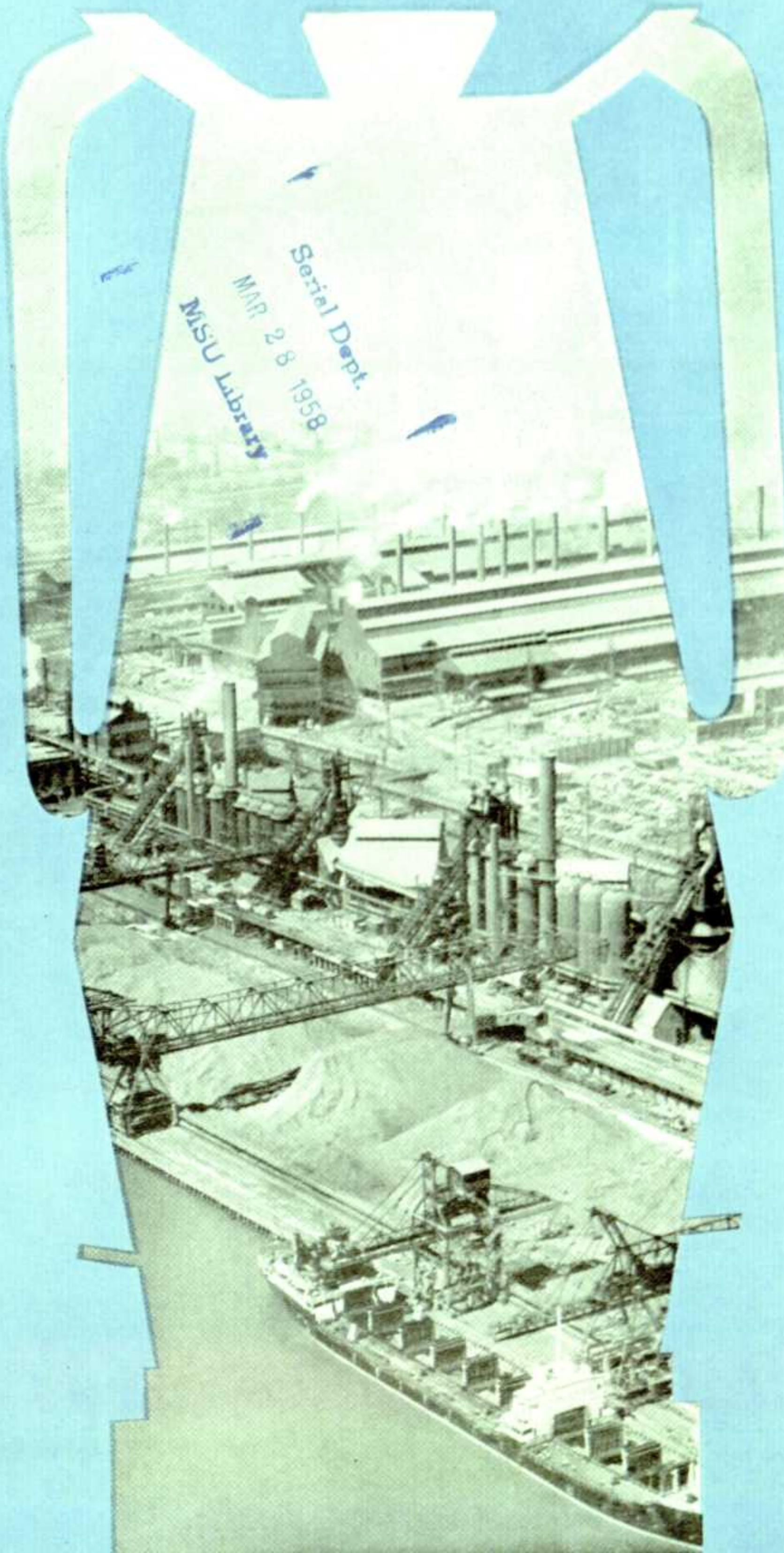
Spartan Engineer



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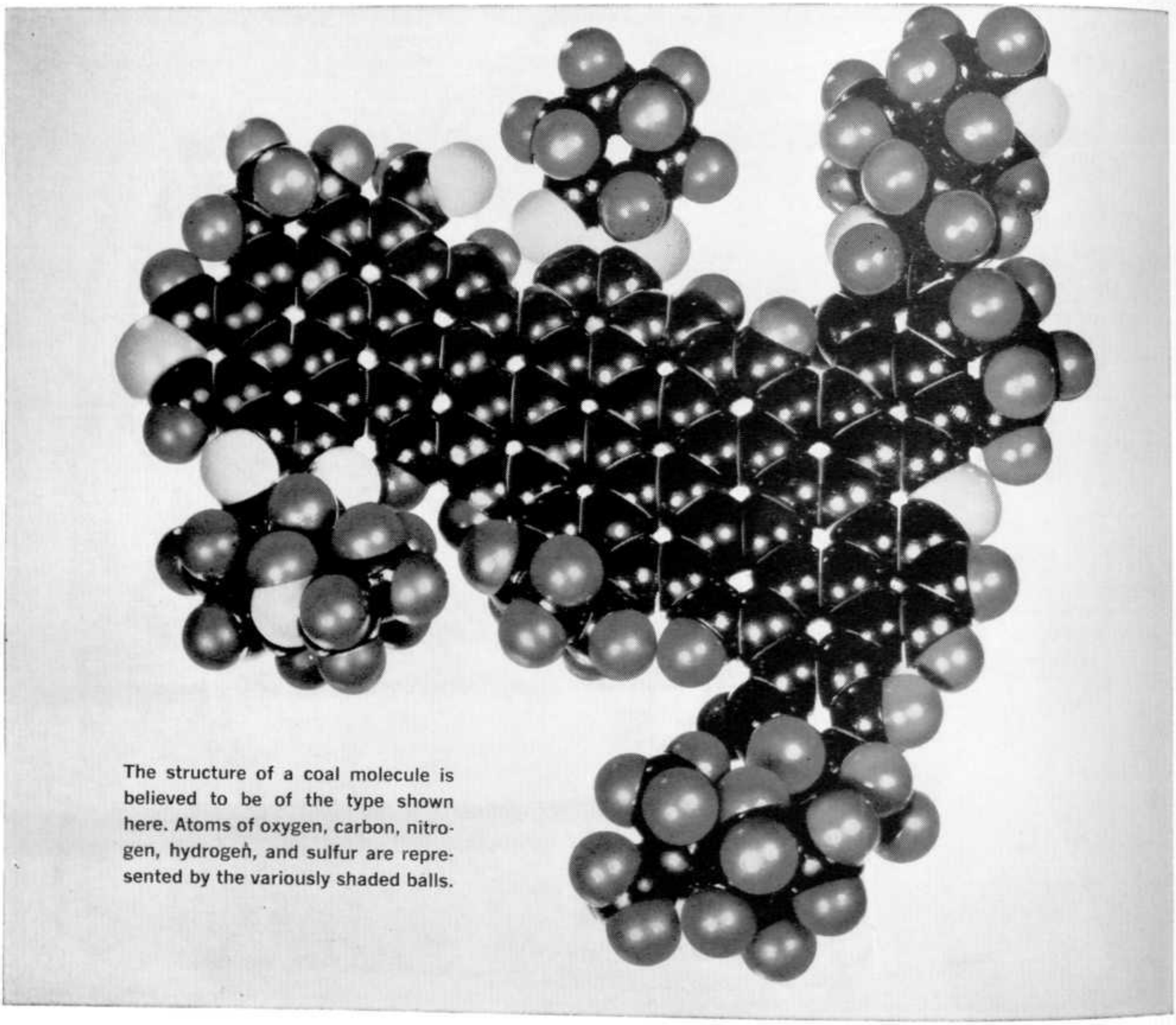


The structure of a coal molecule is believed to be of the type shown here. Atoms of oxygen, carbon, nitrogen, hydrogen, and sulfur are represented by the variously shaded balls.

Here's the alma mater of 200,000 successful grads

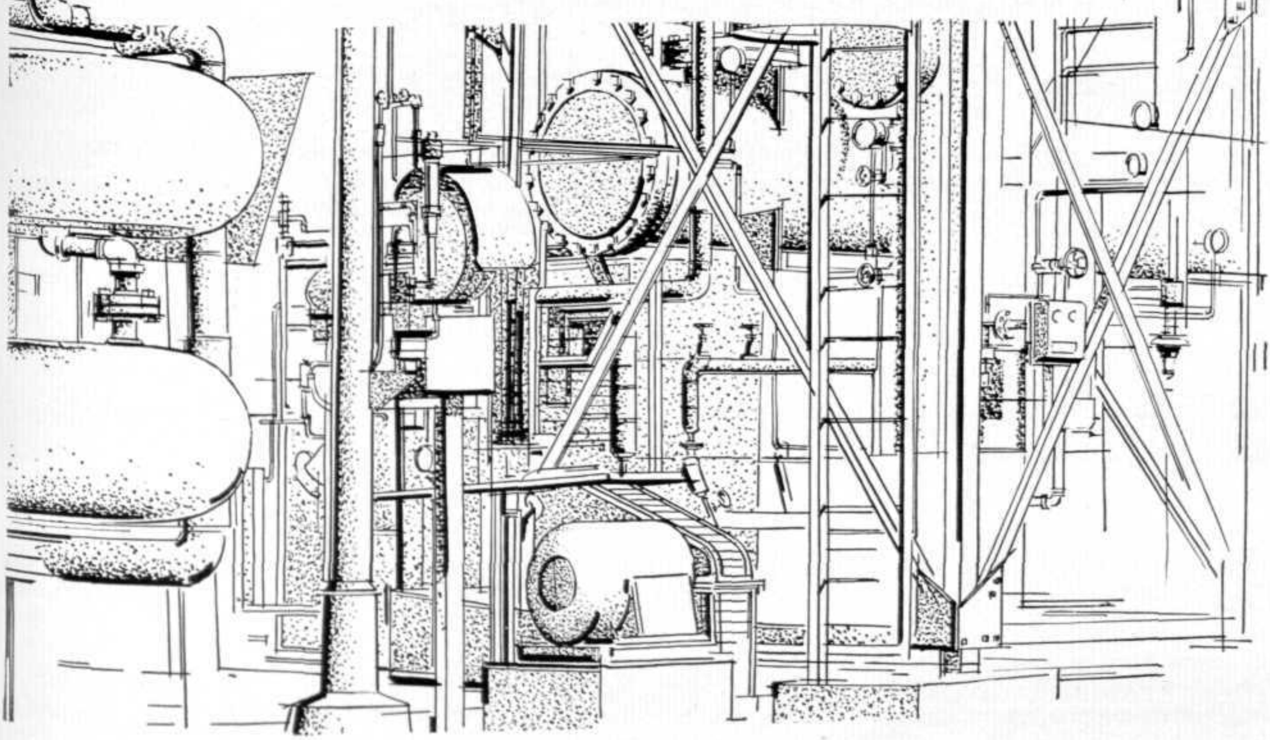
More than 1900 chemicals have been found in coal, and over 200,000 different products are made from them—products like plastics, synthetic rubber, synthetic fibers, and resins. There's still more to come. Only a fraction of the 1900 chemicals in coal are currently used commercially.

Today, United States Steel and other producers of coal chemicals continue to study coal, its structure, and its future potential as a source of basic chemicals.

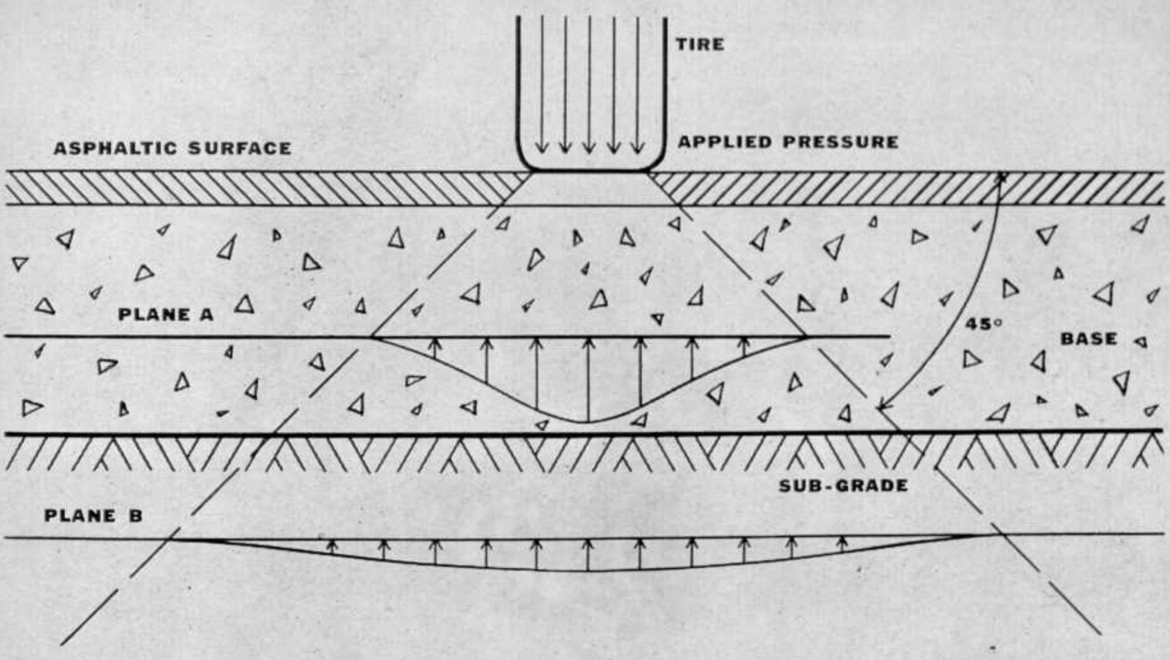
Why, you may ask, are we so interested in chemicals when our principal business is steel? The reason is that it's just good business. In producing coke for our steel-making operations, we also produce chemicals. Thus we are always interested in anything, and *anybody,* that will help to advance the technology of these related products, improve their quality and in general reduce the over-all cost of manufacture and provide better products and better service for our customers.

It's a big job and we need a lot of good people to do it—physicists, chemists, geologists, all kinds of engineers—people with *your* training. If you want to explore the earth's surface for ore, delve into the commercial use of coal chemicals, help rocket designers solve new problems with new steels, there might well be a place for you at United States Steel. Write for our booklet, "Paths of Opportunity"—United States Steel, Personnel Division, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

USS United States Steel

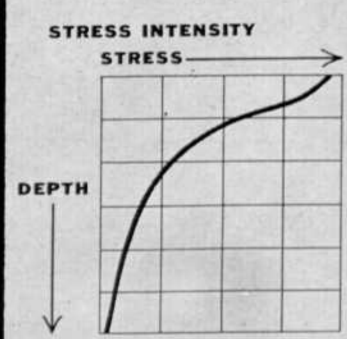


ASPHALT ENGINEERING BULLETIN #4



Assume a loaded wheel on a typical Asphalt pavement consisting of Asphalt surface, base course and natural sub-grade. The entire load is transmitted to the pavement by the tire. The load, applied at the surface, is distributed downward and outward through the Asphalt pavement and base into the native soil or sub-grade. The load spreads out at an angle of approximately 45° in the manner indicated above.

Look at the curved line. It shows the approximate manner in which intensity of stresses in flexible type pavements decreases in depth. The total load affects the shape of the curve: the greater the unit load, the greater the stress at the given depth . . . except that it cannot exceed 100% of the contact pressure at the surface.



Design of flexible ASPHALT pavement

The flexibility of modern Asphalt Pavement is one of the great achievements of scientific road-building.

It is the planned result of layer-"Pon-layer construction that "locks" surface to foundation to help spread the weight load, absorb shock and pounding without cracking.

Modern Asphalt paving is designed to make maximum use of native soil and other native materials such as sand, stone, slag and gravel. This is one important reason for the economy of modern Asphalt roads.

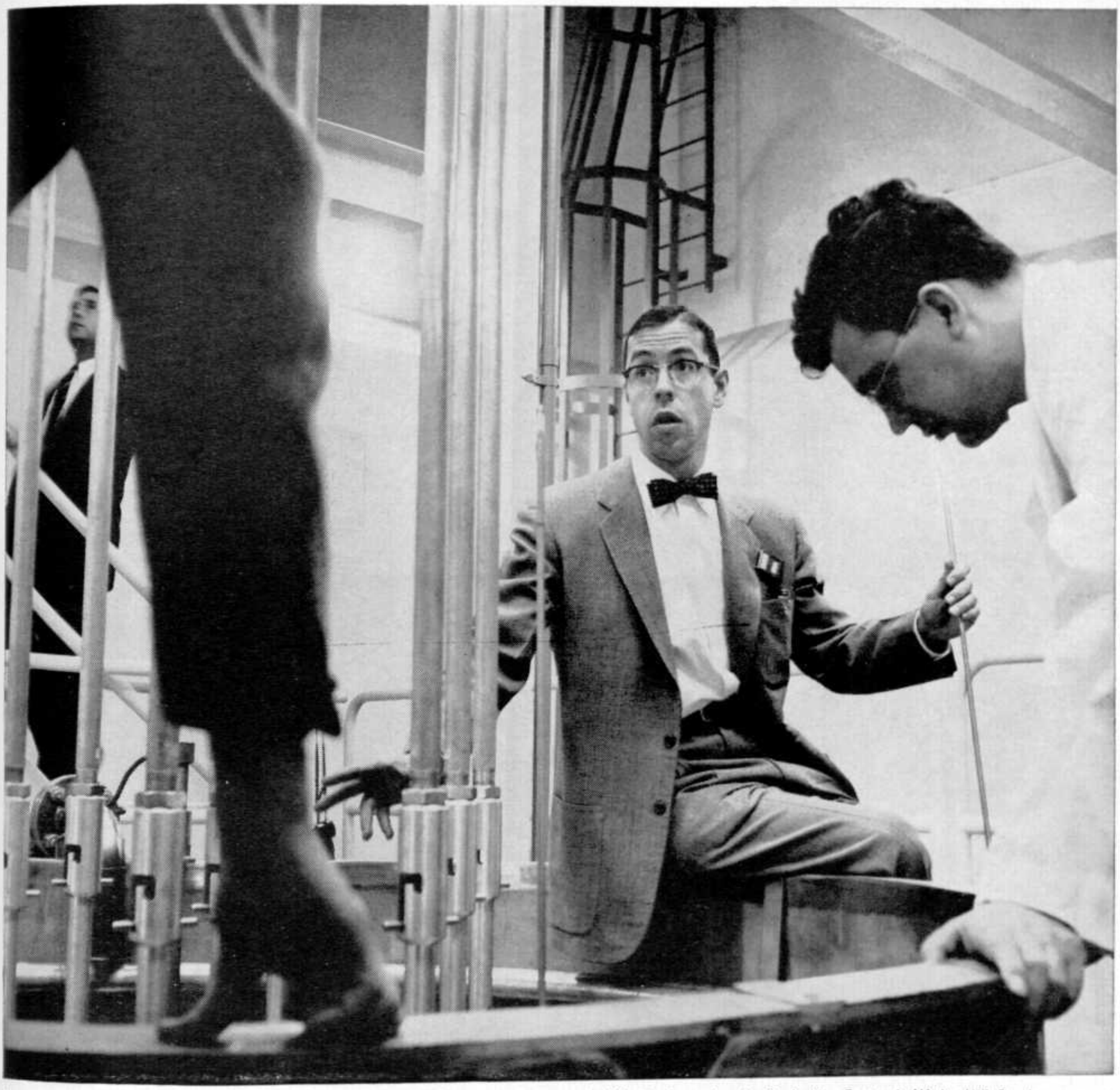
Study the diagrams on this page. They show how the load is distributed on modern Asphalt construction and how the maximum stress varies with depth of pavement.

Be sure to cut out and file this data theft and those previously inserted in this publication. Make them your professional reference material.

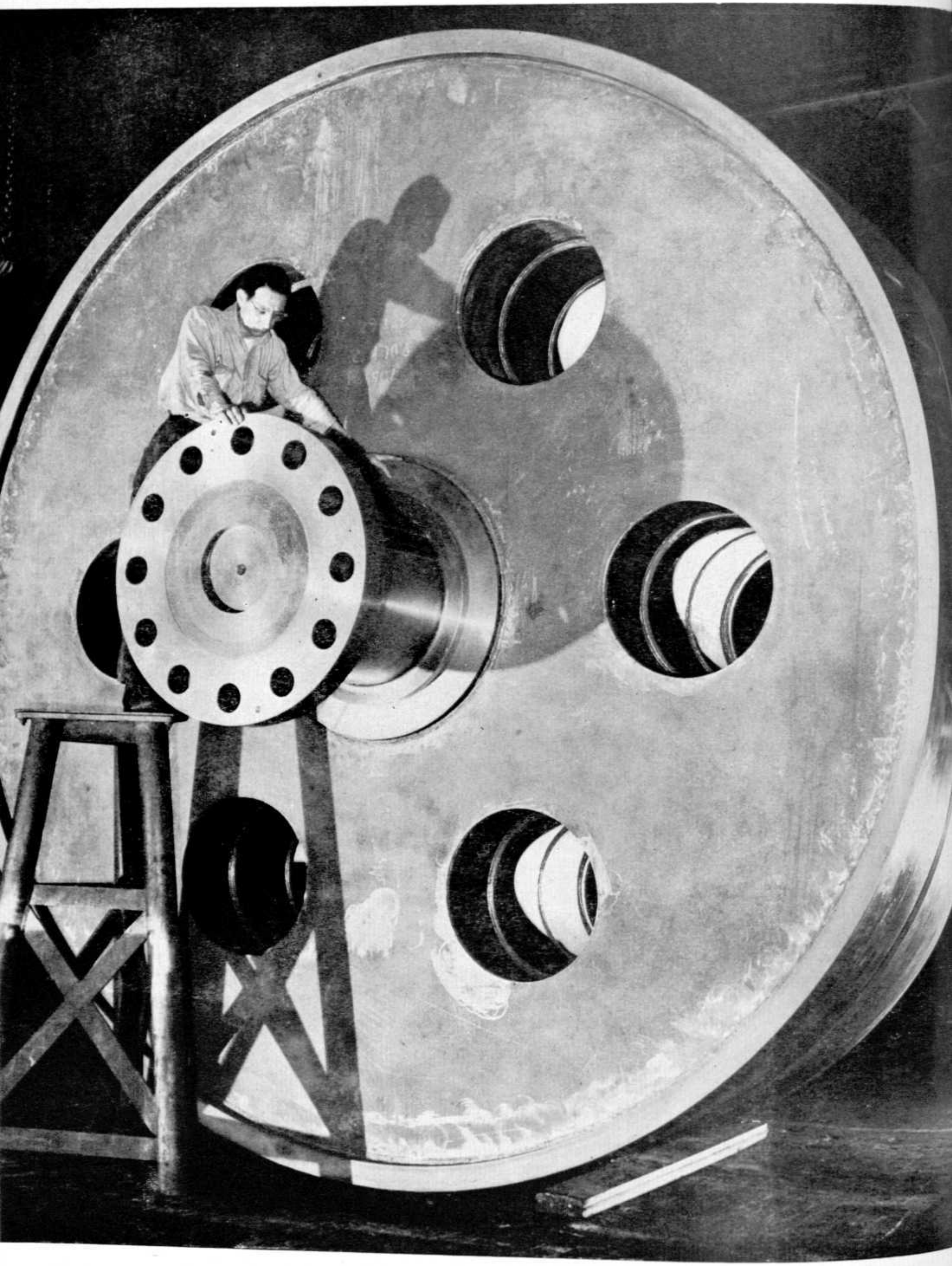
Ribbons of velvet smoothness . . .
MODERN **ASPHALT** HIGHWAYS

THE ASPHALT INSTITUTE, Asphalt Institute Building, College Park, Maryland

Left to right: Lou Bernardi, Notre Dame, '54; Norman Lorenson, Mich. St., '55; Ernest Schurmann, M.I.T., '53; Dick Swenson, Purdue, '50.



