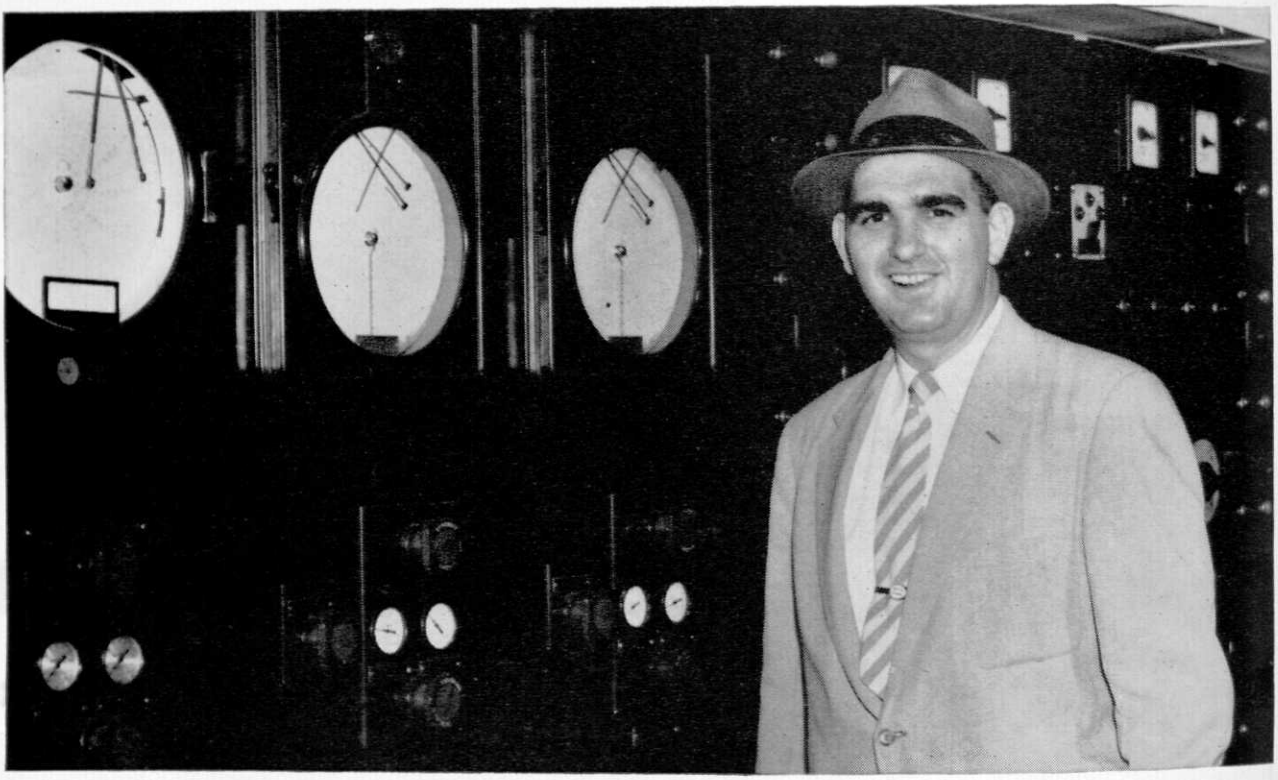
Spartan Engineer

Special ENGINEERING EXPOSITION Issue

VOLUME 10 NUMBER 4 MAY, 1957 PRICE 25¢

Harry M. Crooks, class of '49, speaks from experience when he says:

"At U. S. Steel there is a wide and varied choice of opportunities offered, under the most agreeable working conditions."



THE RAPID RISE of Harry M. Crooks to his present responsible position is typical of that experienced by many hundreds of college graduates who have joined forces with U. S. Steel.

Presently Assistant Superintendent of the Power and Fuel Department, National Works, National Tube Division of United States Steel, Harry M. Crooks graduated in January, 1949 with a BS degree in Mechanical Engineering, after serving three years in the U. S. Navy. He started with U. S. Steel on February 1 as a student engineer. Within a year-and-a-half he was made Process Engineer in the Power and Fuel Department, and ten months after that, Power Engineer.

After three years as Power Engineer, he was promoted on March 1, 1954 to his present job as Assistant Superintendent, with a wide range of responsibilities, including all power and fuel utilities throughout the large National Works plant. This position includes supervision of mill and furnace air supplies for the steelmaking process, steam and mixed gases for power, and open hearth oil and tar. In carrying out this work, he supervises a force of 250 men.

Mr. Crooks decided to work at U. S. Steel because he felt that U. S. Steel had one of the finest training programs available in industry today. During his training, he arrived at the personal conclusion that, being an engineer, his best opportunities were in the operating branch of the steel industry.

Quoting Mr. Crooks: "Through the training received at the mill, the engineer has the opportunity to work in and become acquainted with every phase of steelmaking and with every department of the plant."

If you are interested in a challenging and rewarding career with United States Steel, and feel you can qualify, get in touch with your placement director for additional information. We shall be glad to send to you our informative booklet, *Paths of Opportunity*, on request. Write to United States Steel, Personnel Division, Room 1662, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

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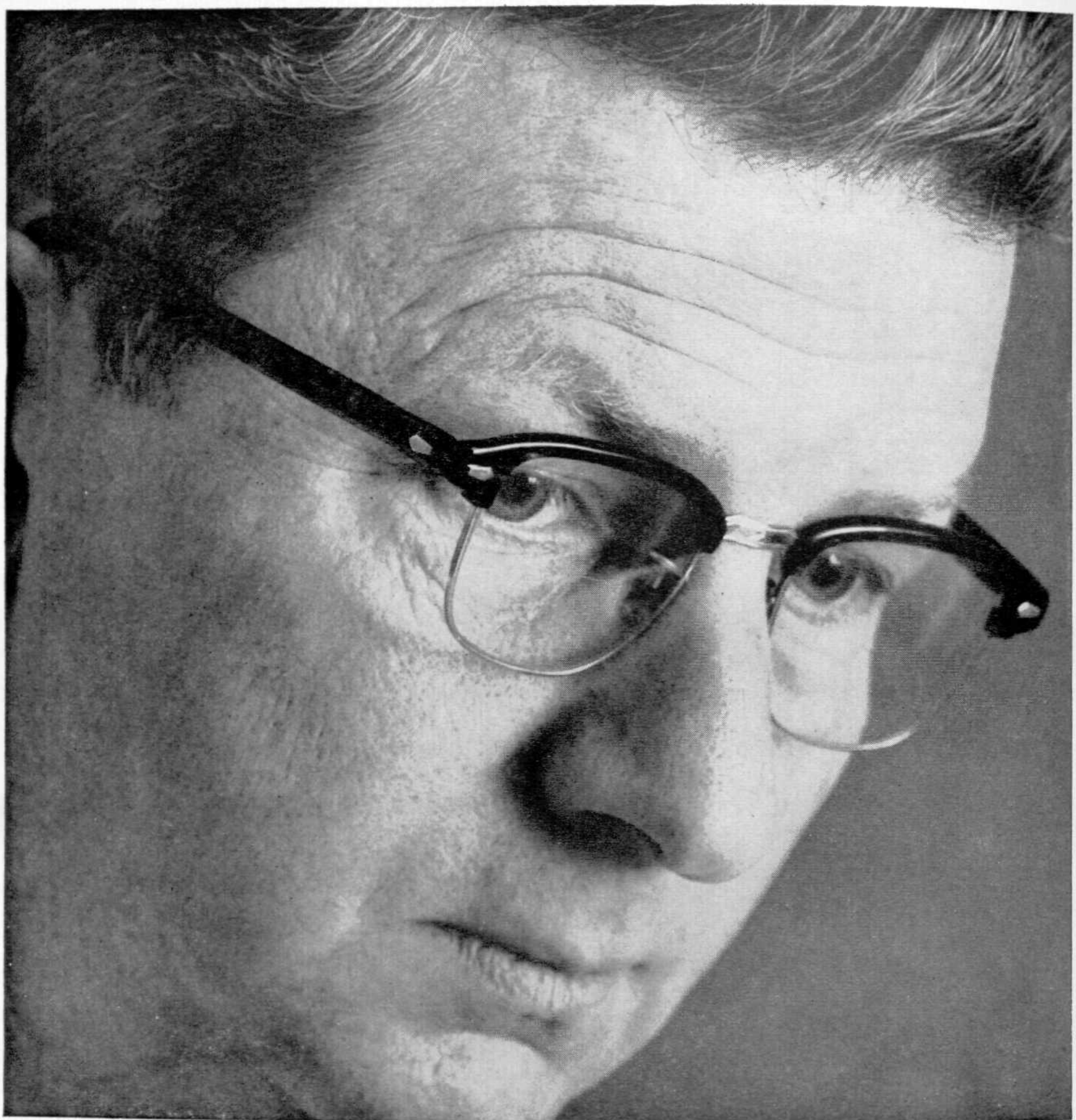

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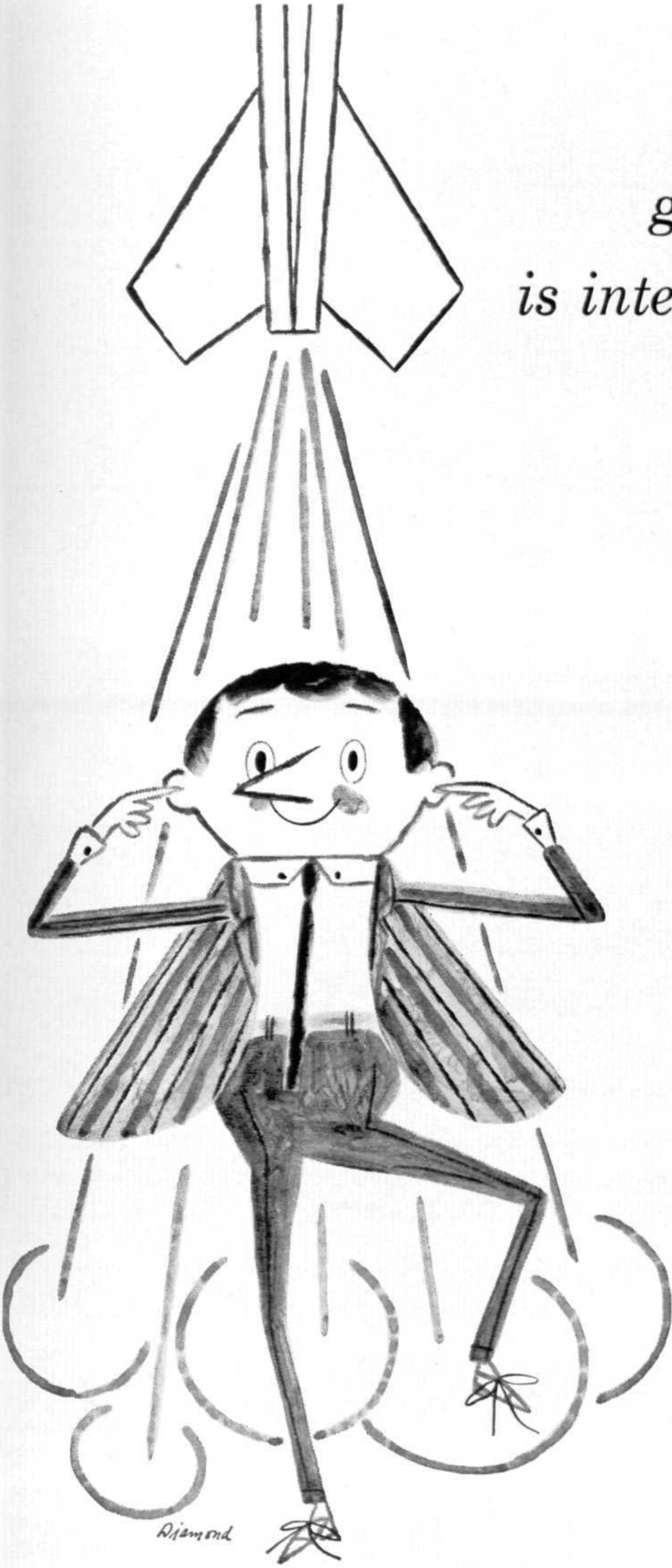
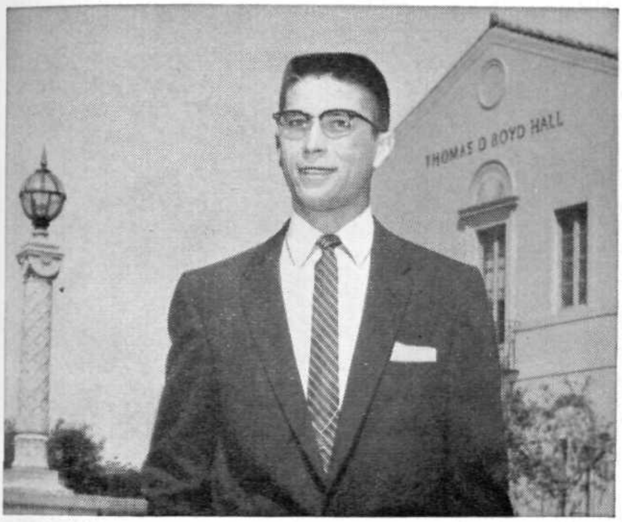


Questions students ask Du Pont

—and some of the answers in summary form

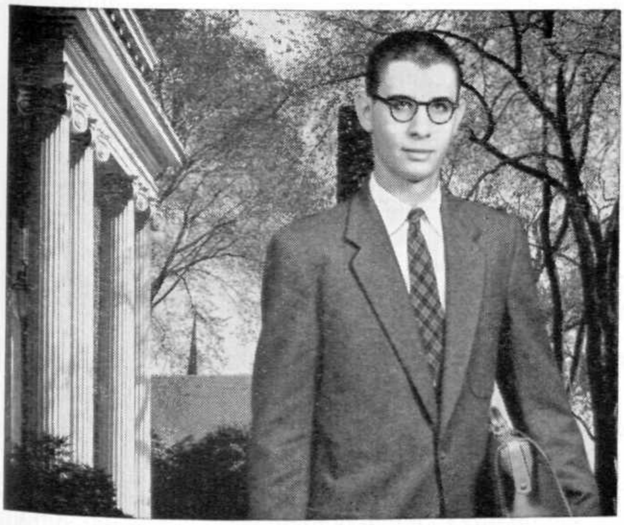


"Do you hire men who have definite military commitments?" asks Oran A. Ritter, Jr., of Louisiana State University.

Yes, because Du Pont has always been interested in men on a long-term basis. Du Pont has employed many graduates with military commitments even though they were due to report for duty a few weeks after joining the Company.

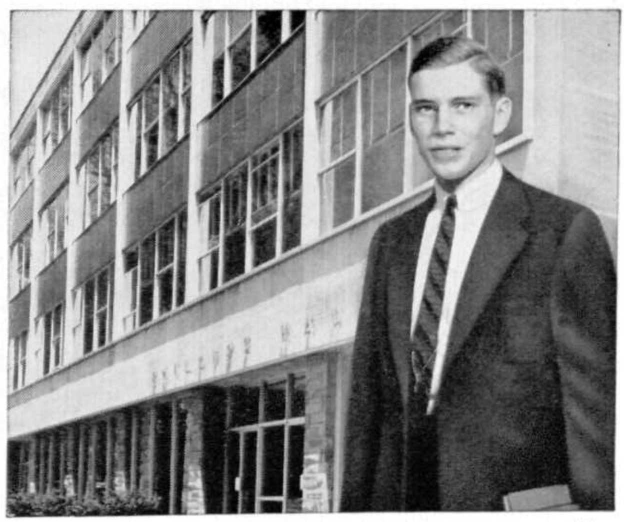
"Would a graduate degree help my chances for advancement at Du Pont?" asks John C. Nettleton, of Villanova University.

Many factors are involved, and an advanced degree would undoubtedly have a favorable effect in all technical work, but it would probably be of more direct benefit in research or development at Du Pont than in production, marketing or sales.



"Where would I work for Du Pont?" asks Gaylord E. Moss, of Tufts College.

Du Pont has more than 140 plants and research and development laboratories scattered through 26 states. If you have a definite preference, and Du Pont has an opening there for which you're qualified, your chances of getting it are good.



"How are chances for advancement in a large company like Du Pont?" asks Herschel H. Loomis, Jr., Cornell University.

Good! Du Pont is large, but it's made up of 11 independent departments — like smaller companies — under one management. And it's a basic policy to promote from within and on merit as Company growth creates openings.

We can give only brief answers to these questions in this space. But we'll be glad to answer them more fully, and to try to answer other questions you may have that bear more directly on your own future. Why not write us today? Address: The Du Pont Company, 2507C Nemours Building, Wilmington 98, Delaware.

DU PONT

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BETTER THINGS FOR BETTER LIVING

...THROUGH CHEMISTRY

WATCH "DU PONT THEATER" ON TELEVISION

Spartan Engineer

of michigan state university

VOLUME 10 NO. 4 MAY, 1957

FEATURES

DEPARTMENTS

Cover: THREE OF THE MICROMIDGET RACE CARS THAT WILL RACE SATURDAY, MAY 11, DURING THE ENGINEERING EXPOSITION.

