While demonstrating the model, Dr. Castruccio, an authority in space guidance and communications problems, explained the construction and operation of the moon power station. First, he pointed out that the sun at zenith pours upon the lunar surface something like 6000 kw of power per acre, and that the proposed lunar power station would use this light or radiant energy to generate electrical power.

Basic components of the actual power station consist only of wire mesh and a chemically coated plastic. Giant sheets of a thin plastic material

(Continued on Page 59)

Claudia Jean Lemke

Engineer's Girl For November

CLAUDIA JEAN LEMKE

Home town: Cedar River, Mich.

Age: 20

Sorority: Delta Delta Delta

Specs: 5' 2"
Green eyes
Brown hair
34-23-34

Major: Radio & Television

Campus Activities: Union Board Chorus Line
MSU Rifle Club

Hobbies: Dancing
Sketching
Sports
Hunting

Status: Single

(Photos by Al Royce)

M. E. Labs Use Miniature Equipment

J. H. Hemmye and L. C. Price
Mechanical Engineering Department
Michigan State University

Although the equipment is scaled down with accompanying efficiency loss, the same physical laws apply.

I

INCREASED enrollment in engineering colleges across the country has forced administrators to search tor means of providing adequate instructional facilities within the present physical plant. This pressure has been felt keenly in the mechanical laboratory where groups oi students were expected to perform experiments on mechanical equipment, It became necessary either to increase the size of the testing groups or to duplicate equipment. Large groups would mean that only a lew students would be able tO participate in the experiment while the rest observed and copied data. The only feasible solution to this dilemma was to provide more equipment without increasing the Boor space required—in other words to miniaturize.

The trend to smaller equipment has emphasized once more the necessity of selecting and sticking to a philosophy of lab instruction—equipment versus fundamentals. In the past when tests were made on a large machine, lack of flexibility led naturally to emphasis on the special features of that machine, rather than to the presentation of fundamenal physical laws. For instance, the student became familiar with the operation of one type of turbine governor, but was poorly informed on the thermodynamic phenomena which are common to all turbines.

Other advantages are to be found in small laboratory test set-ups. Cost is an important factor in the selection of educational laboratory equipment. In most cases the use of small units will permit the construction of two, three, or more units for less than it would cost for one large one. There is another aspect to the matter of cost. The most expensive part of a large installation usually lies in the original equipment and its erection; not much is left for instrumentation. This situation is usually reversed in going from large to small equipment. Fractional horsepower motors, small blowers, pumps, compressors, and turbines, etc., are relatively inexpensive. Installation costs also are greatly reduced. Instrumentation then becomes a sizeable percentage of the total cost and therefore received the careful evaluation it deserves.

Space, or rather the lack of space has led to this discussion. It is evident that a number of 10 gallon-per-minute centrifugal pump sets could be installed in the space required for one 500 gallon-per-minute system. This economy of space can be further exploited by taking advantage of small and light components to build portable units which when not in use may be stored in areas not suitable for instructional purposes. The ultimate may be a series of units mounted on pallets so that they may be stacked on top of each other and conveniently stored out of the way until needed.

The efficiencies determined from miniaturized equipment are generally lower than those obtained from large scale equipment, but the same physical laws apply. Small installations also tend to be more flexible than are their large scale counterparts. For example, one feels definitely ill at ease running excessive back pressure on a 250 psi, 150 horsepower turbine, while this sort of test can be run easily and safely on a 90 psi, 25 horsepower turbine. In essence then, one has a great deal more freedom to do more worthwhile things with small pieces of test equipment.

In the M. E. laboratory at Michigan State several pieces of equipment have been assembled lately which might be regarded as examples of miniaturization. The principal ones thus far are two blowers, a centrifugal pump, and two diesel engines. Brief descriptions follow:

(1) Low speed, low pressure blower. This blower has a ten-inch discharge pipe, a nine-inch wheel, and a three-quarter horsepower motor direct connected. The motor is driven through a variator which allows a wide variation in speed. The torque is measured by a spring coupling having a scale on its periphery which can be read by means of a stroboscopic light. The whole setup is mounted on casters and is complete with monometers, transducer, and electronic speed measuring equipment.

(2) High speed high pressure blower. This equipment was gotten together when we had to duplicate the blower setup. It was designed to be able to perform the same kind of experiments as with blower number one, but with the idea of providing a variety of equipment. The blower has a six-inch discharge pipe, a ten and a half inch wheel and is driven by a three horsepower motor which runs at constant speed. Varia-

(Continued on Page 62)

As an aid to students, THE SPARTAN ENGINEER presents:

FUDGE FACTORS

A Complete conversion table for your notebook

THESE EIGHT PAGES MAY BE REMOVED AS A BOOKLET AND KEPT FOR READY REFERENCE.

Fudge Factors

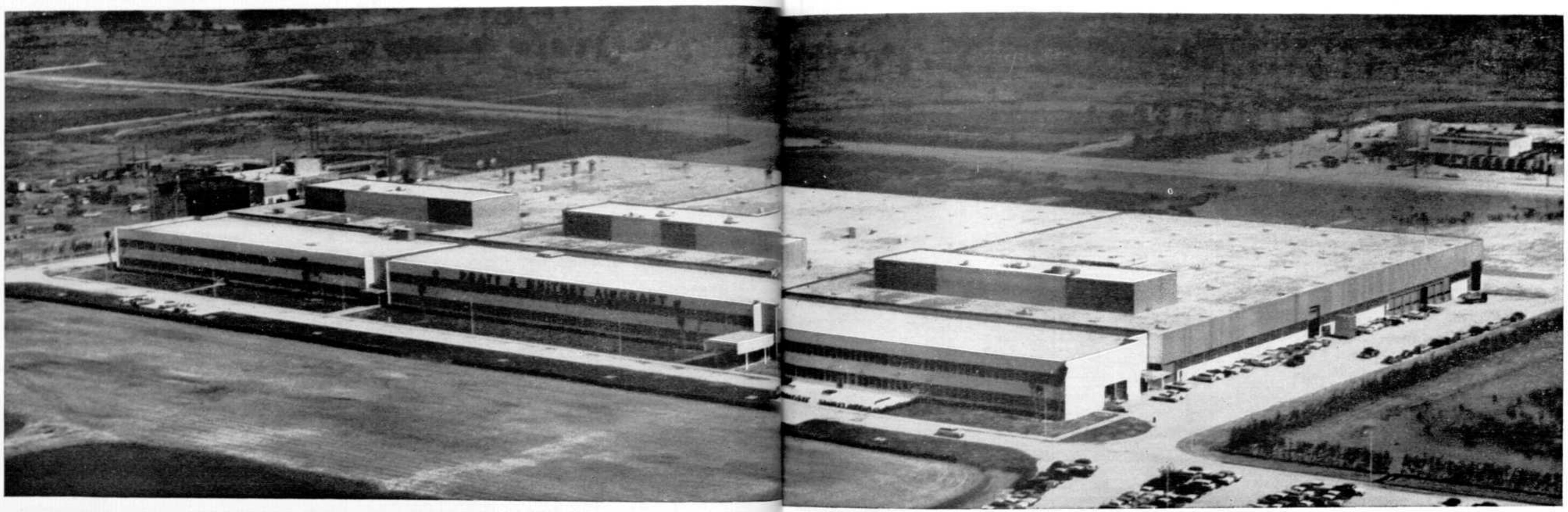
MULTIPLY	BY	TO OBTAIN
Abamperes	10	amperes.
Abamperes	$3x10^{10}$	statamperes.
abamperes per sq. cm.	64.52	amperes per sq. inch.
abampere-turns	10	ampere-turns
abampere-turns	12.57	gilberts
abampere-turns per cm.	25.40	ampere-turns per inch
abcoulombs	10	coulombs.
abcoulombs	$3x10^{10}$	statcoulombs
abcoulombs per sq. cm.	64.52	coulombs per sq. inch.
abfarads	10^{9}	farads
abfarads	10^{15}	microfarads.
abfarads	$9x10^{20}$	statfarads.
abhenries	10^{-9}	henries
abhenries	10^{-6}	millihenries.
abhenries	$1/9x10^{-20}$	stathenries.
abmhos per cm. cube	$1.662x10^{2}$	mhos per mil foot.
abmhos per cm. cube	10^{3}	megmhos per cm. cube.
abohms	10^{-15}	megohms
abohms	10^{-3}	microhoms.
abohms	10^{-9}	ohms.
abohms	$1/9x10^{-20}$	statohms.
abohms per cm. cube	10^{-3}	microhms per cm. cube.
abohms per cm. cube	$6.015x10^{-3}$	ohms per mil foot.
abvolts	$1/3x10^{-10}$	statvolts.
abvolts	10^{-8}	volts.
acres	43,560	square feet.
acres	4047	square meters.
acres	$1.562x10^{-3}$	square miles.
acres	5645.38	square varas.
acres	4840	square yards.
acre-feet	43,560	cubic-feet.
acre-feet	$3.259x10^{5}$	gallons.
amperes	1/10	abamperes.
amperes	$3x10^{9}$	statamperes.
amperes per sq. cm.	6.452	amperes per sq. inch.
amperes per sq inch	0.01550	abamperes per sq. cm.
amperes per sq inch	0.1550	amperes per sq. cm.
amperes per sq inch	$4.650x10^{8}$	statamperes per sq. cm.
ampere-turns	1/10	abampere-turns.
ampere-turns	1.257	gilberts.
ampere-turns per cm.	2.540	ampere-turns per in.
ampere-turns per inch	0.03937	abampere-turns per cm.
ampere-turns per inch	0.3937	ampere-turns per cm.
ampere-turns per inch	0.4950	gilberts per cm.
areas	0.02471	acres.
areas	100	square meters.
atmospheres	76.0	cms. of mercury.
atmospheres	29.92	inches of mercury.
atmospheres	33.90	feet of water.
atmospheres	10,333	kgs. per sq. meter.
atmospheres	14.70	pounds per sq. inch.
atmospheres	1.058	tons per sq. foot.
Bars	$9.870x10^{-7}$	atmospheres.
Bars	1	dynes per sq. cm.
Bars	0.01020	kgs. per square meter
Bars	$2.089x10^{-3}$	pounds per sq. foot.
Bars	$1.450x10^{-5}$	pounds per sq. inch.
board-feet	144 sq. in.x1 in.	cubic inches.
British thermal units	0.2530	kilogram-calories.
British thermal units	777.5	foot-pounds.
British thermal units	$3.927x10^{-4}$	horse-power-hours.
British thermal units	1054	joules.
British thermal units	107.5	kilogram-meters.
British thermal units	$2.928x10^{-4}$	kilowatt-hours.
B.t.u. per min	12.96	foot-pounds per sec.
B.t.u. per min	0.02356	horse-power.
B.t.u. per min	0.01757	kilowatts.
B.t.u. per min	17.57	watts.
B.t.u. per sq. ft. per min	0.1220	watts per square inch.
bushels	1.244	cubic feet.
bushels	2150	cubic inches.
bushels	0.03524	cubic meters.
bushels	4	pecks.
bushels	64	pints (dry).
bushels	32	quarts (dry)
Centares	1	square meters.
centigrams	0.01	grams.
centiliters	0.01	liters.
centimeters	0.3937	inches.
centimeters	0.01	meters.
centimeters	393.7	mils.
centimeters	10	millimeters.
centimeter-dynes	$1.020x10^{-3}$	centimeter-grams.
centimeter-dynes	$1.020x10^{-8}$	meter-kilograms.
centimeter-dynes	$7.376x10^{-8}$	pound-feet.