Harvey Graves (Dartmouth, BA '50, MSEE '51) discusses a reactor experiment at the Westinghouse Reactor Evaluation Center, in Waltz Mill, Pa. As manager of the Nuclear Design Section, Mr. Graves works with Dr. Wilfried Bergmann (Vienna, PhD '51), on right, and other young scientists who operate the facility.



Spartan Engineer

of michigan state university VOLUME 11 NO. 3 MARCH, 1958

FRONTISPIECE: Gear for Bunyan's watch?

This 27 ton 12' diameter gear is actually a gear wheel which will be used in each of 2 reduction sets aboard the SS Brazil.

Courtesy of General EleCtn£

Cover: by Elaine Lepel

MEMBER ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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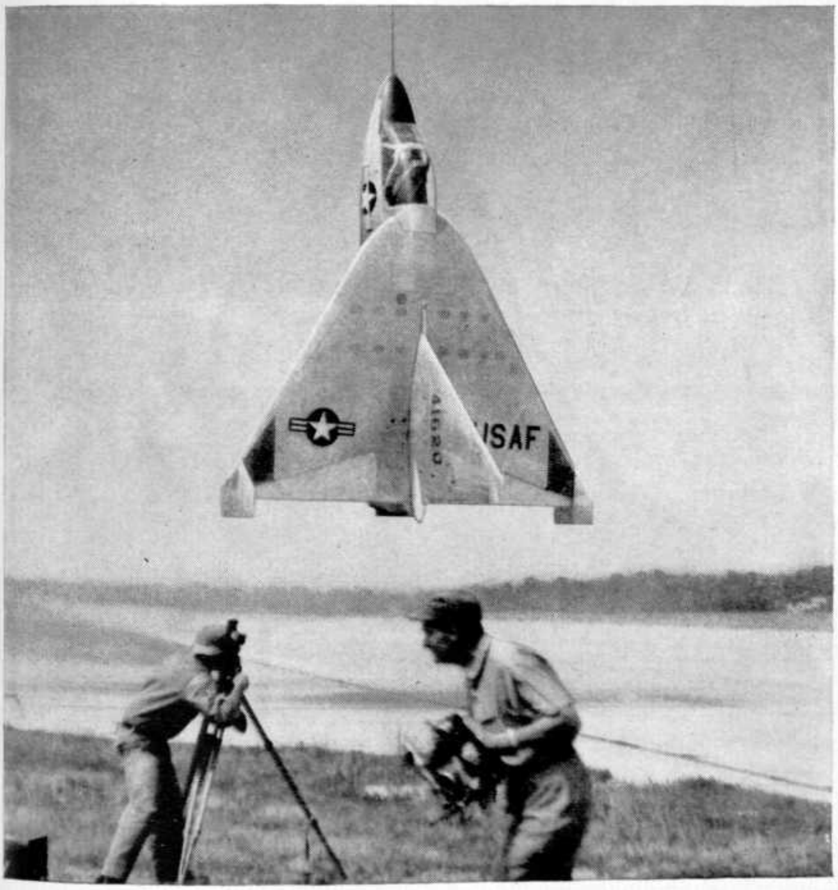
Ryan's Diversification Creates Wide Opportunity for Engineers



X-13 Vertijet Adds New Punch to Airpower

Washington — Unveiled in an unprecedented flight at the Pentagon, the Ryn X-13 Vertijet gave military officials a glimpse of the future of airpower. Like a huge bat, the Vertijet unhooked itself from its nose cable. hovered vertically, then whipped over into horizontal flight and roared out of sight.

World's first jet VTOL aircraft, the Vertijet combines the flashing performance of jet power with the mobility of missile launching. It frees supersonic airrpower from runways and airports. without landing gear, flaps, actuators, the X-13 concept means less weight—more performance in speed and climb.

In the words of a top Air Force general, "The Vertijet has provided milltary planners with a new capability for manned aircraft of the future."

Achieved in close cooperation with the Air Force and Navy, the Vertijet is based upon Ryan's unsurpassed 21/4 million manhours of research, development, and test in VTOL aircraft.

Navy, Army to Use New Ryan Navigator

San Diego — Navy aircraft — piston engine, jets and helicopters will soon be equipped with Ryan lightweight automatic navigators and ground velocity indicators. Lightest, simplest, most reliable, most compact of their type, these systems are self-contained and based on continuous-wave radar.

The navigators provide pilots with required data such as latitude, longitude, ground speed and track, drift angle, wind speed and direction, ground miles covered and course and distance to destination. Ryan is also developing guidance systems for supersonic missiles.

More Orders for Ryan Firebees

San Diego-Nearly $20 million worth of Ryan Firebee jet drone missiles have been ordered by the Air Force and Navy in 1957. In operational use, the Firebee is the nation's most realistic "enemy" target for evaluating the performance of air-to-air and ground-to-air missiles. It possesses the high speed, altitude, maneuverability and extended duration needed to simulate "enemy" intercept problems.

America's number-one jet drone, the Firebee is another example of Ryan's skill in blending aerodynamic, jet propulsion and electronics knowledge to meet a challenging problem... answer a vital military need.

JOB FACTS FROM DU PONT

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING ...THROUGH CHEMISTRY

LIBERAL EMPLOYEE BENEFIT PROGRAM AT DU PONT INCLUDES INSURANCE, SAVINGS AND STOCK PLANS

WHAT'S YOUR LINE? DU PONT NEEDS ALL KINDS OF ENGINEERS

DuPont has always needed chemists and chemical engineers, and still does. But today, there's critical need for engineers in almost every other field—civil, mechanical, electrical, instrumental and industrial engineering, to name a few.

Expansion is the major reason. In 1957, for example, sales at DuPont were nearly two billion dollars. Four new plants were being built. New research programs were being launched, New products were moving into the production and marketing stages. Engineers and scientists of all kinds work in 75 Du Pont plants and 98 laboratories in 26 states All of this tends to broaden opportunities for the young scientist and engineer at DuPont.

If you're interested in finding full scope for your ability, and this includes a great many special fields, Du Pont offers you plenty of opportunity to move ahead.

SEND FOR INFORMATION BOOKLET ON JOB OPPORTUNITIES AT DU PONT

Booklets on jobs at Du Pont are yours for the asking. Subjects covered include: mechanical, civil, metallurgical, chemical, electrical, instrumentation and industrial engineers; atomic energy technical sales, business administration, research and development. Name the subject that interests you in a letter to Du Pont, 2494-F Nemours Building, Wilmington 98, Del.

PERSONALIZED TRAINING

by
F. L. Johns
Du Pont Representative

When you join Du Pont as a scientist or engineer, you're given an actual project assignment almost at once and begin to learn your job by doing it. That's the essence of our training philosophy at Du Pont.

Our objective is to give you responsibility at the outset and qualify you quickly for more, because the more ice grow, the more tie need trained leaders.

Although there is no one training program at Du Pont (each of our many departments runs its own), all have several basic features in common. All are personalized—tailored to the new man's background and interests. All involve close supervision on an informal, day-to-day basis. And all permit periodic evaluation of the new man.

This flexible system helps the new man to move ahead according to his abilities. He gets to know Du Pont and his job quickly. He gets a head-start on future responsibility.

You probably have questions about this program and how you'd fit into it. I'll be glad to try to answer them when I visit your campus. Why not sign up for a Du Pont interview at your placement office now?

Means More Security, Greater Real Income To Young Graduates

Du Pont believes that the employee builds his own job security by the way he does his work, by his contributions to the progress of the Company and by his readiness to accept responsibility.

But Du Pont meets the employee more than halfway with a program of benefits designed to help him as he advances.

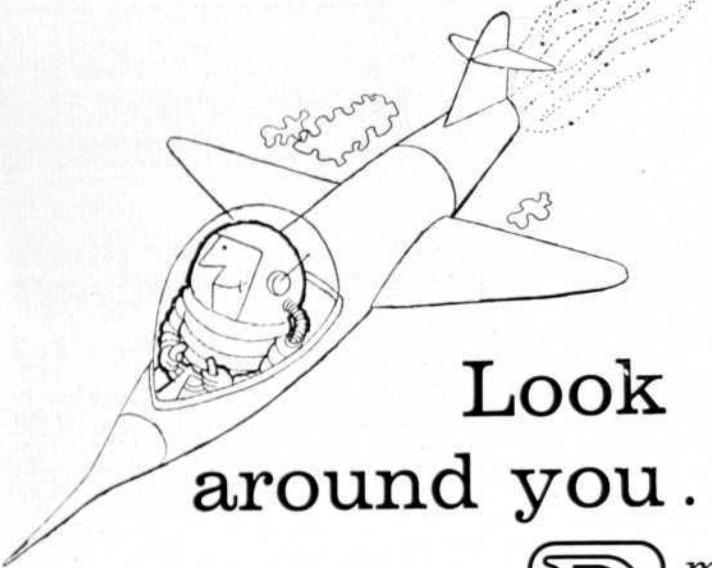
Your employee benefits go to work the day you join the Company. They grow and build equity for you as the years go by. Vacations, life insurance, group hospital and surgical **coverage,** accident and health insurance, pension and bonus plans are all part of the program.

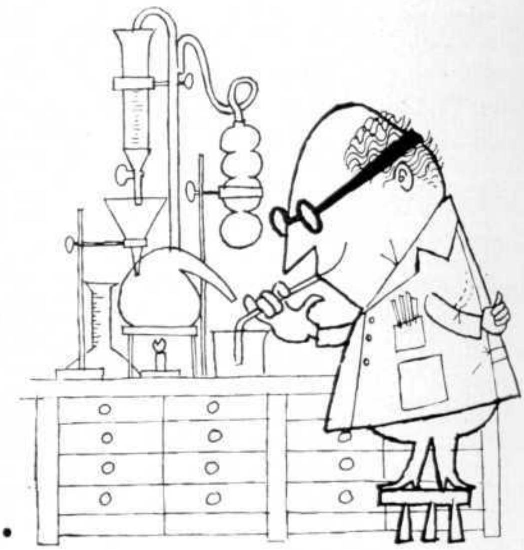
Let's look at a special example, the Thrift Plan. You become eligible for it after one year with the Company. For each dollar you invest in U. S. Savings Bonds, the Company contributes twenty-five cents toward the purchase of Du Pont common stock in your name. Roughly 65 per cent of the Company's 90,000 employees arc now participating in the plan.

When you're deciding on a career, security is only one consideration. But it's an important one to you and your family. At Du Pont, security is a bright part of the future **awaiting** the college graduate.

* * *

More than 700 of the some 1100 degree-granting colleges and universities in the U. S. are represented at Du Pont. Of these 700, more than half are the smaller liberal arts colleges.





Look around you . . .

PPG *makes big things happen in exciting products*

Paints, chemicals, glass, plastics, fiber glass . . . all these products have **exciting** family trees. And at Pittsburgh Plate Glass Company, tomorrow's offspring promise to be even more intriguing.

Look around you . . . at paint, for example. It's much more than mere color. Paint protects. It must be thoroughly researched and carefully compounded to withstand infinite variations oi atmosphere, heat, stress and other conditions. Or look at chemicals . . . their roles in the creation and **development** of textiles, metals, paper, agriculture, missiles, medicine. You name it, chemicals are there, making important contributions. Glass. These days, it can be made to remain rigid at blast furnace temperatures, withstand supersonic speeds, have the tensile strength of bronze. And it's much the same story **for** plastics and fiber glass. Everywhere you look —in architecture, industry, the home, *everywhere'* PPG products find new, exciting applications with fascinating and challenging potentialities.

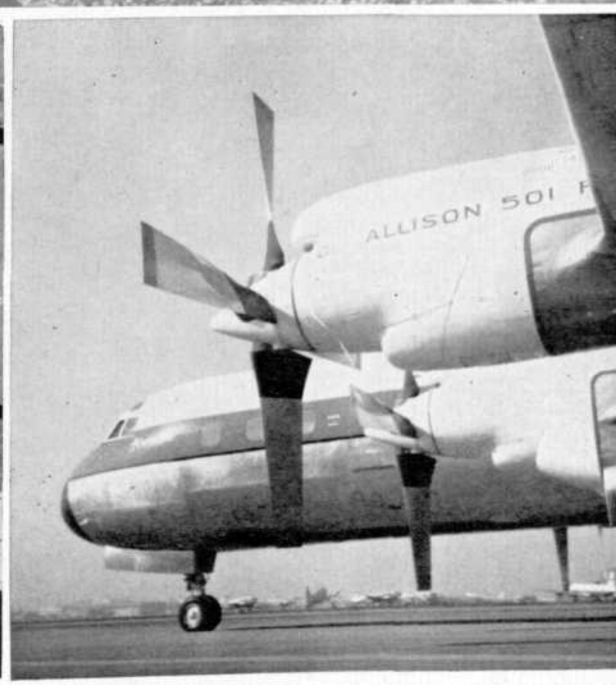
Are you seeking a career that requires creative thinking, utilizes all your skills and know-how, offers a chance to learn **the** latest techniques? Then look **into** your enticing career **possibilities** with the Pittsburgh Plate Glass **Company.** Contact **your** Placement Officer *now*, or write to **the** Manager of College Relations, Pittsburgh Plate Glass Company, One Gateway Center, Pittsburgh 22, Pennsylvania.

75th ANNIVERSARY 1883—1958

PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS • FIBER GLASS

PITTSBURGH PLATE GLASS COMPANY

345 PLANTS, MERCHANDISING BRANCHES, AND SALES OFFICES LOCATED IN 250 CITIES



INDIANAPOLIS, IND.: (Special) Lockheed Aircraft Corporation and the Allison Division of General Motors Corporation have teamed up to produce a commercial Passenger transport that promises to revolutionize air transportation on the medium-and-short-range flights. Cruising at more than 400-mph the Allison Prop-jet Lockheed Electra will bring jet-age speed and comfort to passengers and set new standards of operating economy for air lines of the world.

Teamwork within Allison, just like the Lockheed-Allison team, is **highly prized** by newly graduated engineers. If you would like to know more about the Allison team, write Personnel Department, College Relations, Allison Division of General Motors Corporation, Indianapolis, Indiana.

Operation Purity

by Richard Geeck

Pure metals, a highly desirable attainment, is the object of numerous companies and research laboratories. The author points out the activity of industry in its endeavor to achieve the theoretical 100% purity.

EVER since man has stumbled on nuggets of copper and gold in the bed of some ancient stream, he has been dealing with metals in various degrees of impurity. Even today, commerieally pure metals contain a small amount of impurities. **So-called** pure gold is about 0.4 percent copper and other impurities. It was not until recently that science and industry have begun to approach truly pure metals. Pure metals in this case being whittled down to less than one part impurity in 1(X) million. Since man's history can be written in terms of metals, this is the beginning of a new metallurgical age.

The great difficulty to begin with was that all metals are found to react with other elements of the earth's crust to a great extent. For centuries men struggled with crucibles and fire, trying to separate some of the more easily separated metals from their ores. The long Bronze Age gradually gave way to the Iron Age. After this came the industrial revolution, as iron was rapidly refined on a large scale to steel. Then the steel was found to have a large range of properties when alloyed with other metals. As time went on, more and more difficult metals began to be separated from their ores, such as aluminum and magnesium.

Beyond these older metals, however, is a range of highly reactive metals, such as titanium, zirconium and hafnium, which are not only very difficult to separate from their ores, but are very difficult to keep in this state. When an attempt is made to melt them, they combine very readily with the oxygen and nitrogen of the air and with the container in many cases. When these metals react in this manner they form brittle, spongy masses with no resemblance to metals at all. In fact, until the last decade they were only theoretical metals. All metals to a greater or lesser degree react in the same way, which explains why, under the traditional smelting and refining processes, none has yet been secured in an absolutely pure state.

Until a metal is isolated in such purity, its properties can not be known to the fullest extent. This is one aspect in science in which part of the phenomenon is a mystery. Alloying, i.e., proceeds by laws not fully understood.

The first real desire to obtain a pure metal came from the scientfic passion for measurement. The atomic weight of silver had to be settled as accurately as possible to provide a key reference in the table of elements. It was Theodore W. Richards of Harvard University who finally succeeded in preparing a tiny amount of very pure silver and establishing its weight as the international standard. Later, with the developments of metallurgical microscopy, the electron microscope and X-ray diffraction, it was found that a pure metal typically has a tight, crystalline structure in which atoms are arranged in regular, perfectly spaced polyhedral forms, called a crystal lattice. When a metal is mixed with another to form an alloy it is found that this second metal distorts the lattice in a regular way, generally adding strength, hardness, or other properties to the alloy; impurities such as gases, slags, or other minerals cause haphazard breaks or discontinuities in the lattice, generally weakening the material.

The New Jersey Zinc Company was one of the first companies to make advances towards purer metals in the late 1920's. They purified zinc by fractional distillation and obtained a degree of purity with less

The basic steps in tantalum production are shown in this photo. In front of the scientist are roundels of high-purity tantalum made by Electro Metallurgical Company. These small, cylindrical shapes are pressed into electrodes similar to the one at left, and arc-melted under vacuum. On the right is an ingot produced by this method. Tantalum is used in high-efficiency capacitors, such as those being examined, vacuum tubes, and for chemical processing equipment.

than 0.005 percent impurity. This zinc was used in the big automobile die-casting market, because the pure zinc, unlike ordinary zinc, was corrosion-resistant and made strong, cheap alloys for precision casting.

There was really no great push for pure metals until the second World War. It was at that time that accumulated knowledge and curiosity regarding metals **became** linked to the driving demands of three advancing technologies. Atomic energy, for example, Squired a purity in metals extending from its base metal, uranium, right up to the reactor itself. Supersonic aircraft required metals able to withstand tremendous heats, this seemingly being a quality of purity led to the development of pure titanium. Finally, new electronic devices required ultra-pure metals both new and old in order to function at all.

The first result was **the** discovery in metals of many remarkable new properties which were not known until these metals **were prepared** in the pure form. This was not entirely unexpected by scientists. For example, the reduction of carbon in iron from 4 to 1 Percent makes all **the** difference between brittle cast iron to tough steel. Alloys get their wide ranges from small amounts of other metals which are added to give the alloy different properties. The present drive for purity leaves hardly a new or old metal untouched, and the sheer range of new properties is completely different.

Chromium is another metal which shows remarkably different properties when in the pure state.

Chromium as we know it is a hard, brittle metal used almost exclusively in plating and in such alloys as stainless steel. But, chromium when purified is soft at room temperature as compared with the impure chromium. It is almost as ductile at room temperature as soft wire. Vanadium is another metal like chromium which is very brittle in its common form. In fact, vanadium is used as a toughening agent in tool and spring steels. Like chromium, vanadium becomes quite ductile when pure at room temperature.

More remakable properties have shown up in the laboratory. The General Electric Research Laboratory-has had *a* big hand in metal purification since the

(Continued on Yagc 56)

Boxes,

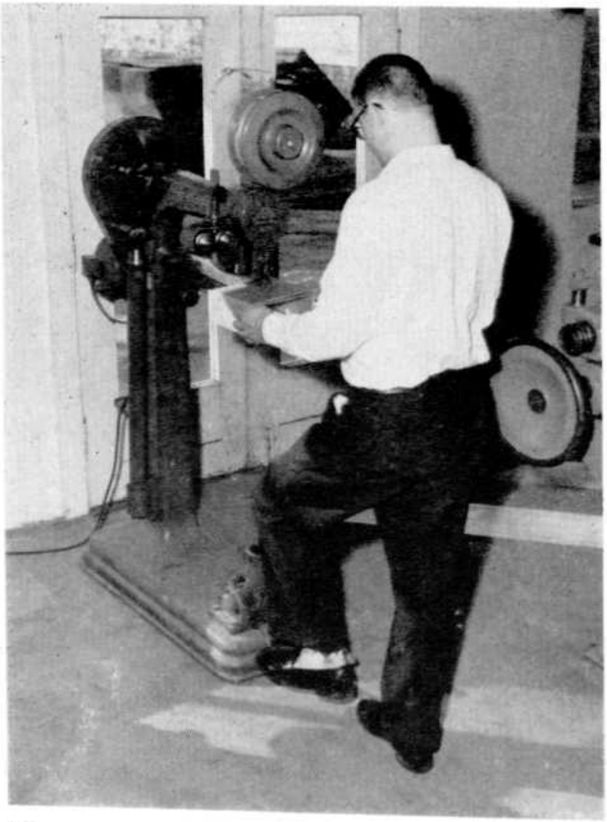
Boxes,

Boxes . . .

by Larry Paulet GCA '59

Tensile strength tester is used in several packaging applications.

Student operates a metal-stitching machine.



The packaging industry, a 15 billion dollar business, is demanding college-trained personnel for design and development

PACKAGING, **a** relatively new field, is providing challenging opportunities to college-trained **personnel** in a **15** billion dollar **industry.**

Only five years ago, after repeated requests from the packaging industry, Michigan State University established a curriculum in packaging. Today. with 144 undergraduate and 9 graduate students enrolled, the School of Packaging is progressing rapidly, **ana** is providing the packaging **industry** with **personnel** capable of originality and **responsibility.**

After World War **II,** it **became** evident that poor packaging had resulted in **waste** amounting to **mulions** of dollars. **Consequently, a** need arose for personnel **trained in** materials, statistics, **operations,** and management.

The program **at** M.S.U. was inspired by John Ladd of the General Box Company. After a thorough investigation, Dr. A. J. Panshin, Head, Department of Forest Products, paved the way for approval of the first curriculum in packaging ever offered by any university.

At the present time, there are eight specific packaging courses in the curriculum, and many other allied subjects are offered to give the student a wide range of course study in business, mathematics, chemistry, physics, and engineering. Also, a student may take up to 36 credits in electives such as marketing, purchasing methods, production control, food preservation, and management.

This flexibility in the curriculum offers the student an opportunity to take courses that will help him in his particular interest, whether it be technical sales, product development, or package designing and testing.

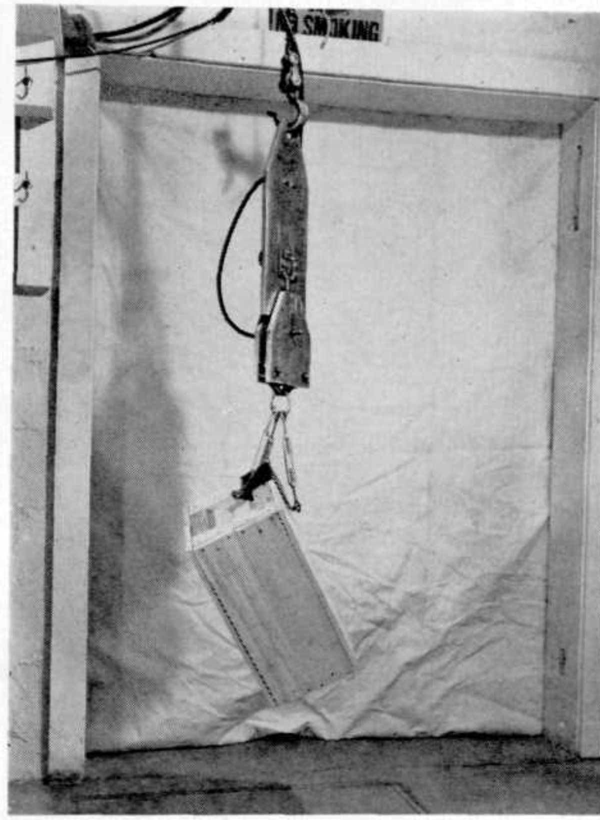
The curriculum is periodically revised to keep abreast with progress and meet the demands of the industry. An Industry Advisory Committee, a permanent **body** representing venders and users of packaging materials, as well as consultants and editors in the field, meet every year on the M.S.U. campus to offer suggestions, review courses, and bring the curriculum **up** to date. As a result, a graduate is recognized when he enters the business, and there is no apprenticeship needed or required to familiarize him with recent developments.