MEMBER ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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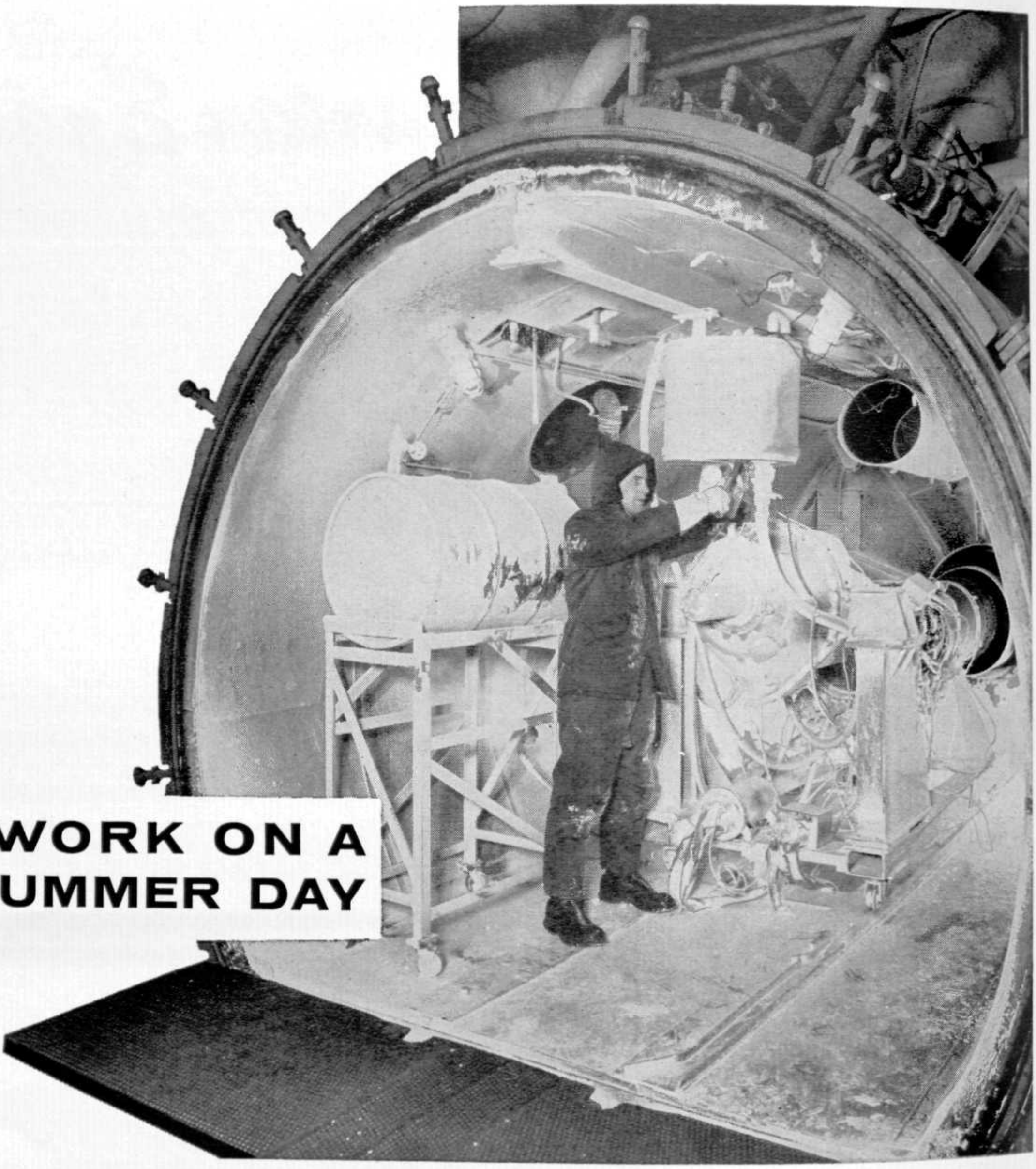


NICE WORK ON A HOT SUMMER DAY

THE temperature at altitudes of 36,000 feet and above goes far below zero, so it's standard procedure to demonstrate the starting capabilities of modern jet aircraft engines in a man-made "climate" of a brisk minus 67°F.

At Allison, demonstration tests are run periodically on both military and commercial aircraft engine models in cold weather tanks like the one shown above.

And, how do they get the tank's inside temperature down to the required 67° below zero? Here is one way Allison engineers do it. Outside air is cooled first with air-to-water heat exchangers. Then, a mechanical refrigeration system takes the air temperature to below zero. For the third step, the cold air is run through a turbine section of an Allison T-38 engine. As the gas expands, it comes out at about a minus 130°F. There is some warming as the air is piped to the cold tank, but usually, warm air has to be added to bring the tank temperature UP to a minus 67° Fahrenheit!

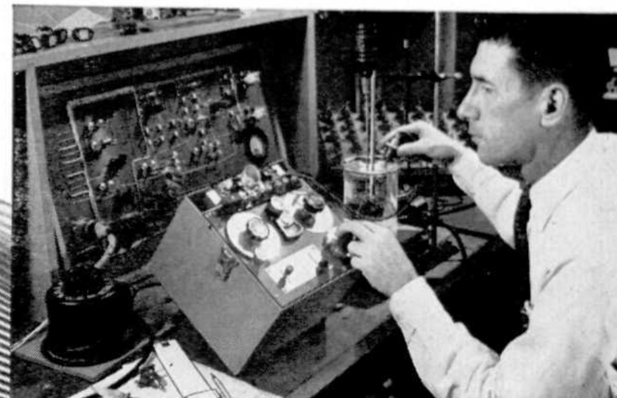
Fuel and oil tanks are located inside the test chamber, and they—with the engine—are permitted to "soak" in the frigid temperature before firing up. Tests of 72 hours "soak" duration have been made on Allison Prop-jet engines. Of course, the front opening is clamped shut for the test, and performance is checked by remote controls. But, occasionally, it's necessary for an engineer to "bundle up" and go inside the cell. It's nice summer work.

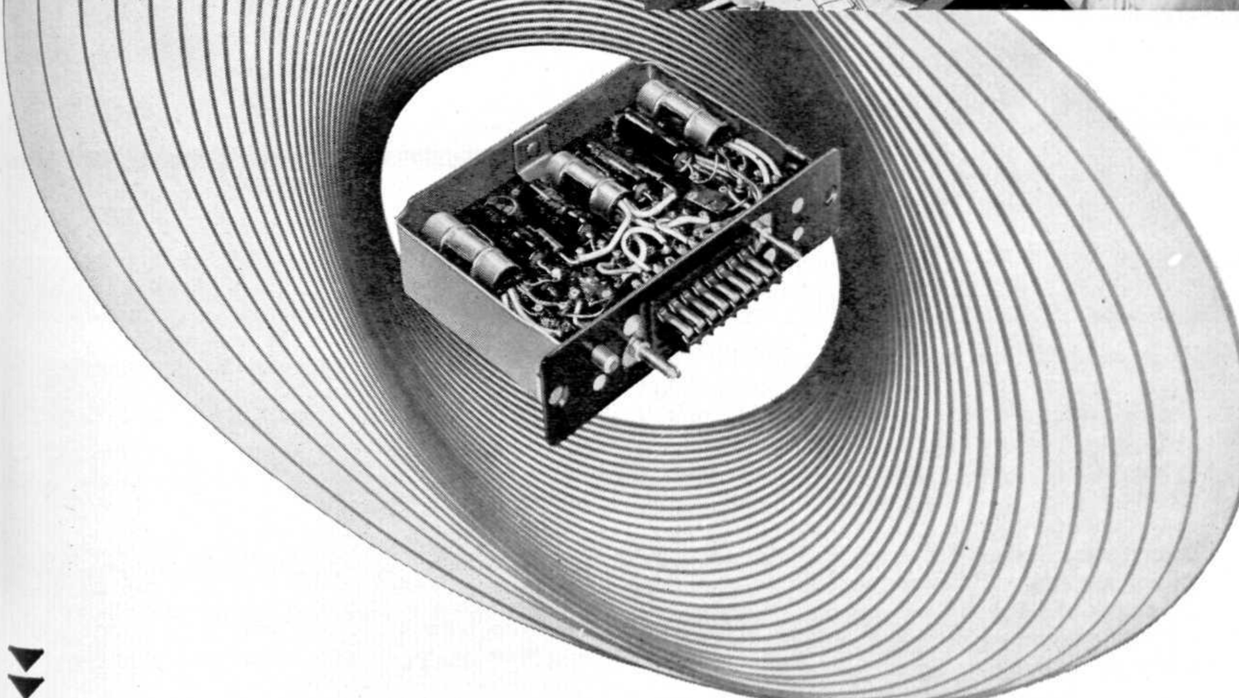
★ ★ ★

Allison now is in the midst of an engineering expansion and development program representing an expenditure of $75 million. Completion of the program will make the Allison engineering Research and Development Center one of the most complete in the world . . . an ideal place to apply your academic training. Write for information about your future career at Allison: Personnel Dept., College Relations, Allison Division, General Motors Corporation, Indianapolis 6, Indiana.

To the engineer capable of original thinking...

Highly accurate AiResearch electronic amplifier used in precision analogue computer networks. Built to withstand 50 G's vibration, has over 20 megohm input impedance and less than 1 ohm output impedance.





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If you're the sort of engineer to whom an obstacle is only a challenge, you'll be interested in working with us. You'll have the finest research and laboratory facilities at your disposal...have your choice of location among the Los Angeles, Phoenix and New York areas. Also, financial assistance and encouragement will help you continue your education in the graduate schools of fine neighboring universities.

All modern U.S. and many foreign aircraft are Garrett equipped. We have pioneered such fields as refrigeration systems, pneumatic valves and controls, temperature controls, cabin air compressors, turbine motors, gas turbine engines, cabin pressure controls, heat transfer, electro-mechanical equipment, electronic computers and controls.

We are seeking engineers in all categories to help us advance our knowledge in these and other fields. Send resume of education and experience today to: Mr. G. D. Bradley

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A frank statement about the future in Field Engineering

At first glance, Field Engineering may not seem to possess the potential and stature often associated with other engineering activities.

At *Hughes*, however, nothing could be further from the truth.

Men who undertake the responsible task of evaluating Hughes-produced military equipment in the field are in the enviable position of becoming thoroughly familiar with the complete design and operation of the advanced electronics systems involved.

Essentially, Field Engineering embraces all phases of support required to assure maximum field performance of Hughes armament control systems and guided missiles. E.E. and Physics graduates selected for this highly important and respected phase of our engineering activities work with the armed forces and airframe manufacturers at operational bases and plants in continental United States and overseas.

The knowledge, background and experience so gained assure unusual opportunities for more specialized development in other divisions of the Research and Development Laboratories at Hughes. In fact, few openings in engineering today offer the rewards and opportunities which are available to the Technical Liaison Engineers, Field Engineers, Technical Training School Engineers, Technical Manuals Engineers, and Field Modifications Engineers who comprise the Field Service and Support Division.

Engineers and physicists selected for this highly respected phase of our activities at Hughes enjoy a number of distinct advantages. These include generous moving and travel allowances between present location and Culver City, California. For three months before field assignments you will be training at full salary. During the entire time away on assignments from Culver City, you'll receive a generous per diem allowance, in addition to your moving and travel expenses. Also, there are company-paid group and health insurance, retirement plan, sick leave and paid vacations . . . and reimbursement for after-hours courses at UCLA, USC, and other local universities.

E.E. or Physics graduates who feel they are qualified to join the Field Engineering staff at Hughes are invited to write for additional information about this exciting and rewarding opportunity to establish a challenging career in electronics. Write to:

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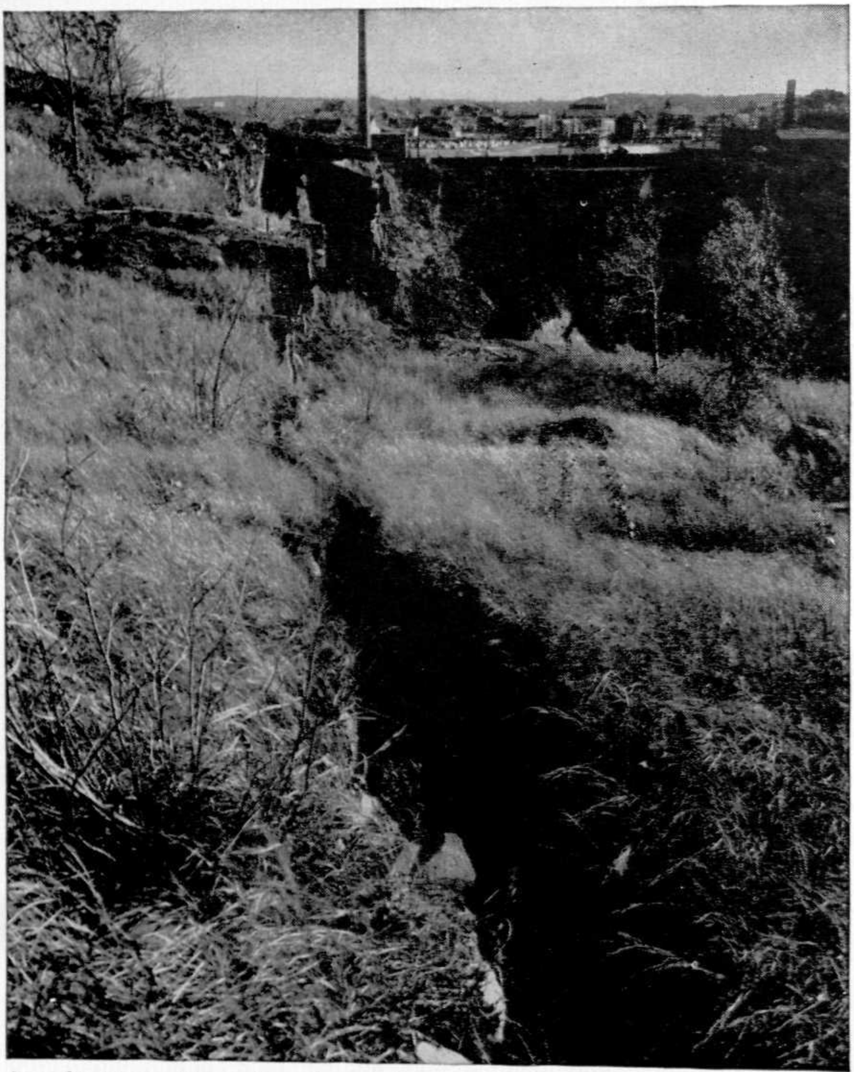

A **crack** at the earth's surface shows bulk mining is proceeding far underground.

Panel caving is one of two bulk mining methods which account for 70 per cent of the company's total nickel output.

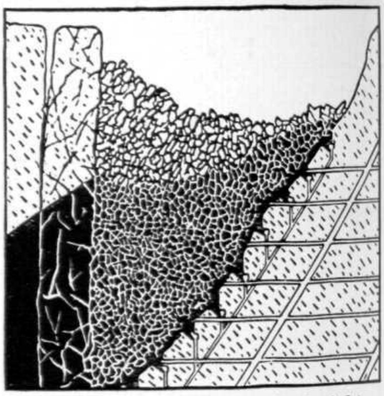

Diagram of panel caving in Creighton mine. The heavy panel of ore and rock sinks, breaking up as it moves down.

Which Mining Method is BEST?

There is no one best method of getting ore out of the ground. Type of ore; type of rock; even the location of the mine must be weighed. Inco uses five underground mining methods at Sudbury:

Square Set *Cut and Fill*
Shrinkage *Blasthole*
Panel Caving

Once only "waste rock"... now a new source of Nickel

How Inco's mine engineers utilize a panel-caving method in order to recover nickel from huge ore deposits that formerly were not practicable to mine

Panel caving is one of the newest mining methods put into use by The International Nickel Company.

The tonnage of ore handled by this method is immense. Sometimes a single block measures 200 by 800 feet. It may weigh as much as 1½ million tons.

As these heavy masses move downward they break into pieces small enough to drop through chutes and into machine crushers deep inside the mine. From crushers the ore goes a quarter mile by conveyor to hoists that lift it to the mine head.

From there, the ore is milled as fine as sand. The concentrate is then pumped to the Inco reduction plant 7½ miles away.

Panel mining; new concentrating machinery; new, continuously improved operating practices; pipeline transport. Add them together and you can see how they make possible production of nickel from ore deposits once only "waste rock."

Inco has prepared a full-color sound film—*Mining for Nickel*—that shows the operations of modern nickel mines. 16mm prints are loaned for showings before technical societies, engineering classes of universities and industrial organizations. For details, write Dept. 130f,

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

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

Question:

What makes
a company a good
place to work?

Answer:

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

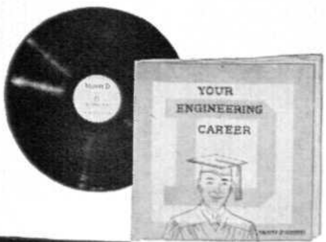
This record tells why—musically

— we'd like to send you a platter

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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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

The Key to Modern Progress

by D. D. McGrady, Associate Professor of Metallurgical Engineering Department

Materials are the key to modern progress. The centuries-old arts of metallurgy and ceramics have long been responsible for much of America's technical advancement. With the development and use of high-speed jet engines and atomic radiation, starting just over a decade ago, it soon became evident that man's inventiveness was out-stripping available materials. In electronics, chemistry, aviation, and atomic energy, requirements continued to develop which the metals of the old technology were unable to satisfy.

As a result, new types and areas of metallurgy and ceramic started to evolve. The chief characteristic of this new phase of development has been the driving, scientific interest in the fundamental of crystalline solids: metals and ceramic materials.

The cause of this new approach to the study of metals and ceramic materials can be traced directly to the condition that, for the first time in history, the properties of materials have fallen behind the industrial arts they serve. In order to meet the constant and continuing demands of an ever-changing world for new and better materials, it was necessary for metallurgy to transform itself from an empirical craft into a sophisticated science.

The new metallurgy has made its best showing in the largely military-sponsored fields of high-speed flight, electronics, and nucleonics. Nevertheless, in a score of critical areas, the properties of materials—and a lack of understanding of their behavior—are retarding and limiting the development of new applications and devices. Metallurgists across the nation are today engaged in a research program of unparalleled scope and complexity in an attempt to overcome the material barrier which is hampering and slowing America's technological progress. As metallurgical research reveals more information about the nature and response of metals and alloys it is possible to hasten those developments which are currently bottlenecked on design engineers' drawing boards because of unavailable or costly materials.