MULTIPLY	BY	TO OBTAIN
centimeter-grams	980.7	centimeter-dynes.
centimeter-grams	10^{-5}	meter-kilograms.
centimeter-grams	$7.233x10^{-5}$	pound-feet.
centimeters of mercury	0.01316	atmospheres.
centimeters of mercury	0.4461	feet of water.
centimeters of mercury	136.0	kgs. per square meter.
centimeters of mercury	27.85	pounds per sq. foot.
centimeters of mercury	0.1934	pounds per sq. inch.
centimeters per second	1.969	feet per minute.
centimeters per second	0.03281	feet per second.
centimeters per second	0.036	kilometers per hour.
centimeters per second	0.6	meters per minute.
centimeters per second	0.02237	miles per hour.
centimeters per second	$3.728x10^{-4}$	miles per minute.
cms. per sec. per sec.	0.03281	feet per sec. per sec.
cms. per sec. per sec.	0.036	kms. per hour per sec
cms. per sec. per sec.	0.02237	miles per hour per sec
circular mils	$5.067x10^{-6}$	square centimeters.
circular mils	$7.854x10^{-7}$	square inches.
circular mils	0.7854	square mils.
cord-feet	4 ft.x4 ft.x1 ft.	cubic feet.
cords	8 ft.x4 ft.x4 ft.	cubic feet.
coulombs	1/10	abcoulombs.
coulombs	$3x10^{9}$	statcoulombs.
coulombs per sq. inch	0.01550	abcoulombs per sq. cm
coulombs per sq inch	0.1550	coulombs per sq. cm.
coulombs per sq. inch	$4.650x10^{8}$	statcouls. per sq. cm.
cubic centimeters	$3.531x10^{-5}$	cubic feet.
cubic centimeters	$6.102x10^{-2}$	cubic inches.
cubic centimeters	10^{-6}	cubic meters.
cubic centimeters	$1.308x10^{-6}$	cubic yards.
cubic centimeters	$2.642x10^{-4}$	gallons.
cubic centimeters	10^{-3}	liters.
cubic centimeters	$2.113x10^{-3}$	pints (liq.).
cubic centimeters	$1.057x10^{-3}$	quarts (liq.).
cubic feet	$2.832x10^{4}$	cubic cms.
cubic feet	1728	cubic inches.
cubic feet	0.02832	cubic meters.
cubic feet	0.03704	cubic yards.
cubic feet	7.481	gallons.
cubic feet	28.32	liters.
cubic feet	59.84	pints (liq.).
cubic feet	29.92	quarts (liq.).
cubic feet per minute	472.0	cubic cms. per sec.
cubic feet per minute	0.1247	gallons per sec.
cubic feet per minute	0.4720	liters per second
cubic feet per minute	62.4	lbs. of water per min.
cubic inches	16.39	cubic centimeters.
cubic inches	$5.787x10^{-4}$	cubic feet.
cubic inches	$1.639x10^{-5}$	cubic meters.
cubic inches	$2.143x10^{-5}$	cubic yards.
cubic inches	$4.329x10^{-3}$	gallons.
cubic inches	$1.639x10^{-2}$	liters.
cubic inches	0.03463	pints (liq.).
cubic inches	0.01732	quarts (liq.).
cubic meters	10^{6}	cubic centimeters
cubic meters	35.31	cubic feet.
cubic meters	61,023	cubic inches.
cubic meters	1.308	cubic yards.
cubic meters	264.2	gallons.
cubic meters	10^{3}	liters.
cubic meters	2113	pints (liq.).
cubic meters.	1057	quarts (liq.).
cubic yards	$7.646x10^{5}$	cubic centimeters.
cubic yards	27	cubic feet.
cubic yards	46,656	cubic inches.
cubic yards	0.7646	cubic meters.
cubic yards	202.0	gallons.
cubic yards	764.6	liters.
cubic yards	1616	pints (liq.).
cubic yards	807.9	quarts (liq.).
cubic yards per minute	0.45	cubic feet per second.
cubic yards per minute	3.367	gallons per second.
cubic yards per minute	12.74	liters per second.
Days	24	hours.
Days	1440	minutes.
Days	86,400	seconds.
decigrams	0.1	grams.
deciliters	0.1	liters.
decimeters	0.1	meters.
degrees (angle)	60	minutes.
degrees (angle)	0.01745	radians.
degrees (angle)	3600	seconds.
degrees per second	0.01745	radians per second.
degrees per second	0.1667	revolutions per min.
degrees per second	0.002778	revolutions per sec.
dekagrams	10	grams.
dekaliters	10	liters.
dekameters	10	meters.
dollars (U.S.)	5.182	francs (French).
dollars (U.S.)	4.20	marks (German).
dollars (U.S.)	0.2055	pounds sterling (Brit.)
dollars (U.S.)	4.11	shillings (British)
drams	1.772	grams.
drams	0.0625	ounces.
dynes	$1.020x10^{-3}$	grams.
dynes	$7.233x10^{-5}$	poundals.

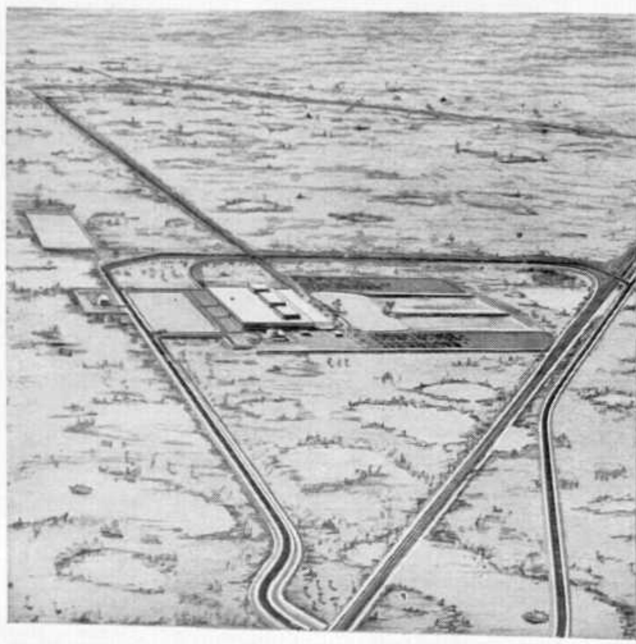
MULTIPLY	BY	TO OBTAIN
dynes	2.248×10^{-6}	pounds.
dynes per square cm.	1	bars.
Ergs	9.486×10^{-11}	British thermal units.
Ergs	1	dyne-centimeters.
Ergs	7.376×10^{-8}	foot-pounds.
Ergs	1.020×10^{-3}	gram-centimeters.
Ergs	10^{-7}	joules.
Ergs	$2,390\times10^{-11}$	kilogram-calories.
Ergs	1.020×10^{-8}	kilogram-meters.
ergs per second	5.692×10^{-9}	B.t. units per minute.
ergs per second	4.426×10^{-6}	foot-pounds per min.
ergs per second	7.376×10^{-8}	foot-pounds per sec.
ergs per second	1.341×10^{-10}	horse-power.
ergs per second	1.434×10^{-9}	kg.-calories per min.
ergs per second	10^{-10}	kilowatts.
Farads	10^{-9}	abfarads.
Farads	10^{6}	microfarads.
Farads	9×10^{-11}	statfarads.
fathoms	6	feet.
feet	30.48	centimeters.
feet	12	inches.
feet	0.3048	meters.
feet	.36	varas.
feet	1/3	yards.
feet of water	0.02950	atmospheres.
feet of water	0.8826	inches of mercury.
feet of water	304.8	kgs. per square meter.
feet of water	62.43	pounds per sq. ft.
feet of water	0.4335	pounds per sq. inch.
feet per minute	0.5080	centimeters per sec.
feet per minute	0.01667	feet per sec.
feet per minute	0.01829	kilometers per hour.
feet per minute	0.3048	meters per minute.
feet per minute	0.01136	miles per hour.
feet per second	30.48	centimeters per sec.
feet per second	1.097	kilometers per hour.
feet per second	0.5921	knots per hour.
feet per second	18.29	meters per minute.
feet per second	0.6818	miles per hour.
feet per second	0.01136	miles per minute.
feet per 100 feet	1	per cent grade.
feet per sec. per sec.	30.48	cms. per sec. per sec.
feet per sec. per sec.	1.097	kms. per hr. per sec.
feet per sec. per sec.	0.3048	meters per sec. per sec.
feet per sec. per sec.	0.6818	miles per hr. per sec.
foot-pounds	1.286×10^{-3}	British thermal units.
foot-pounds	1.356×10^{7}	ergs.
foot-pounds	5.050×10^{-7}	horse-power-hours.
foot-pounds	1.356	joules.
foot-pounds	3.241×10^{-4}	kilogram-calories.
foot-pounds	0.1383	kilogram-meters
foot-pounds	3.766×10^{-7}	kilowatt-hours.
foot-pounds per minute	1.286×10^{-3}	B.t. units per minute.
foot-pounds per minute	0.01667	foot-pounds per sec.
foot-pounds per minute	3.300×10^{-5}	horse-power.
foot-pounds per minute	3.241×10^{-4}	kg.-calories per minute.
foot-pounds per minute	2.260×10^{-5}	kilowatts.
foot-pounds per second	7.717×10^{-2}	B.t. units per minute.
foot-pounds per second	1.818×10^{-3}	horse-power.
foot-pounds per second	1.945×10^{-2}	kg.-calories per min.
foot-pounds per second	1.356×10^{-3}	kilowatts.
francs (French)	0.193	dollars (U.S.).
francs (French)	0.811	marks (German).
francs (French)	0.03865	pounds sterling (Brit.).
furlongs	40	rods.
Gallons	3785	cubic centimeters.
Gallons	0.1337	cubic feet.
Gallons	231	cubic inches.
Gallons	3.785×10^{-3}	cubic meters.
Gallons	4.951×10^{-3}	cubic yards.
Gallons	3.785	liters.
Gallons	8	pints (liq.).
Gallons	4	quarts (liq.).
gallons per minute	2.228×10^{-3}	cubic feet per second.
gallons per minute	0.06308	liters per second.
gausses	6.452	lines per square inch.
gilberts	0.07958	abampere-turns.
gilberts	0.7958	ampere-turns.
gilberts per centimeter	2.021	ampere-turns per inch.
gills	0.1183	liters.
gills	0.25	pints (liq.).
grains (troy)	1	grains (av.).
grains (troy)	0.06480	grams.
grains (troy)	0.04167	pennyweights (troy).
grams	980.7	dynes.
grams	15.43	grains (troy).
grams	10^{-3}	kilograms.
grams	10^{3}	milligrams.
grams	0.03527	ounces.
grams	0.03215	ounces (troy).
grams	0.07093	poundals.
grams	2.205×10^{-3}	pounds.
gram-calories	3.968×10^{-3}	British thermal units.
gram-centimeters	9.302×10^{-8}	British thermal units.
gram-centimeters	980.7	ergs.
gram-centimeters	7.233×10^{-5}	foot-pounds.

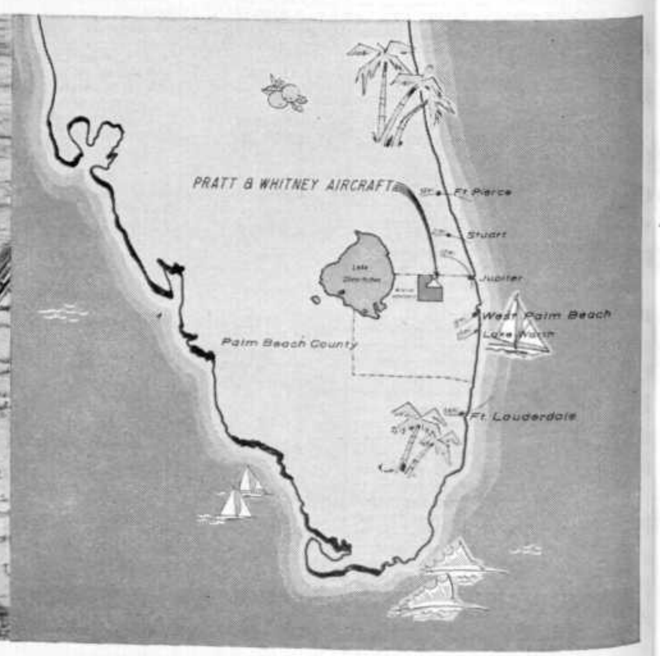
MULTIPLY	BY	TO OBTAIN
gram-centimeters	9.807×10^{-5}	joules.
gram-centimeters	2.344×10^{-8}	kilogram-calories.
gram-centimeters	10^{-5}	kilogram-meters.
grams per cm.	5.600×10^{-3}	pounds per inch.
grams per cu. cm.	62.43	pounds per cubic foot.
grams per cu. cm.	0.03613	pounds per cubic inch.
grams per cu. cm.	3.405×10^{-7}	pounds per mil-foot.
Hectares	2.471	acres.
Hectares	1.076×10^{5}	square feet.
hectograms	100	grams.
hectoliters	100	liters.
hectometers	100	meters.
hectowatts	100	watts.
hemispheres (sol. angle)	0.5	sphere.
hemispheres (sol. angle)	4	spherical right angles.
hemispheres (sol. angle)	6.283	steradians.
henries	10^{9}	abhenries.
henries	10^{3}	millihenries.
henries	$1/9\times10^{-11}$	stathenries.
horse-power	42.44	B.t. units per min.
horse-power	33,000	foot-pounds per min.
horse-power	550	foot-pounds per sec.
horse-power	1.014	horse-power (metric)
horse-power	10.70	kg.-calories per min.
horse-power	0.7457	kilowatts.
horse-power	745.7	watts.
horse-power (boiler)	33,520	B.t.u. per hour.
horse-power (boiler)	9.804	kilowatts.
horse-power-hours	2547	British thermal units.
horse-power-hours	1.98×10^{6}	foot-pounds.
horse-power-hours	2.684×10^{6}	joules.
horse-power-hours	641.7	kilogram-calories.
horse-power-hours	2.737×10^{5}	kilogram-meters.
horse-power-hours	0.7457	kilowatt-hours.
hours	60	minutes.
hours	3600	seconds.
Inches	2.540	centimeters.
Inches	10^{3}	mils.
Inches	.03	varas.
Inches of mercury	0.03342	atmospheres.
Inches of mercury	1.133	feet of water.
Inches of mercury	345.3	kgs. per square meter.
Inches of mercury	70.73	pounds per square ft.
Inches of mercury	0.4912	pounds per square in.
Inches of water	0.002458	atmospheres.
Inches of water	0.07355	inches of mercury.
Inches of water	25.40	kgs. per square meter.
Inches of water	0.5781	ounces per square in.
Inches of water	5.204	pounds per square ft.
Inches of water	0.03613	pounds per square in.
Joules	9.486×10^{-4}	British thermal units.
Joules	10^{7}	ergs.
Joules	0.7376	foot-pounds.
Joules	2.390×10^{-4}	kilogram-calories.
Joules	0.1020	kilogram-meters
Joules	2.778×10^{-4}	watt-hours.
Kilograms	980,665	dynes.
Kilograms	10^{3}	grams.
Kilograms	70.93	poundals.
Kilograms	2.2046	pounds.
Kilograms	1.102×10^{-3}	tons (short).
kilogram-calories	3.968	British thermal units.
kilogram-calories	3086	foot-pounds.
kilogram-calories	1.558×10^{-3}	horse-power-hours.
kilogram-calories	4183	joules.
kilogram-calories	426.6	kilogram meters.
kilogram-calories	1.162×10^{-3}	kilowatt-hours.
kg.-calories per min.	51.43	foot-pounds per sec.
kg.-calories per min.	0.09351	horse-power.
kg.-calories per min.	0.06972	kilowatts.
kgs.-cms. squared	2.373×10^{-3}	pounds-feet squared.
kgs.-cms. squared	0.3417	pounds-inches squared.
kilogram-meters	9.302×10^{-3}	British thermal units.
kilogram-meters	9.807×10^{7}	ergs.
kilogram-meters	7.233	foot-pounds.
kilogram-meters	9.807	joules.
kilogram-meters	2.344×10^{-3}	kilogram-calories.
kilogram-meters	2.724×10^{-6}	kilowatt-hours.
kgs. per cubic meter	10^{-3}	grams per cubic cm.
kgs. per cubic meter	0.06243	pounds per cubic foot.
kgs. per cubic meter	3.613×10^{-5}	pounds per cubic inch.
kgs. per cubic meter	3.405×10^{-10}	pounds per mil. foot.
kgs. per meter	0.6720	pounds per foot.
kgs. per square meter	9.678×10^{-5}	atmospheres.
kgs. per square meter	98.07	bars.
kgs. per square meter	3.281×10^{-3}	feet of water.
kgs. per square meter	2.896×10^{-3}	inches of mercury.
kgs. per square meter	0.2048	pounds per square ft.
kgs. per square meter	1.422×10^{-3}	pounds per square in.
kgs. per sq. millimeter	10^{6}	kgs. per square meter.
kilolines	10^{3}	maxwells.
kiloliters	10^{3}	liters.
kilometers	10^{5}	centimeters.
kilometers	3281	feet.
kilometers	10^{3}	meters.