After his second or third year, each packaging student must acquire 12 weeks of practical experience within the **industry.** Only after this close association with the industry, can a student realize and appreciate the challenging problems that he will be confronted with atter graduation.

Packaging design is both an economic and engineering problem. **The** container must **withstand** all abuses **in** transportation and storage, **yet** it must **be** within a **reasonable** cost to the consumer. There **have been** cases **where** the package **was** worth more than the product **enclosed.** Also, if the volume of a **package** can be reduced only one or two cubic **inches** Per cubic toot, the cost ot **storage** area and transportation can **be reauced appreciably.**

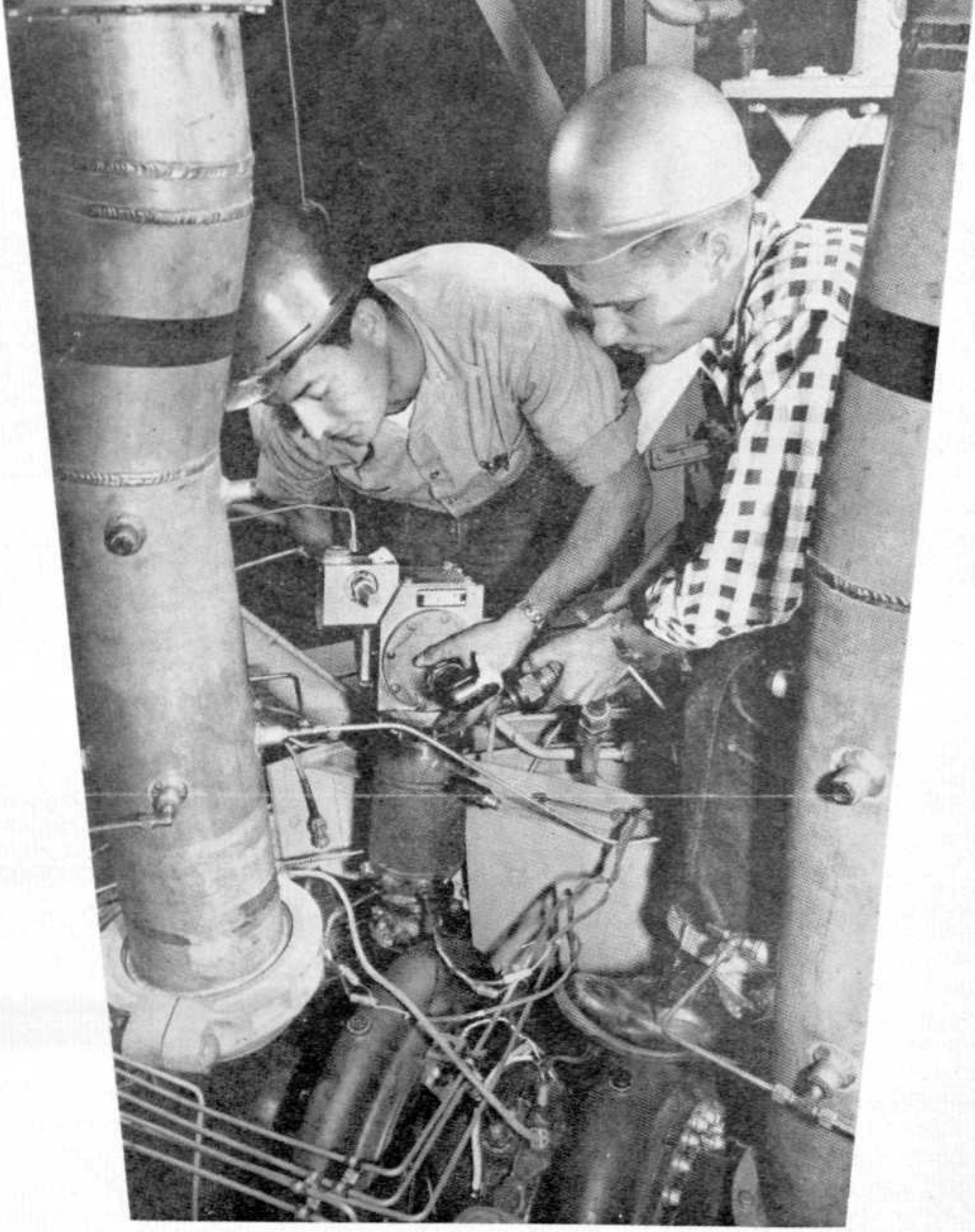
There is a great **demand for college-trained personnel** in this field who are ambitious, and desire to tackle these **problems.** The **pay** is on a par with **the engineering profession,** and there are many more Positions available than there are **qualified people to** fill them.

The packaging **industry** is **only** in a stage of inf**ancy,** and the potentialities have hardly been **scratched. In** the **future, however,** with men of vision and ability in its ranks, the **industry** is anticipating better and cheaper packaging for all industrial and commerical consumers.



TOP—The box under durability analysis is ready for testing.

BOTTOM—After repeated cycles, the box has parted and the load is exposed.



A rocket engine gas generator and turbopump, hidden in a maze of instrumentation, propellant tubing and bracing, pertorm amazing feats of engineering. Mechanics are installing a blade valve for turbine pump testing.

The Mighty Midgets

SMALL PUMPS AND GENERATORS PUT MUSCLES IN ROCKETDYNE'S POWERFUL MISSILE ENGINES

Reprinted from Skyline, North American Aviation Co.

BY NOW THE "UNSUNG HERO" theme has become an old wheeze in success stories. Star **quarterbacks** don't win football games; it's the **"forgotten"** men on the line. Business tycoons would be back pushing a broom if it weren't for the hundreds of **"little** people" who backed them in their rise **to** success.

Rocket engines, the newest successes in the **power** package field, must go right along with this tradition of modesty. The roaring, flame-spitting thrust chamber of a rocket engine owes much of its glory to two comparatively pint-sized units without which the rocket couldn't hunch itself off the launching pad.

The gas generator and the turbopumps are the mighty midgets of rocket engines. While the attention of the world is centered on the ATLAS, THOR, JUPITER, NAVAHO, and REDSTONE missiles, and the thundering Rocketdyne engines that power them, **these** two stalwarts remain hidden in a maze of propellant tubing and engine bracing, ready at the opening of a valve to perform amazing feats.

The turbopump must be capable of gulping down an amount of propellant equal to the contents of a railroad tank car in less than two minutes. The gas generator, to turn the pump at its incredible speeds, must develop power equal to that generated by the motors of six modern automobiles. At the same time, the two components must be extremely light weight to meet one of the **primary** requirements for use in a rocket engine.

Little Pump Has a Big Job

The bulk of the flame and the fury of a rocket **engine** firing takes place within the thrust chamber-**the** spot which, like the football quarterback, gets the major share of credit for all the "ground" gained. **But that** flame and fury could not exist unless there was a turbopump, operating like a buzz saw, sucking the propellants out of the tanks and hurling them at tremendous flow rates and exceedingly high pressures into the thrust chamber. When you consider the tremendous effort being expended to lift a hasketball-sized satellite into an earth orbit for the **Project** VANGUARD, you can understand whv the turbopump must be extremely light. There is no telling where, in this world or out of it, a turbo-Pump may be carried in the flight of a missile. A pound saved is a wonderful achievement.

Revolutions-per-minute is not a true indication of the efficiency of a turbopump, but it is an indication of the busy life led by the pump. A speed of 10,000 revolutions per minute is commonplace in the Rocketdyne turbopumps. Speeds of 22,500 rpm **are** not unknown, and the **engineers** are striving for 30,000.

Testing of the turbopumps is accomplished at Components Test Laboratory in Rocketdyne's Pro**pulsion** Laboratory. CTL's two highly utilitarian **buildings** are dedicated to one aim-guaranteeing the reliability of components before they are sent up to join the engines on the big stands. They are blunt. **squared-off** buildings, surmounted by tanks and chopped up with test pits. The laboratory is **equipped** to probe into any **Component** and accept it or **reject** it with all the **finality of** a **surgeon peering** into a chest cavity.

At CTL are two **massive** generator units dial formerly were in Southern **California's Pacific Elec**trie streetcar sub-stations at **Pomona** and Etiwanda. The power from these two generators is used to feed three electric motors from a U.. S. **Navy** submarine that less than ten years ago was **prowling** the Pacific Ocean. The submarine motors are linked to speed increasers that provide the **necessary** revolutions to turn the pumps at the desired test speed. For most of the tests, soft water is used as a fluid because the chemicals present in San Fernando Valley water are enough to upset the delicate calculations involved in calibrating a high-speed pump.

In other pump tests, liquid oxygen and rocket engine fuels are used as fluids to **duplicate** the actual conditions within the rocket engine where **highly** explosive mixtures of propellants ram through the turbopump only a seal's space away from each other. The engineers must restrain the liquid oxygen on one side of the turbopump from any unfriendly mixture with rocket engine fuel, four hundred degrees higher, on the other side.

Pumps Turn at Sonic Speeds

During a test the pumps whine in sonic and ultrasonic modes, and the speed increaser causes the thick concrete flooring to quiver. On signal, then-is an abrupt cutoff. Within seventeen seconds a pump spinning at 22,500 rpm is brought to a complete halt.

Remember that at Components Test Laboratory it is necessary to utilize two massive streetcar substation generators and **three** huge motors to turn over a pump at desired test **speed.** What takes the place of this bulky set-up when the turbopump is placed within the rocket engine?

The answer is a gas generator, a unit that may be likened to an ostrich egg nestled within a miniature pot bellied stove. A gas generator is a device which produces a usable gas by means of chemical decomposition, recombination or combustion. It's an extremely small component that could be tucked into the drawer of an engineer's desk-with room for a lunch bucket left over. Yet it develops as much as 1800 horsepower.

When the gas generator is in operation, fed by the same propellants that ignite in the big thrust chamber, there is an extended, controlled explosion creating a rush of gas. The gas causes the blades of the turbopump to whirl; the pumps suck the propellants from the missile tanks, hurl them through the injector into the thrust chamber-and the missile is on the way.

Because the by-products of a gas generator firing are inflammable gases, at the Test **Laboratory** ten-

***(Continued** on Page 58)*

Trade in Your "Black and White"

A new development in color picture-tube engineering may make a $300 receiver possible

by Jack Colegrove, '57

A.RTHUR GODFREY was seated in **a** big overstuffed **chair** sipping **a cup** of tea as he introduced Faye Emerson **to** the first commercial color-television audience in history. The time was July, 1951; the place-a large CBS-TV studio on 63rd street in New York City; and the audience consisted of those fortunate enough to possess one of the two hundred color sets in cxistance, or who had made their own adapter. The hour-long variety show had many other CBS-TV personalities as well, including Ed Sullivan, Garry Moore and Sam Levenson who in their turn performed for the limited, but appreciative audience. Miss Emerson's red gown had a tendency to fade to a greenish tint on occasion, and Godfrey's ears glowed a dull shade of red but these and other slight imperfections were deemed inconsequential in light of the magnificence of color reception. A new milestone had been reached in a progressive entertainment medium. Yet, as we shall see subsequently, tint TV was to become the center of much criticism and public controversey.

Had CBS's mechanical color television transmission system progressed to a point whereby TV viewers would accept it? Would these same viewers invest upwards of $1000 in a receiver that could be used only four or five hours per week for the present?

These and many other questions were yet to be answered. Let us go back and trace those steps which led to this initial broadcast and subsequent TV-color programming.

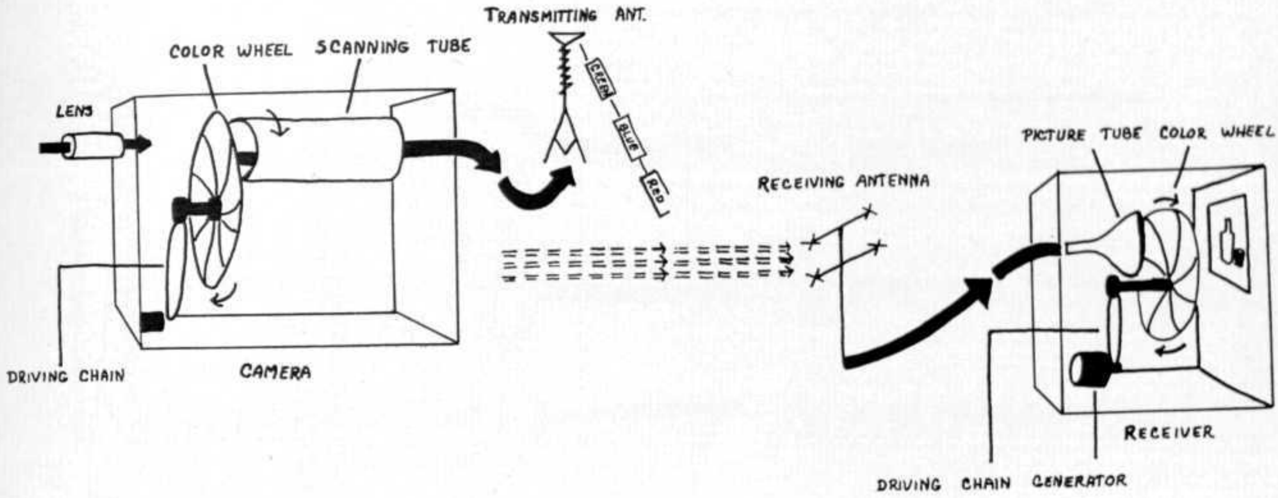
Early in 1947 the Columbia Broadcasting System demonstrated in a closed showing its new "Field Sequential" color transmission system to members of the Federal Communications Commission, the press, and the TV industry in a concerted **effort** to **have** their system licensed as the first color broadcasting service. Rival Radio Corporation of America (RCA) objected that an approval of CBS's mechanical system would be unfair to U. S. televiewers in that it could not be received on present black and white sets. Furthermore, they insisted that the resulting quality was poor, and had little chance for improvement. They asked the FCC to rule against CBS, with the promise that they would have a far superior electronic system perfected within four to five years that could be received on present black and white sets.

After some deliberation, the FCC, in March of 1947, announced that color television was not at present perfected to the point where it could be licensed commercially. It was to be a few years more before the U. S. was to enjoy tint-TV.

Television as an entertainment medium was beginning to capture the public's fancy and those most concerned with its availability—viewers, advertisers and broadcasters-began clamoring for television m color. It is interesting to note that of these three, only the broadcasters (and only **a** minority of them) continued to support color-TV once it had been initiated, but more of this later.

Three and **a** half years later, CBS-TV once **again** petitioned the FCC **to** grant them **a** license to transmit in color with their improved "Field Sequential system. In an effort to thwart CBS's move **to** #»» control in color-casting, RCA demonstrated its T> chroic Mirror" transmission **method.**

RCA's system had as **its** basis three **"dichroic** mirrors" which were able to direct the three priman



CBS-TV "Field-Sequential" System. Reprinted from "LIFE," February 27, 1950, Page 66.

colors, red, green and blue, in two different directions by transmitted light. Reportedly, RCA's electronic method would transmit more distinct images and present a truer representation of color diversity than CBS's mechanical system.

However, the FCC ruled that CBS's improved system was superior to that of the RCA method and, in view of the improvements evident in CBS's entry, the commission granted a license to the Columbia Broadcasting System in November, 1950, which allowed the network to telecast programs in color.

The CBS system of transmitting color images employed a three-color revolving wheel which rotated behind the lens of the camera. The disc was composed of three color filters which separated the incoming image into its three primary colors. The red segment of the wheel filtered the image so as to permit only the red portion to pass through. In like manner the other two filters permitted the entrance of only the blue and the green portions, all in succession. These three color signals were then converted into electrical impulses and transmitted.

In the home the receiver intercepted the signal and by means of a synchronized color-wheel the signal was once again separated into its three constitutent primary colors. The green image is formed as the green segment of the wheel passes over the face of the tube and in exact manner the red and blue images are formed.

When CBS got the green light to commence color-casting, they purchased the "Air King' television receiver manufacturing company for the express purpose of producing adapters for monochrome receivers then in use. This move was necessitated by the refusal on the part of set manufacturers to supply the public with the necessary attachments. It seems that the executives at CBS were the only men in the industry who felt that their system of color transmission had a future. Set manufacturers were not willing, naturally, to invest huge sums of money in a project they thought to be only temporary.

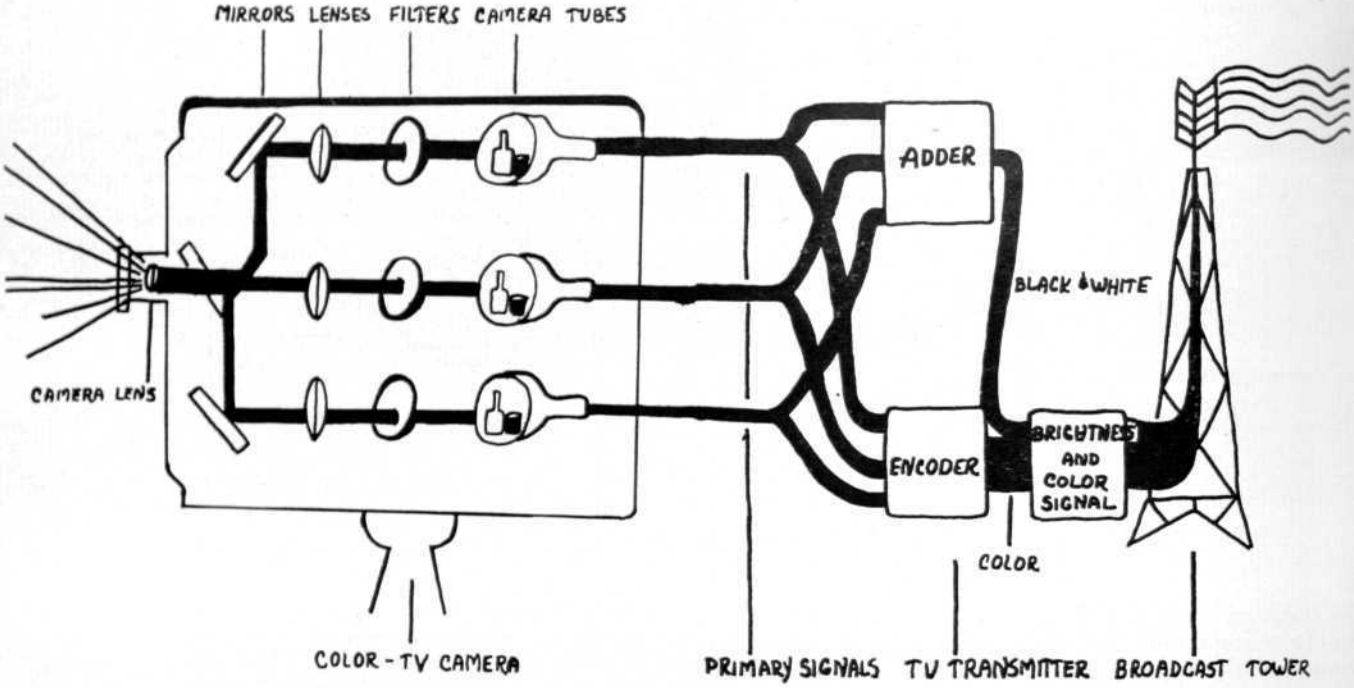
During the early months following the color program featuring top network personalities, CBS-TV did only limited color-casting on five eastern affiliates. These were mostly during day-light hours when regularly scheduled monochrome programs were not being broadcast. The network's entry into regularly scheduled color-casting consisted of two daily daytime thirty minute shows: "Modern Homemakers" and "The World Is Yours." These two programs were sponsored by five participating advertisers who bought thirty and sixty-second time segments to display their products, much in the manner as present-day station-break commercials are **presented.**

Indeed, rough sledding was encountered by the network. The price of the receivers was a barrier to their purchase and, manufacturers were unable to reduce the price because of the diminutive demand. Due to the sparse audience advertisers were reluctant to pour money into color programming. This meant that color-telecasting would continue to operate on a limited basis, so that even those who could afford the $1000 receivers were prone to forget the whole thing!

The Columbia Broadcasting System had invested heavily in color-TV with the view of strengthening their position as the number one television network. It was rapidly becoming apparent that they had invested unwisely. It would seem that CBS had found themselves on their own revolving wheel, slightly off-balance on a course that led them nowhere, yet, afraid to step off and risk being completely thrown off-balance!

In 1951 the federal government helped the network save face by ordering all color-TV set production halted to preserve scarce materials, as the nation faced an international crisis. Chromatic-TV was nearly

(Continued on Next Page)



Compatible Color-Television Broadcast Signals-RCA. Reprinted from "New York Times," Section VI, February 28, 1954, Page 16.

Forgotten as CBS-TV made only token **efforts to continue** their color **programming.**

Coincident **with the** news **of** a Korean truce from **the** Far East, came the news from New York that HCA, with its subsidiary, the National Broadcasting Company, was ready to demonstrate its **perfected** "Dot Sequential" color transmission system. Early **entry** into practical color-TV followed when RCA shelved the "Dichroic Mirror" tube, and developed a new **all-electronic** direct-view color tube.

Sixty **newsmen** at an NBC-TV studio in Washington watched a program televised in color from Wardman Park Hotel on both color and monochrome sets. The reception was of a quality superior to the current CBS system, and the demonstration clearly proved its compatibility.

After a demonstration before the Federal Communications Commission, RCA petitioned the board for a license replacing CBS's "Field Sequential" system. An announcement was quick in coming. In August, 1953, the FCC officially authorized RCA's "Dot Sequential" system as the standard color-broadcast method.

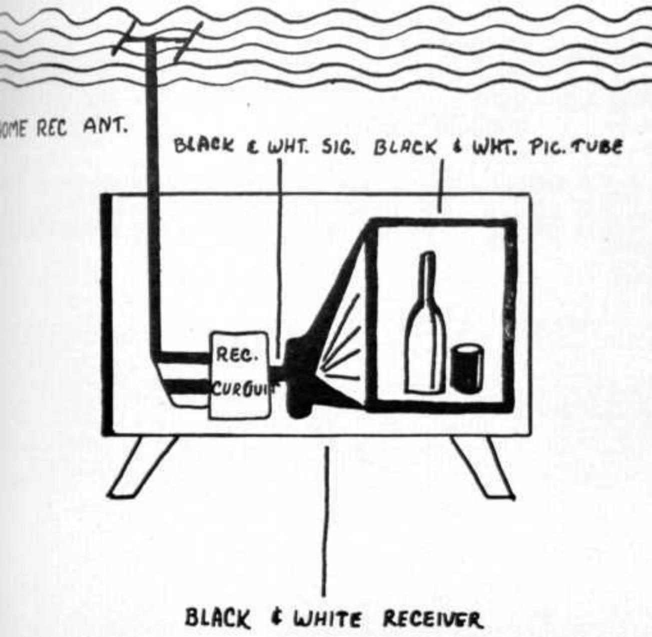
Whereby the CBS system captured the scene with one color tube, RCA utilizes three tubes, or "guns," one for each primary color. The camera actually takes three separate pictures through one lens by means of a system of filter-mirrors. Each mirror traps one color and allows the two remaining colors to pass through. These three distinct color images are directed to the corresponding color tubes where they are converted into electrical impulses. They are now once again mixed, and the resulting signal is divided into two segments. The first segment goes to the "adder." This unit blends the three combined **color** impulses to give the proper proportions of brightness, and constitutes the black and white segment of the color signal. The second portion, the "subcarrier," is fed to the "encoder" which combines the color signals proportionately to render the right values of "saturation" (intensity) and "hue" (color shading). The two signals are now recombined and transmitted together to the home receiver.