A company that is primarily a producer of metals is keenly interested in improving the quality of its product. Those companies that are essentially consumers of metal are obviously concerned with obtaining the best materials for their products. The "best" could be any of a number of things—light weight, durability, close tolerance, electrical conductivity, resistance to high temperature, fatigue or corrosion resistance, or a low neutron capture cross section, among others.

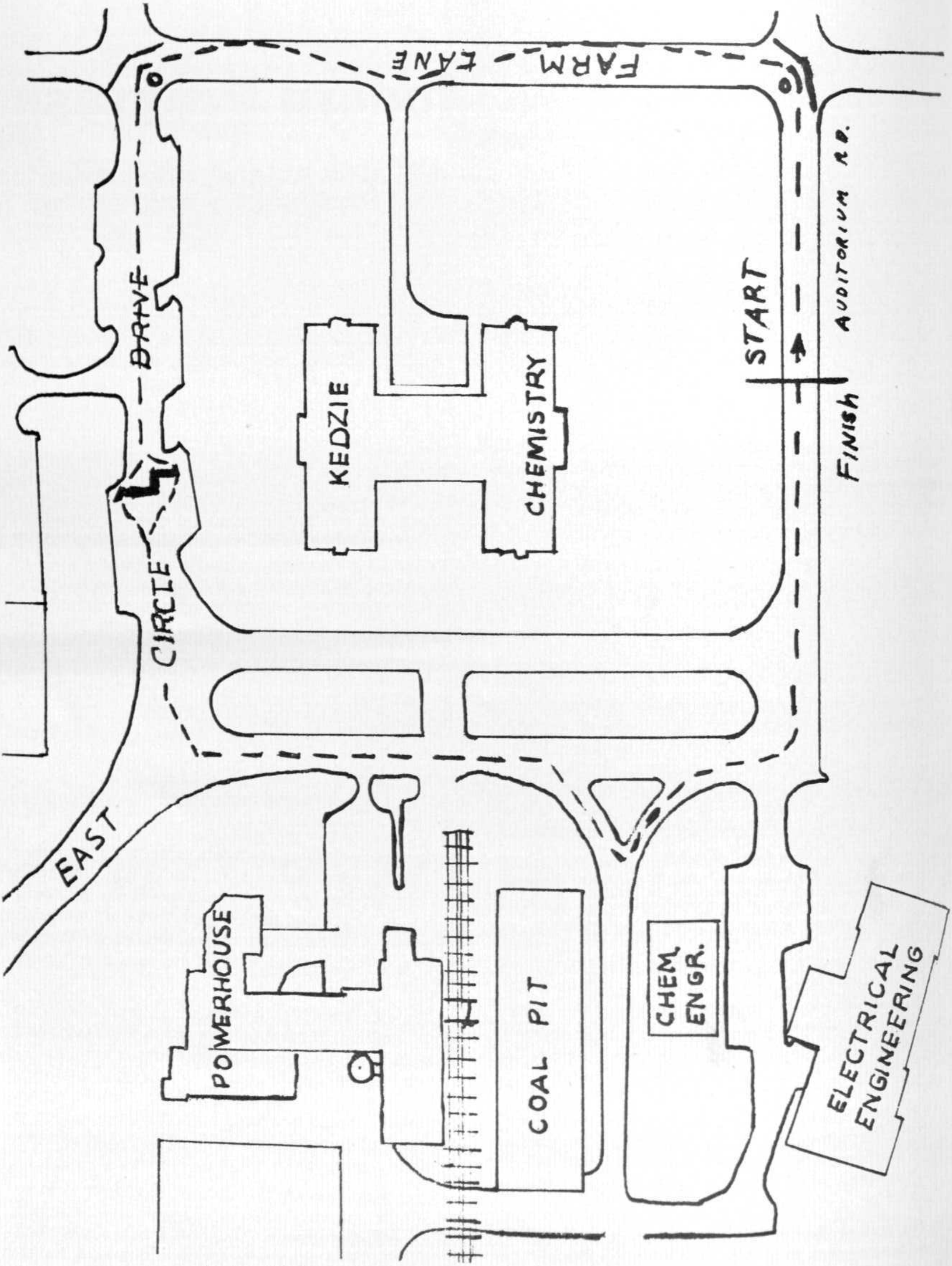
The design, development and manufacture of electrical apparatus are controlled and limited by materials and processes—whether for the improved performance of established products or for the ever-increasing variety of new ones. Technical progress in a product frequently depends on the performance of the metals and ceramics in them, as with the incandescent lamp of some 50 years ago or aircraft gas turbines and atomic power plants today. The efficiency of the gas turbine could be greatly increased if a metal was available that could maintain its strength at a temperature above 1800°F without losing resistance to corrosion and oxidation. Similarly, progress toward low-cost nuclear power will be only as rapid as permitted by the development of new and better materials than can withstand exposure to nuclear radiation in conjunction with the more familiar engineering requirements.

Examples of other areas where material properties are limiting developments are the ceramic materials that are the insulators on power poles for the transmission of electricity, the thermal insulating materials in furnaces and refrigerators, and the barium-titanate or ferro-electric materials which are used in sonar applications.

The size and effectiveness of a clock motor are determined by the material properties of the rotor and the performance of television transformer cores is determined by the oxide materials contained in them. If the energy losses of magnetic sheet steel for power transformers could be reduced one-half, the efficiency of electrical transmission in America could be tremendously improved.

Zirconium, a metallic element, has been known since 1824, but only in the last 10 years has it reached commercial importance. The first feasible extraction process for Zirconium was the iodide process developed in 1925. The Kroll process, which is adaptable to

(*Continued on page 68*)



Course of Midget Auto Race to start at 1:30 P.M., Saturday, May 11.

Your 9th Annual Engineering Exposition

By Bob Fredericks, EE '57

Once again the campus spotlight is focused on the Michigan State Engineers, for it is May, and time for the 9th Annual Engineering Exposition. It's the time of the year when the engineers temporarily take time out from their studies, to present an appealing view of Engineering to many guests, particularly to high school students.

The Engineering Council is in charge of the organization of the exposition. Its members, with Fred Tenhoor as its General Chairman, have worked many long hours to set up exhibits that will point out the accomplishments, challenges and opportunities of Engineering. This year, as in the past, there are exhibits presented by the engineering students, industrial exhibits and some special shows. General Motors is here with a special show "Preview of Progress" and Bell Telephone is showing "Voice Beneath the Sea." There will be cash prizes awarded to the individual with the best exhibit based on originality, engineering application, and presentation. First prize is $15; second, $10; third, $5. These prizes are in addition to the Dean's Trophy which goes to the department with the best representation and presentation.

Each year during the exposition, the JETS (Junior Engineering Technical Society) club presents individual and group projects which they have worked on during the year. JETS club members are high school students, who have special interest in science and engineering, and plan to study to become engineers. Their projects are judged for originality and scientific accuracy. Prizes are given which include scholarships, drafting instruments, slide rules and other tools of the profession. The JETS Club was formed in 1950, by Dean Lorin Miller and Professor Harold Skamser of the Engineering College at M.S.U. It was formed to stimulate the necessary interest in students who may have the ability to develop into top notch engineers. Today there are 116 clubs in 20 states and two foreign countries, many of whom will participate in this exposition.

The midget auto race will again be a feature attraction this year and will be held Saturday afternoon, about 1:30, ½ hour after the time trials. A "Jet Flyover" will signify the start of the race. These mighty midget autos are built by the engineering students and have powerful two horsepower motors. The cars can obtain average speeds of about 25 mph. The midget autos are built for speed and acceleration, and this year's course makes it a necessity that they also be built for durability. Last year, the race was won by the Electrical Engineers car, driven by Duane Patten, with the Agricultural Engineers entry second. This year, a minimum of six and possibly eight cars will participate. Some of the entries being Electrical Engineers, Ag. Engineers, Triangle, S.A.E., Civil and Mechanical Engineers. Your author is predicting another victory for the Electrical Engineers. The race will start in front of the Band Shell on Auditorium Road. (See diagram for course of the race). The course is about ½ mile long and will be circled

(Continued on page 65)

Duane Patton crosses finish line as the Electrical Engineers' entry wins 1956 midget auto race.

"Anti Social" Silicones

What they can do for you

by Victor E. Papendick, Ch.E. '58

What are Silicones? Silicones are chemical compounds consisting of the element silicon and oxygen with other elements. You are already familiar with some silicon compounds. Common sand is a compound of silicon and oxygen. A piece of quartz rock is another crystal form of this substance. The glass in your home is also a silicon compound. The car polish or floor wax you use may contain silicone. Your raincoat may also be coated with silicone.

There are three basic producers who make silicones. These three producers are Dow Corning, General Electric Silicone Products Department, and the Silicones Division of Union Carbide and Carbon. There are very few little firms producing silicones. The tricky engineering and the large capital investment are too great for small producers.

Commercial production of silicones, as a family of chemical compounds, was started less than fifteen years ago. Production is rapidly expanding now. In 1951 about five million pounds of silicones were produced. The production had expanded to more than thirty million pounds by 1956. Silicon production has grown from almost nothing fifteen years ago to more than forty million per year. The industry now employs about 2,500 people. None of the three producers of silicones is an independent organization producing only silicones. They are part of larger corporations, therefore the sales and production figures are not made public. Estimates for the total sales of the industry in 1956 range from thirty-seven million to fifty million dollars.

In the 1920's, because of the growth of plastics, much interest was shown in the possibility of making hybrid compounds by mating plastics with glasses or silicon compounds. In the 1930's Corning Glass explored this field. They developed a variety of usuable hybrids. At about the same time General Electric started a long range study of silicone-glass insulation. By 1942 Corning research had reached the point where commerical production could be planned. Corning Glass joined Dow Chemical in 1943 to organize Dow Corning. Both General Electric and Dow Corning produced several silicone products for the armed forces during World War II.

The first silicones were fluids. Some of the fluids were thin like water and others were thick like oil. The thickness or viscosity of these fluids hardly changed at all with the variations in temperature. Many fluids, such as petroleum oil, become quite thin when heated. When they are cooled they become thick and do not pour easily. When silicone fluids were first produced they were used for damping fluids in instruments. They also were added to petroleum oils to prevent foaming. When they were first manufactured, limited production prevented the silicone fluids from other uses. The need for fluids, to be used at extremes of temperature, has provided many new uses for silicone liquids.

Why are silicones of such value? They are important because of half a dozen major characteristics. They are excellent dielectrics or insulators for electrical circuits. Wide ranges of temperatures do not affect them. They do not easily react with other materials. Water is repelled by silicones. Some silicones have a rubbery quality.

Silicone rubber is now the big thing in the silicone industry. It has been estimated that 20% to 30% of the total amount of silicones produced is rubber. In 1944 both Dow Corning and General Electric independently developed silicone rubbers. The first rubber was more like cheese then rubber. This rubber resisted high temperature and was strong enough to be used for gaskets in searchlights and aircraft superchargers. Research has improved these rubber compounds. They now have physical properties close to organic rubbers. They have some very important

Victor E. Papendick, the author of "ANTI-SOCIAL" SILICONES, is a junior, majoring in Chemistry. Victor is 25 years old, a veteran of the U.S. Air Force and is from Grayling, Michigan. He is presently residing at 1114 K University Village with his wife and son.

properties that makes them superior to organic rubbers. They are quite resistant to high temperatures and do not break when bent at temperature as low as minus 180 degrees fahrenheit.

The different varieties of silicone rubber have many uses. They are used to impregnate fabrics, which are laminated to tubing and hoses for extreme temperature applications. A non-sticking rubber composition has been made for covering press-rolls on paper making machines. Another silicone rubber was developed for use on jet planes. It is heat resistant and doesn't swell. It has more than a 500 degree fahrenheit temperature range. A transparent silicone rubber interlayers for safety-glass windshields and canopies on supersonic jet aircraft has been developed that is unaffected by temperatures greater than 350 degrees.

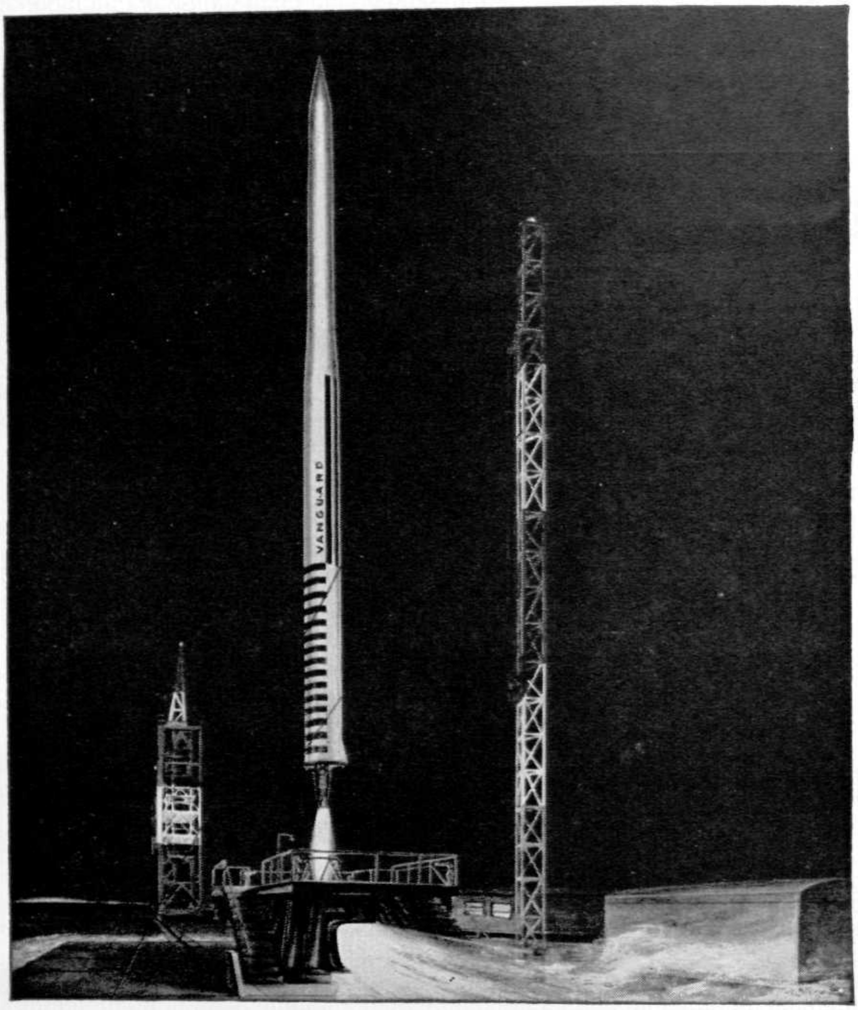
One form of silicone rubber is quite different from ordinary rubbers. It is a flexible rubber which conducts electricity. It can be molded or run under hot rolls to shape it without changing its electrical properties. Organic rubbers usually change under such conditions. This rubber is also very resistant to heat. It can be made easily into different or odd shapes. It could be used as an electric heater which wouldn't break as easily as a ceramic or graphite heater. Electrical conducting tubing or hoses can be made from this rubber. It will drain off static charges and thus prevent sparking. This type tube or hose is used to handle explosive gases or dusts. This silicone rubber does not react with most chemicals and it resists weather very well.

Silicones have the characteristic of repelling water. Masonry and concrete can be treated with special solutions or emulsions of silicones to prevent deterioration. Leather and textiles can also be made permanently waterproof with silicones. How would you like to have your shoes and raincoat waterproof, yet still not have the pores of the leather or the fabric closed up? This is what silicone can do for you. Silicone coated fabrics allows air to come in, but it keeps water out.

It was the search for heat resistant dielectrics or insulators that started the commercial development of silicones. To obtain the full advantage of glass-tape insulation in electric motors, a resin had to be found that would not deteriorate at high temperatures like conventional electric varnishes. Motors using silicone resins can be run more efficiently and give more horsepower at higher temperatures. Motors using silicone resin and glass tape insulations had their life expectancy increased 10 to 100 times the life of motors using conventional resins such as shellac.

Silicones are said to be "antisocial." Other materials do not readily stick to a surface that has been treated with silicone. Because of this property they are used for release agents for metal-castings and rubber-forming molds. An example of this use is the automobile tire industry. Before the tires are molded, the inside of the molds are coated with silicone. The silicone prevents the rubber from sticking to the mold and the tires can be easily removed. Silicones are also used for release agents in glassmaking equipment, plywood manufacturing, plastic molding machinery and even bread pans in bakeries. At the end of World War II it was the rubber industries' use of silicones for release agents that kept the silicone business going during the transition from military to commercial peace time use. During this period lubricants and polishes were made, resins were improved and developed into superior high temperature coatings and the silicone rubbers were given much better physical properties. Today silicones can be used in industry in one form or another.

(*Continued on page 74*)


VANGUARD

JETS on Exhibition

by Patrick Miller, Mth. '57

In a short time, most of us will go down to visit the 9th Annual Engineering Exposition at M.S.U. As we wander around Olds Hall and its vicinity, we will be amazed by many of the displays. Some of these will seem to be a work of art. Truly, the craftsmanship, ingenuity, and work that the engineer contributes to these devices causes us to appreciate the engineering profession.

The displays usually represent years of work and achievement. In some, there is an indication of things to come in the future. One display, in particular, will have this characteristic. Of course, it is probably present in a different manner than that to which one is usually accustomed. At this display, we should get some idea of what the future engineer is like. Just how is he preparing to make a better tomorrow? What are his present ideas, and how seriously does he pursue at them? Needless to say, this display is sponsored by the JETS (Junior Engineering Technical Society) clubs throughout the nation.