(Continued on Page 38)



FLORIDA RESEARCH AND DEVELOPMENT CENTER...





ISOLATION—Ten square miles comprise the site of Pratt & Whitney Aircraft's new Florida Research and Development Center. Experimental shops and offices covering some 17 acres are in the foreground, while the tests areas, barely visible in upper left, lie four *miles* in the background.

LOCATION—The new Center is located at United, Flonda, midway between West Palm Beach and Lake Okeechobee, in the upper Everglades area. It is almost surrounded by a wildlife sanctuary. Most employees live m the cities and towns along the east coast of Florida, driving to the Center on excellent new highways.

Another Unmatched Engineering Facility to Advance Propulsion Systems of the Future

Future aircraft and missiles may require propulsion systems far different from those in wide use today — different in size, power output, appearance, and perhaps even in the basic method of utilizing energy.

To probe the propulsion future . . . and to build and test greatly advanced propulsion systems for coming generations of flight vehicles, Pratt & Whitney Aircraft is now operating its new Florida Research and Development Center. This facility supplements Pratt & Whitney's main research and development installations in Connecticut.

The new Florida Center, financed and built by Pratt & Whitney Aircraft, is unique in America's air industry. Here a completely air-conditioned plant with 17 acres under roof is specially designed and equipped for the development of new power plants of virtually any type. Testing is handled in special isolated areas; the nearest is four miles from the plant and many miles from any inhabited area. The new Center can be greatly expanded on its 10-square-mile site. Continued isolation is insured by a vast wildlife sanctuary in which the Center is located.

Of the many people employed at the Center today, about half are scientists, engineers and highly trained technicians. By late next year, the total number is expected to be almost doubled.

The new Florida Research and Development Center is one more reason why Pratt & Whitney Aircraft is able to continue producing the world's best aircraft propulsion systems . . . in whatever form they take.

For further information regarding an engineering career at Pratt & Whitney Aircraft, contact your college placement officer.

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

CONNECTICUT OPERATIONS — East Hartford

FLORIDA RESEARCH AND DEVELOPMENT CENTER — United, Florida

FUDGE FACTORS

(Continued from Page 35)

MULTIPLY	BY	TO OBTAIN
kilometers	0.6214	miles.
kilometers	1093.6	yards.
kilometers per hour	27.78	centimeters per sec.
kilometers per hour	54.68	feet per minute.
kilometers per hour	0.9113	feet per second.
kilometers per hour	0.5396	knots per hour.
kilometers per hour	16.67	meters per minute.
kilometers per hour	0.6214	miles per hour.
kms. per hour per sec.	27.78	cms. per sec. per sec.
kms. per hour per sec.	0.9113	ft. per sec. per sec.
kms. per hour per sec.	0.2778	meters per sec. per sec.
kms. per hour per sec.	0.6214	miles per hr. per sec.
kilometers per min.	60	kilometers per hour.
kilowatts	56.92	B.t.u. units per min.
kilowatts	4.425×10^{4}	foot-pounds per min.
kilowatts	737.6	foot-pounds per sec.
kilowatts	1.341	horse-power.
kilowatts	14.34	kg.-calories per min.
kilowatts	10^{3}	watts.
kilowatt-hours	3415	British thermal units.
kilowatt-hours	2.655×10^{6}	foot-pounds.
kilowatt-hours	1.341	horse-power-hours.
kilowatt-hours	3.6×10^{6}	joules.
kilowatt-hours	860.5	kilogram-calories.
kilowatt-hours	3.671×10^{5}	kilogram-meters.
knots	6080	feet.
knots	1.853	kilometers.
knots	1.152	miles.
knots	2027	yards.
knots per hour	51.48	centimeters per sec.
knots per hour	1.689	feet per sec.
knots per hour	1.853	kilometers per hour.
knots per hour	1.152	miles per hour.
Lines per square cm.	1	gausses.
lines per square inch	0.1550	gausses.
links (engineer's)	12	inches.
links (suveyor's)	7.92	inches.
liters	10^{3}	cubic centimeters.
liters	0.03531	cubic feet.
liters	61.02	cubic inches.
liters	10^{-3}	cubic meters.
liters	1.308×10^{-3}	cubic yards.
liters	0.2642	gallons
liters	2.113	pints (liq.).
liters	1.057	quarts (liq.).
liters per minute	5.855×10^{-4}	cubic feet per second.
liters per minute	4.403×10^{-3}	gallons per second.
$\log^{10} N$	2.303	$\log_{10} N$ or $\ln N$.
$\log_{10} N$ or $\ln N$	0.4343	$\log_{10} N$.
lumens per sq. ft.	1	foot-candles.
Marks (German)	0.238	dollars (U.S.).
Marks (German)	1.233	francs (French).
Marks (German)	0.04890	pounds sterling (Brit.).
maxwells	10^{-3}	kilolines.
megalines	10^{6}	maxwells.
megmhos per cm. cube	10^{-3}	abmhos per cm. cube.
megmhos per cm. cube	2.540	megmhos per in. cube.
megmhos per cm. cube	0.1662	mhos per mil foot.
megmhos per inch cube	0.3937	megmhos per cm. cube.
megohms	10^{6}	ohms.
meters	100	centimeters.
meters	3.2808	feet.
meters	39.37	inches.
meters	10^{-3}	kilometers.
meters	10^{3}	millimeters.
meters	1.0936	yards.
meter-kilograms	9.807×10^{7}	centimeter-dynes.
meter-kilograms	10^{5}	centimeter-grams.
meter-kilograms	7.233	pound-feet.
meters per minute	1.667	centimeters per sec.
meters per minute	3.281	feet per minute.
meters per minute	0.05468	feet per second.
meters per minute	0.03	kilometers per hour.
meters per minute	0.03728	miles per hour.
meters per second	1968	feet per minute.
meters per second	3.284	feet per second.
meters per second	3.0	kilometers per hour.
meters per second	0.06	kilometers per min.
meters per second	2.237	miles per hour.
meters per second	0.03728	miles per minute.
meters per sec. per sec.	3.281	feet per sec. per sec.
meters per sec. per sec.	3.6	kms. per hour per sec.
meters per sec. per sec.	2.237	miles per hour per sec.
mhos per mil foot	6.015×10^{-3}	abmhos per cm. cube.
mhos per mil foot	6.015	megmhos per cm. cube.
mhos per mil foot	15.28	megmhos per in. cube.
microfarads	10^{-15}	abfarads.
microfarads	10^{-6}	farads.
microfarads	9×10^{5}	statfarads.
micrograms	10^{-6}	grams.
microliters	10^{-6}	liters.
microhms	10^{3}	abohms.
microhms	10^{-12}	megohms.
microhms	10^{-6}	ohms.
microhms	$1/9 \times 10^{-17}$	statohms.
microhms per cm. cube	10^{3}	abohms per cm. cube.
microhms per cm. cube	0.3937	microhms p. in. cube.

MULTIPLY	BY	TO OBTAIN
microhms per cm. cube	6.015	ohms per mil foot.
microhms per inch cube	2.540	microhoms p. cm. cube.
microns	10^{-6}	meters.
miles	1.609×10^{5}	centimeters.
miles	5280	feet.
miles	1.6093	kilometers.
miles	1760	yards.
miles	1900.8	varas.
miles per hour	44.70	centimeters per sec.
miles per hour	88	feet per minute.
miles per hour	1.467	feet per second.
miles per hour	1.6093	kilometers per hour.
miles per hour	0.8684	knots per hour.
miles per hour	26.82	meters per minute.
miles per hour per sec.	44.70	cms. per sec. per sec.
miles per hour per sec.	1.467	feet per sec. per sec.
miles per hour per sec.	1.6093	kms. per hour per sec.
miles per hour per sec.	0.4470	M. per sec. per sec.
miles per minute	2682	centimeters per sec.
miles per minute	88	feet per second.
miles per minute	1.6093	kilometers per min.
miles per minute	0.8684	knots per minute.
miles per minute	60	miles per hour.
milligrams	10^{-3}	grams.
millihenries	10^{6}	abhenries.
millihenries	10^{-3}	henries.
millihenries	$1/9 \times 10^{-14}$	stathenries.
milliliters	10^{-3}	liters.
millimeters	0.1	centimeters.
millimeters	0.03937	inches.
millimeters	39.37	mils.
mils	0.002540	centimeters.
mils	10^{-3}	inches.
miner's inches	1.5	cubic feet per min.
minutes (angle)	2.909×10^{-4}	radians.
minutes (angle)	60	seconds (angle).
months	30.42	days.
months	730	hours.
months	43,800	minutes.
months	2.628×10^{6}	seconds.
myriagrams	10	kilograms.
myriameters	10	kilometers.
myriawatts	10	kilowatts.
Ohms	10^{9}	abohms.
Ohms	10^{-6}	megohms.
Ohms	10^{6}	microhms.
Ohms	$1/9 \times 10^{-11}$	statohms.
ohms per mil foot	166.2	abohms per cm. cube.
ohms per mil foot	0.1662	microhms per cm. cube.
ohms per mil foot	0.06524	microhms per in. cube.
ounces	8	drams.
ounces	437.5	grains.
ounces	28.35	grams.
ounces	0.0625	pounds.
ounces (fluid)	1.805	cubic inches.
ounces (fluid)	0.02957	liters.
ounces (troy)	480	grains (troy).
ounces (troy)	31.10	grams.
ounces (troy)	20	pennyweights (troy).
ounces (troy)	0.08333	pounds (troy).
ounces per square inch	0.0625	pounds per sq. inch.
Pennyweights (troy)	24	grains (troy).
Pennyweights (troy)	1.555	grams.
Pennyweights (troy)	0.05	ounces (troy).
perches (masonry)	24.75	cubic feet.
pints (dry)	33.60	cubic inches.
pints (liquid)	28.87	cubic inches.
poundals	13,826	dynes.
poundals	14.10	grams.
poundals	0.03108	pounds.
pounds	444,823	dynes.
pounds	7000	grains.
pounds	453.6	grams.
pounds	16	ounces.
pounds	32.17	poundals.
pounds (troy)	0.8229	pounds (av.).
pound-feet	1.356×10^{7}	centimeter-dynes.
pound-feet	13,825	centimeter-grams.
pound-feet	0.1383	meter-kilograms.
pounds-feet squared	421.3	kgs.-cms. squared.
pounds-feet squared	144	pounds-ins. squared.
pounds-inches squared	2.926	kgs.-cms. squared.
pounds-inches squared	6.945×10^{-3}	pounds-feet squared.
pounds of water	0.01602	cubic feet.
pounds of water	27.68	cubic inches.
pounds of water	0.1198	gallons.
pounds of water per min.	2669×10^{-4}	cubic feet per sec.
pounds per cubic foot	0.01602	grams per cubic cm.
pounds per cubic foot	16.02	kgs. per cubic meter.
pounds per cubic foot	5.787×10^{-4}	pounds per cubic inch.
pounds per cubic foot	5.456×10^{-9}	pounds per mil foot.
pounds per cubic inch	27.68	grams per cubic cm.
pounds per cubic inch	2.768×10^{4}	kgs. per cubic meter.
pounds per cubic inch	1728	pounds per cubic foot.
pounds per cubic inch	9.425×10^{-6}	pounds per mil foot.
pounds per foot	1.488	kgs. per meter.
pounds per inch	178.6	grams per cm.