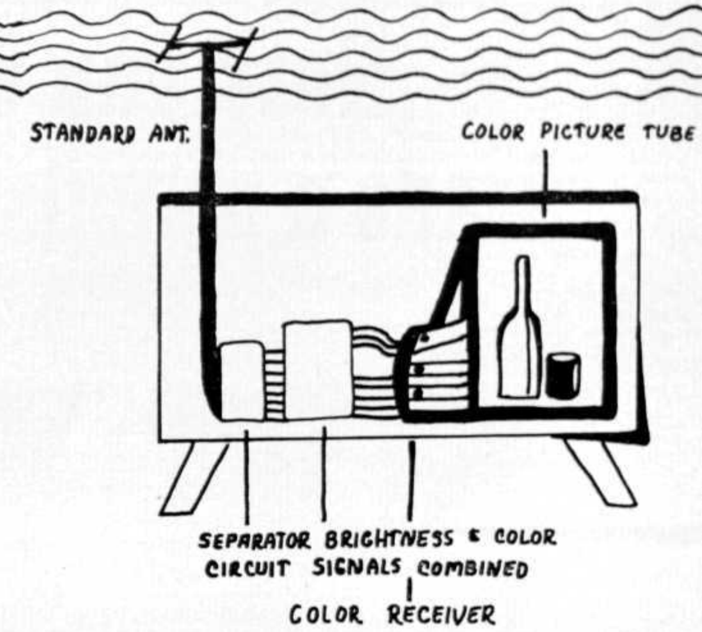
At the receiver the incoming signal is conducted to an electronic "separator" which serves to part **the** monochrome and color signals. If the receiver is a conventional black and white set, the "subcarrier," which conveys color information, is rejected and the remaining portion, when focused on the face of the tube, appears as a black and white image.

If the receiver is a compatible set, however, **the** subcarrier is fed to the "decoder" for separation into its three primary colors once again. These are relayed to the corresponding tube in the three-gun picture-tube, and then projected on the screen.

The face of the picture-tube is covered with 351,000 dots, or "phosphors," arranged in triangular groups. Each clot is capable of reacting to a certain color impulse delivered by the corresponding color **gun.**

Behind the tube-face is a metal screening mask with 117,000 minute holes focused on each triangular group of clots. Each gun shoots a stream of electrons in horizontal lines running from left to right on the face of the picture-tube. Therefore, when the beam oi each gun is uncovered by one of the minute holes in the mask, the corresponding color dot appears at that point on the screen.





The "Dot Sequential" system **as** developed by RCA was the product of three years study by the National Television System Committee under the supervision of RCA vice-president, Dr. Elmer W. **Engstrom.**

It would appear that color-television had come of age and would enjoy a prosperous future. Yet, as we shall see, this was not the case. In April, 1956 RCA forecast that sales of color receivers would reach the half-million mark by the end of the year, when actually only 130,000 units had been **purchased.** RCA and its subsidiary, the National Broadcasting **Company,** had lost 6.9 million dollars since its entry **in** color programming and color set production.

The lack of extensive color programming, high maintenance costs, and inconsistantly good **reception** have been factors leading to the public's lethargy in fully accepting TV's latest innovation. The biggest single hurdle, however, has been the high cost of color receivers. The three-gun picture-tube itself costs upwards of $250 and its corresponding circuitry is very complex and also costly. It appears however, that there may be hope. A few of the 21-inch receivers on the market since June 1956, have been reduced in price to $495. This is a reduction of 505? since the first compatible set was introduced early in 1954. This initial set in the color market had a 12-inch screen that sold for $1000.

A new advance in color picture-tube engineering was announced a little over a year ago that may make possible the marketing of a $250 or $300 color receiver. Dr. Ernest O. Lawrence, through the auspices of the Radiation Laboratory of the University of California, obtained a patent on his "Chromatron" one-gun color picture-tube for the Chromatic Television Laboratories Inc. The new picture-tube does not utilize a shadow mask and is composed of a much simpler wiling arrangement than that present in **the** RCA units. The absence of the mask allegedly increases the picture brilliance by 70'/, but the important factor is that the one-gun Lawrence tube can be manufactured for $100 or less. Further, Chromatic Inc. engineers say the "Chromatron" is not limited in size, and that advance tests have given color registration and brightness levels far superior to the RCA units now being employed.

The Lawrence principle involves the **focusing of** the electron beam on the phosphoric screen **much** in the same manner as on the RCA tube, but with only one scanning gun. Instead of the phosphors being arranged in triangular groups **of** dots, they **are** "shot" out in five horizontal lines about 0.001 inches thick. Behind these lines is mounted **a** grid of vcr\ fine wires so arranged that alternating conduction wires can carry different electrical charges. The charge on the wires directs and focuses **the** electron beam so that, as the grid charge changes, the beam will strike one, two, or all three primary color phosphors. The grid changes depend upon the nature of the transmitted image.

The Lawrence tube, by nature of its relative simplicity, does not require the close dimensional tolerances necessary in its more complicated predecessor, thereby reducing the cost of manufacturing. Also, the color-selector grid will do away with the necessary color-encoder in present sets.

The development of Dr. Lawrence's "Chromatron" tube may be the answer to exorbitant receiver and maintenance costs, and poor receotion. Now NBC-TV is doing their best to present colorcasting in quantity as well as quality. The network at present is following a policy of presenting at least one major evening show

(Continued on Page 52)

CLUBS AND SOCIETIES

A. I. Ch. E.

The student section of the American Institute of **Chemical Engineers** has **as** its main objective **to** acquaint the Chemical engineering student to his professional society while he is still in school. Any student enrolled in chemical **engineering** can become a member.

The student section here at State has two meetings **a** term. The program for the last meeting was **a** talk on "Eonomics of Chemical Processes" given by Mr. G. H. Wesseman, who is employed by the **Standard** Oil **Company of** Indiana.

Last term two of **the** student members went to the A.I.Ch.E. Convention in Chicago. Their expenses were paid by the **Procter** and Gamble Company.

This year Michigan State has been chosen as **the** host for the 7th annual North Central Regional Conference of the Student Chapters of A.I.Ch.E. The chairman for the conference is Wes Rearick and working under him are, Grant **juchartz** and Miles **Talbert.**

The officers of A.I.Ch.E.:

President . . . . Charles Griffen
Vice President . . . . Roderick **MacKay**
Secretary . . . . Carl Thearin
Treasurer . . . . Gerald Knapp
Faculty Advisor . . . . Dr. R. W. Ludt

Phi Lambda Tau

The Phi Lambda Tau Fraternity was founded at Michigan State College in 1925, to mark with distinction those who, as Engineering undergraduates, have demonstrated their administrative ability or have shown unusual initiative.

Undergraduates become **scholastically** eligible at the beginning of their Junior year if their scholastic average for the previous two years is favorable. Eligibility is also based upon such activities as campus organizations, social fraternities, campus politics, outside work, athletics, music, and publications.

Phi Lambda Tau is unique in that it has only one chapter and that being the one founded **at** Michigan State University. Some of the various activities that the members participate in are field trips, picnics. Engineering Exposition projects, banquets, and service functions such as campus tours and **aid to** activities sponsored by Professional Engineers.

The officers of Phi Lambda Tau are:

President . . . . Jim Clock
Vice President . . . . Duane Dolph
Treasurer . . . . Glenn Gardner
Secretary . . . . Ronald Hamelink
Corresponding Secretary . . . . Stanky **Badelt**
Faculty Advisor . . . . Prof. L. V. Nothstine

PHI LAMBDA TAU

Row 1: Izzo, Meinert, Bingley, Badelt, Clock, Gardner, Dolph, Fleming, VanVliet; Row 2: Wagner, Lake, Strobel, Feller, Taulbee, Hobolth, Larder, Bellinger; Row 3: Olsson, Schreihans, Lantz, Black, Smith, Wells, Cruise, Colby, Bierlein.

Pi Tau Sigma

Pi Tau Sigma **is a** national **honorary** mechanical engineering fraternity. The chapter here at State was installed in 1950 through the help of Professor L. C. Price and former Dean of Engineering, L. G. Miller.

To be eligible for membership you have to be in the top 25% of the Junior Class or the top 35% of **the** Senior Class. In the junior year only 17% can be taken in and 33% in the senior year. This means a good scholastic record is needed to be eligible but also the student is judged on leadership, personality, dependability and probable future success in mechanical engineering.

The out-going officers are Joe **Colucci,** President; Keith Salisbury, Vice President; Wayne Sebrell, Corresponding Secretary; Charles Kirchhoff, Recording Secretary and Richard McCormic, Treasurer.

New Officers for 1958-1959:

President	Jack Slocum
Vice President	John Sovis
Corresponding Secretary	Laverne Root
Recording Secretary	Jack Garter
Treasurer	Keith Wood
Faculty Advisor	P. J. Thorson

Tau Beta Pi

Tau **Beta** Pi is **a** national **honorary For** all **engineers. To be** eligible, a student must **be** in **the** top K **of** the Junior Class and have an all-college above 3.3. Seniors must be in the top ,i **of their** class and have an all-college **above a 3** point.

Each **fall term the** seniors arc taken in along with the three top students from the junior class. Winter term **the** rest **of the** juniors are taken in.

Tau Beta Pi meets three times a term. **The)** hold their meetings in their own room **on** the fourth floor of Olds Hall. Mr. Olds requested this room for them when he gave the money for the building.

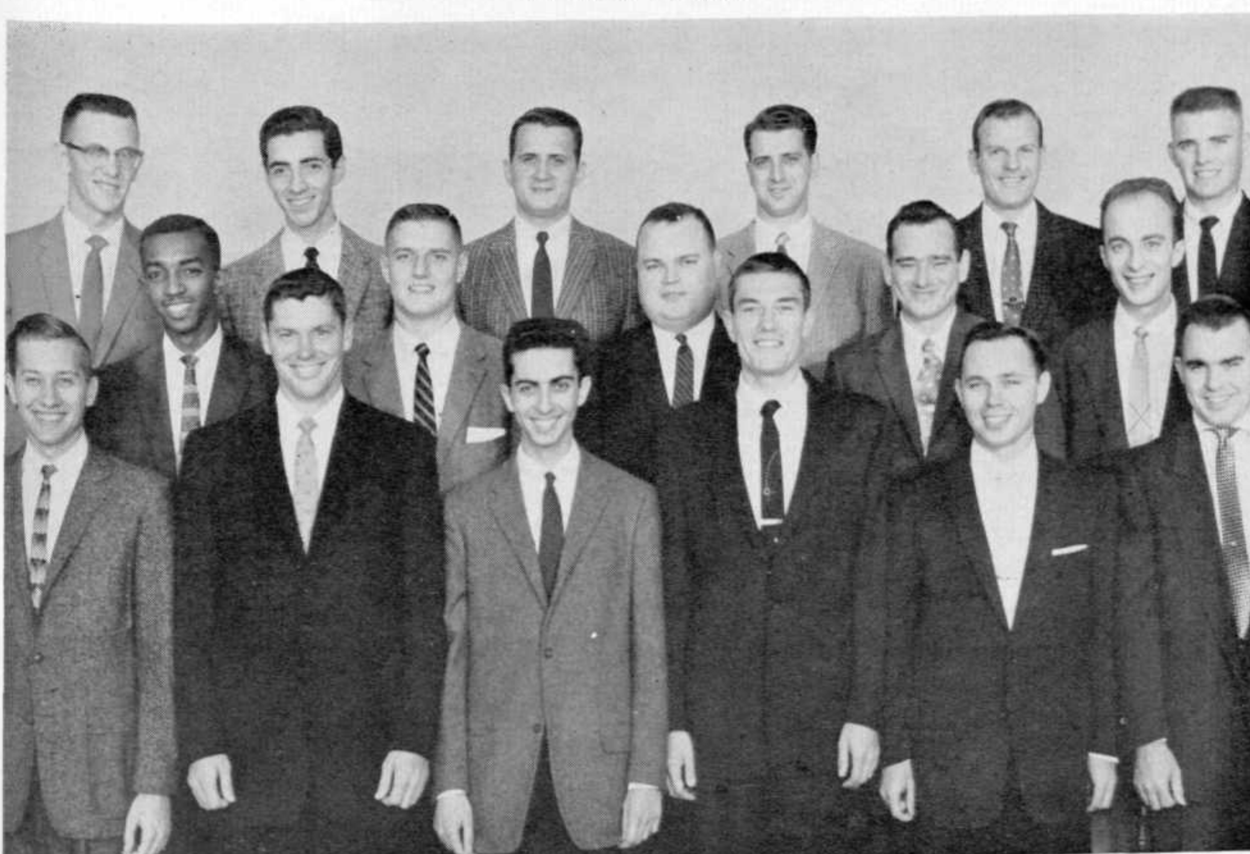
Officers for Tau Beta Pi:

President	Lowell Smith
Vice President	Richard Plugge
Recording Secretary	Wayne Robertson
Corresponding Secretary	Philip Cline
Treasurer	Robert LaFraugh

Faculty Advisors:

Mechanical Engineering	**C. H. Pesterfield**
Electrical Engineering	I. (). Ebert
Civil Engineering	A. H. Leigh
Agricultural Engineering	C. W. Hall
Faculty Treasurer	I. E. Morse

PI TAU SIGMA



Row 1: Kuzma, McCormick, Colucci, Salisbury, Sebrell, Decker; Row 2: Moss, Taulbee, Plant, Latson, Halkides; Row 3: Arnold, Laham, Fairly, Legault, Tuer, Sovis.

(Continued on Page 48)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FUDGE FACTORS

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

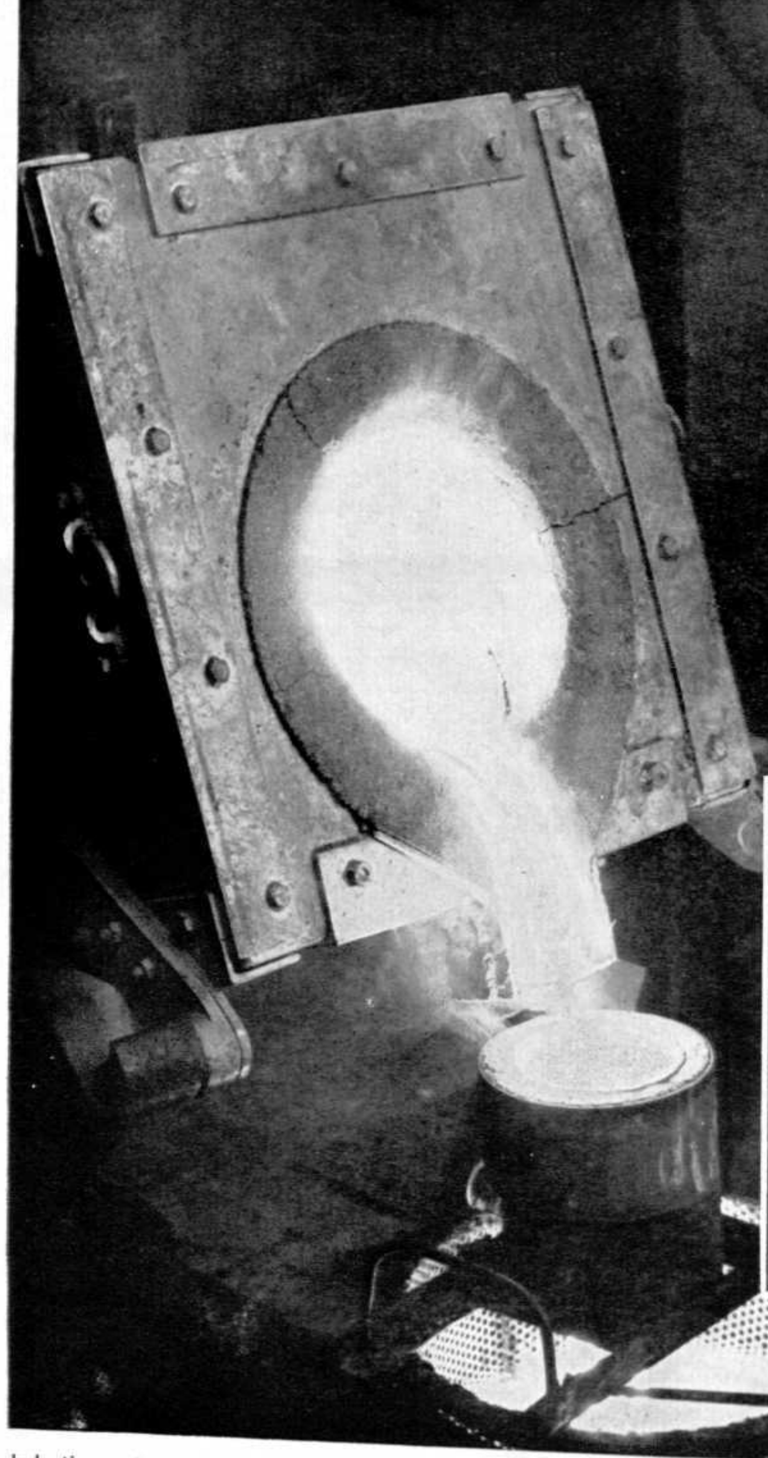
Fudge Factors

MULTIPLY	BY	TO OBTAIN
Abamperes	10	amperes.
Abamperes	3×10^{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	3×10^{10}	statcoulombs
abcoulombs per sq. cm.	64.52	coulombs per sq. inch.
abfarads	10^{9}	farads
abfarads	10^{15}	microfarads.
abfarads	9×10^{20}	statfarads.
abhenries	10^{-9}	henries
abhenries	10^{-6}	millihenries.
abhenries	$1/9\times10^{-20}$	stathenries.
abmhos per cm. cube	1.662×10^{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	$1/9\times10^{-20}$	statohms.
abohms per cm. cube	10^{-3}	microhms per cm. cube.
abohms per cm. cube	6.015×10^{-3}	ohms per mil foot.
abvolts	$1/3\times10^{-10}$	statvolts.
abvolts	10^{-8}	volts.
acres	43,560	square feet.
acres	4047	square meters.
acres	1.562×10^{-3}	square miles.
acres	5645.38	square varas.
acres	4840	square yards.
acre-feet	43,560	cubic-feet.
acre-feet	3.259×10^{5}	gallons.
amperes	1/10	abamperes.
amperes	3×10^{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	4.650×10^{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	9.870×10^{-7}	atmospheres.
Bars	1	dynes per sq. cm.
Bars	0.01020	kgs. per square meter
Bars	2.089×10^{-3}	pounds per sq. foot.
Bars	1.450×10^{-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	3.927×10^{-4}	horse-power-hours.
British thermal units	1054	joules.
British thermal units	107.5	kilogram-meters.
British thermal units	2.928×10^{-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	1.020×10^{-3}	centimeter-grams.
centimeter-dynes	1.020×10^{-8}	meter-kilograms.
centimeter-dynes	7.376×10^{-8}	pound-feet.

MULTIPLY	BY	TO OBTAIN
centimeter-grams	980.7	centimeter-dynes.
centimeter-grams	10^{-5}	meter-kilograms.
centimeter-grams	7.233×10^{-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	3.728×10^{-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	5.067×10^{-6}	square centimeters.
circular mils	7.854×10^{-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	3×10^{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	4.650×10^{8}	statcouls. per sq. cm.
cubic centimeters	3.531×10^{-5}	cubic feet.
cubic centimeters	6.102×10^{-2}	cubic inches.
cubic centimeters	10^{-6}	cubic meters.
cubic centimeters	1.308×10^{-6}	cubic yards.
cubic centimeters	2.642×10^{-4}	gallons.
cubic centimeters	10^{-3}	liters.
cubic centimeters	2.113×10^{-3}	pints (liq.).
cubic centimeters	1.057×10^{-3}	quarts (liq.).
cubic feet	2.832×10^{4}	cubic cms.
cubic feet	1728	cubic inches.
cubic feet	0.02832	oubic 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	5.787×10^{-4}	cubic feet.
cubic inches	1.639×10^{-5}	cubic meters.
cubic inches	2.143×10^{-5}	cubic yards.
cubic inches	4.329×10^{-3}	gallons.
cubic inches	1.639×10^{-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 raeters	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	7.646×10^{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	1.020×10^{-3}	grams.
dynes	7.233×10^{-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.
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 36)



What's doing...

at Pratt & Whitney Aircraft in the field of Materials Engineering

The development of more advanced, far more powerful aircraft engines depends to a high degree on the development of new and improved materials and methods of processing them. Such materials and methods, of course, are particularly important in the nuclear field.

At Pratt & Whitney Aircraft, the physical, metallurgical, chemical and mechanical properties of each new material are studied in minute detail, compared with properties of known materials, then carefully analyzed and evaluated according to their potential usefulness in aircraft engine application.

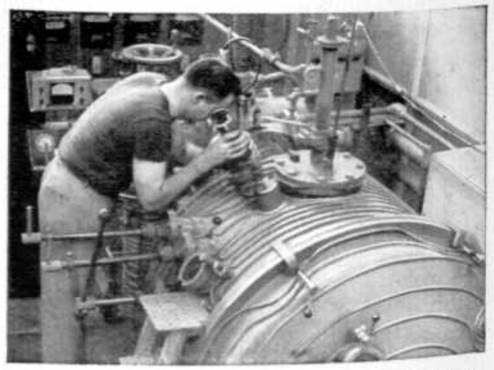
The nuclear physics of reactor materials as well as penetration and effects of radiation on matter are important aspects of the nuclear reactor program now under way at P & W A. Stress analysis by strain gage and X-ray diffraction is another notable phase of investigation.

In the metallurgical field, materials work involves studies of corrosion resistance, high-temperature mechanical and physical properties of metals and alloys, and fabrication techniques.

Mechanical-testing work delves into design and supervision of test equipment to evaluate fatigue, wear, and elevated-temperature strength of materials. It also involves determination of the influence of part design on these properties.

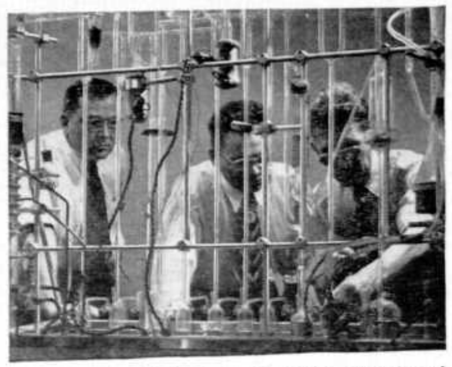
In the field of chemistry, investigations are made of fuels, high-temperature lubricants, elastomeric compounds, electro-chemical and organic coatings. Inorganic substances, too, must be prepared and their properties determined.

While materials engineering assignments, themselves, involve different types of engineering talent, the field is only one of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program — with other far-reaching activities in the fields of mechanical design, aerodynamics, combustion and instrumentation — spells out a gratifying future for many of today's engineering students.