An important aspect of these clubs is individual or group projects. The members work on their projects during the school year in the various high schools. Usually the club member works on something which is of high interest to himself. With the help of his pilot (club advisor) and other club members, he will make his project. The project may be anything that shows application of engineering principles. It may be a model house, a magnetic train, a repulsion coil, or one of many other possible devices.

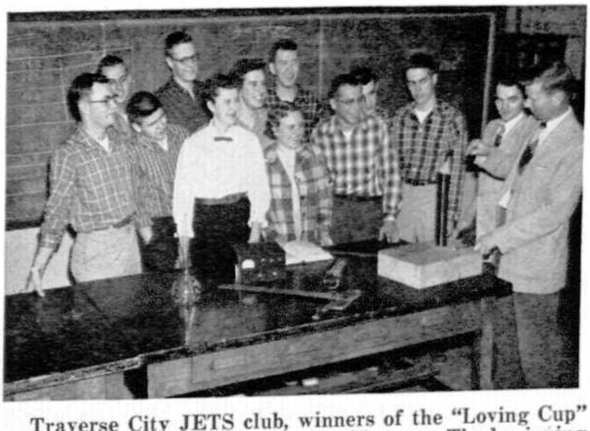
We may wonder just how extensively the student works at his project. Usually in the fall of the year, the member began thinking about projects for the coming year. After some research he came up with an idea. Now he is ready to begin collecting data on his device. This may involve writing to various industries, consulting engineers, and other sources. Within a short time, he will have a fairly good idea of the purposes, applications, etc. of his project.

With a working theory in mind, the young engineer may take to the drawing boards. He draws the "blueprints" for his project. When his drawings are completed, he may take them to the club pilot. His pilot goes over them with him and his little dream is ready to make its first step into reality. Sometimes other members will look over his plans. They may add comments ranging from "good idea" to "it will never work."

By this time the school year is well underway. The young engineer begins to face the problem of getting the necessary material for his project. He may need some metal work done, or he may need a special sized gear. Possibly he need glass cut in a special way. There are many possibilities. The high school shop is usually open to him. There he can do much of his metal work, but he may need a special part which he cannot make. Friends may offer suggestions which he will look into. He may find this special part in the discarded "junk" pile of some factory, or some boy in the town may be able to produce it for him.

He continues in this manner. Soon he has his necessary parts collected and he is ready to assemble his project. Now time is running out—the Engineering Exposition is just weeks away. This means he had better devote more time to his project. At last the

(Continued on page 66)



Traverse City JETS club, winners of the "Loving Cup" in 1956, are preparing for another big year. The beginning of a few projects are shown on the table.

The Enrico Fermi Atomic Power Plant

by Fred Rudek, Ch.E. '59

Fred P. Rudek, the author of "The Enrico Fermi Power Plant," is from Brooklyn, New York and is a Junior, majoring in Chemical Engineering. He attended the State University of New York and received an A.A.S. degree in Chemical Technology. Fred is also a member of the student affiliate of the A. I. Ch. E.

It was 52 years ago, in 1905, that Dr. Albert Einstein announced to the world his startling Theory of Relativity—the theory that matter is also concentrated energy. The now famous equation e-mc^2, (energy equals mass X velocity of light squared) can be interpreted to mean that the form of a very tiny amount of matter could be converted to energy. Einstein upset the old concept of our universe and unlocked the door to the Atomic Age.

Today, atomic energy is a fast developing industry. Aside from the use of the atom as a weapon of national defense, nuclear energy has proven itself to be beneficial to the people of the world in many significant ways. But of all the benefits that atomic energy has brought to us, the most promising seems to be in its use as a new source of heat energy to drive our turbine generators.

Atomic power seems to have been discovered just in time to prevent serious worry about our fuel reserves. Actually one of the most compelling reasons for developing atomic power is to extend these reserves.

Last year the United States produced approximately 40 percent of the world's electric power output. About 80 percent of this power was produced by steam-driven turbine generators. The heat energy, necessary to produce the steam for the turbine-generators, was derived from reserves of coal, oil, and gas. This tremendous output of electrical energy consumes equally tremendous amounts of fossil fuels (coal, oil, and gas). With no letup of the expansion rate in sight, experts have predicted that, by 1975, the electric power needs of the United States will be three or four times higher than last year's output. At that rate existing fuel supplies will become dangerously depleted, and fuel costs will begin to rise. Accompanying the rise in fuel costs will be a rise in the cost of electric power. When the production costs become prohibitive, then production will be cut—this is something we cannot afford to do.

Our only answer seems to be in the utilization of nuclear power. At the present time we have at our disposal two nuclear fuels that offer an energy reserve at least 20 times greater than the total known reserves of coal and oil. These two elements are uranium and thorium. Both of these elements are naturally occuring elements that can be mined, refined, and prepared for use as nuclear fuels.

Scientists have estimated that the heat which is potentially available in one pound of uranium is equivalent to the amount of heat energy derived from 2,600,000 pounds of coal. In terms of potential electrical power output the advantage of uranium over coal is essentially proportional to the difference in the heat energy produced by each.

There is one hitch though that must be kept in mind. At the present time our reactors are using only the fissionable isotope of uranium as a source of power. This isotope of uranium which is directly fissionable, is U-235. If we continue to depend on the quantities of this isotope that are available, as our only source of fissionable material, then all the uranium reserves now known to exist in the world will give *less* energy than the known reserves of coal. This is because U-235 is only 0.7 percent of the uranium we find in nature. This would seem to place us right back where we started from. This is not true.

For quite some time now, atomic scientists and engineers have been experimenting with a type of reactor that will regenerate its own fuel. Recent developments have even indicated that more fuel can be produced than is consumed. Reactors of this type are known as breeder reactors. It has become obvious that breeder reactors will be of the utmost importance for a large scale atomic power economy. It is not unreasonable to assume that in 30 to 50 years, a large fraction of our power will be derived from atomic energy. This will only be possible if the supply of atomic fuel is sufficient. Breeders seem to be indespensable for this purpose.

Other countries have fully recognized the importance of breeders. This is particularly true of Great Britain, which has the greatest need for atomic power because of the high cost of mining coal from partly exhausted coal fields and because of an actual shortage of coal which goes hand in hand with this. Britain has therefore taken the lead in the actual construction of atomic power reactors, and in its program is including fast breeders in an important way. They started their breeder development in 1951, and are now expecting to put a full scale breeder reactor into operation in 1958. This means that they are now several years ahead of our development in this field. Our first breeder reactor is not scheduled to go into operation until 1960. (This reactor is now under construction at Lagoona Beach, Michigan. It is to be operated by the Power Reactor Development Company.) Even little Belgium is thinking seriously of the development of breeder reactors.

The United States did have an initial lead in this field, but let it slip away. The Argonne National Laboratory built an experimental breeder reactor of about 1000 kilowatts power as far back as 1950. This reactor, the EBR-I, provided us with a great deal of scientific information, and in particular, definitely established that breeding is possible. But high power breeders are still several years away. The reactor in Michigan is one of the few full scale power breeders that are in the actual construction stage here in the United States.

I hope I haven't misled you into thinking that the United States has been standing still in the development of nuclear power. Actually the U. S. has taken steps to encourage industry to undertake research and construction program in the nuclear power field. In the Atomic Energy Act of 1954 provisions were made to allow interested industrial firms limited access to restricted information. They were also given permission to finance private research investigations at some of the atomic energy laboratories around the country.

Another step toward the introduction of private industry into the nuclear power field came in January, 1955. It was then that the Atomic Energy Commission announced its Power Demonstration Reactor Program. They also extended an invitation to industry inviting them to submit proposals for the construction of reactors of various types.

Industry was quick to answer, and a number of proposals were submitted for the consideration of the A.E.C. Among these proposals was one from the Power Reactor Development Company, to design, construct, own and operate a developmental breeder reactor. The proposed site was Lagoona Beach, Michigan—about thirty miles southwest of Detroit.

The Power Reactor Development Company is composed of twenty-one industrial organizations, organized under the laws of the State of Michigan. The PRDC was organized to fulfill the following purposes which are expressed in its Articles of Incorporation:

"To be a business league of members of industries in the United States interested in the conservation of natural resources and the economical production of electric energy, and to study, develop, design, fabricate, construct and operate one or more experimental nuclear power reactors and any and all component parts, to the end that there may be an early demonstration of the practical and economical use of nuclear energy for the generation of electric energy, together with such industrial and scientific products and by-products and applications as may seem desirable . . ."

On August 4, 1956, the PRDC was granted a provisional construction permit and four days later ground was broken for the first privately owned breeder reactor in the United States.

The Power Reactor Development Company thoroughly investigated the engineering and economic aspects of many basic types of nuclear reactors before reaching their decision to build a breeder reactor. They found that the breeder reactor showed the most promise of becoming competitive with conventional power plants, so it won out over the more conventional types of reactors already in operation at different laboratories throughout the country.

The PRDC plant has been named after the late Dr. Enrico Fermi, an Italian-American scientist who, with a number of associates, was the first to initiate a sustained nuclear chain reaction. Dr. Fermi was also one of the first scientists to recognize the importance of the breeder principle. He maintained that the first nation to develop the breeder reactor would lead the world in nuclear progress. Thus it was with Dr. Fermis' prophecy in mind that the Board of Directors of the PRDC chose to call their project the Enrico Fermi Atomic Power Plant.

The breeder reactor is similar to other types of nuclear reactors in that it releases heat energy through controlled nuclear fission. However, it differs from most other reactors in two major ways:

1. It produces more fissionable material than it consumes.
2. It uses high energy (fast) neutrons without the use of a moderator.

The full name of the PRDC reactor is—fast neutron breeder reactor. The name implies that the

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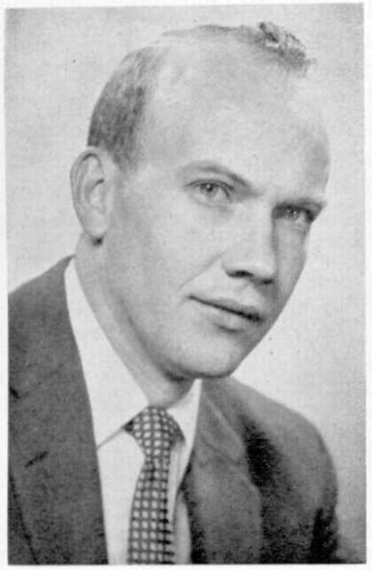

DR. HERMAN E. KOENIG

Mechanical Engineers Beware...

Lagrange's Equations Are Not Fundamental

by *MYRIL B. REED and HERMAN E. KOENIG*
Professors in Electrical Engineering at
Michigan State University

DR. MYRIL B. REED

Editors Note: This article is a follow up on the article in the last issue of the Spartan Engineer, "Kirchhoffs 'Laws' Are Not Laws at All."

Lagrange's equations are considered by many to be the foundations of Mechanics.

Some Schools use the Lagrange equations in working with electro-mechanical systems, however, it is indicated in this article that this is actually a step backward in progress and the better approach is to convert the whole system to a linear graph with subsequent reduction to the final system of equations.

Historically, some of the earliest attempts to systematically analyze electrical networks were made in terms of Lagrange's equations and energy concepts taken from mechanics. In fact, "explanations" of electrical phenomenon, in general, were, and still are, attempted in terms of the physical concepts of forces, particles and mass borrowed from mechanics. Electric current is defined as the flow of charge, or electrons, and voltage as the "difference-of-potential" resulting from separation of the charges. The electron is defined as a particle of mass having a certain physical dimension. While some early and some very late attempts at electrical network analysis also followed the techniques developed in mechanics, namely, Lagrange's equations and the energy concepts, electrical network theory, as it is known today, *did not* develop on a foundation of Lagrange's equations. Rather, an entirely new and different technique has been developed. Unfortunately, the generally-used methods of formulation have, for the most part, failed to leave behind the rather awkward and essentially irrelevant physical models borrowed from mechanics.

The network diagram, or equivalent circuit as it is sometimes called, represents the starting point in electrical network analysis. When the question is raised as to precisely what is the network diagram or equivalent circuit, many interesting points with far-reaching implications come to light. First of all, the diagram is more correctly referred to as a linear graph studied formally under the mathematical designation of topology. A pair of variables, called the voltage and current variables, are associated with each element or line segment of the linear graph. These variables are mathematically undefined and are used simply to represent the indications of a pair of meters, one placed in series with and the other in parallel with the measure points in the physical system. The numbers taken from the meters are *the realities* of concern, not the imaginary physical models in common use. The invention of an imaginary "physical" model involving little charged particles moving around in the wires adds nothing to the solution of the problem. In fact, the danger of physical models is that too often the investigator or student spends too much of his time looking for the "thing" called voltage and current, instead of concentrating on the relevant aspects of his problem—mathematical correlate, patterns of meter indications, reshaping of the physical device, etc.

The second important point to be noted in connection with network theory is that the indicating instruments have been so constructed (either consciously or unconsciously) that the summation of the $i(t)$ and $v(t)$ variables, associated with the graph and representing the meter indications, sum to zero, at the vertices and around closed paths respectively. These algebraic equations, called the vertex and circuit equations, along with the differential equations showing the mathematical relationship between each $i(t)$ and $v(t)$ associated with the graph elements constitute a sufficient set of equations for systematically formulating the dynamic equations for any system, however complex.

Finally, in the formulation of electrical network equations, the concept of energy appears in a secondary manner, i.e., it is *derived* by means of the time integral of the product of the two primary variables, $v(t)i(t)$. Energy is still fairly widely viewed as one of the "things" of the electrical system, but is really of no concern or use in the basic study of these systems. The model of a physical "thing," energy, except for one outstanding group of proponents, has largely been relegated to a position of no importance in electrical network theory.

If the other areas of physical science are viewed from the same perspective, exactly the same pattern results. Namely, the number indications taken from sensed instruments are the realities and not what is said about what they represent. In mechanics, for example, if $f(t)$ represents the indication of the "force meter" and $x(t)$ the indication of the "displacement meter," then these two variables respectively obey the vertex and circuit equations of a linear graph of the mechanical system. The graph of the mechanical system or any other system is established in exactly the same way as that of the electrical system, namely, by associating an element or line segment of the graph with each pair of measure points in the physical system.

As in the case of the R, L, and C coefficients in electrical networks, the k, b and m coefficients (spring constant, damping constant, and mass constant) are to be considered simply as coefficients in the differential equations relating the $f(t)$ and $x(t)$ variables associated with the element of the graph. They are not physical "things"!

Note that when viewed as a problem of correlating numbers taken from indicating instruments, the theory of linear graphs developed in the study of electrical networks is immediately extendable to the analysis of *all physical systems*. The only requisite is that it be possible to find *or invent* a pair of indicating instruments such that

a. the summation of the indications taken from one type of instrument (the through measurement) sum to zero at the vertices of the graph.

b. the summation of the indications taken from the second instrument (across measurement) sum to zero around the circuits.

c. the two indications taken relative to the same pair of measure points can be correlated by a mathematical function. If a solution is to be realized, the correlating function must be an ordinary linear, constant-coefficient differential equation.

But what about Lagrange's equations and the conservation of energy? Are they fundamental to the analysis of all systems? Do they simply represent an alternate formulation technique, or perhaps neither? The need for a systematic method of formulating the equations for the electro-mechanical systems, or interrelated systems in general, has forced many people in the profession to face this question and make a decision. Some have concluded that Lagrange's equations and classical mechanics are fundamental to all physical sciences and consequently have made efforts to formulate electro-mechanical problems using Lagrange's equations. The basic philosophy leading to this conclusion is that energy is a physical "thing" and energy conversion the basic problem.

It is possible to show that certain primary variables, with properties determined by a system of ordinary, linear, constant coefficient, differential equations, satisfy Lagrange's equations, i.e., the so-called energy relations. However, this *does not* mean that these Lagrange equations can in any sense serve as a base for establishing the differential equations or the properties of the solution of the differential equation. Quite the contrary. The basis for this conclusion can be presented by analogy in terms of the following example.

A set of algebraic equations has an easily formed sum which is definite and has definite properties. But

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GD GENERAL DYNAMICS

DIVISIONS

CL CANADAIR LIMITED

EB ELECTRIC BOAT

GA GENERAL ATOMIC

ED ELECTRO DYNAMIC

CV CONVAIR

SC STROMBERG-CARLSON

the energetic sea

In vessels
powered by the airless "burning"
of nuclear fuels,
men may soon make voyages of discovery
to unknown continents that lie beneath
the ocean's surface; and, so,
prospect for new metals
in the waters of,
extract new minerals from
the mountains of, seek
new elements on the shelves
and beaches of,
herd new flocks to the grasses of,
draw new energies from the tides, the waves,
the atoms of,
the energetic sea.

The Revolution At M.S.U.

by J. D. Ryder

J. D. RYDER
Dean of the School of Engineering

A good professor always works to improve his courses; a dean attempts to improve the work offered by his college. The engineering teaching profession as a whole has been working to improve its efficiency. Engineering teachers have an organization known as the American Society for Engineering Education which, with industry advice, has been studying means of improvement of engineering education. Of course, it is necessary to recognize that such studies are made by committees, committees are made of people, frequently college professors, and the committee reports are therefore a reflection of the thinking of the individuals. In addition, the reports may reflect the varying backgrounds, experience and training of the committee members. Thus reports of committees should be taken as stimulants to the thinking of the individual reader rather than as gospel to be followed blindly.

In this connection an engineer once worked out some equations which led him to the result that the ideal committee was composed of 1.97 people, thus a majority of one was always available to settle any question. It has also been said that if four new ideas are needed on a subject then appoint a committee of three people—one will be of two minds on the subject!