MULTIPLY	BY	TO OBTAIN
pounds per mil foot	2.306×10^{6}	grams per cubic cm.
pounds per square foot	0.01602	feet of water.
pounds per square foot	4.882	kgs. per square meter.
pounds per square foot	6.944×10^{-3}	pounds per sq. inch.
pounds per square inch	0.06804	atmospheres.
pounds per square inch	2.307	feet of water.
pounds per square inch	2.036	inches of mercury.
pounds per square inch	703.1	kgs. per square meter.
pounds per square inch	144	pounds per sq. foot.
Quadrants (angle)	90	degrees.
Quadrants (angle)	5400	minutes.
Quadrants (angle)	1.571	radians.
quarts (dry)	67.20	cubic inches.
quarts (liq.)	57.75	cubic inches.
quintals	100	pounds.
quires	25	sheets.
Radians	57.30	degrees.
Radians	3438	minutes.
Radians	0.637	quadrants.
radians per second	57.30	degrees per second.
radians per second	0.1592	revolutions per second.
radians per second	9.549	revolutions per min.
radians per sec. per sec.	573.0	revs. per min. per min.
radians per sec. per sec.	9.549	revs. per min. per sec.
radians per sec. per sec.	0.1592	revs. per sec. per sec.
reams	500	sheets.
revolutions	360	degrees.
revolutions	4	quadrants.
revolutions	6.283	radians.
revolutions per minute	6	degrees per second.
revolutions per minute	0.1047	radians per second.
revolutions per minute	0.01667	revolutions per sec.
revs. per min. per min.	1.745×10^{-3}	rads. per sec. per sec.
revs. per min. per min.	0.01667	revs. per min. per sec.
revs. per min. per min.	2.778×10^{-4}	revs. per sec. per sec.
revolutions per second	360	degrees per second.
revolutions per second	6.283	radians per second.
revolutions per second	60	revs. per min.
revs. per sec. per sec.	6.283	rads. per sec. per sec.
revs. per sec. per sec.	3600	revs. per min. per min.
revs. per sec. per sec.	60	revs. per min. per sec.
rods	16.5	feet.
Seconds (angle)	4.848×10^{-6}	radians.
spheres (solid angle)	12.57	steradians.
spherical right angles	0.25	hemispheres.
spherical right angles	0.125	spheres.
spherical right angles	1.571	steradians.
square centimeters	1.973×10^{5}	circular mils.
square centimeters	1.076×10^{-3}	square feet.
square centimeters	0.1550	square inches.
square centimeters	10^{-6}	square meters.
square centimeters	100	square millimeters.
sq. cms.-cms. sqd.	0.02402	sq. inches-inches sqd.
square feet	2.296×10^{-5}	acres.
square feet	929.0	square centimeters.
square feet	144	square inches.
square feet	0.09290	square meters.
square feet	3.587×10^{-8}	square miles.
square feet	.1296	square varas.
square feet	1/9	square yards.
sq. feet-feet sqd.	2.074×10^{4}	sq. inches-inches sqd.
square inches	1.273×10^{6}	circular mils.
square inches	6.452	square centimeters.
square inches	6.944×10^{-3}	square feet.
square inches	10^{6}	square mils.
square inches	645.2	square millimeters.
sq. inches-inches sqd.	41.62	sq. cms.-cms. sqd.
sq. inches-inches sqd.	4.823×10^{-5}	sq. ft.-feet sqd.
square kilometers	247.1	acres.
square kilometers	10.76×10^{6}	square feet.
square kilometers	10^{6}	square meters.
square kilometers	0.3861	square miles.
square kilometers	1.196×10^{6}	square yards.
square meters	2.471×10^{-4}	acres.
square meters	10.764	square feet.
square meters	3.861×10^{-7}	square miles.
square meters	1.196	square yards.
square miles	640	acres.
square miles	27.88×10^{6}	square feet.
square miles	2.590	square kilometers.
square miles	3,613,040.45	square varas.
square miles	3.098×10^{6}	square yards.
square millimeters	1.973×10^{3}	circular mils.

MULTIPLY	BY	TO OBTAIN
square millimeters	0.01	square centimeters.
square millimeters	1.550×10^{-3}	square inches.
square mils	1.273	circular mils.
square mils	6.452×10^{-6}	square centimeters.
square mils	10^{-6}	square inches.
square varas	.0001771	acres.
square varas	7.716049	square feet.
square varas	.0000002765	square miles.
square varas	.857339	square yards.
square yards	2.066×10^{-4}	acres.
square yards	9	square feet.
square yards	0.8361	square meters.
square yards	3.228×10^{-7}	square miles.
square yards	1.1664	square varas.
statamperes	$1/3 \times 10^{-10}$	abamperes.
statamperes	$1/3 \times 10^{-9}$	amperes.
statcoulombs	$1/3 \times 10^{-10}$	abcoulombs.
statcoulombs	$1/3 \times 10^{-9}$	coulombs.
statfarads	$1/9 \times 10^{-20}$	abfarads.
statfarads	$1/9 \times 10^{-11}$	farads.
statfarads	$1/9 \times 10^{-5}$	microfarads.
stathenries	9×10^{20}	abhenries.
stathenries	9×10^{11}	henries.
stathenries	9×10^{14}	millihenries.
statohms	9×10^{20}	abohms.
statohms	9×10^{5}	megohms.
statohms	9×10^{17}	microhms.
statohms	9×10^{11}	ohms.
statvolts	3×10^{10}	abvolts.
statvolts	300	volts.
steradians	0.1592	hemispheres.
steradians	0.07958	spheres.
steradians	0.6366	spherical right angles.
steres	10^{3}	liters.
Temp. (degs. C.) +273	1	abs. temp. (degs. C.).
Temp. (degs. C.) +17.8	1.8	temp. (degs Fahr.).
temp (degs. F.) +460	1	abs. temp. (degs. F.).
temp. (degs. F.) —32	5/9	temp. (degs. Cent.).
tons (long)	1016	kilograms.
tons (long)	2240	pounds.
tons (metric)	10^{3}	kilograms.
tons (metric)	2205	pounds.
tons (short)	907.2	kilograms.
tons (short)	2000	pounds.
tons (short) per sq. ft.	9765	kgs. per square meter.
tons (short) per sq. ft.	13.89	pounds per sq. inch.
tons (short) per sq. in.	1.406×10^{6}	kgs. per square meter.
tons (short) per sq. in.	2000	pounds per sq inch.
Varas	2.7777	feet.
Varas	33.3333	inches.
Varas	.000526	miles.
Varas	.9259	yards.
volts	10^{8}	abvolts.
volts	1/300	statvolts.
volts per inch	3.937×10^{7}	abvolts per cm.
volts per inch	1.312×10^{-3}	statvolts per cm.
Watts	0.05692	B.t.u. units per min.
Watts	10^{7}	ergs per second.
Watts	44.26	foot-pounds per min.
Watts	0.7376	foot-pounds per sec.
Watts	1.341×10^{-3}	horse-power.
Watts	0.01434	kg.-calories per min.
Watts	10^{-3}	kilowatts.
watt-hours	3.415	British thermal units.
watt-hours	2655	foot-pounds.
watt-hours	1.341×10^{-3}	horse-power-hours.
watt-hours	0.8605	kilogram-calories.
watt-hours	367.1	kilogram-meters.
watt-hours	10^{-3}	kilowatt-hours.
webers	10^{8}	maxwells.
weeks	168	hours.
weeks	10,080	minutes.
weeks	604,800	seconds.
Yards	91.44	centimeters.
Yards	3	feet.
Yards	36	inches.
Yards	0.9144	meters.
Yards	1.08	varas.
years (common)	365	days.
years (common)	8760	hours.
years (leap)	366	days.
years (leap)	8784	hours.

These conversion factors first appeared in the November '54 and January '55 issues of the CITY COLLEGE VECTOR.

The night Before Finals

'TWAS the night before finals and all ME's
Were down at the "Gables" busy as bees.
When out in the street there arose such a clatter
We found it disturbed our intellectual chatter.
With a flourish of slide rules and delirious yells,
We estimated its magnitude at ten decibels.
With a Hey! and a Ho! we displaced toward the door;
Barely aware of the stress in the floor.
It was snowing outside and had gotten quite frisky—
We dreamed of a glass of BTU'S (whiskey);
There in the moonlight stood, what do you think?
The whole MSU staff, I shudder to think!
They stood in two rows, all bridles and reins.
Their heads looked too large for their miniature brains.
The whole ugly lot was hitched to a sleigh,
The dean had long ears; we could hear him bray.
Up in the seat sat a strange-looking elf,
He smoked a cigar and seemed pleased with himself.
He looked at us all, then chuckled, then laughed.
In a twinkling we knew we were getting the shaft.
We knew on the morrow we'd be beat to submission,
So we started throwing bottles at that wild apparition.
The old elf sat up and we heard him cryin',
"On Ebert, on Rotty, on Wood and Ryan,
On Hedges, on Smith, on Cooper and Jack."
"Tomorrow," he shouted, "We'll get them back."
Upward they rose; disappeared in the gloom
We displaced back again into the room.
We thought of the elf; it seemed every year
They make finals tougher. We shouted "More beer!"

Finagle's Laws

(Continued from Page 28)

right off. This is one step ahead of choosing the right way, which turns out to be a wrong way, which has to become a right way.

Second Law: The more innoc.....is the revision appears to be at first, the further its influence will extend and more plans will have to be redrawn.

Third Law: If, when the completion of a design is imminent, field dimensions are finally supplied as they actually are-instead of as they were meant to be—it is always simpler to start all over.

Fourth Law: Even If it is impossible to assemble a part incorrectly, still a way will be found to do it wrong.

Corollary I-It is usually unpractical to worry beforehand about interferences—if you have none, someone will make one for yon.

The Law of the Lost Inch:

In designing any type of construction, DO over-all dimension can be totaled correctly after 4 p.m. Friday.

Corollary I—Under the same conditions, if any minor dimensions are given to 1/16 of an inch, they cannot be totaled at all.

Corollary II-The correct total will be self-evident at 9:01 Monday morning.

Deliveries that normally take one day will take five when you are waiting.

When adjusting (or drawing or computing, etc.) remember that the eye of the chief inspector (engineer, draftsman, etc.) is more accurate than the finest Instrument.

Alter adding two weeks to a schedule for unexpected delays, add two more weeks lor unexpected delays.

In any problem, if you find yourself doing an unending amount of work, the answer may be obtained by inspection.

Finagle's Creed:

Science is Truth—don't be misled by facts.

Finagle's Motto:

Smile—tomorrow it will be worse.

ENGINEERS DICTIONARY

REVISED ENGINEERING VOCABULARY

IT IS IN PROCESS: So wrapped up in red tape that the situation is almost hopeless.

WE WILL LOOK INTO IT: By the time the wheel makes a full turn, we assume you will have forgotten about it, too.

A PROGRAM: Any assignment that can't be completed by one telephone call.

EXPEDITE: To confound confusion with commotion.

CHANNELS: The trail left by interoffice memos.

COORDINATOR: The guy who has a desk between two expediters.

CONSULTANT (or expert): Any ordinary guy more than fifty miles from home.

TO ACTIVATE: To make carbons and add more names to the memo.

TO IMPLEMENT A PROGRAM: Hire more people and expand the office.

UNDER CONSIDERATION: Never heard of it.

UNDER ACTIVE CONSIDERATION: We're looking in the files for it.

A MEETING: A mass mulling by master-minds.

A CONFERENCE: A place where conversation is substituted for the dreariness of labor and the loneliness of thought.

TO NEGOTIATE: To seek a meeting of minds without knocking together of heads.

RE-ORIENTATION: Getting used to working again.

RELIABLE SOURCE: The guy you just met.