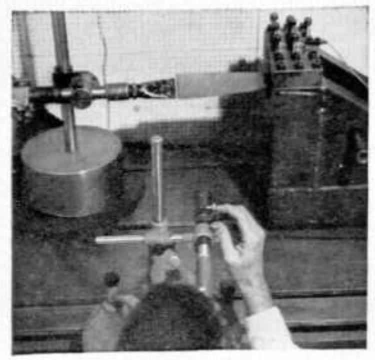


Vacuum melting has opened up new horizons for development of alloys. Here, a Pratt & Whitney Aircraft metallurgist is shown as he supervises preparation of an experimental high-strength nickel-base alloy, melted and cast under high vacuum.

Engineer measures residual stress in a compressor blade non-destructively, using X-ray diffraction. Stress analysis plays important part in developing advanced aircraft engine designs.



The important effects of gases on the properties of metals have been increasingly recognized. Pratt & Whitney chemists are shown setting up apparatus to determine gas content of materials such as titanium alloys.



P & W A engineer uses air jet to vibrate compressor blade at its natural frequency, measuring amplitude with a cathetometer. Similar fatigue tests use electromagnetic excitation.

Induction melted heat of high-temperature alloy being poured in P & W A's experimental foundry. Molten metal is strained into large water tank, forming metal shot which is remelted and cast into test specimens and experimental parts. Development and evaluation of improved high-temperature alloys for advanced jet engines is one of the challenges facing metallurgists at P & W A.

Pratt & Whitney Aircraft operates a completely self-contained engineering facility in East Hartford, Connecticut, and is now building a similar facility in Palm Beach County, Florida. For further information about engineering careers at Pratt & Whitney Aircraft, write to Mr. F. W. Powers, Engineering Department.

World's foremost designer and builder of aircraft engines

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

EAST HARTFORD 8, CONNECTICUT

FUDGE FACTORS

(Continued from Page 33)

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.

14K OPPORTUNITY

for

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WRITE TO MR. T. K. BYE

HAMILTON STANDARD

DIVISION OF UNITED AIRCRAFT CORPORATION

200 Bradley Field Rd., Windsor Locks, Conn.

Edited by Norm Dill

Today's Most Important New Prime Mover

Development in aircraft gas-turbines has been due to new metallurgical and manufacturing techniques.

OVER 2000 years ago man successfully harnessed the energy in an expanding gas—in effect, discovering the principle of the gas turbine. Since 130 B.C., when Hero of Egypt built the first gas turbine-a small, hot-air driven toy carousel—men have continued to improve upon his idea.

During the 16th century the turbine principle was applied to turn a roasting spit. This was the first practical application of the gas turbine.

On November 30, 1791, shortly after the close °f the American Revolution, the British Patent Office issued patent No. 1833 to John Barber. This patent described a gas-turbine power plant that included in elementary form all the principal components of the modern plant. Yet until about 1940, few engineers took this type of power plant seriously-the average Person still thinks of it as a modern invention.

The principle of the turbine itself dates back to antiquity. And although it's apparent from Barber's Patent that the principle of the gas-turbine power plant was understood from at least the beginning of the 19th century, neither steam nor gas turbines wire built during most of that century. Instead, the reciprocating steam engine was developed early and remained for many years the dominant type of power plant. Probably the high operating speeds required for large turbine outputs and high efficiencies were excessive for the materials and bearings of the day. Nor was theory, especially as it pertained to turbine nozzles, adequate to provide a good foundation for practical design.

Early in the 20th century, however, the steam turbine was perfected; and in a few years it had almost completely superseded the reciprocating steam engine. You might logically expect parallel development of the gas turbine. On the contrary, almost contemporaneously with the perfection of the steam turbine, development of the reciprocating internal combustion engine began. And many years passed before attention turned to the gas turbine.

Industry became interested in the industrial possibilities of the gas turbine as a result of a doctorate thesis written by Sanford A. Moss in 1900. Dr. Moss was given facilities in Schenectady to continue his research and development work on turbosuperchargers and gas turbines.

Because of its greater ease of manufacture and correspondingly decreased cost for low pressure ratios, the centrifugal type progressed much more rapidly than axial-flow compressors. From 1910 onward a large number of centrifugal compressors were built for blast-furnace and other industrial applications. During the closing days of World War I, the centrifugal compressor was selected for the turbosupercharger —the immediate predecessor of the aircraft gas—turbine power plant. Meanwhile, although Sir Charles Algernon Parsons had built a few axial-flow compressors in the 1900 to 1910 period, for many years development of this type proceeded slowly.

Engineers' interest in the independent gas-turbine power plant didn't lag while the steam turbine and the reciprocating internal combustion engine were in process of development. Though a number of investigators were active in gas-turbine research previous to and just after 1900 and though their work constituted a necessary foundation for later development, no practical power plants were produced. Charles Lemale and Rene Armengaud in France, Norman Davy in England, and Dr. Sanford A. Moss

(Continued on Page 52)

Full-time, off-the-job GRADUATE ENGINEERING TRAINING helps speed careers at Western Electric

STUDY CENTER. New York's Coliseum Tower houses one of three special study centers set aside for W.E.'s Graduate Engineering Training Program. Other centers are in Chicago and Winston-Salem, N. C. Product design principles are one of the many technical subjects our engineers cover in *Introduction to Western Electric Engineering*, the first phase of the program.

Right now, **Western** Electric engineers are back "on campus" in a unique new Graduate Engineering Training Program. They're attending courses at special study centers **established** by the company in Chicago, New York and Winston-Salem, N. C. It's a rare chance to study advanced engineering and get full pay at the same time.

These "students" are guided by **a** teaching staff of top Western Electric engineers, outside experts and professors from leading universities. They're learning the latest technical developments . . . boning up on everything from manufacturing processes to computer applications.

When the program reaches its peak, some 2,000 to 3,000 Western Electric engineers **will** attend each year .. . studying in an atmosphere as close to a university graduate school as is practical for industry.

This engineering "university" was born because of the ever-increasing complexity of Western Electric's job as the manufacturing and supply unit of the Bell Telephone System. Today W. E. engineers are right in the middle of exciting fields like microwave radio relay, electronic switching and automation. Graduate engineering training is designed to spur their development and advancement throughout their entire careers.

How Graduate Engineering Training would work for you

The program gets under way after approximately six months on-thc-job experience. First off:

1. A nine-week *Introduction to* ***Western*** *Electric Engineering* helps you learn about your W.E. engineering field, sharpens your skills in getting ideas across. Technical subjects include communications systems, product design principles, military electronic systems.
2. Another nine-week program, *General Development,* starts after your first year with us, helps broaden and strengthen your engineering background. Besides technical subjects like engineering statistics, measurements and instrumentation, and electronics, you receive grounding in human relations and the socio-economic importance of engineering.
3. To meet continuing needs for **formalized** technical training, *Advanced Development* offers four-week courses tailored to the individual needs of the engineers selected to attend. These courses are designed to help develop creative engineering abilities. Computer applications, switching theory, feedback control systems, and semi-conductor devices and circuits are sample topics covered in this phase.

Besides taking part in the Graduate Engineering Training Program, engineers are eligible for our Tuition Refund Plan for after hours study at nearby colleges.

In short, there's a unique opportunity **at** Western Electric to develop a professional career ... and work in the exciting **world of** communications.

Knowledge born in the classroom often sparks on-the-job ideas. These engineers are working on transistor manufacturing problems.

OPPORTUNITIES FOR ENGINEERING GRADUATES

(Supervisory and administrative opportunities exist in each field)

Analysis for manufacturing operations: Machine and tool requirements—M.E., E.E.; Space requirements—M.E., I.E.; Test facility requirements—E.E.; Personnel requirements—I.E.; Electric power, light and heat requirements—E.E.; Raw material requirements—Chem. E., Met. E., Phy. Sc.; Procedures and processes—M.E., I.E., Time and motion studies — I.E., Investigation of manufacturing difficulties—M.E.; Quality control—M.E., E.E.

Planning telephone central offices: Equipment requirements — E.E.; Power and cable requirements—E.E.

Development and design: New machines and tools—M.E., E.E.; Material handling methods—M.E., I.E.; New equipment and processes—M.E., E.E.; Repair shop methods—M.E.; Testing facilities—E.E.; Testing methods—E.E.; Job evaluation studies—I.E.; Wage incentive studies—I.E.; Production control studies—I.E.; Improved chemical processes—Chem. E., Met. E., Phy. Sc.; New application for metals and alloys—Chem. E., Met. E., Phy. Sc.; Raw material test procedures—Chem. E., Met. E., Phy. Sc.; Service to military on electronic devices—E.E.

For further information write: Engineering Personnel, Room 1030, 195 Broadway, New York 7, N. Y.

Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

• Western Electric has major manufacturing plants at Chicago and Decatur, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Burlington, Greensboro and Winston-Salem, N. C.; Buffalo, N. Y.; North Andover, Mass.; Lincoln and Omaha, Neb.; St. Paul and Duluth, Minn. Distribution Centers in 32 cities. Installation headquarters in 16 cities. General headquarters: 195 Broadway, New York, N. Y. Also Teletype Corp., Chicago 14, Ill.

NEW DEVELOPMENTS

Edited by Norm Dill

Hold My Hand, But Not Too Tightly

Mechanical "hands" that can disassemble an **aircraft jet** engine "bolt by bolt" are part of the remote handling equipment in one of the world's largest shops for handling radio-active equipment.

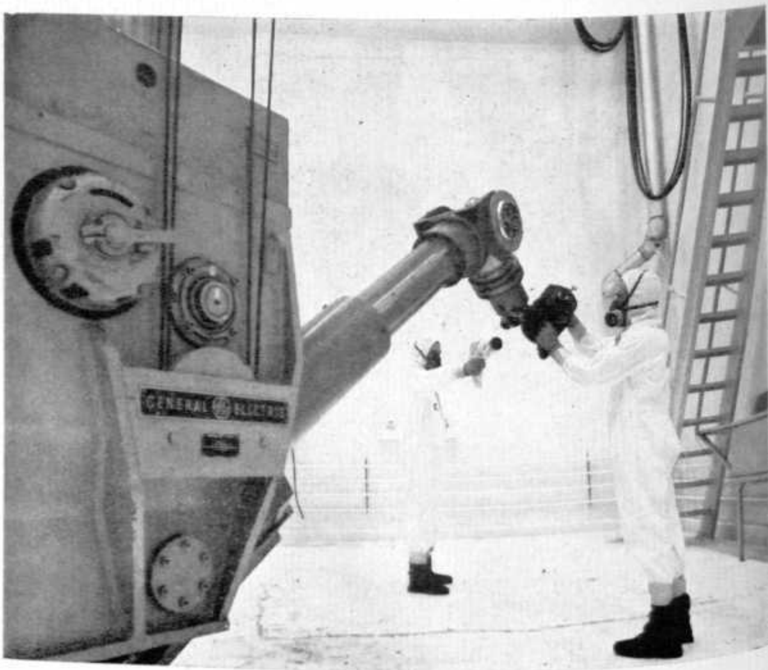
The huge "hot" shop, 160 **feet** long, 50 feet wide and 63 feet high, is part of the Atomic Energy Commission's test facilities utilized by the General Electric Company.

Remote handling tools in the "shop" range from a 100-ton crane down through O'Man, a huge machanical "arm" to a much smaller master-slave manipulator **for** making intricate mechanical adjustments.

The O'Man manipulator can handle from 500 **to** 3,000 pounds, depending on the arm length and position used. This giant manipulator is suspended from **a** crane bridge and can cover the entire working area of the shop.

Operators **of** these manipulators and four other electrically controlled wall-mounted manipulators are protected by concrete walls some seven feet thick and by nine windows of lead glass and zinc bromide, six feet thick. Each window contains 500 gallons of zinc bromide **to** protect operators from stray nuclear radiation.

Enough controls are located at each window to operate any piece of servicing equipment in the entire shop. Radio contact can be maintained by operators in the control galleries with other operating sites and with **a** lead shielded locomotive used to haul equipment to be maintained in and **out** of the huge shop.



GIANT HAND—A technician operates a huge mechanical "hand" at AEC's aircraft nuclear propulsion test site, Idaho Falls, Ida. Designed and built by General Electric, the manipulator can handle from 500 to 3,000 pounds and can easily disassemble an aircraft jet engine, bolt by bolt.

The shop is serviced by a track system which enters through large remote-controlled double doors at the west end. Smaller entrances are provided **for** personnel who must enter the "hot" shop.

On the floor of the shop are two large capacity turntables for rotating heavy equipment that must be serviced. Rotation of these nuclear aircraft propulsion equipment components provides easier access by tool and better view from any of the nine observation windows.

Connecting with the main "hot" shop are smaller shops for handling radioactive equipment, including one area for servicing O'Man and other remote handling equipment.

Also connecting with the "hot" shop by water canal is a water-filled storage pool for fuel elements and other radioactive units. The pool, 120 feet long, 60 across and 24 deep, is filled with water that is much purer than ordinary distilled water for sale in drug stores.

Visual observation of work in the "hot" shop is difficult because distances involved between observer and equipment often exceed 50 feet.

Six of the viewing windows in the main shop are 18 feet above the shop floor and two are 30 feet above it. One window is located in the cell for maintaining the remote handling equipment.

Viewing aids used include binoculars, spotting telescopes, mirrors and closed circuit industrial television, with preparation being made for installation of a television network that includes black and white, color, 3-D stereo vision or any combination of these, with viewing screens at all operator locations.

Depth perception depends to a great extent on the stereo vision of the technician, since size, color and shadows are not always available as depth perception aids.

One Step Beyond Push-Button Warfare

"This goes one step beyond push-button warfare, for at the Talos Defense Unit you don't even need to push a button to send this weapon into action."

That was the description of the first completely automatic system for firing and guiding missiles to their targets. The base, is an electronic control center which can go into action by itself in response to warning signals from remote outposts.

A decade ago, it would have seemed like a figment of science fiction to speak of a base that could fire a missile and guide it to its target without the help of a human hand. But here it is, before you, today.

The Talos Defense Unit (TDU) is composed of three structures—one a long, low concrete and steel building (316 x 80 feet horizontally, 30 feet tall) containing the control center, and the other two circular **magazines with the launchers, resembling anti-aircraft** guns, in the **center and numerous cells** on the **perimeter** to house **the** missiles **themselves.** All three arc built to **withstand** (the **pressures of the** missile take-off and near misses **From** enemy bombs, and all are airliltercd **for** protection **of** the **equipment** and **personnel.**

In general **terms** and within **the bounds of** military security-this is what the TDU is designed to do:

Suppose a fleet of **enemy bombers,** or perhaps a single missile, is detected by one of the numerous warning systems spanning the North **American** continent. A signal is sent to the **TDU,** where it is received by a series of data-handling and computing machines. These decode **the information** and **analyze** the number **of** attackers, their location, course and speed of approach.

Next a scheduling and programming computer sets the logical points of interception. Then it starts the machinery to load the missiles onto the launchers and fire them at the proper time and in the **proper** direction.

In this stage—still without the lifting of a human hand—the blast-proof concrete-and-steel cell doors swing open to release the missiles the computer has selected. The cells have reinforced concrete walls two feet thick and are so constructed that, should one of the missiles go off by mistake, the blast would go upward through the roof rather than horizontally to detonate the other missiles.

As a cell is opened, one of the launchers circles to face it and sends a small cart down a railed bridge to the door. Swiftly the missile is loaded on the cart and rolled onto the launcher. Then the launcher swings to the desired position of fire. After an automatic check-out—and at the proper time—the projectile is fired. All of this is done automatically.

There are two stages of flight after the initial upward thrust. First the missile follows a guidance beam to the vicinity of the target. Second, as the missile approaches the target, a secret "homing" device senses its presence and "locks on" to the target to close in for the kill.

During all of this action, the military personnel at the TDU merely observe and monitor the performance of the equipment. However, several modes of operation that are less automatic and employ some human operators are possible. Both the equipment and the operators are maintained in a constant state of readiness by use of automatic practicing devices and system-checkout equipment. These employ tape, bearing data on a simulated engagement, which is played through the system.

One of the numerous advantages of the Talos unit is the fact it can fire single missiles or numerous missiles simultaneously at a number of different targets and can continue to fire over an extended period of time. Also, it can carry either a high-explosive or nuclear warhead.

(Continued on Next Pane)

The "Talos" missile is about 20 feet long, 30 inches in diameter and weighs 3,000 pounds. It is accelerated by a large solid fuel booster rocket some 10 feet long, which is jettisoned when the missile reaches cruising speed. At this time the main ramjet engine, using kerosene as fuel, ignites and provides thrust to keep the missile at constant speed throughout its Bight. The engine develops 40,000 horsepower.

Completion of the land-based unit now enables the Army to use the same weapon produced for the Navy, an important factor from an economy standpoint.

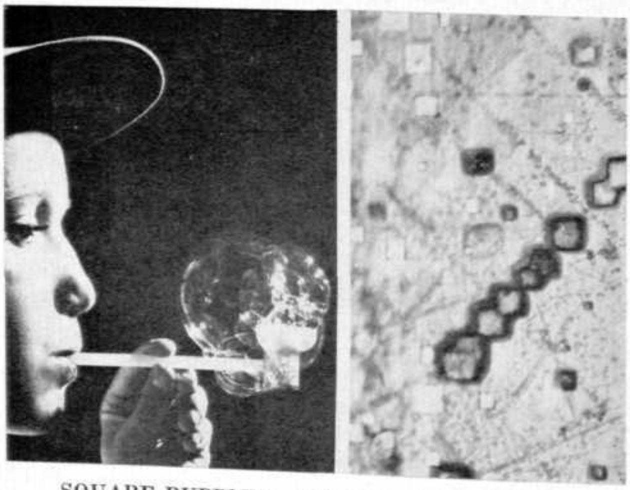
Square Bubbles

Square bubbles, the first such phenomena ever observed in nature have been found by a General Electric Company scientist during experiments at the Knolls Atomic Power Laboratory (KAPL).

Peter Senio, a metallurgist at the laboratory, disclosed that brilliantly colored microscopic bubbles in square and rectangular forms appear in lithium fluoride crystals after they have been irradiated with neutrons in a reactor, then heated above 600 degrees Centigrade (1,112 degrees Fahrenheit).

Square bubbles, Senio said, never have been in any other material. No bubbles of any kind were discovered by Senio in lithium fluoride that was not first irradiated with neutrons.

Lithium fluoride, he explained, is a clear, glass-like material he irradiates to study the effects of neutron bombardment and to associate the results with materials that make up a nuclear reactor.



SQUARE BUBBLES—Although round bubbles are produced by small boys and most of the time by nature, a General Electric metallurgist has reported square bubbles in nature.

Physical changes Senio is looking for appear in lithium fluoride within a few days rather than in months as is the case in many metals.

During his studies, Senio found that lithium bubbles appear first in bright colors. The colors, lie said, show that these bubbles have a third dimension, even though they are extremely thin, measuring only about three one-hundred-thousandths of an inch.

As the bubbles thicken, they turn white.

Senio said he believes formation of helium and tritium gases in the irradiated lithium is responsible for the bubbles. So far, however, he is at a loss to explain why square and rectangular bubbles appear rather than conventional spherical ones.

At first glance, he said, the box-like bubbles have no practical value, but should lead to important scientific findings regarding the fundamental atomic structure of matter.

"It will take a lot of study to explain why nature allows bubbles of this type to form in one material and not in others," he said.

These unique bubbles are formed this way:

Small pieces of clear lithium are irradiated with neutrons in a reactor. Once irradiated, they turn black.

Next, these crystals are heated in a laboratory furnace. When they reach about 450 degrees Centigrade (842 degrees Fahrenheit), they turn clear, or almost clear, again.

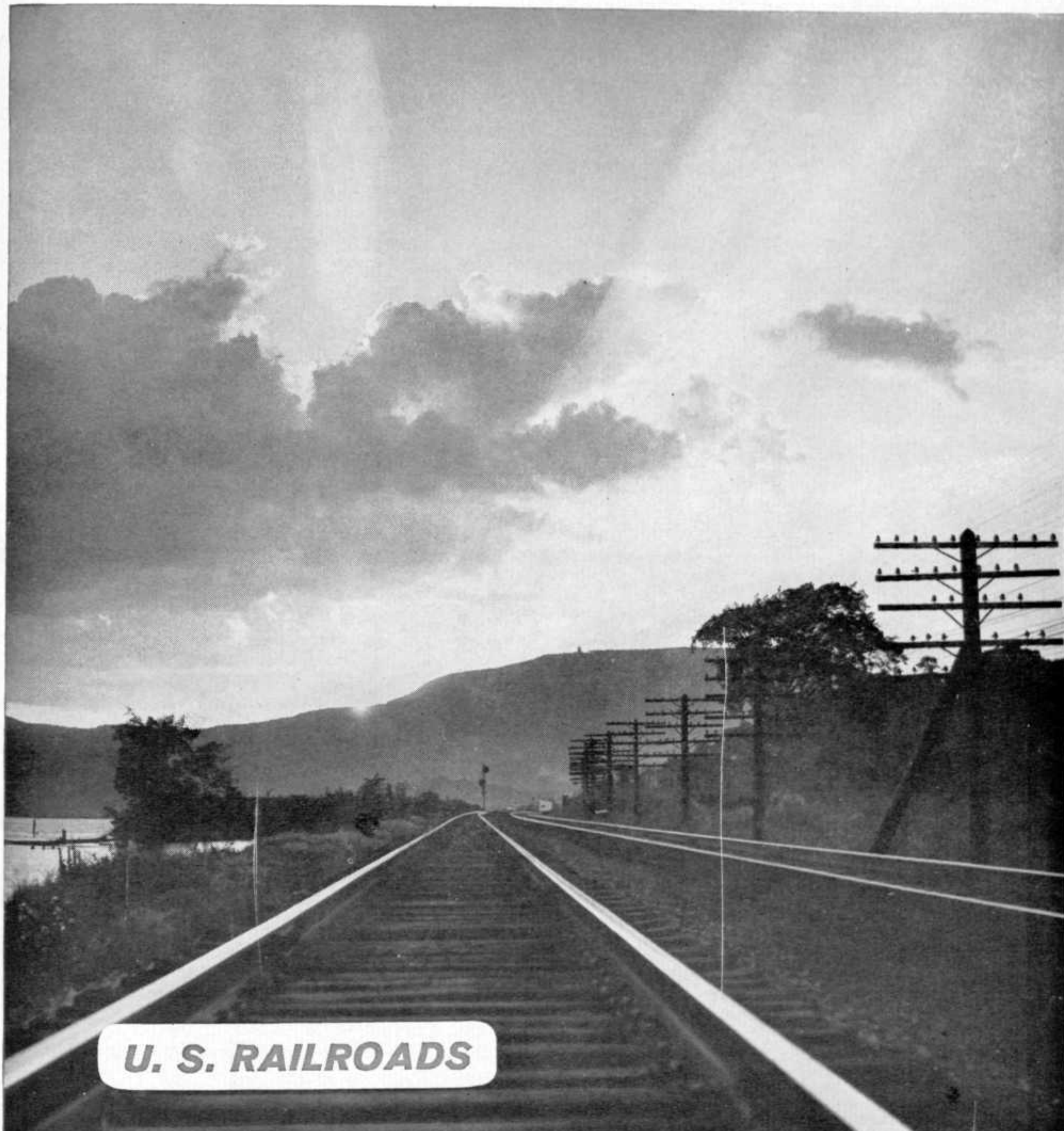
When heated to about 700 degrees Centigrade (1,292 degrees Fahrenheit) for several hours, they look frosty to the naked eye. At this stage they are taken from the furnace and allowed to cool. Studied under a microscope, the crystals reveal color squares formed inside and most frequently along natural faults in the lithium fluoride crystals. Over-all appearance of groups of the bright bubbles is somewhat similar to squares used in stain glass windows arranged in cubist design.