Returning, however, to the report of the ASEE committee on the "Evaluation of Engineering Education," it can be assumed that it was seriously prepared, but still was the result of the thinking of about thirty-five minds, was a compromise, and should be employed as a guide to thinking as to generalities, but should not be taken as rigid and firm in its details. It will also be assumed that it has not been read by engineering students (it has 36 pages, which seems a sufficient reason therefore) but that as juniors or seniors, possibly beyond the reach of any of its recommendations for stiffer courses, you may still be interested in its effects on the preparation of younger engineers who will follow along after you.

Essentially the report does recommend stiffer courses, less in the nature of skills and techniques, more of engineering science and mathematics. These seem the needs for the engineer of the future, the man who will design the machines and systems of the year 2000. If you do not know who he is, look in your mirror. The year 2000 is 43 years away—within the professional lifetime of you students now in the engineering college. You are to work with the jets and rockets of the future, not the steam engine of the past. The steam engine was simple, the rocket is not.

Concerning mathematics, the report recommends proficiency to at least the differential equation level for all—MSU is now at that level—it also defines a set of basic engineering sciences as

1. Mechanics of solids (statics, dynamics, and strength of materials).
2. Fluid mechanics.
3. Thermodynamics.
4. Transfer and rate mechanisms (heat transfer, mass transfer, and momentum).
5. Electrical theory (circuits, fields, and electronics).
6. Properties of materials (micro and macro views of structure).

You may recognize some of these as titles of courses you have had, or will take. Some will not appear in your curriculum—some are important to one kind of engineer, some to others, many to all engineers. The effect of the ASEE report will be to make all teachers aware that engineering education is dynamic, that it is a never-finished job, that we must work to fit it to the needs of the engineer of the future.

Perhaps this may allow a few of you to understand the upheavals in curriculum, the changes in courses, the additional work heaped on staff in preparing new material. All this is designed to keep our MSU engineering education a dynamic thing. If a body does not move he may be dead!

Fossil Fuels:

How long will they last and what then?

GORDON UTTER

Our good coal will be gone by 1995

Economical Gas and Oil will be gone by 1970

In 1800 the United States was a small, weak, and undeveloped country. England was just the opposite. She was the first country to develop extensively her resources and industry and as a result she led the world in trade and progress during the 18th and 19th centuries. Few people could imagine that someday the United States would replace England as the world power. After the middle of the 19th century the United States discovered its vast resources of coal and iron and it began to develop as an industrial nation. With its extensive deposits of coal near both, transportation and a labor supply, the United States grew rapidly and by 1900 had equaled in strength the other great powers. In the early 20th century the automobile came into being and along with it petroleum also became important. With its extensive resources of coal and petroleum and their development, the United States soon passed England in economic strength to become the world power.

Today we enjoy the comforts of regulated heating in the home, transportation by the automobile, the railroad, and the airlines, and as previously mentioned the prosperity of a highly developed industrialization. All of this would have been impossible without our fossil fuels.

As long as a steady stream of fuel comes flowing in to meet our needs, most of us never worry about how long our greatest sources of energy will last although we know the reserves are finite and someday they will be depleted. Everyday we are using more and more energy. There are two reasons for this. One is the increasing population. In 1951 the world population was computed to be about 2,411,000,000. At the present rate of increase it is calculated that by 2050, 7.3 billion people + or — 1 billion will be living in the world. This will increase the need for energy since each person requires a given amount of energy. Another reason for the increasing consumption of energy is that the per capita consumption of energy is increasing. The increase is evident in the fact that more than half of the fossil fuel (coal, petroleum, and gas) energy consumed has been consumed since 1920. With the rapidly increasing consumption how long will our fossil fuels last? First, let's consider our reserves of petroleum.

Most of our computed reserves are based on the recent work of Lewis G. Weeks, chief geologist of the Standard Oil Company of New Jersey. He has computed that there are 67 billion barrels of onshore reserves in the United States. Of these reserves, half of them have been proven by drilling. He believes that there are 10 to 20 billion barrels of offshore reserves. This gives the United States a maximum total of 87 billion barrels of reserves. In the rest of the world Weeks believes there are over 600 billion barrels of onshore reserves of which 1/5 has been proven by drilling. In addition he has come up with the figure of 300 billion barrels of offshore reserves. He believes that his estimate may be small for the rest of the world and in estimating the total maximum oil reserves in the world he set the number at 1280 billion barrels.

At present the world is using ¾ million barrels of petroleum every hour of which the United States has been using one half. The consumption of petroleum is increasing at the rate of 10% a year. In 1959 the world will be using a million barrels per hour and 3.9 billion barrels for the year. Foreign production in 1956 stood at 3.2 billion and is increasing at the rate of 230 million per year. This will bring the production to 3.9 billion barrels in 1959. Thus, at present trends production will equal consumption in 1959. Since 1948 the production of the United States has run behind consumption and we have had to import oil at the increasing rate of 70 million barrels a year. Last year we had to import 500 million barrels and it is believed that by 1959 we will have to import 700 million barrels. If the world already has demands as great as production in 1959, where will the United States get the necessary imports? All of the previously mentioned figures are assuming present trends in production and consumption. The United States could increase production and meet the demand, but it would mean using up our strategic reserves and shortening the overall life of petroleum.

Comparing the reserves and production Weeks believes that production will be forced to decline in 10 or 15 years in the United States and shortly after in the rest of the world. All of the important oil fields in this country that were opened before 1940 have now passed their peaks of production. 9 of the producing states have passed their peaks along with 8 producing countries abroad. In about 1965 or 70 production in the United States can be expected to start on the downgrade due to depleted reserves and by 1980 production will begin to decline in the rest of the world. Despite the decrease in production our demands will still be increasing. Demands in the United States in 1975 is computed to be twice the production. Palmer Putnam in his book, *Energy of the Future,* states that 1970 is the last date on which economically recoverable gas and oil will be available.

So far in our computation of oil reserves we have not included two potential sources. They are the oil shales and the tar sands. It is believed that there are a million, million tons of recoverable oil shale in the world of which the United States has 55%. The average content of petroleum in these shales is 10 gallons per ton. The most important oil shale in the United States is located in Colorado. At Rifle, Colorado the U. S. Bureau of Mines has an experimental producing plant. It can produce petroleum at a cost only slightly greater than the drilling method of obtaining oil showing that someday it may be economical to develop the oil shales extensively. The U. S. G. S. (United States Geological Survey) estimates that there are 200 billion barrels of oil recoverable from our oil shales using only the reserves that will produce 15 gallons a ton. However, the oil now being recovered at the experimental plant at a cost slightly greater than the present costs of producing petroleum is taken from shale assaying 30 barrels per ton. So, with present methods only a few billion barrels of the 200 billion barrels of reserves would prove economical for production. Two other major problems to the use of oil shale are the facts that it requires a place to dispose of billions of tons of ash remaining after distillation and the fact that a tremendous amount of water is required in an area which has a scarcity of water. At the present time the production of oil from oil shale is negligible.

It is believed that there are as many as 300 billion barrels of petroleum in the Athabasca tar sands in northern Alberta. However, much of it is deep under the earth and as a result will never be recovered economically.

At the present extraction of oil from the oil shales or oil tars is not economical. However, as our reserves become smaller our oil will be harder to get. We will have to drill deeper and drill more holes to find a producing oil pool. In 1943 the average depth of wells was 2976 feet. In 1953 it was 4062 feet with several wells much deeper. One exploratory well was 20,000 feet deep. The greater the depth of drilling and the amount of exploration required the greater will be the cost of production. When the cost of production raises

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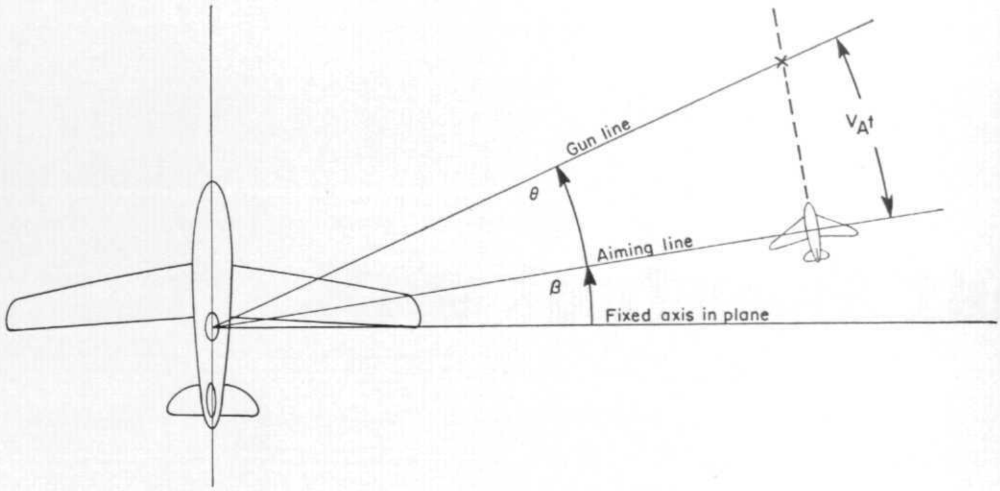


FIG. 1

A Lead Computing Gun Sight Gyro

Edited by Al DeRuiter

The design of a lead-computing gun sight requires a built-in device to supply automatically the required lead for the gun if the gunner keeps the target in his sight. It is naturally quite impossible for a gunner to properly estimate the required lead with the speeds of aircraft today, so that the most that can be required of the gunner is that he keep the target correctly sighted. Therefore, this problem asks for a stability and response analysis of a gyroscope-eddy current disk system created to provide the required lead.

Explaining Figure 2

In Figure 2, motor 1 and eddy current disk 2 comprise a gyroscope pivoted on axis 3-3 in gimbal 4, which is in turn pivoted in the main frame on the sight of axis 5-5. The pivot bearings have negligible torques and the gyroscope is statically balanced about the center of gimbal suspension. Motor 1 is an induction motor capable of maintaining speed essentially constant under operating conditions. Eddy current disk 2 has the form of a segment of a sphere with its center at the center of gimbal suspension. It rotates with the rotor of motor 1 and forms part of the gyroscope flywheel.

Electromagnet 6 is fastened to the frame of the sight so that its flux links the conducting sheet on the face of the eddy current disk. Under static conditions its axis is aligned with the gyro spin axis. If the gyro axis is displaced from the magnet axis, eddy currents are induced in the disk, producing a retarding force which has a component torque about the spin axis and another about an axis perpendicular to it. The latter tends to precess the gyro to line up with the magnet axis. Since this torque varies essentially linearly with displacement, the main motion is described by a time constant T which depends on the excitation of the magnet. If the direction of the magnet axis is changed, the gyro follows it, with a lag angle depending on the rate of change of direction and on the strength of the magnet field.

Operation of the Lead-computing Gun Sight

In use as a computer, the frame of the sight is fastened to a gun carriage with the magnet axis parallel to the gun axis. An optical system is linked to the gyro to set up an aiming line parallel to the gyro axis.

The gunner moves the gun so that the aiming line stays on the target. Because the gyro is lagging the gun, it follows that the gun leads the target. The strength of field is adjusted so that this lead angle is tXpB, where pB is the angular tracking rate of the aiming line, and t is approximately the time of flight of the bullet to the target.

If the gun motion is halted, the lead angle decays exponentially with a time constant T.

Data on Figure 1

$r\theta = V_A t = rtpB$

V_A=Velocity of target

θ=Lead Angle

r=Distance to Target

t=Time of Flight of Bullet to Target

For very large velocities of disk material under the magnet pole the reactance of the current paths displaces the current pattern slightly from the pole. However, for the velocities considered here it may be assumed that the force acts under the center of the pole. Its magnitude is proportional to the relative velocity and its direction is opposite to the direction of travel of the disk material under the center of the pole. This description serves to allow representation of the various components of the damper force for the analysis. Later it should be possible to represent the effects of this force in terms of the time constant T.

When the gyroscope is disturbed, its transient motion is a nutation, or oscilation about its center of suspension. The resultant displacements and motions of the eddy current disk produce eddy current torques which may damp the nutation or cause it to build up, depending on the proportions of the system. Thus the eddy current system which serves to generate the computer lead angle may feed energy into the initially small nutational motion. To absorb this energy a tuned damper is mounted on the shaft (5-5) of the outer gimbal ring(4). This consists of a disk coupled to the shaft elastically and with viscous damping. The elastic and viscous forces are created only by relative motion between the shaft and disk. Thus for steady rotation, no forces are exerted.

A Stability Criterion

The desired results are a stability criterion for the system and, *rate of change of nutation amplitude* as a function of the spin moment of inertia, rotor speed, time constant T, and the moments of inertia of the gyroscope about axis 3-3 and of the gyroscope and gimbal about axis 5-5. Products of inertia of the gyro and gimbal about the pivot and spin axis are negligible. Keep results in literal form as long as possible. The following numerical data are offered as typical values:

W of spin=1400 rad/sec

I of rotor about spin axis=.0018 in. lb. sec.^{2}

I of gyro about 3-3=.005 in. lb. sec.^{2}

I of gyro and gimbal about 5-5=.007 in. lb. sec.^{2}

T=1 sec.

Solution Outline

To investigate the operation of the lead computing device, the equations of motion must be solved. The equations of motion are obtained from an application of Newton's laws to a rigid body. The result is Euler's torque equation.

To solve this equation, the torque applied to the body must be evaluated. This consists of the torque due to the tuned damper as well as that due to the eddy current disk. This torque is equated to the rate of change of angular momentum.

The exact equation, as written, is nonlinear but can be linearized through the method of small motions.

The stability of the linearized equation can be investigated in a number of ways. Perhaps the simplest of these is Routh's criterion. This, however, indicates only that the system is stable or unstable. To determine how stable the system is, further work must be done.

A knowledge of vector algebra is very helpful in working this problem.

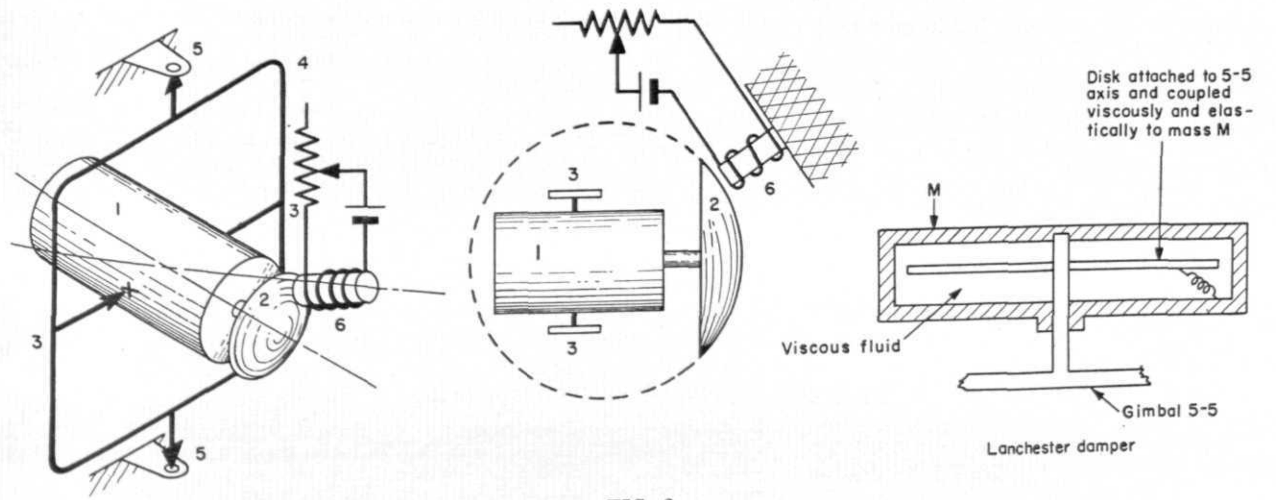


FIG. 2

No blue sky...just black and white facts

to back up our belief that

you and Collins should get together

We're going to build a proposition which we believe deserves your most serious consideration, if you are a mechanical or electrical engineer. This proposition is built on pure and simple fact—no high flown promises or broad generalities. Our proposition: you and Collins should get together. We present these facts to support it.

FACT NUMBER 1:
Collins Radio Company's sales have increased 10 fold in each of three successive seven year periods. 1933 sales were $100,000; 1940 sales, $1,000,000; 1947 sales, $10,000,000; 1954 sales, $100,000,000, and 1956 sales, $126,000,000. (Note graph.) This company *has grown, and is growing* at a phenomenal rate. Total employment is 9,000 of which 24% are research and development personnel.
You grow when the company you work for grows.

FACT NUMBER 2:
As shown in the graph at right, the employment of research and development personnel has increased steadily despite fluctuation in sales. Notice that even during periods of national sales regression Collins continued to strengthen its engineering staff.
Collins has based its growth on the solid foundation of stability in the engineering department.

FACT NUMBER 3:
At Collins, the ratio of engineers to total employees is extremely high, far higher than the average among established companies engaged in both development and production. First and foremost, Collins is an engineering company.
Engineering is king at Collins—never takes a back seat to production expediency.

FACT NUMBER 4:
Collins' reputation for quality of product is universally recognized. It has led to Collins' phenomenal sales record. At Collins there is no compromise when quality is at stake.
If you're the man we want, you'll get real satisfaction out of this quality-consciousness.

FACT NUMBER 5:
Electronics is Collins' only interest. In no way is it subsidiary to the manufacture of industrial or consumer products. Collins builds electronic equipment, not airplanes or vacuum cleaners. Every research, development and production facility is devoted to progress in electronics.
If electronics is your interest, you'll like the climate at Collins.

FACT NUMBER 6:
There is a limitless variety of fields and types of work for the Collins engineer. Recent Collins work in air and ground communication, and aviation electronics include developments in transhorizon "scatter" propagation; single sideband; microwave and multiplex systems; aircraft proximity warning indicator; aviation navigation, communication and flight control; broadcast; and amateur equipment.