INFORMED SOURCE: The guy who told the guy you just met.

UNIMPEACHABLE SOURCE: The guy who started the rumor originally.

A CLARIFICATION: To fill in the background with so many details that the foreground goes underground.

WE ARE MAKING A SURVEY: We need more time to think of an answer.

TO NOTE AND INITIAL: Let's spread the responsibility for this.

SEE ME, OR LET'S DISCUSS: Come down to my office, I'm lonesome.

LET'S GET TOGETHER ON THIS: I'm assuming you're as confused as I am.

GIVE US THE BENEFIT OF YOUR PRESENT THINKING: We'll listen to what you have to say as long as it doesn't interfere with what we've already decided to do.

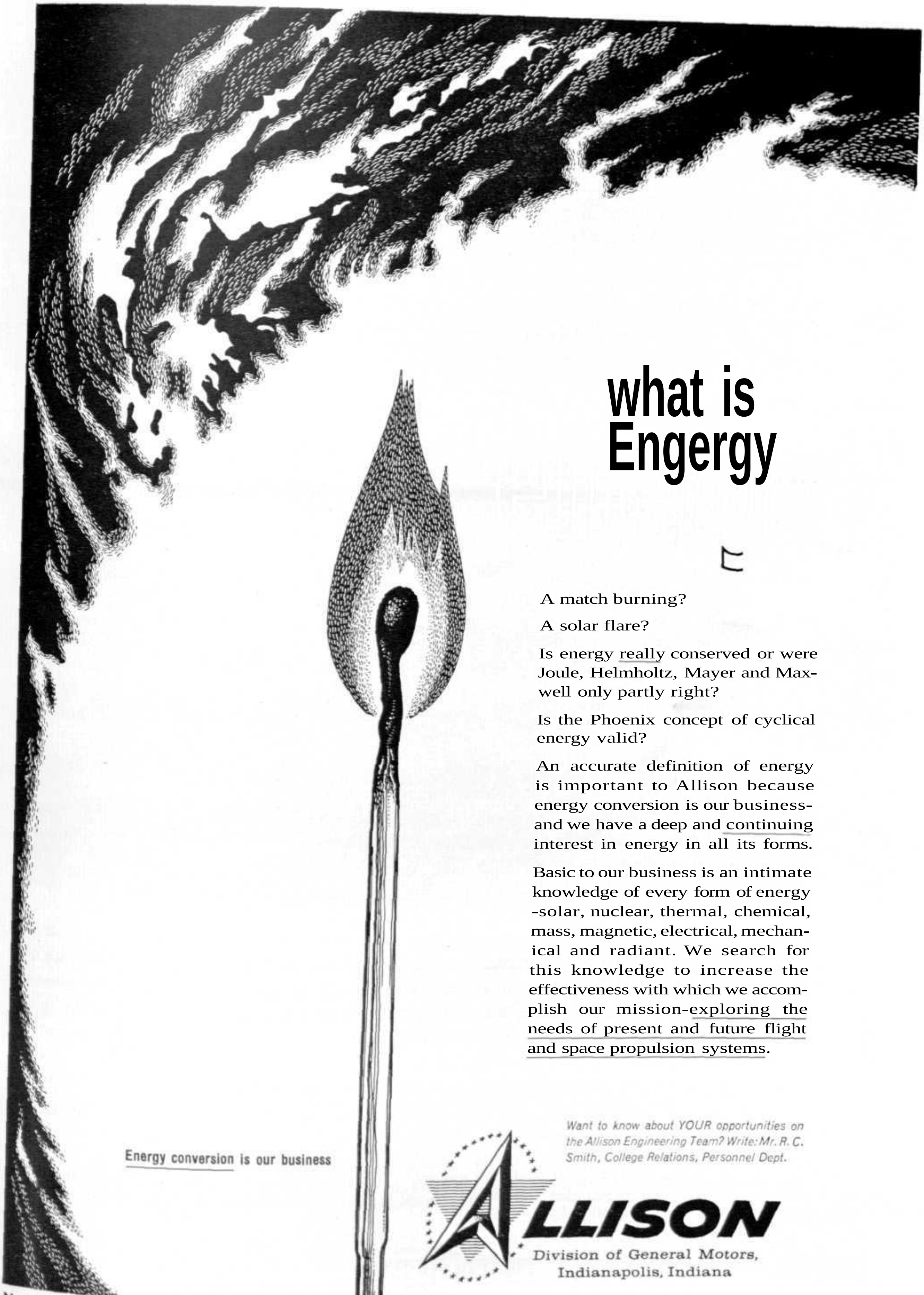
Work with the G A S industry... the nation's sixth largest

H. BROWN BALDWIN
B. S. Mech. Eng., U. of Vermont, 1949.
Began as Cadet Engineer, Boston Gas Co., 1950. Became Staff Engineer in Distribution Development Section, 1952; Staff Engineer in charge of Development, 1955; Distribution planning Engineer, 1956. Worked closely with company's natural gas conversion programs. Now advisor to Distribution Department charged with developing processes, machines, specifications. Assists management in preparing cost estimates, job analyses, other projects.

W. C. DAHLMAN
B. S. Gas Eng., Texas A. & I., 1938.
Began as Engineer trainee with Lone Star Gas Company after graduation from Texas A. & I. with first four-year Gas Engineering degree offered by institution. Joined Houston Natural Gas Company in 1942. Became District Engineer in Texas City and then District Manager in Beeville and El Campo. Dahlman is currently Chief Engineer with full engineering responsibility throughout the twenty counties in the company's Texas Gulf Coast System.

The Gas industry—the sixth largest in the nation—has a total investment of over *$15* billion. Last year the industry set a new all-time record in number of customers, volume of Gas sold, and dollar revenue. In fact, Gas contributed 25% of the total energy needs of the nation as compared with 11.3% in 1940. The Gas industry is a major force in the growth development and economic health of this country.

There are many opportunities for you in the Gas industry. The industry needs engineers, and does not over-hire. You won't be regimented. There's always room for advancement. With utility companies and with manufacturers of Gas equipment, there's a future for you as an engineer. Call your nearest Gas Utility. They'll be glad to talk with you about your opportunity in the Gas industry. •*American Gas Association.*


what is
Engergy
A match burning?
A solar flare?
Is energy really conserved or were Joule, Helmholtz, Mayer and Maxwell only partly right?
Is the Phoenix concept of cyclical energy valid?
An accurate definition of energy is important to Allison because energy conversion is our business-and we have a deep and continuing interest in energy in all its forms.
Basic to our business is an intimate knowledge of every form of energy -solar, nuclear, thermal, chemical, mass, magnetic, electrical, mechanical and radiant. We search for this knowledge to increase the effectiveness with which we accomplish our mission-exploring the needs of present and future flight and space propulsion systems.
Energy conversion is our business
Want to know about YOUR opportunities on the Allison Engineering Team? Write: Mr. R. C. Smith, College Relations, Personnel Dept.
ALLISON
Division of General Motors, Indianapolis, Indiana

Raytheon Graduate Program

FOR STUDY AT HARVARD, M.I.T. AND CALTECH IN 1959-60

HARVARD

The Raytheon Graduate Program has been established to contribute to the technical development of scientists and engineers at Raytheon. It provides the opportunity to selected persons employed by Raytheon, who are accepted as graduate students by Harvard University, Massachusetts Institute of Technology and California Institute of Technology, to pursue at Raytheon's expense, regular courses of study leading to a master's or doctor's degree in science or engineering in the institution of their choice.

M. I. T.

The Program requires, in general, two or three semesters of study, depending on circumstances, with the summer months spent in the Company's research, engineering, or manufacturing divisions. It includes full tuition, fees, book allowances and a salary while at school. Students are eligible for health, accident, retirement and life insurance benefits, annual vacation and other privileges of full-time Raytheon employees.

To be considered for the Program, applicants must have a bachelor's degree in science or engineering, and should have outstanding student records, show technical promise, and possess mature personal characteristics. They may apply for admission to the Program in anticipation of becoming employees of Raytheon.

YOU ARE INVITED TO ADDRESS YOUR INQUIRY to Dr. Ivan A. Getting, Vice President, Engineering and Research, outlining your technical background, academic record, school preference, and field of interest, prior to December 1, 1958.

CALTECH

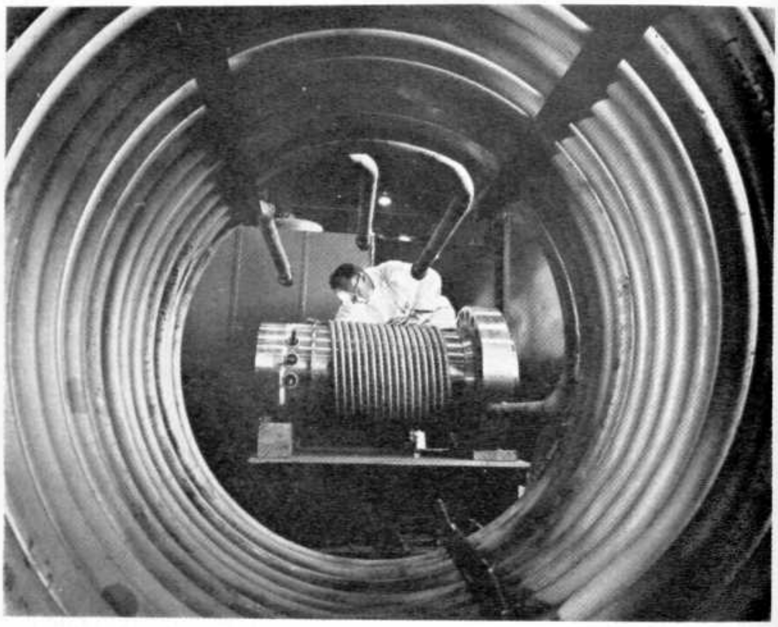
RAYTHEON MANUFACTURING COMPANY, Waltham 54, Mass.

Excellence in Electronics RAYTHEON

NEWS VIEWS

(Courtesy of Westinghouse)

(Right) Seen through a set of cooling coils, a canned motor-pump, rated at 300 horsepower, with its own wrapping of coils is made ready for the atomic power plant. These units will circulate 6,250 gallons of water per minute **through** the primary loop of the reactor to extract its heat. The pumped fluid tills fhe motor cavity, hut is excluded from the rotor and stator windings hecause both the **rotating** and stationary parts of the **pump** are "canned" in corrosion-resistant jackets. The **cooling** coil.s keep motor **temperature!** at satisfactory **operating** levels.

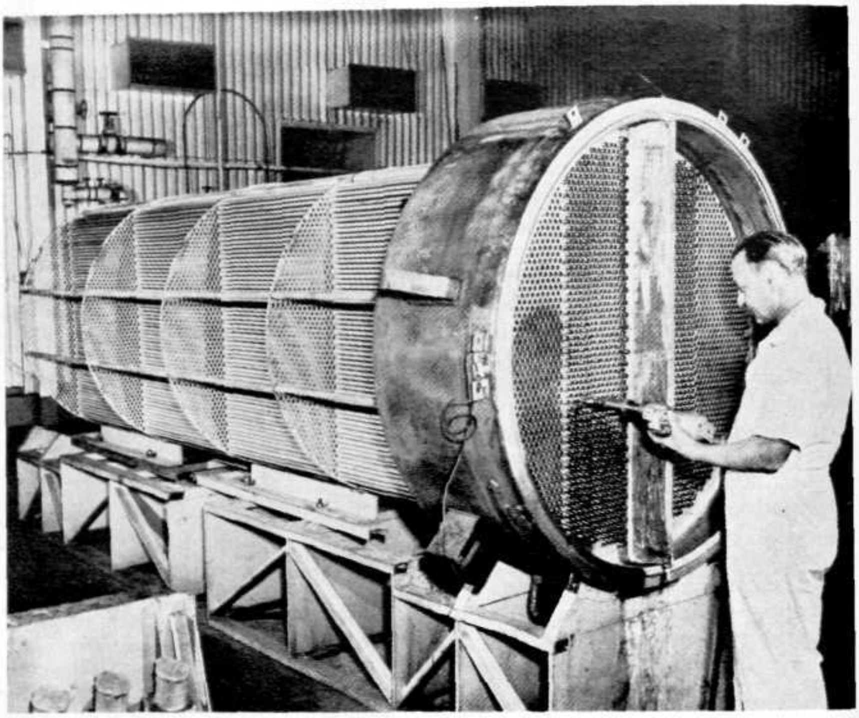


Uranium oxide pellets are loaded into stainless steel tubes approximately four feet in length at the Westinghouse Electric Corporation's atomic power department where the fuel elements are being prepared for Belgium's first atomic power plant. Ninety of these pellets are sealed inside each tube. The core of the nuclear power reactor—first ever exported by an American company—will consist of 32 tube bundles each with a total of 132 tubes bringing together a critical mass of more than 557,000 pellets.