If the temperature of the furnace is boosted above 700 degrees Centigrade, the bubbles inside the crystals turn white and their corners begin to round.

As the melting point of lithium fluoride, 842 degrees Centigrade, (1,547 degrees Fahrenheit), is approached, the bubbles grow and combine to form new shapes that resemble sausages, donuts, boomerangs and many other familiar objects.

Ultimate form of the bubbles during heating near the **melting point of** the crystals, appears to be Spherical as would be **expected.**

(Continued on Page 46)


U. S. RAILROADS

NEW DEVELOPMENTS

(Continued from Page 44)

Elevator Furnace Equipped With Automatic Quenching Arrangement Transfers 4000 Pound Load In 7 Seconds

A problem in fast quenching heat-treated aluminum **has** been solved by an electric elevator furnace, equipped with an automatic elevator quench, which **transfers** the load from **furnace** to quench in just seven seconds.

The furnace has four zones, handles a 4,000 lb. charge at 1,000 degrees F maximum operating temperature. Temperature variation throughout the load is 10 degrees F or less after stabilization at control **temperature.**

Loads of coiled 24 S aluminum alloy sheet material as large as 6 ft. wide and 12 ft. long are regularly processed in the furnace. Remote recording thermocouples are used during performance testing. Within 15 minutes, most of the load is at temperature, and 20 minutes the inner-most part of the coils reaches the heat-treat temperature. Similar rapid heating is obtained on extrusion and formed parts loads.

A Neutron Flight Analyzer

Two engineers at the Knolls Atomic Power Laboratory here have developed a new electronic computing device for measuring, counting and classifying time of flight of neutrons from a nuclear reactor which accomplishes in an hour what it previously would have taken a man a month to do.

Elmer J. Wade and Donald S. Davidson of KAPL developed the first all-transistorized time of flight analyzer for use in determining the neutron energy distribution of various types of reactors. It contains 256 channels, compared to a device previously in use at KAPL which furnished only 11 channels for recording information on different energy range neutrons.

Employed in reactor development work at Kapl, the analyzer, through its work-saving features, has freed highly trained scientists from routine calculating work. They can now spend time saved in evaluating information the new analyzer provides for them.

Savings in time and labor by the new analyzer are matched by the space it conserves at the laboratory. The device is only 8 inches high, 19 inches long and 13 inches deep, compared to earlier analyzer equipment which took up at least 10 times that amount of space.

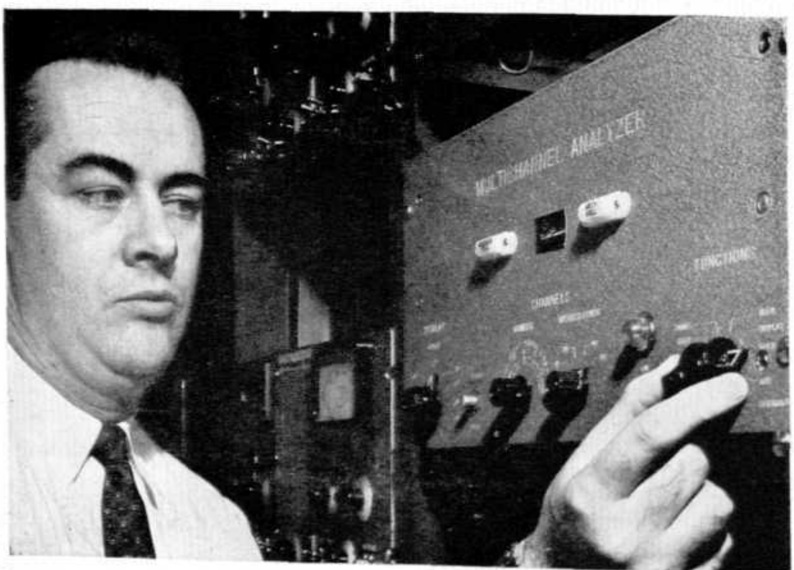
The KAPL engineers said the analyzer works this way:

Development of new reactors at KAPL involves mock-up of various fuel arrangements and accurate measurement of resulting neutron energy spectrum.

This is accomplished in a large part by measuring the time of flight of neutrons over a given distance and recording the number of these neutrons which fall into 256 different velocity ranges. Through various calculations, scientists can convert the velocity of these neutrons into corresponding energy ranges.

To accumulate this vital information, a neutron beam coming out of the thermal test reactor is chopped by a rotating shutter so that velocity can be measured. At the end of a flight path of established length, the neutrons are detected by a counter and the information relayed to the analyzer.

(Continued on Page 49)



HOUR VERSUS MONTH—This small General Electric all-transistorized analyzer rapidly measures, counts and classifies the time of flight of neutrons from an atomic reactor. It does in an hour what it previously took man a month to do.

the beginning of a **million dollar** detective story

Men, vehicles and instruments bound for the middle east

The cast of this story may include a part for you. GSI is a leader in the worldwide search for new petroleum reserves. **Emphasis** is shifting to foreign areas and there is a world of opportunity awaiting those who can qualify for a career in geophysical exploration.

GSI has openings for college graduates trained in geophysics, physics, engineering, math and geology.

For a rewarding career, which may take you from California to Calcutta, join the cast .. . join GSI.

*Write for our booklet, "**With** GSI The World Is Your Office."*

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GEOPHYSICAL SERVICE INC.
Department 12 – Box 35084
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 (*Continued from Page 29*)

The Chemical, Agricultural and Metallurgical Group of the Engineers' Wives held their first meeting on Tuesday evening, February 11. Professor John W. Donnell of the Chemical Engineering Department was the guest speaker. At the March meeting, Mrs. Beatrice Leonardson, Coordinator for Continuing Education in the College of Home Economics, will address the group. Tentative plans have been made for a tour in April and a joint meeting of husbands and wives is scheduled for May.

Engineers' Wives

A new **organization,** "Engineers' Wives," is being **Formed on the** M.S.U. campus. It is sponsored by the Engineering Department, and the purpose of this club is to acquaint the engineering student's wife with the field of engineering through lectures, movies, and discussions.

The first group meeting proved a success with 150 student wives in attendance. It was a business meeting held on January 21st in the Union Building. The faculty advisor is Miss Agnes McCann, assistant to the Dean of Engineering, and the assistant advisor is Mrs. J. D. Ryder, wife of the Dean of the School **of Engineering.**

Club officers are:

President—Marilyn Raymond
Vice President—Zoe Hewitt
Secretary—Carol Schuhardt
Treasurer—Doris Brown

The organization is divided into four individual groups:

Mechanical
Chairman—Sally Daly
Co-chairman—Kathleen Wenke
Civil
Chairman—Sharon Wiseman
Co-chairman—Carole Morgan
Electrical
Chairman—Marilyn Wilson
Co-chairman—Marilyn Archuletta
Met., Chem., and Agricultural
Chairman—Mary Bode
Co-chairman—Connie Gyde

These groups function separately, and meet each month. Once each term, all four groups meet together for a business and social meeting. The next organization meeting will be held April 10, and Dr. C. U. Harris, Head, Department of Applied Mechanics, will give an introductory talk on engineering.

Row 1: Eunice Rice, Marilyn Raymond, Carole Morgan, Sharron Weseman, Judy Webster; Row 2: Sylvia Wensloff, Eleanor Raths, Nancy Robkins, Cathy Badelt, June Graham; Row 3: Bonnie Kershner, Marilyn Hooper, Marjorie Van Patten, Mrs. J. D. Ryder (asst. advisor), Esther Gordon.

NEW DEVELOPMENTS

(Continued from Page 46)

Information on each neutron counted is directed **into** one of 256 channels, each representing **a** velocity range. Up to 65,536 neutron counts is stored in each of these channels.

After the experiment this information is transmitted over cables to electronic calculating equipment which punches information from each channel of the analyzer onto a separate card.

This information is then fed into a digital computer for analysis of the data from the cards and the result is then automatically plotted on a graph which shows the reactor energy characteristics.

The entire operation from neutron count to production of a graph which reveals the energy spectra of the reactor requires only about an hour, compared **to** what would have been **a** month's work for a single scientist recording data manually.

Signals Are Bounced From Meteor Trails

High-frequency radio signals, bounced from meteor trails 60 to 100 miles above the earth, have been used experimentally for the first time to transmit images of printed material over a distance of nearly 1,000 miles without relays.

The novel system was developed for the Cambridge Research Center of the Air Research and Development Command. Principals in the development were Warren H. Bliss, of the technical staff at RCA's David Sarnoff Research Center in Princeton, J. N., and R. J. Wagner, Jr., and G. B. Wickizer, of the RCA Laboratories radio research staff at Riverhead.

Basic research in the field of meteor trails has been conducted in this country notably at Stanford University and the Bureau of Standards, much of it sponsored by the Department of Defense, as well as in Canada and the United Kingdom. In recent years more attention has been given to the effects of meteor reflection on communications. The Canadian Research Board developed **a** teletype system.

Because radio reflections from meteor trails were believed to be of importance to the Air Force, **the** Propagation Laboratory of The Cambridge Research Center had initiated a meteor program in 1953. As a result of this **program,** Dr. Philip Newman and Dr. Joseph Casey of the Cambridge Center came to the conclusion **that** it should be possible to make radio transmission of visual material via meteor trails. RCA, at the request of the Air Force, developed special equipment to investigate this possibility. The first trial of this equipment during early autumn met with instant success. However, the meteor trail phenomenon is **a** complicated one and considerable **further research** will **be required to determine how** best **to** exploit **this** new **capability.**

Scientists **gave** tin's **explanation of meteor trail** propagation:

When **a** meteor enters **the** thin upper **atmosphere** ol the earth, **the** high **velocity of** its passage causes the air particles **to** break down into positive and negative ions. This trail **of** ionized **air,** which **may persist** durin **of a** second up to several minutes alter the **passage** of the meteor, acts as a **reflector** of radio signals which would otherwise radiate out into space. Along a transmission path of the type used in the experimental facsimile system, ionized meteor trails **appear** on an average of several times a minute to close the circuit between transmitter and receiver.

The research team pointed out that meteor path propagation promises ultimately to increase the versatility of all radio communications by providing a means of sending information at times and over distances for which other means may not be available. It also offers a valuable means of supplementing the overcrowded radio spectrum.

According to the report of the three scientists, the experimental system functions this way:

The material to be transmitted is recorded on 35 millimeter film, which is scanned to **produce** a signal in a manner similar to the **techniques** used in television film transmission. The resulting signal is sent out from the transmitter through a highly directive **antenna** aimed in the direction of the distant receiver. At the receiver, the signal is picked up by another directive antenna each time it is reflected during the brief life of an ionized meteor trail, and the information is fed to a cathode-ray tube for display on a viewing screen. In the experimental system, photographic techniques are used to record the image as it appears on the screen.

The research team **reported** that the scanner and transmitter are run continuously, sending copies of a picture over and over at the rate of two complete scans each second. The receiver is also on continuously with the recording unit in a "standby condition."

"When a passing meteor closes the transmission path, the incoming signal trips the recorder . . . to permit reproduction on the phosphor screen," they said. "The circuit then resets for the next burst."

The report stated that the experimental transmitter produces 20 kilowatts of power at a frequency of 40 megacycles, which is in the very-high-frequency range somewhat below the portion of the frequency spectrum used for commercial VHF television service. It added that the "encouraging results" so far have been achieved during preliminary tests of the new equipment prior to the start of a planned research program.

(Continued on Next Page)

New Electronic Panels That Store Images For Prolonged Viewing

Two novel **electronic storage** display pant-Is **that can be** used **for prolonged viewing of** projected light **Images to which** they are exposed for only fractions of **a** second, were described in Washington recently by scientists of the **Radio** Corporation of America.

The **experimental** devices, with potential applications in radar and other electronic display systems, were among several new developments disclosed by scientists and engineers at the third annual meeting of **the** Institute of **Radio** Engineers' Professional **Group** on Electron Devices on November 1. Among the others were new **techniques** which promise to lead to increased sensitivity and versatility in Vidicon **television camera** tubes.

The two **types** of **display** panels described by the specialists include one in which a new electronic **principle** is **employed** to achieve a light amplifier which, after a l/100-second **exposure** to a dim image, stores and displays the image in bright form for several minutes or longer. The other type, employing **different principles** and a more complex structure, was described as a high-resolution storage system combining picture detail with long image persistence.

The first of the two devices was discussed by Dr. F. H. Nicoll, of the RCA Laboratories technical staff at the David Sarnoff Research Center, Princeton, N.J. In the new panel, according to Dr. Nicoll, the **bright** image display persists for several minutes following an exposure of only **1/100-second** to the projected image. He added that the image may be erased in a fraction of a second, if **desired,** leaving the panel **immediately** ready for another exposure.

Dr. Nicoll told the- group that the ability of **the** panel to store a bright image after only a brief exposure results from the discovery of a previously unknown phenomenon in cadmium selenide, a photoconductor material which is an insulator in darkness but becomes a conductor of electricity upon exposure to light. It was found, he said, that under the influence of applied voltage and exposure to light, the conductivity of the cadmium selenide will increase sharply and will remain high for long periods after the light source has been cut off.

The scientist gave the following explanation as to how the newly-discovered principle is applied in the- experimental amplifier:

The panel itself is a "sandwich" formed by a thin layer of cadmium selenide photoconductor on one side, and a layer of electroluminescent material on **the** other, separated by a thin layer of opaque material. The electroluminescent material has the characteristic of emitting light under the influence of an applied voltage. To operate the panel, a voltage is applied across the whole assembly. In darkness, the current is prevented from flowing by the insulating property of the cadmium selenide layer. When the light of the projected image strikes this layer even for as little as l/l(X)-second, however, the cadmium selenide becomes conducting in accordance with the pattern of light, allowing current to pass through the opaque layer to the electroluminescent layer. The electroluminescent material thereupon emits its own light in the same pattern, reproducing the original image in bright form.

Since the cadmium selenide remains conducting for a long time after the light source has been cut off, the current keeps flowing to generate light in the electroluminescent layer. When the image is to be erased, the voltage is interrupted for a fraction of a second. The cadmium selenide then drops back to its insulating condition, ready for the next exposure.

Describing the laboratory device as a panel **three** inches square, Dr. Nicoll said that considerably larger storage panels of the same type can be made. He stated that future devices with these characteristics might be used in many applications to store for prolonged study images that appear only briefly, such as "stills" from television or motion picture sequences, or radar displays.

The other approach to direct-view picture **storage** in a panel device was described by an RCA Laboratories team including E. E. Loebner, H. O. Hook, and D. C. Darling. Developed in two different designs under a Signal Corps Contract, the device was characterized by the scientists as a high-resolution storage system for radar and other display applications in which long persistence and a high degree of detail are required.

As explained by the team, the panels comprise' arrangements of photoconductive and electroluminescent materials in tiny cells on a specially fabricated glass plate. They pointed out that the high resolution was achieved by employing large numbers of cells in a small area-1275 per square inch in one design, and about 1600 per square inch in another.

The scientists explained that the operation **depends** upon the basic principle of employing light-induced conductivity in the photoconductor materia' to permit the flow of current to the electroluminescen' layer. In the new experimental panels, they said, the storage is achieved by an optical feedback process, with the light emitted by the electroluminescent material being used to maintain the conductivity of the photoconductor material. By this means, it was pointed out, storage is theoretically infinite, although in practice the laboratory devices have been limited to **storage** of about fifteen minutes.

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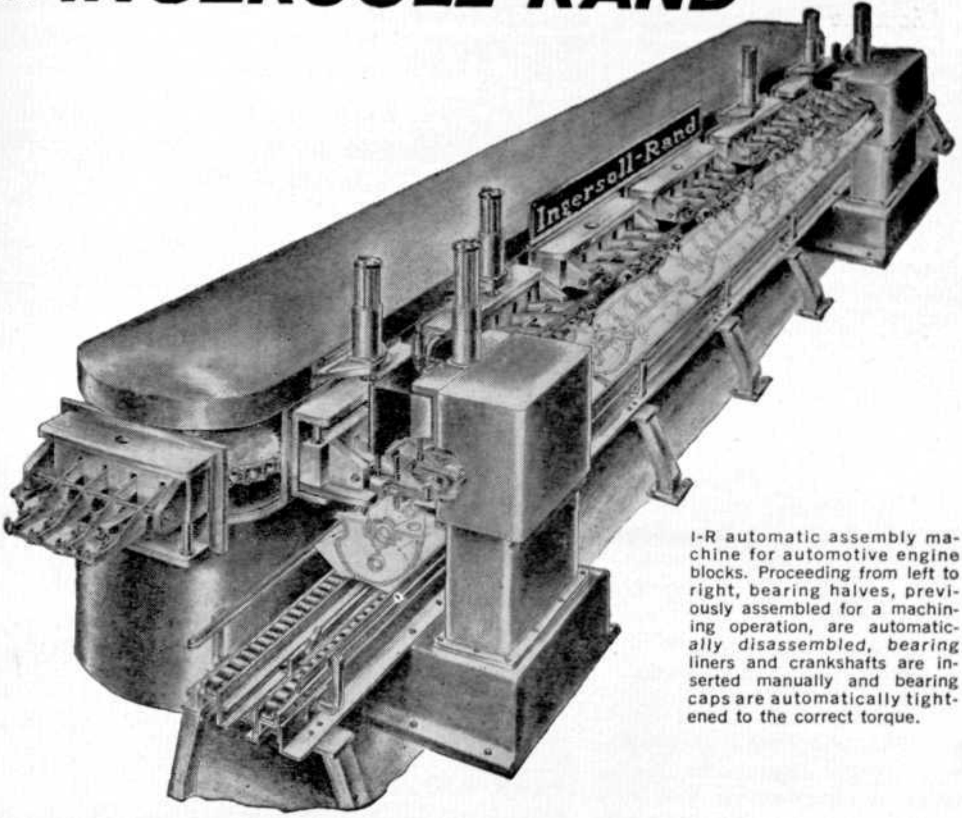
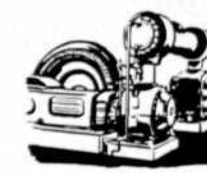
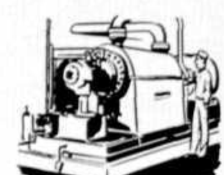


I-R automatic assembly machine for automotive engine blocks. Proceeding from left to right, bearing halves, previously assembled for a machining operation, are automatically disassembled, bearing liners and crankshafts are inserted manually and bearing caps are automatically tightened to the correct torque.

also means
LEADERSHIP
in



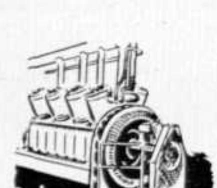
Compressors and Blowers



Centrifugal Pumps

Rock Drills

Steam Condensers



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PRIME MOVER

(Continued from Page 39)

in the United States are representative of the workers in the field at that time. About the beginning of the century, Hans Holzwarth began a long career devoted almost exclusively to the constant-volume, or explosion, gas turbine. This type has met with far less Favor than the constant-pressure type, although the compound aircraft engine operates on essentially the same cycle[1].

In 1918 the Army accepted the first turbosupercharger-a device utilizing a small turbine rotor to increase the normal air intake of an internal combustion engine, permitting greater power and efficiency at high altitude.

Several different ground power plants were built or begun during the 1930's. Among them were two of Holzwarth's design, manufactured by Brown Boveri Limited, the first of which operated successfully for short periods as early as 19.33 and completed a nearly continuous run of 470 hours in September 1937. The August Thyssen Steel Works of Hamborn, Germany, then ordered a second unit of 5000-kw capacity, installed in 1940. Successful operation of the second unit, probably the first large industrial gas turbine in actual service, was reported but details aren't available.

Beginning about 1931, Brown Boveri developed a boiler, in reality a supercharged steam generator. In it, the hot products of combustion are forced around the water tubes at high pressure and high velocity to increase the rate of heat transmission. A gas turbine operated by the waste gases from the boiler furnishes the power for compression. Although not strictly an independent power plant, it provided a powerful stimulus to further development, especially of axial-flow compressors.

The Houdry cracking process for producing gasoline, in which a certain operation is carried out with gas at high pressure and temperature, furnished another stimulus, for the gas expanded in a turbine to deliver sufficient shaft power to drive an electric generator as well as the necessary compressor.

Among the other gas turbines of the 1930's was a constant-pressure unit of George Jendrassik's design built at Budapest, Hungary, in 1935, with assistance from the Hungarian government.

The Jendrassik unit, which included an axial-flow compressor and regenerator, developed about 100-hp net output at 16,400 rpm with a thermal efficiency of 21.2 percent. The Neuchatel unit of 4000-kw capacity uses no cooling water and requires as an auxiliary only a small diesel-driven alternator to supply the starting motor in the event of a complete power failure. (Its efficiency is reported to be about 17 percent since it has no regenerator.) In 1939, Brown Boveri also began designing a gas-turbine locomotive that from 1942 onward operated successfully for long periods on nonelectrified railway lines of the Swiss Federal Railway.

A turbosupercharger is similar to an independent gas-turbine power plant except for the absence of a combustion chamber. Production techniques were well developed for the turbosupercharger. (Shortly thereafter several hundred thousand turbosuperchargers were built to make possible the high-altitude flying of Flying Fortresses, Super-fortresses, Liberators, Lightnings, and Thunderbolts in World War II.)

In September 1941, the Air Force asked General Electric to undertake development of the aircraft gas turbine in the United States and asked Bell Aircraft to design a suitable airplane. Within six months of the time work began, the first unit was completed. And the first jet engine flight in the United States occurred at Rogers Dry Lake (formerly Muroc), California, in October 1942.

Yet the increase of scale involved in passing from turbosuperchargers to independent gas-turbine power plants necessitated not only new tools and other manufacturing facilities but also development of new metallurgical and manufacturing techniques. In general, operating stresses and gas temperatures required were no higher than for the turbosuperchargers. But obtaining the necessary strength in some of the parts with larger dimensions proved more difficult. It isn't surprising, therefore, that in the absence of an emergency the large financial outlays required weren't favored.

COLOR TV

(Continued from Page 25)

in color each night and hopes to expand that to two or more programs per evening during the rest of the 1957-58 season.

Advertisers are beginning to realize the capabilities of color-TV in selling their products. The medium's ability to present the product in all its natural color, as well as the impact that multi-colored images have on the viewer, arc prompting more and more national advertisers to appropriate funds for advertising in color-TV.