There is big opportunity for your special talents.

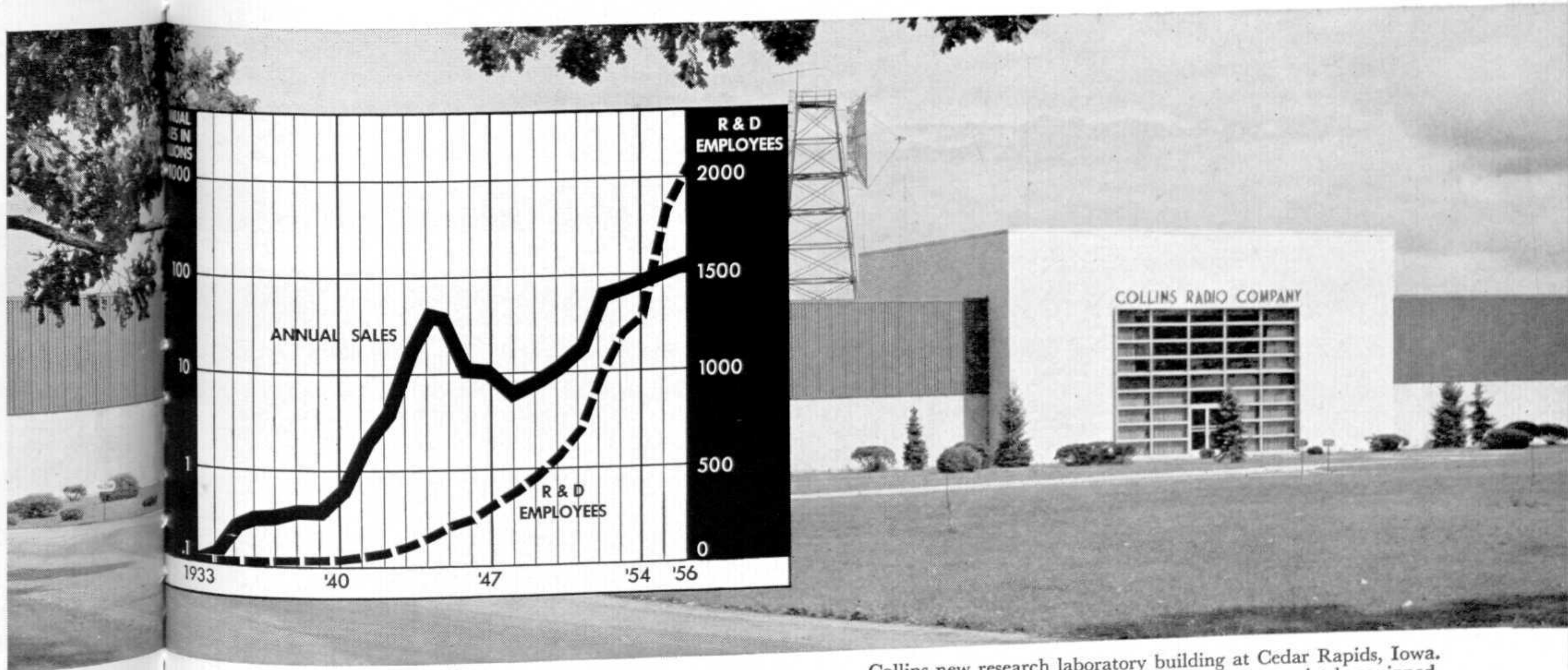
Right now we are prepared to offer you a technical or supervisory assignment in one of many interesting fields. And the sky *is* the limit as far as responsibility and salary are concerned.

You will work in one of Collins' new research and development laboratories located at Cedar Rapids, Iowa; Dallas, Texas; and Burbank, California. Offices and subsidiary companies are located in New York; Washington, D. C.; Miami; Knoxville; Seattle; Hickman Mills, Missouri; Toronto, Canada; London, England; and South America.

All your moving expenses are paid. Company benefits are tops in the industry.

We repeat—if you are a mechanical or electrical engineer, you and Collins should get together. Take the first step now, for more information, write:

L. R. Nuss Collins Radio Co. Cedar Rapids, Iowa	Fred Aiken Collins Radio Co. 2700 W. Olive Ave. Burbank, California	Harold McDaniel Collins Radio Co. 1930 Hi-Line Drive Dallas, Texas



This graph shows the relationship between sales and employment of engineering personnel at Collins. Notice the steady increase in research and development employment despite sales fluctuations.

Collins new research laboratory building at Cedar Rapids, Iowa. Air-conditioned, shielded against radio waves, completely equipped.

Collins CREATIVE LEADER IN ELECTRONICS

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NEW DEVELOPMENTS

Edited by Norm Dill

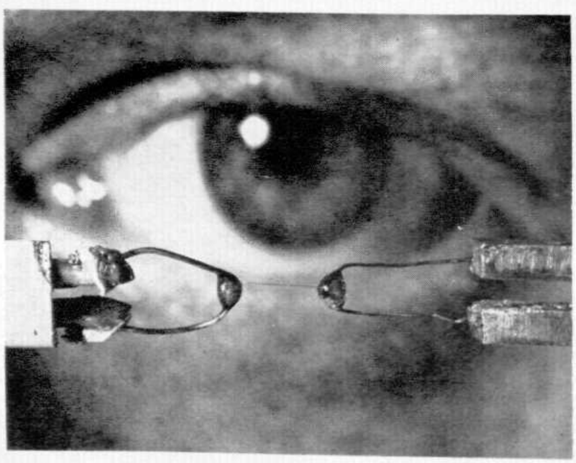
Scientists Use 'Whiskers' to Study Forces Between Atoms

One of modern science's oddities—highly pure and perfect metal crystals known as "whiskers"—are enabling scientists to gain new insight into the enormous forces which bind atoms together.

In a paper delivered during the seventh New York meeting of the American Association for the Advancement of Science at Hotel Martinique on December 29, Dr. R. L. Eisner, research physicist, described a new technique for evaluating these forces by measuring the tensile strength of whiskers of iron and silicon.

Dr. Eisner's technique is one of the most accurate methods known for pulling apart the tiny crystals and measuring directly the applied stress and the amount of strain they undergo. Precise, delicate equipment is required, Dr. Eisner said, because the tiny strands of metal may be 40 millionths of an inch or less in diameter—about one hundredth the thickness of a human hair. Use of the method, the scientist reported, has cast new light on the nature of the interatomic forces which give all metals their ultimate strength.

"In whiskers, a metal exists in a perfect condition," Dr. Eisner said. "In contrast, any ordinary piece of metal contains countless millions of structural imperfections. Under stress, it is these imperfections which govern how and when the metal will break.



Tiny strand of metal one hundredth the thickness of human hair casts new light on the nature of interatomic forces.

They mask any attempt to measure the much larger forces which hold the metal atoms themselves together.

"By conducting tensile tests on whiskers, where imperfections do not exist, we can pull the individual atoms far enough apart, without breaking, to get a measure of the interatomic forces. This enables us, for the first time, to check modern theories of interatomic forces."

In Dr. Eisner's whisker experiments, only a small force—less than one hundredth of an ounce—is required to pull the average whisker apart. This force, which must be controlled and measured with unusual accuracy, is obtained by a light-weight pendulum about 12 feet long. The whisker is "clamped" between the bob of the pendulum and a special "take-up" screw. As the screw is tightened, the whisker pulls the pendulum from its vertical position. Each millionth of an ounce of pull displaces the handling pendulum exactly the same amount—about one ten-thousandth of an inch.

The stretch of the tiny whisker is measured by reflecting a beam of light from flat optical mirrors attached to the clamps at each end of the whisker, to form an "interference pattern." As the whisker stretches, the mirrors move and cause changes in the pattern similar to the changing "rainbow" colors seen in soap bubbles or thin films of oil. These changes are electronically amplified and analyzed to disclose the amount of stretch. The technique accurately measures changes in whisker length down to less than one millionth of an inch.

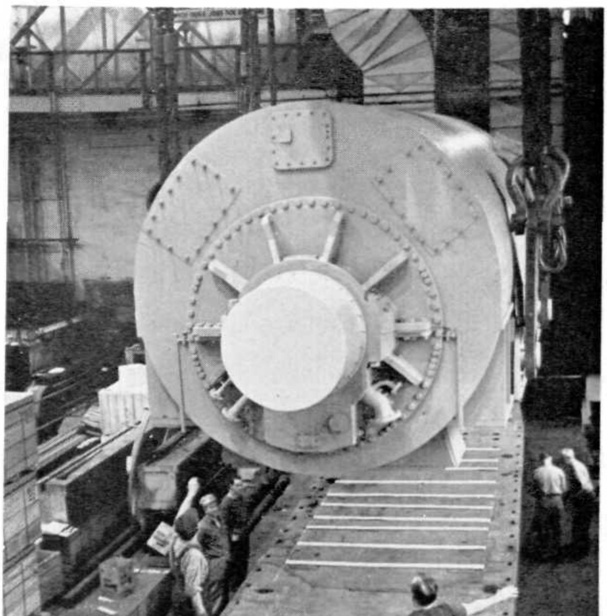
"Our experiments reveal considerable data about interatomic forces," Dr. Eisner said. "We have found that, freed of the limitation imposed by impurities and imperfections, these forces give iron a strength of more than half a million pounds per square inch.

"Whereas in ordinary steel the imperfections cause it to flow and deform at one-tenth its ultimate strength, we have found no such 'plastic' deformation when interatomic forces only are involved. Even the elastic limit of 'soft' metals such as tin in the prefect structural state is at least ten times the maximum in the best steels in common use today.

"We think we are beginning to understand the origin of these interatomic forces which 'glue' atoms so tightly to one another. Our plan is to try our experiments on the very simplest metal atoms in order to gain additional data which, we hope, will verify our theoretical conclusions. Such an understanding, we feel, is a necessary first step toward someday making use of these enormous forces in the new and better metals of the future."

Atomic Power Plant Generator

Bound for Shippingport, Pa., site of the world's first fullscale atomic power plant devoted exclusively to serving civilian needs, this 100,000-kw generator is prepared for shipment at the East Pittsburgh plant of Westinghouse Electric Corporation. Shown being lowered onto a flatcar by two traveling cranes, the 202-ton generator measures nearly 29 feet in over-all length. When installed, the unit will not be housed in a building—the first such installation of its type in this part of the country. Duquesne Light Company of Pittsburgh is building the electric generating part of the Shippingport plan and will operate the over-all plant. The plant is expected to be in operation in 1957.



A 202-ton, 100,000-kw, atomic power plant generator.

New Uses for Radioactive Isotopes

Radioactive isotopes are being used to study certain phases of both production tool and automotive engine wear, Dr. Alexander Somerville said today at the National Industrial Conference Board's 5th annual conference on Atomic Energy in Industry.

"We have found it very practical to operate using short half-life, 24-hour tungsten-187 which is a strong gamma emitter," Dr. Somerville explained. "By using this short half-life material we can obtain a very high sensitivity and reduce the difficult contamination and disposal problems."

"One microgram of tool material can easily be measured in the chips. This amounts to the material worn off the tool during a single second of operation," he said.

A production type lathe had made the "job of properly engineering the installation quite a little more difficult," he declared, but this was offbalanced by the fact that "information is obtained with actual production equipment under simulated production conditions."

In measuring piston ring wear in automotive engines, Dr. Somerville said "our interests differed considerably from those of several oil companies who have already established equipment for doing this type of work."

". . . We were interested in obtaining the highest possible sensitivity so as to study the details of the wear process as a function of time, instead of obtaining information concerning the operation of a given lubricant over a period of several hours under constant operating conditions.

"Higher levels of activity, and more sensitive detection equipment were used to meet these requirements," he said.

Quartz Infrared Lamp Hailed for Versatility

In two and one half years, the smallest, hottest electrical heat source on the market—the tubular quartz infrared lamp—has developed almost unbelievable versatility.

This lamp is three-eighths of an inch in diameter and comes in lighted lengths of 5, 10, 16, 25, 38 and 50 inches at 100 watts per inch! And its applications are legion.

It is used for cooking and food warming—from a hamburger to a roast—but it is also used by railroads and machine shops for shrink-fitting pinions and bearings.

It is used by thousands of secretaries—although they may not know it—in office copying machines.

It touches the lives of millions of people because it is used in the printing industry to set ink in high-speed presses. In the textile industry, this radiant energy source—with other drying facilities—speeds up and improves textile processing.

It is used to produce supersonic wing-surface temperatures for the aircraft industry in a developmental quartz infrared oven with adjustable segments to fit aerodynamic contours. In this application, special 1000-watt quartz lamps, designed for intermittent burning only, are mounted in a closely meshed two-layer grid and operated to produce a total energy concentration of more than 150,000 watts per square foot.

It bakes lacquers, enamels and varnishes in a fraction of the time required by other baking processes.

(Continued on page 44)

Which one is best for you?

HERCULES will help you decide

There are many directions to take in building your future career in the chemical field. And the truth of the matter is that many college graduates are not sure in which direction their future lies.

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Hercules' pace-setting growth and continuing diversification provide many opportunities for careers in creative chemistry. You can learn more about Hercules in your placement office.

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HERCULES
CHEMICAL MATERIALS FOR INDUSTRY

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(*Continued from page 41*)

In drying processes—where liquids must be evaporated—the quartz infrared lamp is replacing gas and oil ovens, electric heaters, and even blowtorches.

Some of the reasons for this expanding and diversified use of quartz infrared lamps are:

1. Quicker heat—Infrared lamps warm up almost instantly. Their energy creates immediate heat when it reaches a product that can absorb it. Even more important in many processes, the time has been reduced from hours to minutes.

2. Efficient operation—Old-type ovens burned fuel that heated the air which in turn heated the product. Direct infrared heating is more efficient.

3. Uniformity—The compactness and simplicity of the quartz infrared lamps permit ready installations providing uniform, constant energy.

4. Cost—Infrared systems are economical to install, simple in construction, and are made largely of standard parts. Maintenance is easy and inexpensive, operating cost is low. No power is used when the unit is not in use. Expensive controls are not needed.

5. Space—Infrared ovens require substantially less space than other types.

6. Comfort and safety—Employees work in a comfortable temperature because infrared adds little heat to the air. Hazards are minimized because the source of heat is enclosed in the bulb.

The amazing versatility of the quartz infrared lamp, according to engineers, is due to its small size, high operating temperature, and ability to withstand the shock of violent temperature change.

The tube is made of fused translucent quartz which has high mechanical strength, low coefficient of expansion, high melting point, superior insulating properties, and resistance to acid and thermal shock. Even when the tube is heated to a cherry red, it almost never cracks when subjected to such extreme abuse as being doused with water or touched with a piece of ice. The lamp is designed to last more than 5000 hours.

Heat From the Atom

Within a few decades, factories, office buildings and other large structures may be heated atomically "without a speck of soot, an ounce of ash or a cubic foot of smog," a General Electric Company engineer predicts.

S. L. Nelson, manager of one of the processing operations at the Hanford atomic plant, says that successful use of reactor waste heat for Hanford buildings has shown that dirt-free atomic heating is technically feasible.

Nelson made these forecasts in an article in the GENERAL ELECTRIC REVIEW, a company engineering publication.

He pointed out, however, that success of his predictions depends on making atomic fuel available for heating purposes, design of a reactor specifically for low-energy heat production and over-all reductions in costs of building and operating reactors. Nelson said that the Hanford installation has shown itself to be "remarkably sound and trouble-free system."

"Although development projects often operate at a loss," he stated, "this system will make a profit, saving the taxpayers a net of about $60,000 a year after a three to seven-year amortization."

Enough heat is recovered in the system to heat more than 1000 average-size houses during the winter season, he added.

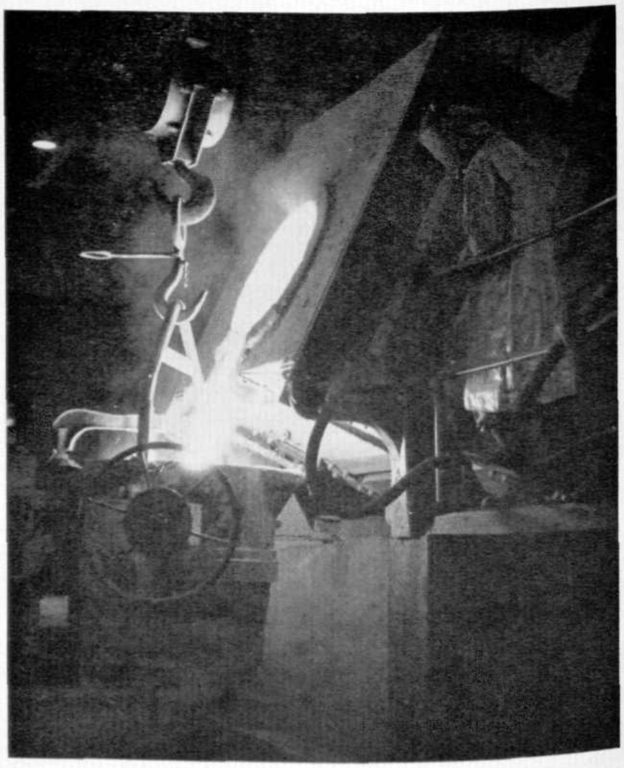
Metal to Help Crack Jet 'Heat Barrier' Developed by Scientists

Scientists have developed a new high-strength, high-temperature metal which is designed to help push back the "heat barrier" now being encountered by jet engines in the nation's new supersonic aircraft.

Announcement of the metal, for use inside the red-hot interiors of jet engines, was made by D. W. Gunther, manager of the Westinghouse Materials Engineering Department. He described it as "a significant advancement in the field of gas turbine disc materials."