(Continued on Page 54)

NEWS VIEWS

(Continued from Page 50)



Steam from this heat exchanger will spin the turbine generator of Belgium's first atomic power plant. Pictured while under construction at the Westinghouse steam division plant, the heat exchanger will carry within its tubes pressurized water which has been heated to a high temperature by the uranium fuel in the reactor. A secondary flow of water passing around the outside of the tubes will absorb this heat and provide the steam for the turbine.

Digits Are Your Tools

(Continued from Page 25)

One very important type of modern calculator, the binary digital computer, owes its existence, in part, to work done by Leibniz that was of even greater importance than his multiplying machine. The binary computer operates with a system of counting based on a scale of twos which has many advantages over our common decimal scale. It was Leibniz who first noted these advantages. The basic electronic elements of a modern binary computer exist in one of two states, off or on. It is easily seen, then, how a counting system of only two digits, one for each state, is applied.

Up until the end of the 16th century, methods of computation had followed a single line of development, that of digital counting. Even the "pencil and paper" short cuts of direct multiplication and long division, perfected during the 15th century and still used today, are **simply** abbreviated forms of such counting. But in 1590 a new concept in computation was conceived.

In that year John Napier, a Scottish baron and one of the greatest mathematicians of his **day,** discovered logarithms. Through the use of this revolutionary device it became possible to replace tedious multiplication with simple addition.[3] Twenty-five years later and two **years** before his death he published the first logarithm tables. It was soon found that a line scale representing logarithms by distances could be used much faster than Napier tables. It was not long before the idea of using two equal wales appeared, and by 1654 the first slide rule was **invented.**

The second major **development** in the evolution of the slide rule came in 1815 when Dr. Peter M. **Roget**

(Continued on Page .58)

3. Logarithms were developed by Napier from the fact that if one power of a number is multiplied by another power of the same number, the answer will equal the number to a power which is the sum of the two original powers. For example, 2^3 times 2^4 (8 x 16) is equal to 2^7 (128). In this example the number 2 is called the base and the numbers 3, 4 and 7 are called exponents. Napier discovered that any number could be expressed as the power of a common base. Using a base of e (approx. 2.72), he then produced his famous logarithm tables, each logarithm being an exponent of e. By using these tables a mathematician can easily change multiplication into addition.

"At Home On the Moon"

(Continued from Page 27)

like rain of interplanetary meteoric dust which descends with great velocity on the barren surface of the moon. The shield would be 460 feet long, 380 feet wide and 83 feet high.

The entire shell of the building, and the protective barrier, would be fabricated of pre-engineered metal sheets secured by simple nut and bolt fasteners and welded structural connections. A unique "truss-skin" design provides completely useable interiors, without internal supports of any kind.

With space at **a** premium inside the **moon** building, the truss-less concept would eliminate space wasted by ordinary structural supports, while the pre-engineered design would permit quick erection with minimum labor and tools.

Inside the moon building are: living quarters, including rooms for sleeping, cooking, eating, and recreation, physics, chemistry and biological laboratories, a control tower for communication, meteorological studies, earth observations, astronomical observations, traffic control, etc.

Air conditioning, heating, power and refrigeration plants, oxygen producing units, extreme-temperature regulating devices, water supply and sewage processing plants are also included along with machine shop and equipment maintenance areas.

Entrance to the moon building is made through an air-lock at one end, adjacent to which would be constructed a rocket landing area. Complete internal pressurization of the hermetically-sealed building provides an **air** pressure of at least 10 pounds per square inch, close to earth's normal atmospheric pressure of 14.7 pounds, the same as pressure used in high altitude airliners.

Special refrigerating and heating plants cope with the extreme temperatures and tremendous temperature gradients which abound on the moon. Day and night on the moon are about two weeks long, with temperatures at lunar midday reaching 214 degrees F; at sunset, 32 degrees F, and at midnight, —243 degrees F.

There are no windows in the moon building, since ultraviolet radiation, normally absorbed by the earth's atmosphere, would be sufficiently intense to render panes of glass or plastic useless through discoloration. Metal shutters protect the plactic observation bubbles.

—SIDETRACKED—

(Continued from Page 52)

He, as he poured the beer: Say when.
She: Okay, right after the next drink.

° ° °

"Do you smoke?"
"No."
"Do you drink?"
"No."
"Do you neck?"
"No."
"Well what do you do for fun?"
"I tell lies."

° ° °

And then there was the rather forlorn engineer who, on seeing a pigeon flying directly overhead, exclaimed "Go ahead, everyone else does!"

° ° °

He: "Have you heard about the new atomic bra?"
She: "No."
He: "Forty per cent fall out!"

Lecturer: If I talk too long, it's because I forgot my watch and there's no clock in this hall.
Voice from the audience: There's a calendar behind you.

° ° °

Doctor: "How's the engineering patient this morning?"
Nurse: "I think he's regaining consciousness. He tried to blow the foam off his medicine."

° ° °

Don't be afraid to use your brain. It's the little things that count.

° ° °

It seems to me that a lot of enterprising young engineers are spending much of their valuable time tinkering with misses in their motors.

"Make the Most of It?

(Continued from Page 28)

What kind of time are you having in college?

Choose your intimate friends carefully. Deal with them generously; not jealously. Do not monopolize your friends. If you discover a "good egg" pass him around.

Avoid cliques and factions. Create a community of friends.

Guard your health. To do so is Christian; is patriotic; is common sense.

The ideal of Socrates was "not to live long but to live well." One lives well and at one's best when in the best of health.

It is easy to be democratic here. This is a friendly campus. But in being democratic, be yourself. Join in some expressive activity.

Being democratic doesn't mean being slovenly in dress and vulgar in language. Respect all people including yourself. Life is a perpetual struggle for the preservation of self-esteem. In being democratic you may restore self-respect to one who has lost it.

There is an essential and precious loneliness in life. In solitude life may be at its very best, its transcendent highest.

Memory of those deep and solitary experiences of "deep mid-silence," dear vision and firm resolution will strengthen you in the "maddening throng," will comfort disappointed spirits.

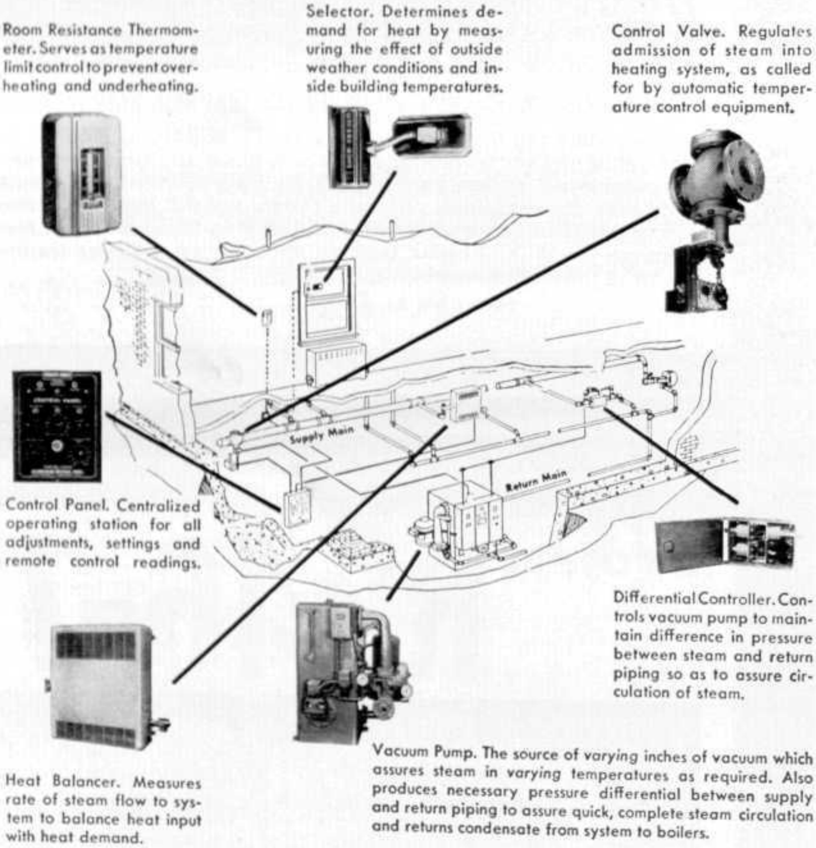
Sixty Degrees C Below To 2,000 Degrees C Above

(*See Frontispiece*)

A completely integrated high-temperature induction melting, sintering, and pressing facility has been put into operation by Westinghouse ceramics engineers at East Pittsburgh, Pa. The laboratory, designed for large-scale research and development work, will help predict product designers' requirements in ceramic materials.

The equipment in the laboratory consists of three basic units: a power supply, a hot press, and a vacuum furnace—equipment that will aid materials development engineers to meet varied demands such as flexibility at 60 degrees C below zero or strength at 2000 degrees C above.

The power supply with an output of up to 40 kw, can be switched to either of the other two units. It provides maximum power for the cost of the equipment, minimum space requirement, and maximum use of the supply.



Digits Are Your Tools

(Continued from Page 55)

developed the log-log scale. This scale made it possible to find any power or root of a number on a slide rule.[4]

Today slide rules have been devised for a large number of specific uses in fields ranging from printing to electrical engineering. Though limited in their degree of accuracy, they are more than adequate for their purposes.[5]

Another distinction claimed by the slide rule is that it was the first calculator built on the analogy principle. All such machines differ from digital calculators in one major respect. Instead of using numbers in their computations, they use physical quantities. In the slide rule the quantity is a magnitude of length; in a modern electronic analog computer it may be a magnitude of current or resistance.

Speculation on the possible uses and future applications of computers is almost limitless. Already psychologists and economists have exploited calculators once used almost exclusively in the physical sciences. Computers have been developed which can run an assembly line, predict the weather, and render a monthly bank statement.

The accomplishments of our computers are at least clever and are often awesome. Indeed, even our amazing Vermont farm boy, Zerah Colbum, seems dwarfed before our more advanced creations of steel and electricity. But is he? For that matter, is any human being?

Anything man invents is nothing more than an extension of his own powers, be it lever or digital computer. This may not always be true, but it certainly is now. Whatever the capacity of a calculator, it still takes a man with his ten gifted digits to operate it.

4. The logarithm of any power of a number is simply the number's logarithm multiplied by the number's exponent. For instance, the logarithm of 5 to the 12th power is equal to 12 times the logarithm of 5 ($\log 5^{12} = 12 \times \log 5$). The log-log scale represents the logarithms of logarithms. Through its use 12 times log 5 becomes log 12 plus log-log 5, and addition once more replaces multiplication.
5. A slide rule answer is usually to three significant figures. For example, the product, 723 x 846, multiplied on a ten inch rule will be read 612,000 rather than the completely accurate answer of 611,658.

Power On the Moon

(Continued from Page 29)

will be stretched and supported over several acres of the moon's surface. Coated **on** these sheets would be an extremely thin layer (about one micron thick) of photosensitive material.

A thin wire mesh will then be placed parallel to, but slightly separated from the plastic sheet and insulated from it. The photoelectric generator would then be ready to produce electric power.

As the sun's rays strike the plastic sheet, the coated surface will emit electrons. These electrons will strike the wire mesh generating a voltage. Upon closing the circuit between the wire grid and the coated surface through a suitable load, current will flow.

This type of electric power plant is the lightest known to man. The total weight of required material would amount to about three pounds per kilowatt.

"In practice," said Dr. Castruccio, "since the voltage generated by each cell is only a few volts, several cells need be connected in series. This can be done quite easily by separating the sheets into several sections by insulating strips, and connecting the sections in series. Doing this, practically any voltage, including 110 volts dc, can be obtained."

A key factor in the operation of such a power supply is that a vacuum must exist as in an electronic tube. Since the surface of the moon is not surrounded by an atmosphere, this condition is present.

Another road block to practical **generation** of photoelectric power is the internal impedance of the unit, Photoelectric cells constructed in **the past had** internal impedance in the order of **one** megohm. Work at the Astronautics Institute of Westinghouse has yielded cells with impedances of about 3000 ohms. Dr. Castruccio said, and new structures have been developed which promise in the near future to have impedances **of only about 0.1 ohm.**

As to solar conversion efficiencies, Dr. Castruccio pointed out that insight gained into the Photoelectric phenomenon now shows promise of **generators having up to 25 percent** efficiency. This compares with about 35 percent for the **conventional earth-**bound generating station. Achievement of this 25 percent would mean

(Continued on Page 61)

Power On the Moon

(Continued from Page 59)

power yields of about 1500 kvv per acre on the moon with the sun at zenith.

Once the power station is constructed, it would operate for 14 days at a time since there are 14 days of sunshine followed by 14 nights. Scientists envision construction and interconnection of a number of these power stations all around the surface of the moon. With this type of lunar electrical network, continuous power would be assured to any point on the moon.

Dr. Castruccio said some of the materials needed to construct the lunar power station may be found on the moon itself though no way is presently available for on-the-moon conversion of such raw materials into usable products. He added, however, that scientists are investigating ways of determining the presence and properties of the moon's materials through the use of unmanned lunar probes or satellites.