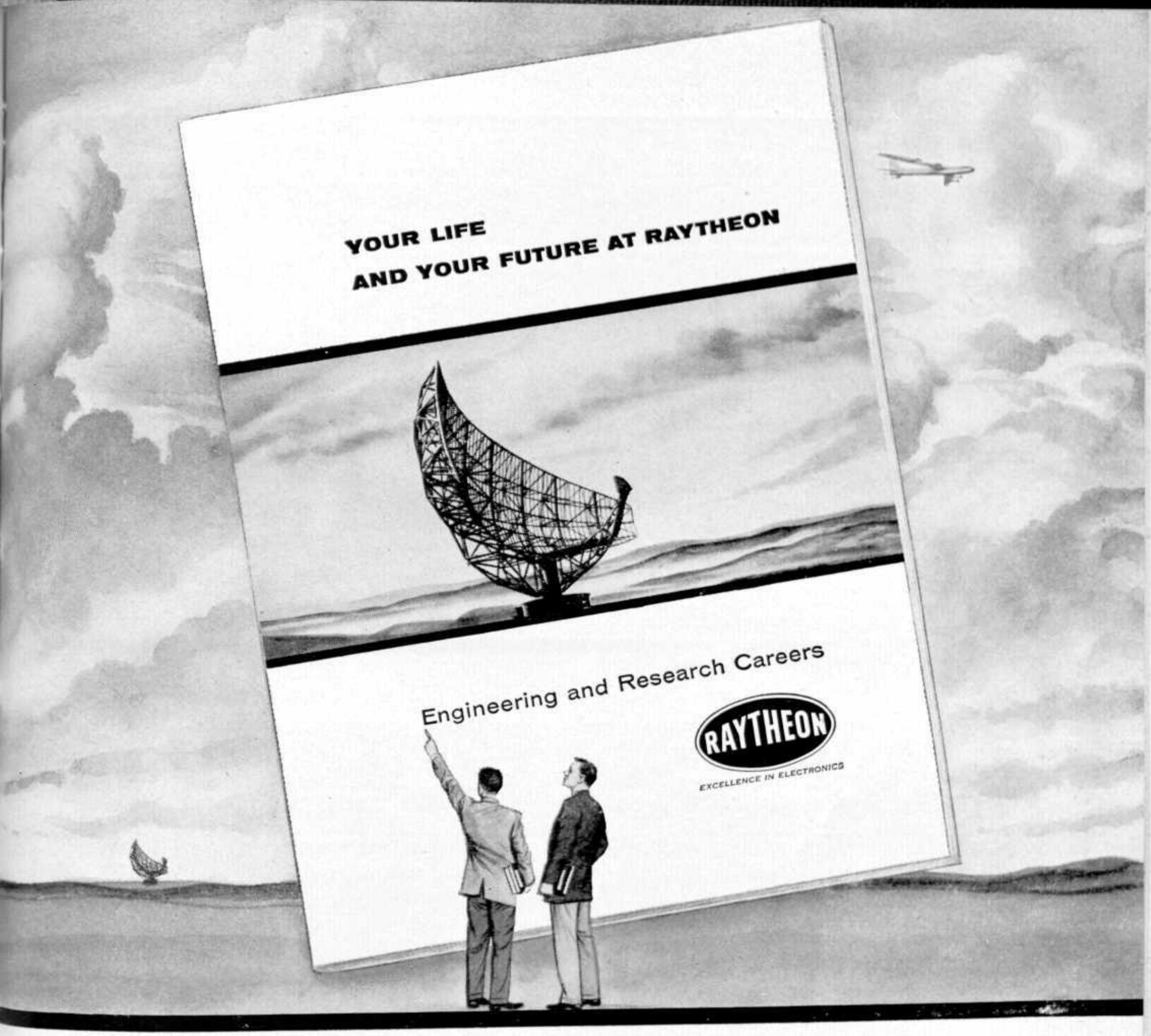
With an impending reduction in set costs, and more and more of the advertiser's dollar being spent in color presentation, it appears as if color-TV will find its way in the next decade.

"Mommy, why is it that Daddy doesn't have much hair?"

"Because he thinks a great deal dear."

"But Mommy, why is it that you have so much hair?"

"Finish your breakfast, dear."



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JUST PUBLISHED-YOURS FREE! An interesting, comprehensive, 16-page brochure that will answer your questions about how to use your training and talents to your best advantage in the job you select. The story is too big, too diverse and too detailed to tell here-that's why we ask you to let us send it to you.

Get this preview of a whole range of exceptionally promising futures for the price of a postage stamp. Find out how a fast-growing company encourages engineers and scientists to develop their potentialities to the fullest.

HIGHLIGHTS FROM THIS HELPFUL BOOK:

Raytheon's Record - review of pace-setting activities in electronics that widen horizons for you.

Research Program-suggestions for your future in either "pure" or applied research.

Development and Design Program -prospects for you in the practical application of research to the manufacture of new electronic products and components.

Manufacturing Techniques Program-latest production processes outlined for you who are inclined toward supervision and management positions.

Application and Sales Program — advantages to you in world-wide field engineering activities; rewarding opportunities in electronic sales.

AND — *important facts you want to know about individualized training, your advancement opportunities, chances for advanced study; company policies and benefits; plant locations; living and recreational prospects.*

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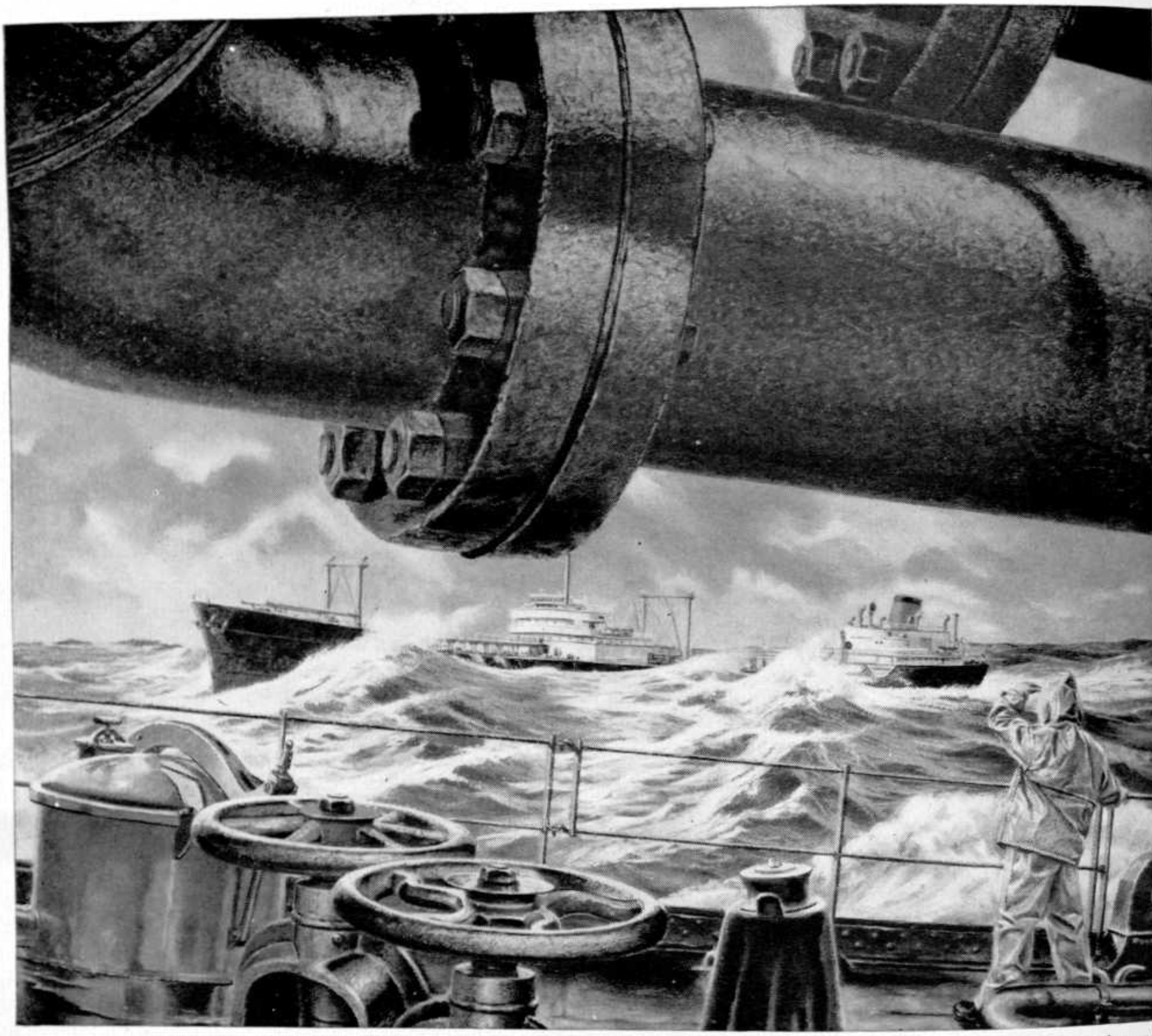

Now on many supertankers, ductile iron is a new material widely used by today's engineers in designing heavy-duty equipment.

Ductile Iron...another Inco Research first

Over five miles of ductile iron pipe going into many of today's supertankers

A deep sea tanker takes many a heavy beating when waves are rough.

With each pitch and roll, she has to *weave.* And her five or more miles of piping have to weave with her.

If it is ductile iron piping, every pipe length *gives* without break or leak.

Bends without breaking

Ductile iron is not only ductile, but also tough. And resistant to the corrosive action of sea water and sulfur laden crude oil.

In some tankers, gray cast iron pipe resists corrosion for ten years or more. Sometimes, though, it's cracked and broken by the pounding of heavy seas that overtax its strength.

In other tankers, steel pipe outrides such storms without damage. But it corrodes so badly it may have to be replaced every three or four years when handling sour crudes.

Ductile iron pipe, tanker owners find, combines the low cost and demonstrated corrosion resistance of cast iron with the tough strength of carbon steel.

So today, many of the newest tankers carry pipe and fittings of ductile iron.

Ductile Iron also under city streets

The properties that prove ductile iron pipe suitable for tankers also commend it to municipal and utility engineers. So this shock-and-corrosion resisting pipe is used for water and gas mains. It may soon be under the streets in your town.

Ductile iron has many uses-from plowshares to jet plane parts. And cost-conscious industry is constantly finding new ways to use this versatile money-saving, Inco-developed material.

For free booklet, "Engineering Properties ... Irons," write: Dept. 232G, Educational Service, Development and Research Div.,

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Question:

What makes a company a good place to work?

Answer:

Among other things, we think "the Human Touch" rates high...

This record tells why-musically

—We'd like to send you a plateter

There are a lot of things to consider in selecting the organization with which you will stake your future. For example, how is the company rated in its field? Is it known as a "quality " company? Is it growing? Is it aggressive? Is it big enough to offer you the opportunities you want? Is it too big—to the point where, of necessity, it deals with numbers instead of individuals?

...We think that last factor is mighty important. We call it the *"human touch"* element and it's pretty well explained, *musically,* in a theme song we had recorded for a recent national sales conference. The Ray Porter singers do some rather unusual vocalizing you'll probably enjoy. Clip the coupon and let us send you a record. It's good listening with a little food for thought thrown in.

mail this coupon for your *"Human Touch"* record

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6060 Rivard Street, Detroit 11, Michigan

I'd like a *"Human Touch"* record and a copy of Square D's brochure, "YOUR ENGINEERING CAREER"

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SQUARE D COMPANY

PURITY

(Continued from Page 17)

purification **of tungsten** tor lamp filaments. General **Electric has** done **considerable** studying of so called **perfect** crystals or microscopic "whiskers" of metals. These were first discovered at the Bell Telephone **Laboratories,** growing **on** cadmium. Crystals of iron, grown at General Electric, are about one-tenth the **diameter** of a human hair. Under tests they show **tremendous** flexibility, indicating a tensile strength of almost a million pounds per square inch, close to the theoretical strength of iron and far beyond that of any known metal or alloy. The theory is that in such small dimensions crystal structure is continuous **enough to** approach **the** ultimate properties of the pure element.

A group of men at the University of Virginia under Allen T. Gwathmey have been growing huge single crystals of high purity metals to facilitate their study in another way. The crystals are about as thick as **a pencil.** These crystals are sectioned and machined into highly polished slices or spheres, so as to cut through or along one or more faces of the crystal. These crystals are actually **a** large scale exactly like those found in the tiny crystals of the regular metal. Various chemical experiments have been carried out on the prepared crystals and the rates of the reaction measured on each of the faces. A dozen metals have **been** studied in this way including copper, silver, nickel and iron. Corrosion varies from face to face as much as 5 times for copper. Friction and wear also varies for each face. Therefore we can say that the different crystal faces differ almost as much as one element to another.

Another small group at the University of Virginia **under** Jesse **W. Beams** has been whirling thin metal films to destruction in the ultraccntrifuge and measuring the forces required. Again the results are startling. The thinner the metal film, the tougher and stronger it is.

All this seems to indicate that if we could get metals pure enough and orient their surface crystals in a desired pattern, we may unfold a whole new range of strengths and special properties. So far few of the new discoveries are explainable, much less practical, but the possibilities are wide. Union Carbide and Carbon Corporation have both been investigating nearly all of their metals in ultra-pure form. About four years ago they brought in two new closed-furnace processes for producing high-purity ferrochrome, an iron compound, and manganese to meet the increasingly tight specifications for jet-aircraft alloys.

The big problem comes when you try to produce pure metals in any great quantities. It is an entirely different proposition preparing pure metals commercially. The first step is to secure them in as pure a state as possible. These processes are usually a chemica process rather than the old metal-smelting techniques.

The difficult part of high-purity metal **production** is the final stages of refining. The effort required to obtain the 99.9% pure is nothing compared to the labor required to remove the last 0.1%. Anything less than 0.05% of impurities is an industrial achievement. Actually in industry purity is not as important as the structural purity or the uniformity of the metal's constituents, for most industrial metals are alloys.

Vacuum methods of refining of one kind or another are the most universal tool of high-purity metals. Industry generally has been staying away from work in vacuums, mainly because of their strangeness, but also because of their added costs in production time. But dealing with metals where the presences of a small amount of oxygen can act as an impurity, a fairly high vacuum is a necessity. Besides this, other advantages have come into play.

Vacuum methods can be divided into two levels. One is embodied in the vacuum arc-furnace, in which a low-vacuum or inert-gas atmosphere is maintained while a larger carbon electrode supplies power and heat to the melting metals. This is the tool for primary titanium and zirconium, as well as for high-purity molybdenum, experimentally produced by the Climax Molybdenum Co. and under intensive development for advanced jet engines because of its high melting point. The other level of use is represented by the high-vacuum melting furnace, in which heat is supplied by induction coils around a center crucible and the vacuum maintained is around 100,000th, of an atmosphere.

Another example of the growth of vacuum melting is the Vacuum Metals Corporation, a 50 percent interest in which was recently acquired by the Crucible Steel Company of America, with plans for large expansion. Vacuum Metals, a small subsdiary of National Research, built part of its business on the vacuum melting of high-purity copper, iron and nickel. Vacuum Metals produces copper which is held to 0.0005* or less of oxygen and nitrogen, 0.001% or less of sulfur and phosphorus and equally small amounts or 13 other trace impurities. Metals of such purities are used widely for electronic tubes.

These metals, however are nowhere near pure enough for the new electronic transistor devices, invented by Bell Telephone. In an endeavor to obtain such purity necessary for electronic transistors, Bell Laboratories have developed an entirely new process that raises the purity of industrial metals to a new frame of reference. Bell Laboratories have produced a pure form of germanium, used as the semi-conducting metal in transistors, to a degree of purity in which almost no impurities are detectable by present methods. Still other companies are developing new methods of preparing pure metals. Westinghouse has done considerable amount of work on levitating or float melting bits of metal, heated and suspended in a vacuum between electromagnetic induction coils to prevent all contact with the furnace walls.

(Continued on Page 58)

I'm in the business and I know...

"Not *too long ago I was in the same situation you fellows are in now. Senior year and the hig decisions. What am I going to do with my education? What am 1 going to do for a living?*

"Well, 1 talked to a number of -people and did as much letter writing and looking around as I could. The way 1 figured it, 1 wanted opportunity ...a fair chance to put my capabilities to work and to be recognized for what I could do. Of course, I wanted to be well paid, too. It all seemed to add up to the aircraft industry ... and to me it still does.

"In the space of just a few years I've worked on quite a few projects, important projects that some day may mean a great deal to this country. They sure meant a lot to me. And I wasn't standing still either. My salary and my responsibilities have increased with each promotion. That means lots of challenges, new and tough problems that we have to solve, but that's the way 1 like it. So, if you- want some advice from this "old grad," choose the aircraft industry. It's the wisest choice, I'm in the business, and I know."

probably no other industry in America has growrr so fast *and advanced so far* in a short time as has the aircraft industry. And yet there is no limit to how far man's inventiveness and imagination can push the boundaries. Radical new concepts that, would have been unthought of just a few years ago are the drawing-board problems of today.

Truly aviation is still in the pioneering stage, and one of the leaders is Northrop Aircraft, which has been making successful contributions to our nation's defense for over 18 years. Projects such as the Snark SM-62, world's first intercontinental guided missile, have identified Northrop as a successful pioneer. And new aircraft such as the supersonic, twin-jet T-38 advanced trainer are maintaining this reputation.

Let us tell you more about what Northrop can offer you. Write now, regardless of your class, to Manager of Engineering Industrial Relations, Northrop Division, Northrop Aircraft, Inc., 1034 East Broadway, Hawthorne, California.

NORTHROP

A Division of Northrop Aircraft, Inc.

BUILDERS OF THE FIRST INTERCONTINENTAL GUIDED MISSILE

PURITY

(Continued from Page 56)

The scientist is not yet satisfied with the purity of metals. This is only a beginning of what he will do. He will not rest until he has refined metals purer still. It may be that he will never achieve a really pure metal or if he does he may never know unless he can develop an instrument which can detect the smallest infinitesimal impurity. The National Bureau of Standards has been granted funds to work on this very problem of attaining pure metals. The striking fact about this whole problem is that when we do obtain ultra pure metals industry will not be able to use them anyway because they will be too soft for practical purposes. Nevertheless, the striving for purity in metals is already creating a whole new level of industry at the same time that it is expanding our basic knowledge of metals.

MIGHTY MIDGETS

(Continued from Page 21)

inch tubes lead away from each testing pit. The gases are purposely ignited at the end of the tubes. Fifty-foot tongues of flame sweep upward against the surrounding mountain, or flare high in the air, geysers flaming yellow against the sky.

Plenty of Action Before Test

A gas generator test is alive with action. One minute the pit is crowded with mechanics, test engineers, and instrumentation people. The next minute a siren wails and a warning voice is heard over the loudspeakers placed at a score of strategic points throughout the laboratory. "Warning. There will be a gas generator test firing in Pit Six in three minutes. All personnel clear the area."

There is a final check by the leadman, a last survey by the test engineer, then the gas generator, pierced with a score of instrument taps, is left alone while the crews retire to the safety of the control room adjoining the pit.

The recording engineer, the test engineer, two development engineers and the four members of the crew, along with an auxiliary fireman, crowd inside the long narrow room Hanked on one side by consoles, and on the other by high banks of recording instruments.

Looking out at Pit Six is an oblong porthole eighteen inches long, four inches wide. Viewed through the thick glass, the gas generator seems small to be the object of so much caution. The test' operator fingers a score of switches. Red lights flash on the console. Voices call readings from the recording instruments on the rear wall. There is a hissing of valves reacting to pressure.

The men at the console call out a check sheet in much the same manner as a pilot and co-pilot in the cockpit of an airliner. Gaseous nitrogen pressure is checked, the recording functions, the manifold and purge pressures. The igniter link is given a speculative flick, and the after-burner is checked. If the slightest doubt is entertained, the test is delayed until the questionable condition is resolved.

Safety Behind Concrete Walls

The air of tension mounts, for the possibility of mischance in a tremendous power package, only **the** thickness of a concrete wall away, is always present. The test engineer bends before the recording instruments making last-second observations. The siren lifts once more. Dead silence in the control room. Then a solitary voice, "Igniter on! START!"

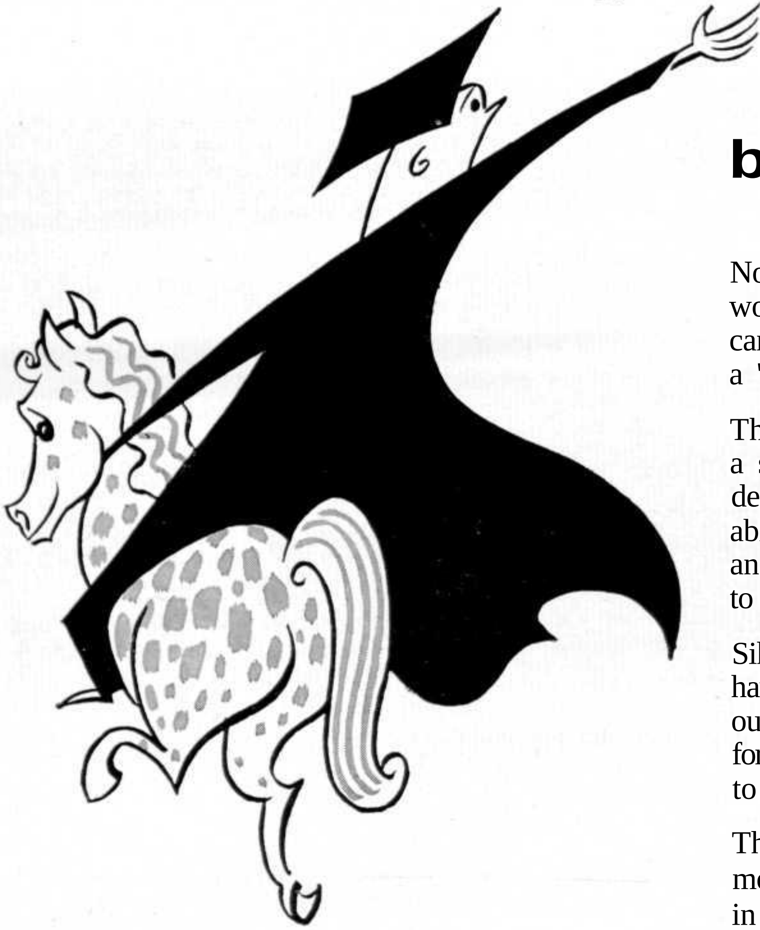
There is a thudding tumult as the gas generator comes to life. A fifty-foot tongue of yellow flame roars from the exhaust pipe, battering against the face of the mountain. On the wall a score of pens quiver over a score of recording charts. Seen through the window, the generator is a ruddy ball of pulsating metal.

A finger presses a button. There is a stunning cessation of noise, a moment of echoing silence, then the all-clear siren is sounded. Someone pulls back a door, and the crew goes back to the test pit. The gas generator, immediately after firing, is still black with intense heat, the metal seeming almost to throb at the abrupt change in conditions. The various operations are conducted with great caution.

Gas generator and turbopump development is a continuous effort at Rocketdyne. What may be the very best gas generator or the most efficient turbopump in rocketry today, tomorrow may be inadequate. The scope of the various engine programs widens daily. More powerful components are always being sought. Every improvement in design, every modification, requires proof-testing. A minor change in one detail starts a sequence of changes in other details. Each one must be proved reliable, desirable.

The success of the missiles powered by Rocketdyne engines is due to a great many factors. Not the least is the reliability of the two mighty midgets, the unsung heroes hidden from the cameras, the turbopump and gas generator.

trying to catch the **brass ring?**



better <u>forget</u> it!

No engineering position
worth getting
can possibly offer you
a "free ride".

The old rules still apply:
a successful career
depends on the amount of
ability you have
and on the capacity of a company
to make good use of that ability.

Sikorsky helicopters
have amply demonstrated
our capacity
for putting engineering talent
to constructive use.

They are the most versatile,
most widely used rotary-wing aircraft
in the world today.