"As jet planes travel faster and faster into the realm of supersonic flight, they encounter what is commonly called the 'heat barrier'—excessive heating

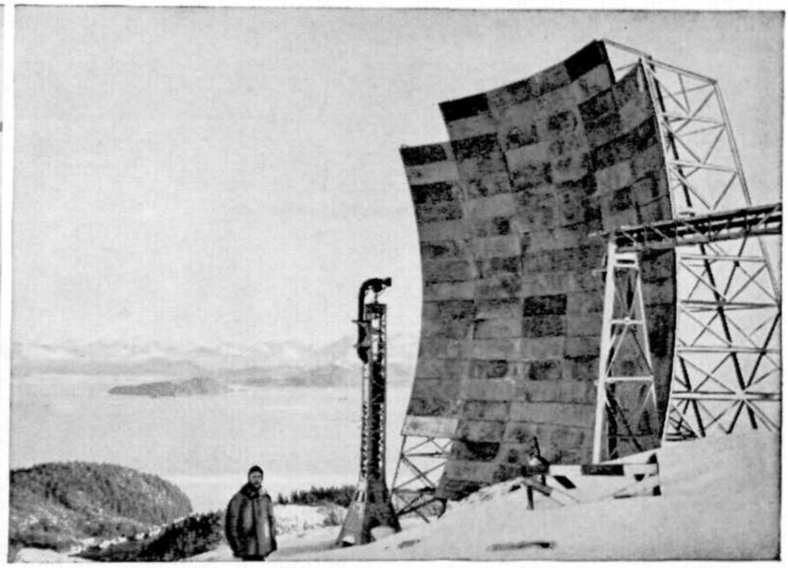
(*Continued on page 46*)



Operators pouring a 3500-pound ingot of the new high-temperature alloy W545.

How John Peacock met "White Alice"

John M. Peacock, B.S.E. in Mechanical Engineering, Princeton, '47.



One of the huge tropospheric antennas used in the "White Alice" project. These screens pick up the "scatter" of UHF radio signals beamed from more than 150 miles away!

"I met 'White Alice' at Bell Telephone Laboratories," says John. "That's the code name for the communications system linking defense installations along 3100 miles of Alaskan borders.

"Laboratories people had made a basic survey to determine the kind of system needed. I was assigned to the group that developed tropospheric antennas for over-the-horizon UHF radio transmission.

"Besides the usual critical problems involved in systems of this sort, we had some extraordinary factors to deal with, too. There were problems of snow. The structures had to withstand 150-mile-an-hour winds. And research showed that in the Arctic up to sixteen inches of ice could accumulate on the antennas. We had to design them to be strong enough to support this weight without collapsing. But the antenna would not function properly with this much ice on its face, so a de-icing system was devised to limit that ice to an inch or less.

"We had to work fast, on a very tight time schedule, in order to beat Alaska's winter close-in. And we did. From start to finish, 'White Alice' was an exciting and interesting project. But now I'm working on another over-the-horizon radio system that's just as absorbing. By the way—it's to be in Florida!"

John M. Peacock has been a Mechanical Engineer with Bell Telephone Laboratories since 1953. Able, imaginative young engineers and scientists will find interesting and rewarding career opportunities throughout the Bell System—at Bell Telephone Laboratories, with Bell Telephone Companies, Western Electric and Sandia Corporation. Your placement officer can give you more information about all Bell System Companies.

BELL TELEPHONE SYSTEM

NEW DEVELOPMENTS

(*Continued from page 44*)

of the plane due to its own impact with the onrushing air," Mr. Gunther declared. "It is the same phenomenon which causes a meteorite to burn to ashes as it falls at high speed through the earth's atmosphere. In aircraft, this heating creates many serious problems, not only in the general structure of the plane, but also in the jet engine which powers it."

Impact heating is now a major consideration in the design of the inlet and compressor of modern jet engines. By using titanium for those parts that were formerly made of aluminum, magnesium and low-alloy stainless steels, engineers can protect these sections of the engine from the effects of impact heating without sacrificing the turbojet's light-weight advantage.

However, back in the turbine section of the engine exists what might be called a second "heat barrier" which is proving to be a much more difficult problem for the turbojet designer. A jet engine gets its energy for propulsion by increasing the temperature of the air passing through it. As a general rule, the greater the increase in air temperature, the more thrust a given engine will produce and the faster the airplane will fly. If the speeds of new fighters, bombers and missiles are to continue up the supersonic scale, their engines must be able to run at higher and higher temperatures and they must do this without having any of their components suffer significant losses in mechanical strength. The new metal is intended as a structural material for use in the turbine section of the jet engine, where the hottest moving parts are found. It offers special promise as a material for constructing turbine discs.

A jet engine turbine disc, Mr. Gunther explained, is a metal wheel that is bolted to the aft end of the rotating shaft of the engine. Anchored to its outer rim are some 50 or more turbine blades. White-hot gases from the burning fuel push against the blades and spin the disc and shaft at speeds up to 20,000 revolutions per minute. The disc, whirling at red-hot temperatures, undergoes stresses as great as 50,000 pounds per square inch.

"Present materials for turbine discs and blades are pushed to the limit by today's jet engine requirements," Mr. Gunther said. "Future progress will depend, in part, on designing better materials of construction. This new disc material, we feel, is a step in this direction-toward providing the jet engine of tomorrow."

Mr. Gunther said that development of the new material was done by Dr. J. T. Brown and Dr. A. W. Hoppe of the Materials Engineering Department's metallurgical development section. The metal, he said, already has progressed to the point where 3500-pound ingots have been prepared on a pilot plant scale.

Dr. Brown disclosed that the new material, which is referred to simply as W545, is an alloy of six essential elements: iron, nickel, chromium, and in smaller proportions, molybdenum, titanium and boron.

"Increasing the operating strength of temperature of a high-temperature alloy can be done by adding greater quantities of these ingredients which cause hardening in the alloy," Dr. Brown explained. "However, this procedure usually results in a loss of ductility, causing the alloy to become brittle and more susceptible to fracture. This low ductility starts to grow during the hardening process when imperfections and dislocations of the atoms occur along the individual grain boundaries of the alloy. It appeared likely that one solution to the problem might be to fill up these spider-web lines of brittleness to make the precipitation reaction more generalized within the grains rather than concentrated at the boundaries. This called for an element whose atom was of such a size that it would not merely move in and be a substitute in the alloy lattice for one of the iron, cobalt, nickel or chromium atoms, which are all about identical in size. It would also have to be a larger size atom than carbon, nitrogen, or oxygen which can actually slip inside the crystal lattice of the alloy. The element boron filled the bill. Approximately ¾ the size of the iron atom, it is too small to be a substitutional-type atom and too large to be the interstitial type.

"Basically, W545 is a modified version of Discaloy, a high-temperature alloy first developed some ten years ago, and an outstanding turbine disc material in its own right," Dr. Brown said.

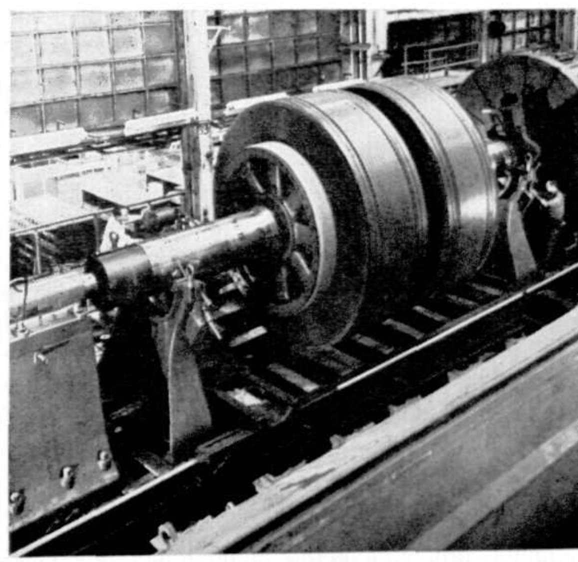
Dr. Brown reported that laboratory quantities of W545 were prepared by melting in an induction-type furnace. The ingots obtained were processed into specimens, which were tested for stress-rupture strength under severe temperature conditions.

"Our tests show W545 to be an outstanding high-strength, high-temperature alloy," Dr. Brown declared. "When heated to a temperature of 1200 degrees Fahrenheit and subjected to a stress of 75,000 pounds per square inch, the W545 test samples withstood these conditions for as much as 300 hours without breaking. Under equivalent conditions, standard turbine disc materials would probably have a lifetime of less than ten hours.

"We think that W545 shows unusual promise as a turbine disc material," Dr. Brown added. "Now that it is being prepared on a pilot plant scale, we think it will soon find its way into experimental jet engines. Its use should permit an increase in the operating temperatures of a jet engine by as much as 100 degrees Fahrenheit, which could mean about 100 miles per hour added to a jet's top speed."

Giant Lathe Cuts Big Jobs Down to Size

Recently installed as part of a $1 million-plus improvement and expansion program at the East Pittsburgh plant of Westinghouse Electric Corporation, this giant lathe speeds the production and repair of large electrical equipment. One of the largest lathes of its type in the country, it measures 50 feet in length and is capable of handling jobs up to 15 feet in diameter. Shown here is a 104-ton double-armature undergoing shaft refinishing. Built by Westinghouse in 1916 for a large eastern steel company, the double-armature is part of a huge motor which powers a rolling mill. After nearly a half-century of service, the armature required only surface refinishing of the shaft itself. A precision instrument despite its size, the lathe trimmed less than ten-thousandths of an inch of metal from the shaft, permitting it to be set in its original bearings without expensive modifications. The capacity of the lathe made it possible to do the job without dismantling the armature, a practice usually necessary on smaller lathes.



Giant Lathe, 50 ft. in length, is capable of handling jobs up to 15 feet in diameter.

World's Largest Electronic 'Brain' Joins the Army

The world's largest electronic "brain" was demonstrated publicly for the first time by the Army Ordnance Corps which estimated that the new system would save "many millions of dollars."

The $4.1 million electronic data processing system, known as Bizmac, is installed at the Army Ordnance Tank-Automotive Command headquarters in Detroit.

The system has reduced months of paper work to minutes of push-button operation. It keeps track of more than 100,000,000 facts about the Army's vast inventory of tank and automotive spare parts throughout the world—everything from nuts and bolts to en-

(*Continued on page 48*)

NEW DEVELOPMENTS

(*Continued from page 47*)

tire engines. Bizmac maintains up-to-the minute information about what supplies are on hand, how fast they are being used, what has to be ordered and in what quantity.

Substantial Savings Seen for Taxpayers

Maj. General Nelson M. Lynde, Jr., Commanding General of OTAC, told newsmen at a press demonstration: "From what we have seen of the Bizmac system in operation so far, we feel that it can contribute importantly to our job in two ways. First, it can streamline our operations and help the system to be more responsive to the Army's demands. Second, it can save the taxpayers substantial sums of money.

"It should make possible a sharp reduction in our inventories because of its more timely processing of records. We estimate that, over the next two years, the amount of inventory that we carry can be cut substantially.

"This would mean that the cost of maintaining our inventory would be reduced by many millions of dollars—and this, of course, would be a continuing saving. At this rate, the Bizmac system would pay for its initial cost, many times over, every single year."

Business Ally in Battle with Paper Work

Brig. General David Sarnoff, said in a statement read at the demonstration that the Bizmac system has many unique features which "mark it as a giant step toward automation in business."

"Because Bizmac can deliver the results of its work in almost any form that modern high-speed business operations require," he said, "it is capable of producing significant improvements in the data processing procedures used by both military and civilian organizations. It provides business with a powerful new ally in the continuing battle with paper work."

The Bizmac installation in Detroit covers about 20,000 square feet of floor space, and includes some 220 units of nineteen different but fully integrated types of equipment. Data on more than 170,000 separate tank and automotive spare parts are fed into the system daily from ten Ordnance depots in the United States and ultimately from overseas depots. Bizmac, under the direction of skilled operators, sifts the data to make sure the right supplies are at the right place at the right time, preventing both costly surpluses and critical shortages that might interfere with a task force's combat readiness.

Performs Wide Variety of Tasks

At electronic speed, the Bizmac system can take inventory, catalog spare parts, prepare manuscripts for catalogs, forecast supply requirements and produce budget summaries. Charles S. Diehl, Chief of OTAC's Electronic Data Processing Branch, said the Bizmac system can:

Complete in forty-eight hours an inventory procedure that once took up to three months.

Handle in a half-hour a price calculation that used to take a clerk five weeks of steady work.

Process by computer in one hour as much work as 400 girls with hand calculating machines could turn out in the same time.

Record information on magnetic tape and read from tape at 1,700 words per second—a rate at which it could finish Tolstoy's "War And Peace" in about five minutes.

Store on a single 10½-inch reel of magnetic tape as much information as was previously held in ten file shelves.

Print shipping orders and other business paper work at a speed of 600 lines a minute.

Reduce by 85 per cent, over the next year, OTAC's visible records which are now on some 10,000,000 file cards, punched cards, metal plates and handwritten sheets.

Four Basic Units in the System

The Bizmac system includes four basic units: Input Devices for preparing and feeding information and instructions into the system; Storage Devices for filing information within the system so that it is readily accessible on demand; Data Processing Devices for sorting and computing as dictated by instructions; and Output Devices for providing finished copies of the information required.

Being developed by RCA engineers since 1949, Bizmac is a highly flexible system designed for standard business procedures. It operates on the "building block" principle so a business organization can use as many or as few units as it needs to do its job. The Detroit installation is the first Bizmac system to go into full operation.

New Aluminum Casting Alloy

LOS ANGELES, CALIF.—A new aluminum casting alloy so strong that a square inch could lift ten Cadillacs has been developed by a Los Angeles company.

Called 42B, it greatly simplifies the job of producing intricate, completely-formed aircraft and missile parts in a single operation.

The new alloy is 40% stronger than the best previous alloy. It cuts to one-third the time formerly required to make this part.

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"Even more startling things are on the boards... and consider all the possible challenges to the imagination. For example, thousands of newly-conceived formulas were considered before the Snark's guidance system was perfected! Hundreds of young engineers, like yourselves, contributed their fresh ideas in the process. Although young, these men are now veterans in this important field. Yet we all know that missile development is still in its infancy.

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At Northrop Aircraft you'll be with a hard-hitting pioneer company that has won distinction in manned aircraft and guided missile production. Among the high-priority projects that will appeal to your ambition and ingenuity is Northrop's Snark SM-62, the first intercontinental guided missile designed for assignment to the Strategic Air Command of the U.S. Air Force.

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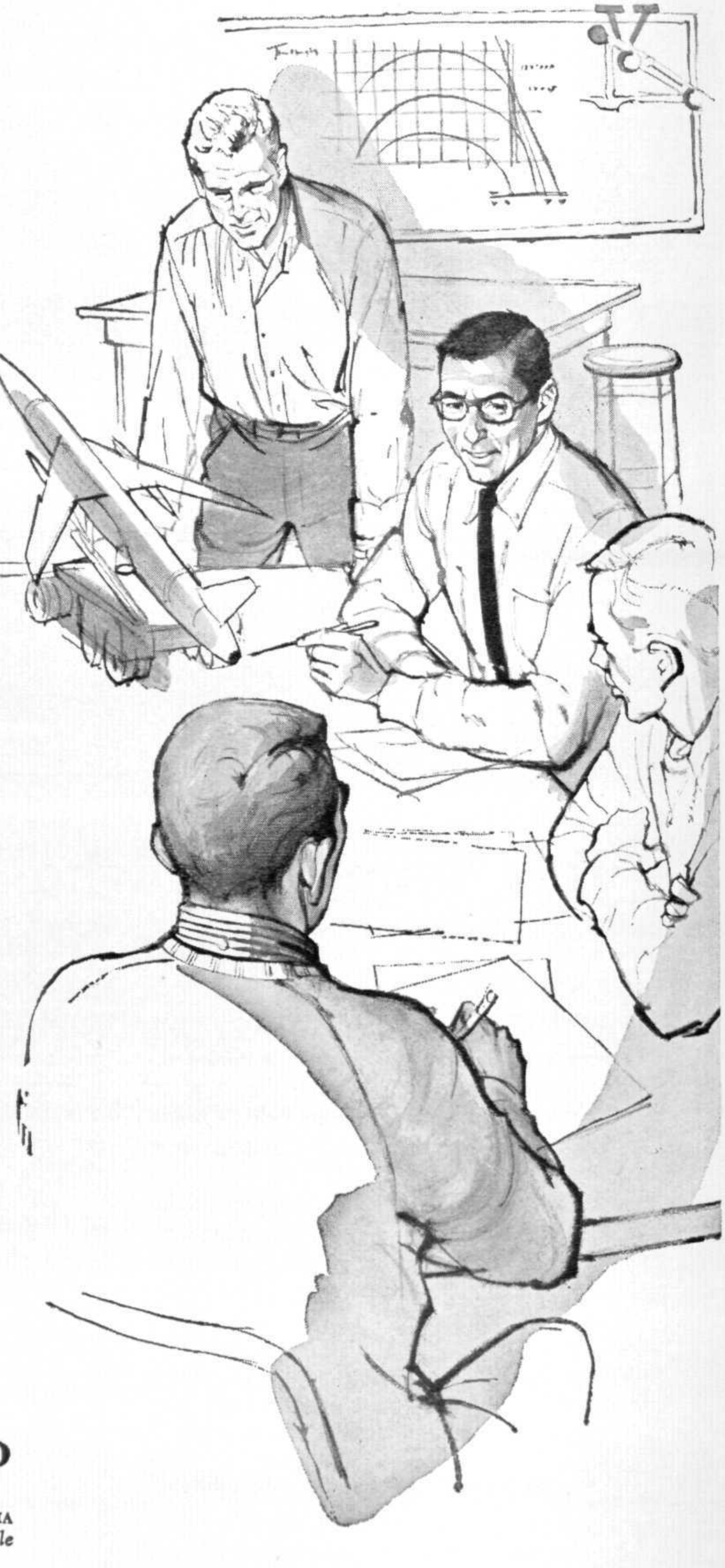
Write now and ask us questions as they apply to your engineering objectives. Tell us your ambitions ... we believe we can relate them to opportunities at Northrop. Address Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., 1019 East Broadway, Hawthorne, California.