Boyd, referring to the Astronautics Institute, said the organization is concentrating its efforts on the solution of problems directly related to space technology.

"Ventures into space can be divided into **two** distinct phases," Boyd continued. "There are, of course, the Prestige exploits for psychological and propaganda warfare purposes. But more important, there are the solid, gradual and methodical advances toward the conquest of space with a minimum economic burden to the country.

In supporting this latter phase, he said much time has been spent investigating space problems over **the** Past few years with the certain **expectation** that one **day** these scientific hopes will become realities.

Three Challenging Questions

(Continued from Page 17)

With the plan of approach and a means of power determined, only two considerations remain in the question of "how?" These are the space ship's design, and the safety of its crew.

By constructing and launching the ship from a space platform, a great deal of freedom in design can be realized. Vehicles designed to travel at high speeds in an atmosphere must contend with air resistance. This fac-

(Continued on Page 63)

M. E. Labs Use Miniature Equipment

(Continued from Page 32)

tion of the blower speed is accomplished by a Reeves variable speed drive between motor and blower. In this case the torque is measured by means of an electric strain guage torque meter. As in the first case, the whole assembly is mounted on casters and is self-contained.

(3) Centrifugal pump. A small centrifugal pump will illustrate the laws of such a pump just as well as a large one. Therefore, this new pump has only a half-inch pipe connection for discharge, a three-quarter inch pipe connection for suction, and is driven by a one-third horsepower motor. The motor is directly connected to the pump, and the speed is measured by means of a transducer and an electronic counter. As in the case of the low speed blower, the torque is measured by means of a spring coupling and a stroboscopic light. A Flowrator measures the rate at which water is being pumped, and its accuracy is checked by means of a weighing tank. Suction and discharge pressures may be measured either by monometers or by the usual pressure gauges. The sump tank for this equipment is two feet nine inches wide, seven feet nine inches long, and two feet deep. The tank is mounted on casters and the rest of the equipment at the two ends of the tank, pump and motor at one end and weighing tank and scales at the other end.

Two small Diesel engines are now being mounted in somewhat the same way except that they with their dynamometers are a little too heavy to mount on casters. They are so mounted that they can be skidded from one location to the other; but they have, of course much less mobility than the fans and pump. The smaller of them is one cylinder four cycle engine which drives a small electric dynamometer. Several things about this setup are worth noting.

(1) It is independent of direct current for excitation by having its own transformer and rectifier so that the dynamometer field circuit can be excited from the regular 110 volt outlets.

(2) It has a pressure pickup in the combustion chamber now. We plan soon to have two pressure pickups in different parts of the combustion chamber, either by putting a second pickup in the present cylinder head or, if that should be impracticable, we shall make a new cylinder head out of welded plate so that we can have two pressure connections. By the use of a double-beam oscilloscope, speed of pressure travels across the combustion chamber.

(3) The cam drive mechanism is being altered now so that the injection timing can be varied while the engine is running, over a maximum of perhaps 45 degrees of crank shaft travel.

(4) The governor has been disconnected; and the amount of fuel injected will be controlled by a hand lever similar to the throttle in a gasoline engine.

The second of these two diesel engines is two-cylinder four-cycle and probably not subject to many alterations.

These diesel engines are taking the place of a large two-cycle one-cylinder slow speed diesel which formerly occupied more laboratory space than the two small ones will occupy.

If these things can be called miniaturization, then we are finding them extremely satisfactory.

(1) The apparatus is relatively inexpensive, and several pieces of small sized equipment can be had for the price of one large piece.

(2) Alterations can be made rather inexpensively in the equipment which make it much more valuable from the standpoint of emphasizing fundamental principles rather than routine tests on commercial equipment.

(3) The space saving features of such equipment are valuable not only because of the smaller size but because a piece of equipment which is not in use can be shoved aside temporarily.

(4) The student is much better able to study the whole process and to see the functioning of the equipment as a whole than he is in the case of large apparatus.

(5) By making it economically possible to have duplication of apparatus, the student is able to use data which he himself took.

Our experiences in carryingout this philosophy have so far been extremely satisfactory, and we expect to continue along this same line wherever possible.

Three Challenging Questions

(*Continued from Page 61*)

tor accounts for the restrictive streamlined construction of jet aircraft and ballistic missiles. As altitude increases, the atmosphere of the earth diminishes **gradually until, at** 120 miles, the air is so thin that the finest vacuum created on earth cannot equal it. By the time the altitude of the manned satellite **is** reached the atmosphere will have long since vanished. At its destination the moon rocket **will** encounter no air for the moon is void of atmosphere. Therefore, because it need not be streamlined, **the** moon rocket can **be built in any** shape considered practical for its purpose.

The problem of **crew safety** has already been studied in depth. Some answers have been found; others **will** call for much more **research.** This is being conducted by both the U. S. Air Force and the **U.** S. **Navy,** and covers such knotty problems as the elimination and disposal of **body** wastes, the dangers of cosmic radiation and psychological pressures of confinement in the total isolation of space. These problems will not **be** quickly or easily **solved,** but the men now working on them seem confident at they **eventually** will be.

For most of us the second question. "Why?" comes **normally before** How?" Whether we are building a barbecue pit, or buying a **new** car. **we** know our reasons before we go ahead with the details. For the scientist, "Why?" goes without **saying. He already** has his answer. He is **seeking** knowledge for its own sake. Many of us may shudder and mourn the loss of **our** tax dollars **to** such ivory tower **goings on,** but **we** cannot escape the **fact** that **such** pure research is **basically responsible for** most of the **technological** wonders **we enjoy today.** There is **little reason** to believe that the **exploration** of space will be any less **fruitful.** One **anticipated dividend of a successful** flight to the **moon is** world-wide **weather. observation on a scale never before possible. This would be a major step toward the obvious** benefits **of complete weather** control.

There is another answer to the question, "Why?" which, if less practical, is perhaps equally as **compelling. Few will deny the value of meeting and mastering challenge.**

Three Challenging Questions

(*Continued from Page 63*)

Such value, if only in terms of human dignity, would be immeasurable should mankind meet the challenge of outer space and reach the moon.

The third, final and certainly most suspenseful question is "When?" In partial answer to this the President's Science Advisory Committee has recently prepared a ten-page space primer, which was commended by Mr. Eisenhower "to all the peoples of the world." According to this document the first vehicle to reach the moon will be an unmanned probe rocket which will measure more precisely the moon's mass and gravity.

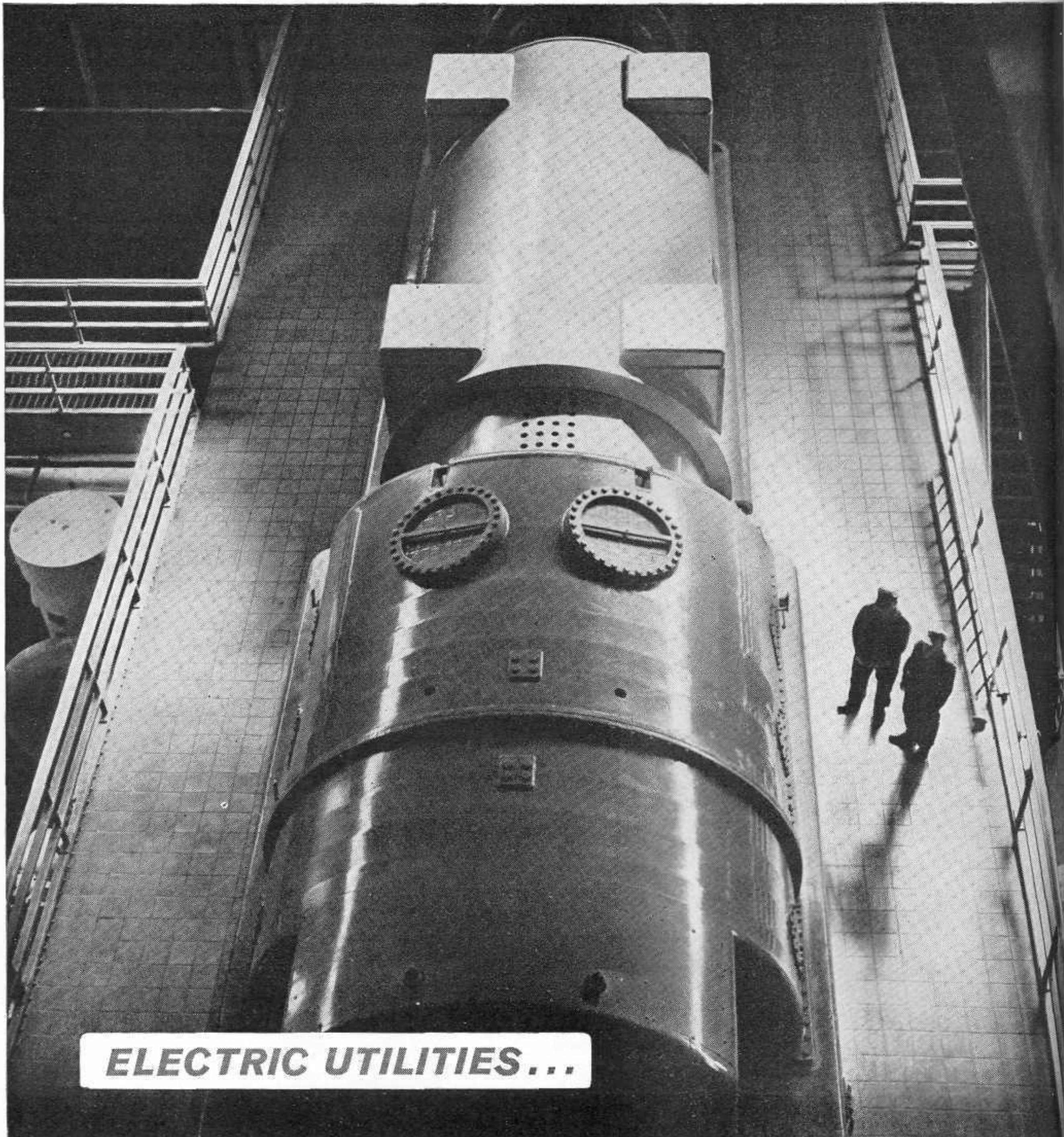
The Pioneer, fired by the Air Force early last month, was intended to accomplish this probe, and give us our first view of the moon's mysterious far side as well.

The next step, still an unmanned rocket, will actually land *on* the moon. It will contain several pounds of sensitive scientific equipment designed to measure precisely the nature of the moon's surface and determine the conditions to be anticipated by the crew of the first manned ship.

Since each successive step will determine to some degree the amount of time before the next, it becomes progressively difficult to predict with certainty when each will take place. It seems probable, however, that we will see the first man on the moon within the next twenty years, and almost certain that he will make it before the end of this century.

The challenge of the moon is being met. The first attempt by the United States to unleash the moon-bound Pioneer on October 11, 1958, was reasonably successful. Although the rocket did not follow the planned trajectory, it did transmit back to scientists important data on cosmic rays, and established a distance record into space of 79,800 miles for a man-made projectile.

The question, "How?" seems nearly answered. The question, "Why?" has already been answered for many of us; for some, unfortunately, it can never be answered, but even these must find their lives affected by the undeniable reply of "soon" to the question, "When?"



Where the Engineer Designs His Own Career

Here's an industry that started big after the war . . . surged ahead in every direction . . . keeps on growing today when others are tapering off . . . and still has its biggest years ahead. The electric utilities business is basically an engineering business. Many of its top executives come from engineering ranks; from systems planning, design, operations, research, or sales; and with backgrounds ranging from electronics and nucleonics to older branches of scientific learning. If you want a career in an *expanding* industry that is based on engineering look to our electric public utilities. We know you'll like working with them. We have been doing it for many years in supplying this great industry with Kerite quality insulated wire and cable. See your placement officer, or write us at 30 Church Street, New York 7, N. Y.

KERITE CABLE

it's the **KERITE** *that makes the difference*

Which of the following are practical applications of COPPER or COPPER ALLOYS?

- ☐ 1. Ship fittings.
- ☐ 2. Television antennae.
- ☐ 3. Heat sinks for missile nose cones.
- ☐ 4. Architectural extrusions.
- ☐ 5. Prefabricated plumbing lines.
- ☐ 6. Pipelines for sodium hydroxide.
- ☐ 7. Collector vanes for solar heating.
- ☐ 8. Resistance heating elements.
- ☐ 9. Resistance-welding electrodes.
- ☐ 10. Gold-plated jewelry.

Now try your hand at these True-False Selections:

- ☐ 11. Proved copper reserves have decreased in the last 20 years. ☐T, ☐F.
- ☐ 12. On the machinability rating scale, Free-Cutting Brass rates 100. ☐T, ☐F.
- ☐ 13. The green patina of copper can be developed artificially. ☐T, ☐F.
- ☐ 14. Copper and copper alloy parts should be joined only by riveting. ☐T, ☐F.
- ☐ 15. Nickel Silver is an alloy of nickel and silver. ☐T, ☐F.