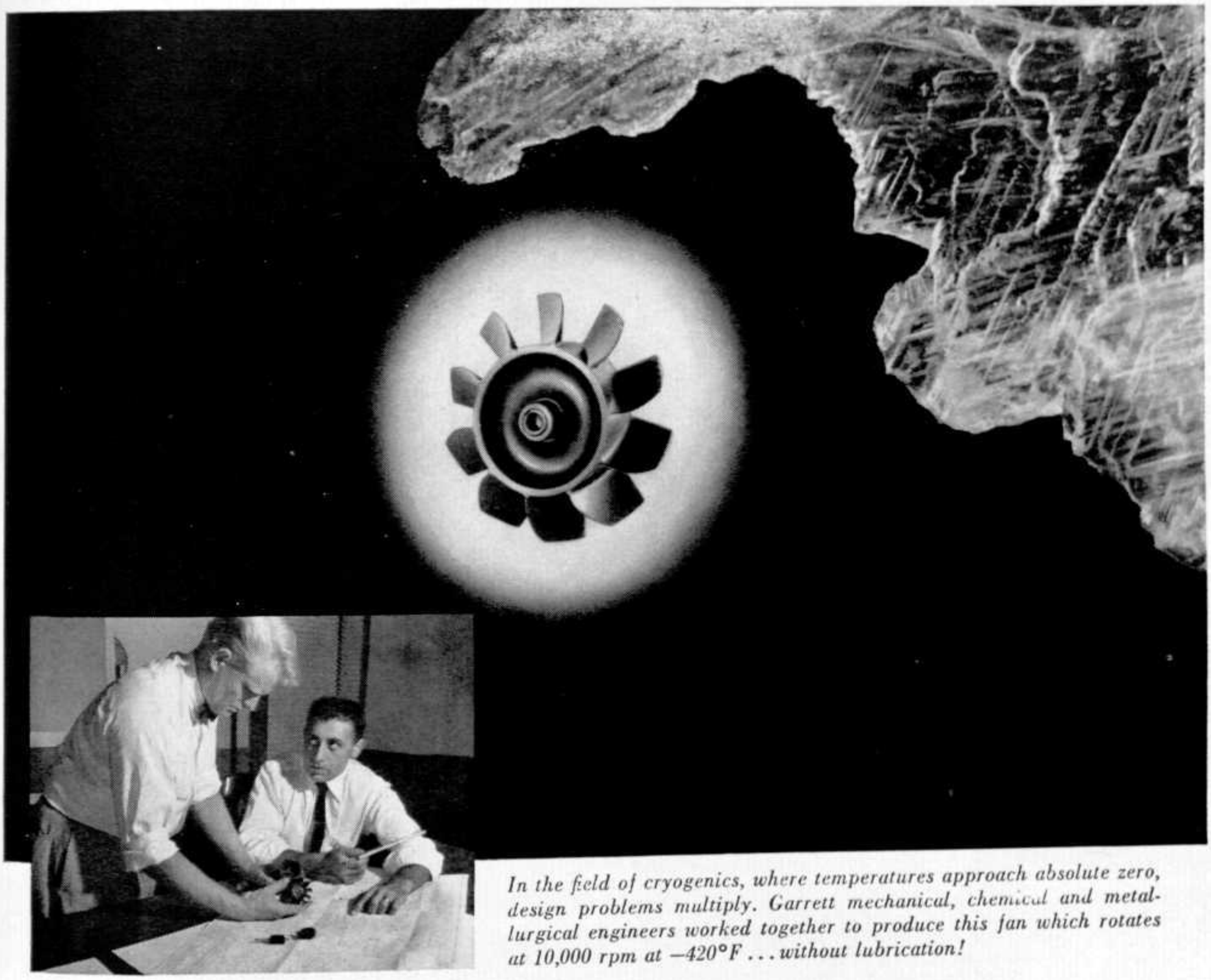
For factual and detailed information about careers with the world's pioneer helicopter manufacturer, write Mr. Richard L. Auten, Bridgeport Personnel Department.

SIKORSKY AIRCRAFT

One of the Divisions of United Aircraft Corporation

BRIDGEPORT and STRATFORD, CONNECTICUT

Maximum results from a college education...



In the field of cryogenics, where temperatures approach absolute zero, design problems multiply. Garrett mechanical, chemical and metallurgical engineers worked together to produce this fan which rotates at 10,000 rpm at −420°F . . . without lubrication!

Education is the springboard for your future. Couple it with the proper engineering experience, such as you receive at Garrett, and you have the ingredients for a successful career in engineering fields which will be expanding for years.

At Carrett, specific opportunities in aircraft, missile and technological fields include: system electronics; computers and flight instruments; gas turbine engines and turbine motors; prime engine development; cryogenic and nuclear systems; pneumatic valves; servo control units and air motors; industrial turbochargers; air conditioning and pressurization and heat transfer.

In addition to direct assignments, a 9-month orientation program is available to aid you in selecting your field of interest. This permits you to survey project, laboratory and administrative aspects of engineering at Garrett. With company financial assistance you can continue your education at outstanding universities located nearby.

Project work is conducted by small groups where the effort of each individual is more quickly recognized and where opportunities for learning and advancement are greatly enhanced. For complete information, write to Mr. G. D. Bradley.

THE GARRETT CORPORATION

9851 S. SEPULVEDA BLVD., LOS ANGELES 45, CALIFORNIA

DIVISIONS: AIRESEARCH MANUFACTURING, LOS ANGELES • AIRESEARCH MANUFACTURING, PHOENIX • AIRSUPPLY
AIRESEARCH INDUSTRIAL • REX • AERO ENGINEERING • AIR CRUISERS • AIRESEARCH AVIATION SERVICE

Pump-turbine design is now the work . . , hydraulics, the field . . . of John Jandovitz, BSME graduate of College of City of New York, '52.

Water conditioning chemical, service, and equipment specialist in Houston is **new** assignment of Arthur Brunn, BS Chem. E., University of Tennessee, *'56.*

Field sales engineering of America's widest range cf industrial products is choice of Roy Goodwill, BSME, Michigan State **College, '54.**

Recent **Training** Course Graduates

select wide choice of careers at Allis-Chalmers

Starting up a cement plant in Mexico after coordinating all work on it is latest job of John Gibson, BS Met. E., University of California, '54.

Nucleonics is chosen field of R. A. Hartfield, BME, Rensselaer Polytechnic Institute, '53. Currently he is working on design and development of new nuclear power plant.

THERE'S variety at Allis-Chalmers. Whether you're thinking in terms of types of industries, kinds of equipment, types of jobs, or fields of work, the diversification of Allis-Chalmers provides unsurpassed variety. For example:

Types of jobs	Industries	Equipment	Fields
Research	Agriculture	Tractors	Metallurgy
Design	Cement	Kilns	Process Engineering
Manufacturing	Chemical	Screens	Mechanical Design
Application	Construction	Earth Movers	High Voltage Phenomenon
Sales	Electric Power	Transformers	Stress Analysis
	Mining	Crushers	Nucleonics
	Nuclear Power	Reactors	Electronics
	Paper	Control	Hydraulics
	Petroleum	Pumps	Acoustics
		Motors	Thermodynamics
		Steam Turbines	

An outstanding training program, started in 1904, is designed to help you find the activity within these groupings for which you are best suited. Up to two years of theoretical and practical training are offered. Direct employment at Allis-Chalmers is available for those with sufficient background.

Learn more about Allis-Chalmers and its training program. Ask the A-C district office manager in your area or write Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.

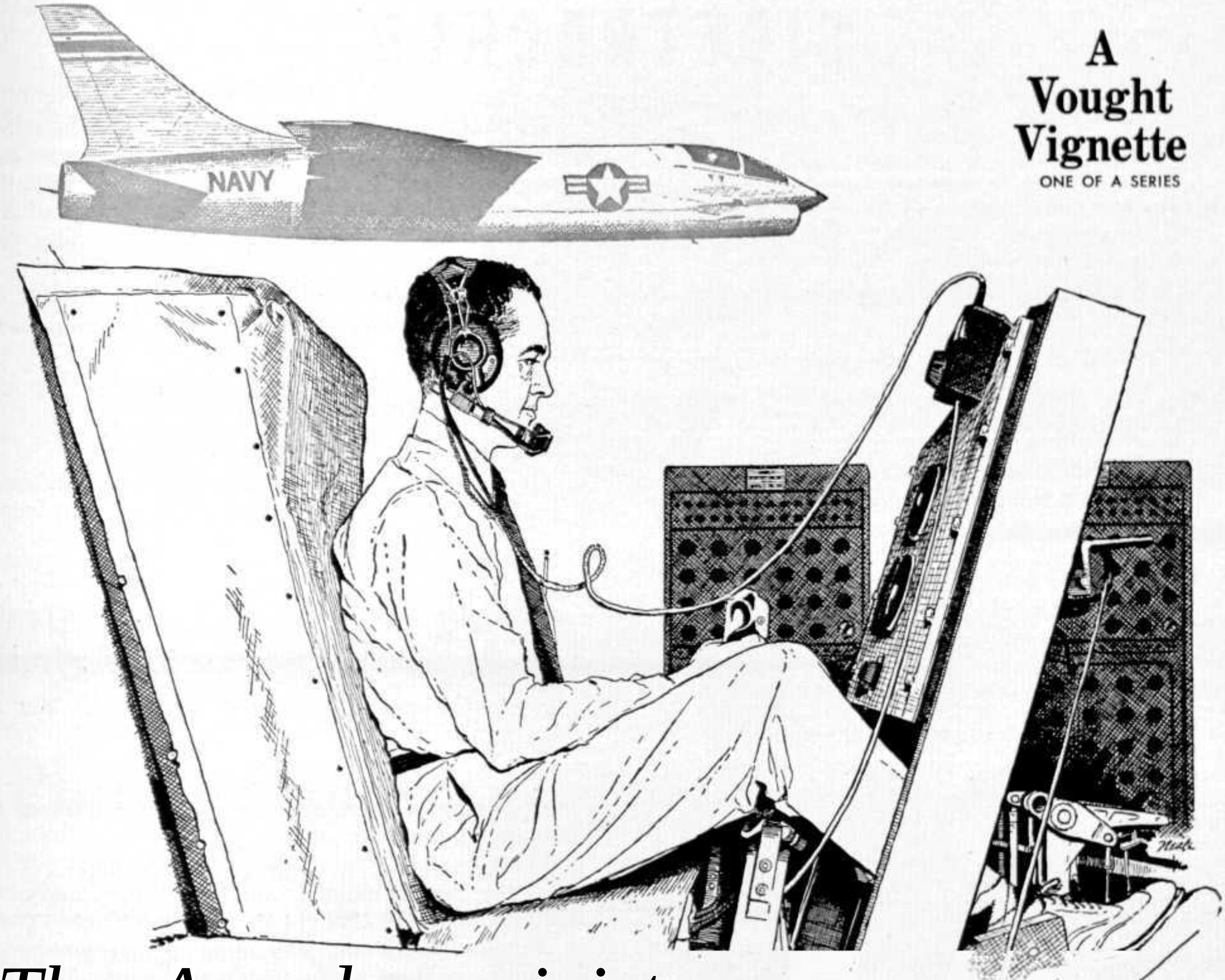
ALLIS-CHALMERS A-C

INDEX TO ADVERTISERS

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

A Vought Vignette

ONE OF A SERIES



The Aerodynamicist Who Test-Hopped Equations

There'd never been a fighter that could barrel at more than 1,000 mph one minute and land on a carrier the next. And, as a result, there was unusually keen advance interest in the flying qualities of the airplane proposed by Chance Vought.

Jim Madden was more than curious. As an aerodynamic design specialist, he would help develop the Crusader's handling qualities. His job began with wind tunnel tests.

Jim converted tunnel information into a graphic Picture of static and dynamic forces affecting Crusader stability. He used analog computers and equations of motion to predict the build-up of forces during maneuvers. Hinge moments, loads, and required rates of control motion were determined and released to Servomechanism and Product Design groups. Soon the Crusader's stabilization and power control packages began to take shape.

Jim's part in the project could have ended right there. But Vought's control system simulator helped him proceed to some thoroughgoing conclusions.

It duplicated the complete rod system and all servomechanisms that would control the speedy new fighter, fa the simulator's cockpit, high above the Structures Lab floor, Jim previewed control responses that test pilots later would experience. Airplane responses to Jim's rudder kicks and aileron movements were recorded on analog computers. Any inability of the control system to position the aircraft during flight was easier to spot . . . and, with test and design engineers on hand . . . easier to correct.

"It was like a big schematic — only better," says Jim of the simulator.

"It gave me a chance to work with the whole system.

"And actually watching aircraft responses to the controls gave me a feeling for how fast they happen."

Another thing that moved fast was Crusader development. Vought's simulator and other facilities detected problems before they compounded. The fighter reached operational readiness in record time.

Research, design and test facilities at Chance Vought allow the **engineer to do a thorough job in advanced problem areas . . . assure high reliability in Vought-developed weapon systems.**

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

SIDETRACKED

"Ah wins."

"What you got?"

"Three eights and a pair of kings."

"No you don't, Ah wins."

"What you got?"

"Three sevens and a razor."

"So you does. How come you **is** so lucky?"

A patient **of** an asylum who had been certified cured was saying good-by to the director of the institution.

"And what are you going to do when you go out into the world?" asked the director.

"Well," said the ex-nut, "I have passed my bar examinations, so I may try to work up a law practice. Again I had **quite** a bit of experience with dramatics in college, so I might try my hand at acting."

He paused and thought for a moment.

"Then on the other hand," he continued, "I may be a teakettle."

"Daddy, why can't I go out and play like the other kids?"

"Shut up and deal."

The young, inexperienced druggist was asked by a young lady for some cough medicine. Looking on the shelf, he could find none.

"Please — cough — cough — you've got to do something — cough — cough — for — cough, cough — me."

So he gave her his own idea of a remedy. Soon the owner returned and asked how business was. He reported that he had just cured a woman's cough. "I gave her a malted with 4 oz. of mineral oil and 5 oz. of castor oil. **She** doesn't dare cough."

A **Boston** spinster was shocked at some language used by workmen repairing telephone wires near her home, so she wrote to the Telephone Company. The manager immediately asked the foreman on the job to make a report and here's what the foreman said:

"Me and Spike Williams were on the job. I was up the pole and accidently let the hot lead fall on Spike-and it went down his neck. Then Spike looked up at me and said, 'Really, Harry, you must be more careful.'"

1st guy: "You got a beer stein for Christmas?"
2nd guy: "No, for drinkin'."

A young man and date pulled over to the side of the road.

She: "You're not going to pull that 'out of gas' routine, are you?"

He: "Naw, I use the 'hereafter' routine."

She: "The 'hereafter' routine?"

He: "If you're not here after what I'm here after then you'll be here after I'm gone."

He was a small and undersized freshman at his first college dance, but despite his smallness and shyness he was sure of himself in his own way. He walked over to a beautiful and over-sophisticated girl and said, "Pardon me, Miss, but may I have this dance?"

She looked down at his small size and lack of fraternity pin and said, "I'm sorry, but I never dance with a child."

The freshman bowed deeply and said, "Oh, I'm sorry; I didn't know your condition."

One day during a war, a tall, strong and handsome Roman soldier broke into a house where he found two luscious maidens and their matronly nurse.

Chuckling with glee, he roared, "Prepare thyselves for a conquest, my pretties."

The lovely girls fell to their knees and pleaded with him, "Do with us as thou wilt, O Roman, but spare our faithful old nurse."

"Shut thy mouth," snapped the nurse. "War is war."

Following is an excerpt from a letter **received** in this office some days ago:

Dear Sir:

In the coming months, you'll be reading many job recruiting ads. We thought that you might need some help in wading through this maze of placementology or jobalony. Here are a few between-the-lines **daf**-fynitions to help you understand what these ads are all about:

TERM — TRUE MEANING

Many opportunities-We need help.

Vlanagement potential—Know how to write **your** name so that no one can read it.

Work with top engineers—Sign up with a toy factory.

Top-level position-A title in lieu of a raise.

Challenging problems—Now that we've made it, we don't know what to do with it.

Experience-What you ain't got enough of till you re too old to use it.

Responsible assignments-Work.

Nearby beaches-Particularly Utah and Nevada where you have thousands of miles of beach.

Less than an hour from—By jet.

Cultural and entertainment facilities-Movies and bars available.

Job interest-Good looking secretary.

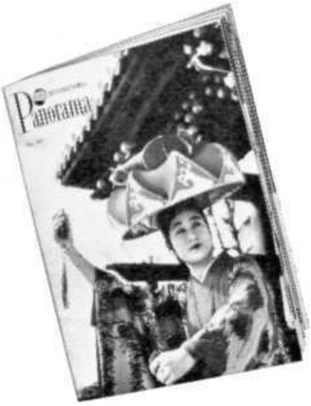
Stimulating assignments-Office party.

Stable company-We lived through the depression.

Full quota of golfing, We're really running a country club; swimming, riding, etc.—manufacturing is just our hobby.

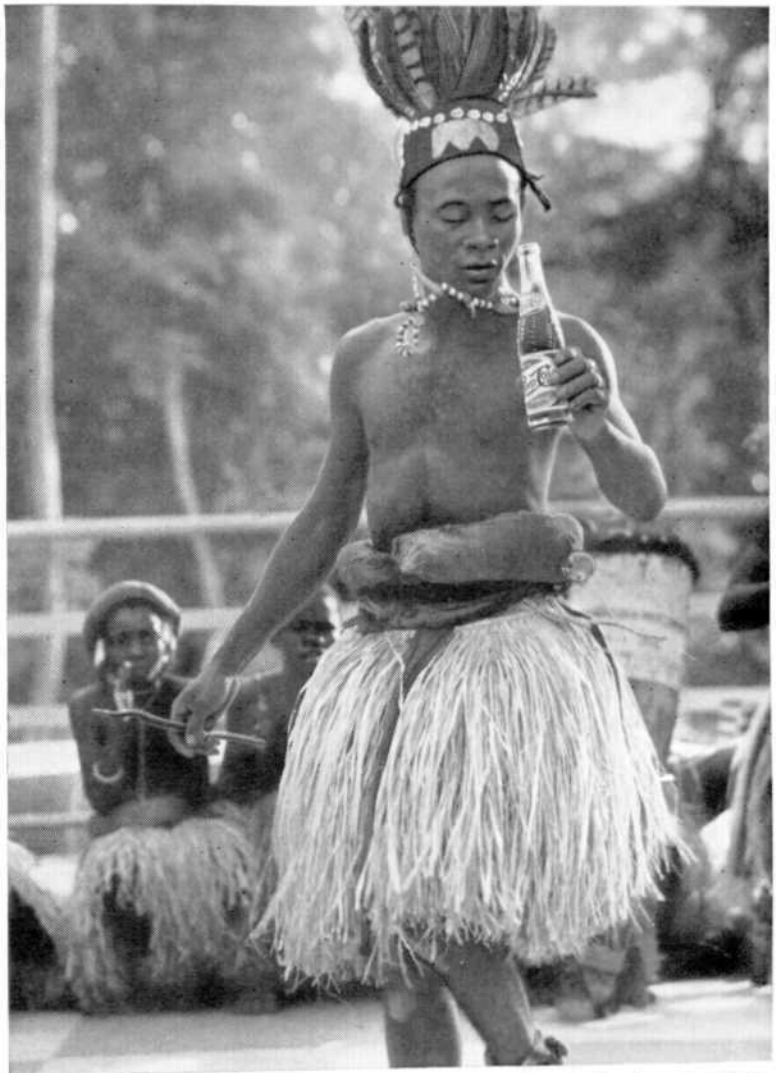
How to give a girl a surprise. Place your arms around waist. Draw her strongly toward you and hold her tight. Start to kiss her. When she says "stop' **release** her. Note amazement **on** her face.

PHOTOGRAPHY AT WORK
No. 30 in a Kodak Series



Pepsi-Cola International Panorama, a magazine of places and people, reaches people around the world, builds recognition for Pepsi-Cola as a product associated with the better, happier side of life.

Photography speaks in every language



What better way to say people take naturally to "Pepsi" whether in Leopoldville or Lichtenstein?

This picture leaves no doubt that Netherlanders are neighborly.

To tell its story in 75 countries, Pepsi-Cola puts pictures to work to add meaning to the product's global billing as "the refreshment of friendship."

To build up an atmosphere of friendliness and understanding in markets around the world, Pepsi-Cola International publishes "Panorama"—and gives the brunt of the job to photography.

Photography knows no language barrier. It is clear to young and old alike—appeals to everyone. With photography, people are real; situations authentic, convincing. This is what makes photography such a powerful salesman.

Large businesses and small csn use this powerful salesmanship—can also use photography to cut costs and save time in many other ways. It can help with problems of product design—can watch quality in production. It trains. It cuts office routine. You'll find that it can work for you, too.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

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.

Kodak
TRADEMARK

One of a series*

Interview with General Electric's W. Scott Hill Manager—Engineering Recruiting

Qualities I Look For When Recruiting Engineers

O. Mr. Hill, what can I do lo get the moil out of my job interviews?

A. You know, we have the same question. I would recommend that you have some information on what the company does and why you believe you have a contribution to make. Looking over company information in your placement office is helpful. Have in mind some of the things you would like to ask and try to anticipate questions that may refer to your specific interests.

Q. What information do you try to get during your interviews?

A. This is where we must fill in between the lines of the personnel forms. 1 try to find out why particular study programs have been followed, in order to learn basic motivations. I also try to find particular abilities in fields of science, or mathematics, or alternatively in the more practical courses, since these might not be apparent from personnel records. Throughout the interview we try to judge clarity of thinking since this also gives us some indication of ability and ultimate progress. One good way to judge a person, I find, is to ask myself: Would he be easy to work with and would I like to have him as my close associate?

Q. What part do first impressions play in your evaluation of people?

A. I think we all form a first impression when we meet anyone. Therefore, if a generally neat appearance is presented, I think it helps. It would indicate that you considered this important to yourself and had some pride in the way the interviewer might size you up.

Q. With only academic training as a background, how long will it be before I'll be handling responsible work?

A. Not long at all. If a man joins a training program, or is placed directly on an operating job, he gets assignments which let him work up to more responsible jobs. We are hiring people with definite consideration for their potential in either technical work or the management field, but their initial jobs will be important and responsible.

Q. How will the fact that I've had to work hard in my engineering studies, with no time for a lot of outside activities, affect my employment possibilities?

A. You're concerned, I'd guess, with all the talk of the quest for "well-rounded men." We do look for this characteristic, but being president of the student council isn't the only indication of this trait. Through talking with your professors, for example, we can determine who takes the active role in group projects and gets along well with other students in the class. This can be equally important in our judgment.

Q. How important are high scholastic grades in your decision to hire a man?

A. At G.E. we must have men who are technically competent. Your grades give us a pretty good indication of this and are also a measure of the way you have applied yourself. When we find someone whose grades are lower than might be expected from his other characteristics, we look into it to find out if there are circumstances which may have contributed.

Q. What consideration do you give work experience gained prior to graduation?

A. Often a man with summer work experience in his chosen academic field has a much better idea of what he wants to do. This helps us decide where he would be most likely to succeed or where he should start his career. Many students have had to work hard during college or summers, to support themselves. These men obviously have a motivating desire to become engineers that we find highly desirable.

Q. Do you feel that a man must know exactly what he wants to do when he is being interviewed?

A. No, I don't. It is helpful if he has thought enough about his interests to be able to discuss some general directions he is considering. For example, he might know whether he wants product engineering work, or the marketing of technical products, or the engineering associated with manufacturing. On G-E training programs, rotating assignments are designed to help men find out more about their true interests before they make their final choice.

Q. How do military commitments affect your recruiting?

A. Many young men today have military commitments when they graduate. We feel it is to their advantage and ours to accept employment after graduation and then fulfill their obligations. *We have a limited number of copies of a Department of Defense booklet describing, in detail, the many ways in which the latter can be done. Just write to Engineering Personnel, Bldg. 36, 5th Floor, General Electric Company, Schenectady 5, N. Y.* 959-8

*LOOK FOR other interviews discussing: • Advancement in Large Companies • Salary • Personal Development.

GENERAL ELECTRIC