1. Yes. Copper, and many of its alloys, have excellent resistance to salt water corrosion.

2. No. The important properties of copper are not needed and lighter, cheaper metals are usually used.

3. Yes. Copper's high heat conductivity protects the delicate instruments inside by quickly dissipating the surface heat of re-entry.

4. Yes. Architectural bronze extrudes readily and is used for a wide variety of architectural shapes.

5. Yes. Because copper tubing can be easily and firmly soldered, it lends itself well to prefabrication. The few unassembled joints are soldered on the site, eliminating the use of threaded fittings.

6. Yes. Copper-nickel alloys have good resistance to many alkalies and are often used in contact with them.

7. Yes. Large vanes of copper are blackened and mounted on a roof to collect the sun's rays. The high thermal conductivity of copper makes it very efficient for this use. The copper carries the heat to a circulating water system.

8. No. The conductivity of copper and its alloys is too high for this purpose.

9. Yes. Here the current is introduced through the electrodes to the parts to be welded. Several copper alloys are well suited for this use because of their high strength at elevated temperatures.

10. Yes. The low-zinc brasses are easily worked and are readily plated for high-quality costume jewelry. Most copper alloys lend themselves well to polishing and plating.

11. False. Reserves have increased. Published figures are no indication of long run availability or total mineral deposits. The industry lists only those reserves which have been "proved" for immediate development. Since the copper industry has grown in these years, so, too, have the proved reserves. Future copper supplies are vastly greater than any known "reserve" figures would indicate.

12. True. Free-Cutting Brass usually can be turned at maximum spindle speed and many other copper alloys at high speeds. A large number of copper alloys are available for easy machining.

13. True. The Copper & Brass Research Association has developed a spray process which has been successfully used to give architectural and ornamental parts an attractive green patina much faster than nature would do it.

14. False. Good joints between copper or copper alloy parts can be made by soldering, brazing or welding.

15. False. The Nickel Silvers are copper alloys. They derive their name from their silver-like color. A typical composition is 65% copper, 18% nickel, 17% zinc, and no silver at all.

The copper alloys, of which there are more than forty that are standard and many more that are special in current use, have many properties just as unique as this "silver" that isn't silver. If you'd like to learn more about them, or if you really flunked this quiz, send for your copy of "A Guide to Copper and its Alloys." The Copper & Brass Research Association, 420 Lexington Avenue, New York 17, N. Y., will be happy to supply it.

HUGHES MASTER FELLOWSHIPS

THE MASTER'S FELLOWSHIP PROGRAM offers direct exposure to a potential professional field combined with **academic training** leading to a Master's degree.

One hundred and thirty-five awards are open to applicants receiving their Bachelor's degree during the coming year in Aeronautical Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering or Physics.

You will pursue a two-year schedule of laboratory work and graduate study. During the summer, you will have the opportunity to work under the guidance of experienced scientists and engineers. You may elect assignments based on your interest and technical experience in Radar Systems, Servomechanisms, Computers, Systems Analysis, Information Theory, Automatic Controls, Physical Analysis, Microwave Tubes, Pulse Circuitry, Semiconductor Physics, Photo Devices, Test Equipment Design, Miniaturization, Electro-mechanical Design, Gyros, Hydraulics, Subminiaturization, Mechanical Design, Instrumentation, Telemetering, Antennas and Wave Guides.

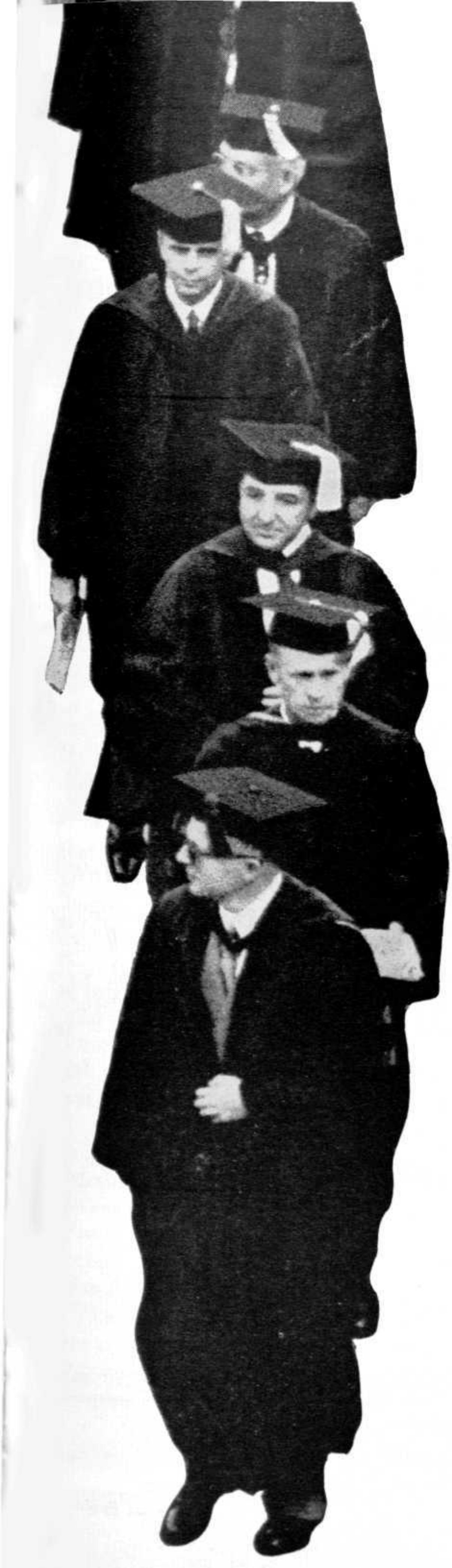
You may request your graduate school from the following seven institutions: University of Southern California, Stanford University, UCLA, University of Arizona, Purdue University, California Institute of Technology, and University of West Virginia.

Fifteen awards are open to applicants receiving their Bachelor's degree in Business Administration during the coming year. The work program will involve interesting assignments in the administrative areas of the company and graduate study will be at UCLA or University of Southern California.

Salary is commensurate with your ability and experience and all company benefits are extended to those participating in **the** program. Tuition, fees, books and thesis preparation and reproduction expenses are provided and travel expenses outside of the Southern California area are paid.

Upon attainment of Master's degree, Fellows may apply for the Hughes Staff Doctoral Fellowship Program.

Consult your College Placement Officer for interview information. Or, write to the Office of Advanced Studies at the address at right.



HOWARD HUGHES DOCTORAL FELLOWSHIPS

If you are interested in studies leading to a Doctor's degree or in post-doctoral research, you are invited to apply for one of the ten awards in the Howard Hughes Fellowship Program.

This unique program offers the doctoral candidate the optimum combination of high-level academic study at California Institute of Technology, and practical industrial experience in Hughes laboratories.

The Howard Hughes Doctoral Fellowship provides an annual award of approximately S7200, of which S1800 is for tuition, books, fees, thesis and research expenses. The remainder is the award of a cash stipend and salary earned by the Fellow.

You should plan to pursue research in the fields of Electronics Engineering, Microwave Physics, Mechanical Engineering, Electron Dynamics, Electronic Computing, Physical Electronics, Propulsion Engineering, Salid State Physics, Aerodynamics, Analytical Mechanics or Information Theory.

The Fellowships are open to students qualified for admission to graduate standing. A Master's Degree or equivalent graduate work must have been completed before beginning the Fellowship Program.

Application closing date: January 15, 1959

HOW TO APPLY: *For information concerning either of the Hughes programs described, write, specifying program of your interest, to: Office oj Advanced Studies—P.G.O., Building 6, Hughes Aircraft Company, Culver City, California.*

The classified nature oj Hughes work makes ability to obtain security clearance a requirement.

the West's leader in advanced electronics

HUGHES

Hughes Aircraft Company, Culver City, California

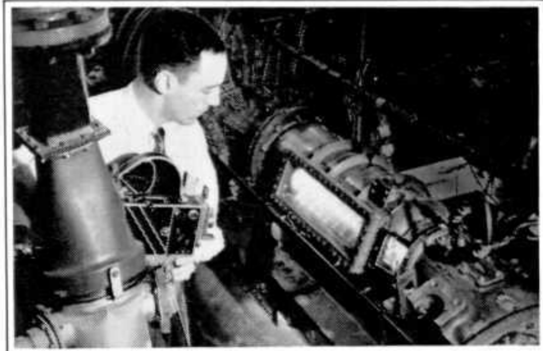
HALF-MILLION POUND PACKAGE— Tilted by the tremendous weight of the huge 467,000-pound generator stator for the Boston Edison Company's Mystic lower station, Everett, Mass., is the MONARCH, the heaviest lift commercial derrick on the east coast. It required nearly the maximum lifting ability of the MONARCH to lift the generator stator and place it on the deck of the reinforced-hull derrick CATSKILL.

ADVERTISERS' INDEX

* Inside back cover
'* Back cover
*** Inside front cover

PHOTOGRAPHY AT WORK—No. 35 in a Kodak Series

For Jets
more thrust, more range, more payload



The motion picture camera is seeing into a turbo-jet combustion chamber operating on a new fuel.

With photography as a tool, the N.A.C.A. Lewis Flight Propulsion Laboratory studies jet engine combustion chambers, and compounds that can result in new high-energy jet fuels

How much faster and farther our aircraft and missiles can go seems now to depend on developing new high-energy fuels. This is a job of the Lewis Laboratory of the National Advisory Committee for Aeronautics.

And as in all kinds of industry, photography is playing an important role in this work. Motion pictures are taken of the interior of jet engine chambers through transparent walls. From the pictures the scientist learns the behavior of the fuel, the flame and exhaust through the engine turbine and tail pipe.

The use of photography in research and the development of new or better products is but one of the ways it is helping all kinds of businesses, large and small alike.

CAREERS WITH KODAK

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production.

If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N.Y.

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Interview with General Electric's
Frank T. Lewis
Mgr., Manufacturing Personnel Development

The Next Four Years: Your Most Important

The United States is now doubling its use of electrical energy every eight years. In order to maintain its position as the leading manufacturer in this fast-growing electrical industry, General Electric is vitally interested in the development of young engineers. Here, Mr. Lewis answers some questions concerning your personal development.

Q. Mr. Lewis, do you think, on entering industry, it's best to specialize immediately, or get broad experience first?

A. Let me give you somewhat of a double-barreled answer. We at General Electric think it's best to get broad experience in a specialized field. By that, I mean our training programs allow you to select the special kind of work which meets your interests—manufacturing, engineering, or technical marketing—and then rotate assignments to give you broad experience within that area.

Q. Are training assignments of a predetermined length and type or does the individual have some influence in determining them?

A. Training programs, by virtue of being programs, have outlined assignments but still provide real opportunities for self-development. We try our best to tailor assignments to the individual's desires and demonstrated abilities.

Q. Do you mean, then, that I could just stay on a job if I like it?

A. That's right. Our programs are both to train you and help you find your place. If you find it somewhere along the way, to your satisfaction and ours, fine.

Q. What types of study courses are included in the training programs and when are the courses taken?

A. Each of our programs has graduate-level courses conducted by experienced G-E engineers. These courses supplement your college training and tie it in with required industrial techniques. Some are taken on Company time, some on your own.

Q. What kind of help do you offer employees in getting graduate schooling?

A. G.E.'s two principal programs of graduate study aid are the Honors Program and the Tuition Refund Program. If accepted on the Honors Program you can obtain a master's degree, tuition free, in 18 months while earning up to 75% of full-time salary. The Tuition Refund Program offers you up to 100% refund of tuition and related fees when you complete graduate courses approved by your department manager. These courses are taken outside normal working hours and must be related to your field of work.

Q. What are the benefits of joining a company first, then going into military service if necessary.

A. We work it this way. If you are hired and are only with the Company a week before reporting to military service, you are considered to be performing continuous service while you are away and you will have your job when you return. In determining your starting salary again, due consideration is given experience you've gained and changes in salary structure made in your absence. In addition, you accrue pension and paid-vacation rights.

Q. Do you advise getting a professional engineer's license? What's it worth to me?

A. There are only a few cases where a license is required at G.E., but we certainly encourage all engineers to strive for one. At present, nearly a quarter of our engineers are licensed and the percentage is constantly increasing. What's it worth? A license gives you professional status and the recognition and prestige that go with it. You may find, in years to come, that a license will be required in more and more instances. Now, while your studies are fresh in your mind, is the best time to undertake the requirements.

Your next four years *are* most important. During that period you'll undoubtedly make your important career decisions, select and complete training programs to supplement your academic training, and pursue graduate schooling, if you choose. These are the years for personal development — for shaping yourself to the needs of the future. If you have questions **still** unanswered, write to me at Section 959-6, General Electric Co., Schenectady 5, N. Y.

LOOK FOR other interviews discussing: • Salary • Advancement in Large Companies • Qualities We Look for in Young Engineers.

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