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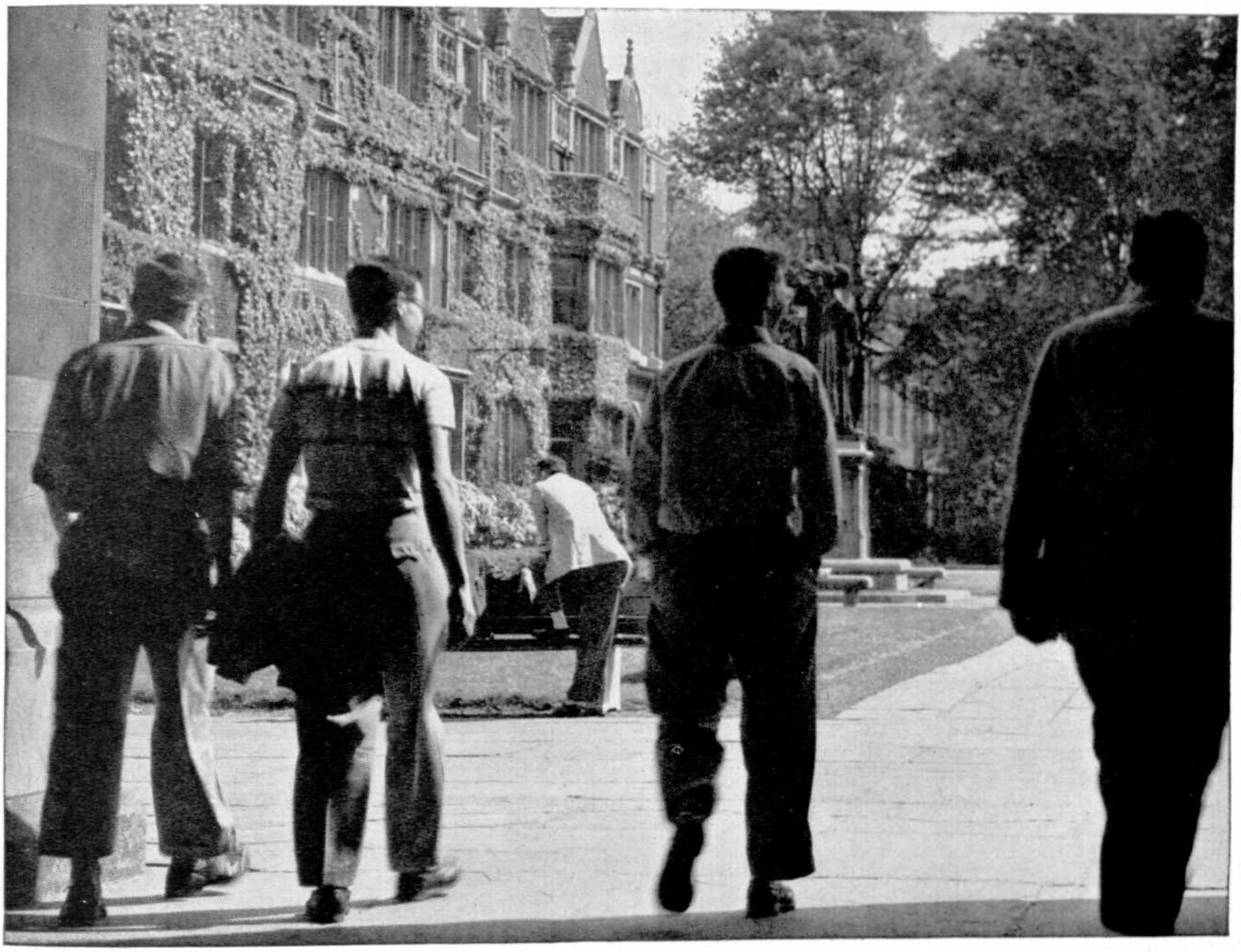

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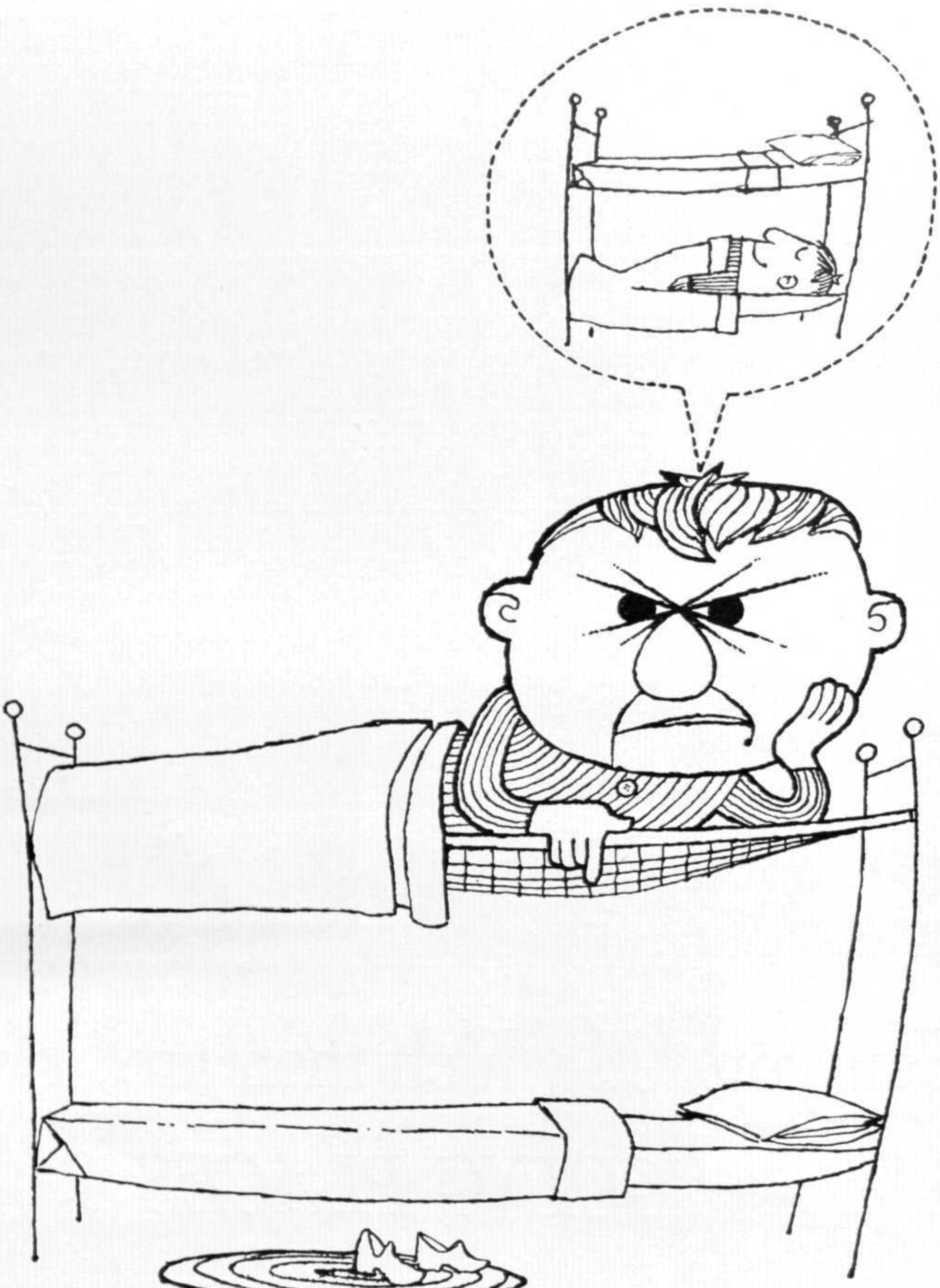


Wires to replace piping and ductwork...

Thermoelectronic Heating and Cooling

Reprint from architectural forum, January, 1957

Five years ago an unusual means of heating and cooling began to be investigated in the laboratories of the Radio Corporation of America. It consisted simply of two tiny slugs of dissimilar metals, joined by an electrical contact. When a direct current is passed through the metals in one direction, it produces a cooling effect at the junction of the two metals. When the current is reversed, heat is produced at the junction. This dual action is known as thermoelectrical—or more properly thermoelectronic—heating and cooling. It is the newest, most radical, most controversial development on the horizon, combining heating and air conditioning in a single system.

Last year a large number of such thermoelectronic units were linked up in series in panels to show that without moving parts and simply by reversing the current, they were capable of heating or cooling a small demonstration room. It must be recognized at once that this system is nowhere near production as yet, that it is still in the early stages of development, which accounts for the controversy. But the development is moving fast, is already drawing in other industrial laboratories and shows promise for the future. In addition, it fits compactly into the type of panel-wall construction toward which building technology is trending.

Peltier's Effect

The principle of thermoelectrical cooling was discovered some 120 years ago by the French physicist Jean Charles Athanase Peltier. He observed that the passage of an electrical current through two closely joined metals, such as bismuth and antimony, produced not only a heating of the junction when current was moving in one direction, as might be expected from the well-known fact that conductors heat up when carrying electricity, but an absorption of heat, or cooling, when current was moving in the opposite direction. This mysterious cooling action became known as the Peltier Effect. For over a century it remained a minor laboratory curiosity.

When, in 1951, at the request of RCA's Chairman David Sarnoff for an electronic method of air conditioning, the RCA Laboratories began searching for some known phenomenon to build on, the quest soon narrowed down to the Peltier Effect. By then the inner structure of metals was quite clearly seen as a close crystal structure of atoms with their shells of electrons loosely held so that electrons might roam freely between the atoms. And the number of known metals and alloys had increased enormously. Moreover, great strides had been made recently in the understanding of a class of materials known as semiconductors, in which the movement of electrons (i.e., electricity) could be initiated and controlled to useful ends. It seemed probable that the Peltier Effect might now be fruitfully studied.

A small group under Nils E. Lindenblad, RCA research engineer, began to hunt for more efficient metals which in combination would improve the Peltier Effect. The goal is to achieve the widest temperature difference between the cold junction and the hot, thereby getting a maximum of heating and cooling for power expended. In five years of searching Lindenblad has come up with materials that increase the efficiency of the unit about eight to ten times over the original starting materials. For obvious competitive reasons RCA is in no hurry to reveal their composition, but they are not simple semiconductor metals. A typical combination, though not one of the best, is zinc antimonide and lead telluride.

How It Works

The first result of this improvement in materials was a small experimental refrigerator unit demonstrated two years ago, followed last year by an improved refrigerator and the room air-conditioning panel previously noted. These presented essentially new problems in engineering and design, particularly in constructing the air-conditioning unit.

The basic unit consists of two tiny rods of thermoelectrical metals mounted on a 4″-long copper-coated aluminum fin and capped by thin 2″ squares of conductive metal. Connecting a great number of such units in series forms a wall panel 6″ thick, in which the squares of conductive metal present a flat surface to the interior of the room while the fins extend out in back to the exterior air or an air passage. Sandwiched between them, in the inter-

(*Continued on page 54*)

THERMOELECTRONIC HEATING

(*Continued from page 53*)

stices between thermoelectrical rods, is a layer of styrene foam plastic or similar material to insulate the warm surface from the cold one, as the case may be. In the cooling cycle, current passing through the units in one direction cools the squares, which thereupon absorb heat from the room and pass it back through the rods to the fins, which by self-convection dissipate the heat to the air. In reverse cycle, the squares are heated while the fins are cooled to a point below the outdoor temperature, thereby drawing heat from the air which, added to the resistance heating of the panel's thermoelectric units, heats the room. In effect, the unit is a reversible heat-pump in which the pumping action is performed by the movement of the electrons between thermoelectrical materials, alternatively heating or cooling an enclosure.

This is by no means the final structure of the system, which may take other and different forms. Further improvements in thermoelectronic materials will allow a reduction in fin size and a consequent reduction in panel thicknes and weight. Or the fin surface may be reduced simply by using a fan to aid in heat dissipation or by circulating a coolant. But the present experimental panel was designed to realize the ultimate advantages of the system: no moving parts, no noise, no drafts. Two panels, about 5 dimensions, were installed in an experimental room, 6'x7' in floor area. Estimations are that the same panels would be adequate for a room about four or five times that area. On 600 watts input to the panels, about 3,600 B.t.u. per hour for heating or cooling are produced to achieve a 25° F. differential in room temperature. This is about 6 B.t.u. per watt hour against 25 B.t.u. produced by a conventional quarter-ton air conditioner.

The Electronic Future

Obviously, all this is still far from the efficiency of conventional air-conditioning equipment as well as the mechanical heat-pump. Lindenblad estimates that the present thermoelectronic system is overall about one-fourth as efficient as conventional systems, though some competitive critics would place it even lower. Thermodynamically, this system, like the heat-pump, operates most efficiently on a 10 to 15° differential in temperature or less. To get more cooling or heating—and experimentally RCA has pushed this up to an 80° differential—the system must operate with less efficiency and a consequent greater consumption of power. Hence, thermoelectronics has the inherent limitations of the heat-pump, particularly as applied to heating.

There are other and lesser problems, chief among which is the problem of condensation. As in the common refrigerator or in panel-cooling systems employing the circulation of cold water, the thermoelectronic cooling surfaces condense moisture from the air. Lindenblad's solution for this is to run one part of the panel colder than the whole to act as a dehumidifier, meanwhile providing a small trough at the bottom of the panel to run off any residual condensation. This would require humidity thermostatic controls, now readily available. In addition, of course, since the whole system runs only on direct current, a rectifying unit would be required in nearly all locations to convert a.c. to d.c., but this is readily solved by small vacuum-tube units, or by even more compact semiconductor rectifiers now coming to the fore.

RCA is confident that the problems can be solved. Actually, with one year given over to a general search of the field, Lindenblad and his group have been working intensively on the Peltier Effect for only four years. Based on the progress made thus far, RCA estimates that it may be ready for production in about five years. For very special applications, where high operating costs might be justified, it is ready now. The major task ahead is to find still more efficient thermoelectronic metals. "We haven't by any means come to the end of the road with respect to achieving greater and greater temperature differences," says Dr. E. W. Engstrom, RCA executive vice president. All electronics grew out of a tiny phenomenon noted in one of the earliest incandescent lamps and called the Edison Effect after its discoverer. Other electrical and electronics companies are not so sanguine about the Peltier Effect, but all the major ones are investigating it and a group of large air-conditioning firms, including such giants as Carrier Corp., have a cooperative research project going on it. Oddly, the largest number of published papers on the subject is now coming out of Russia.

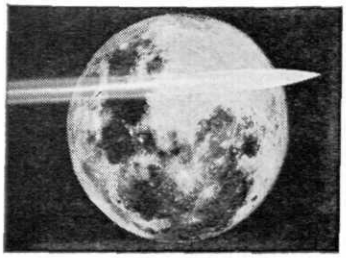
The ultimate target is to bring thermoelectronic heating and cooling up to the efficiency of the heat-pump. Actually, something less than this might be settled for, since economy of operation is not the sole criterion, otherwise much of present-day air conditioning would never be installed. There also is an economy of means which must weigh to the advantage of a system requiring no ducting, no fans, no central plant, no compressors—the whole weight of apparatus yearly growing more complex and consuming a greater and greater part of building costs. This system requires only wire lead-ins to small built-in units or room panels. In the kitchen it may lead to the disappearance of the refrigerator in favor of freeze-drawers and cabinets built into the work area at points of convenience. In buildings it would lead to the incorporation of heating and cooling as an integral part of wall structure or in ceilings (in which case an exhaust stack would be required). Architecturally, the possibilities are varied and the technicians expect that architectural design will do much to shape the system to final use.

Thermoelectronics is representative of many other developments which seek new, more subtle and freer means to handle such problems as light and energy. It is research that opens up the future.

Graduates in engineering, physics, applied math., allied sciences:

You can do much better than a "standard" career today!

Careers, like cars, come in various models. And nowadays such things as security, adequate compensation, vacations-with-pay are not "extras" any more—they're just "standard equipment"!



MISSILE DEVELOPMENT

As an individual, **you** decide whether you want white wall tires or maybe a sportscar. You should do no less in choosing where you want to work. At North American, fringe benefits are second-to-none; but you can get much more than that. Such extras as creative work, advanced technology, latest facilities to implement your work—these all add up to rewards an ordinary job cannot give. You'll work with men of high professional standing. Your personal contribution will earn quick recognition.

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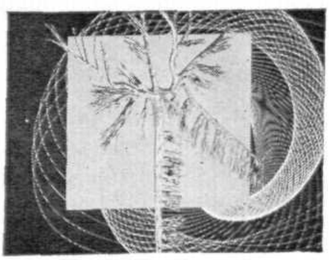

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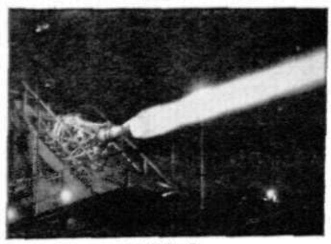

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At this Division you will see a new industrial era taking shape, and play your part in putting the peaceful atom to work for mankind. Nuclear Reactors of various kinds, for both power and research applications, are designed and delivered to order by Atomics International. With many "firsts" to their credit, these dedicated men continue to spearhead the progress in this exacting field.

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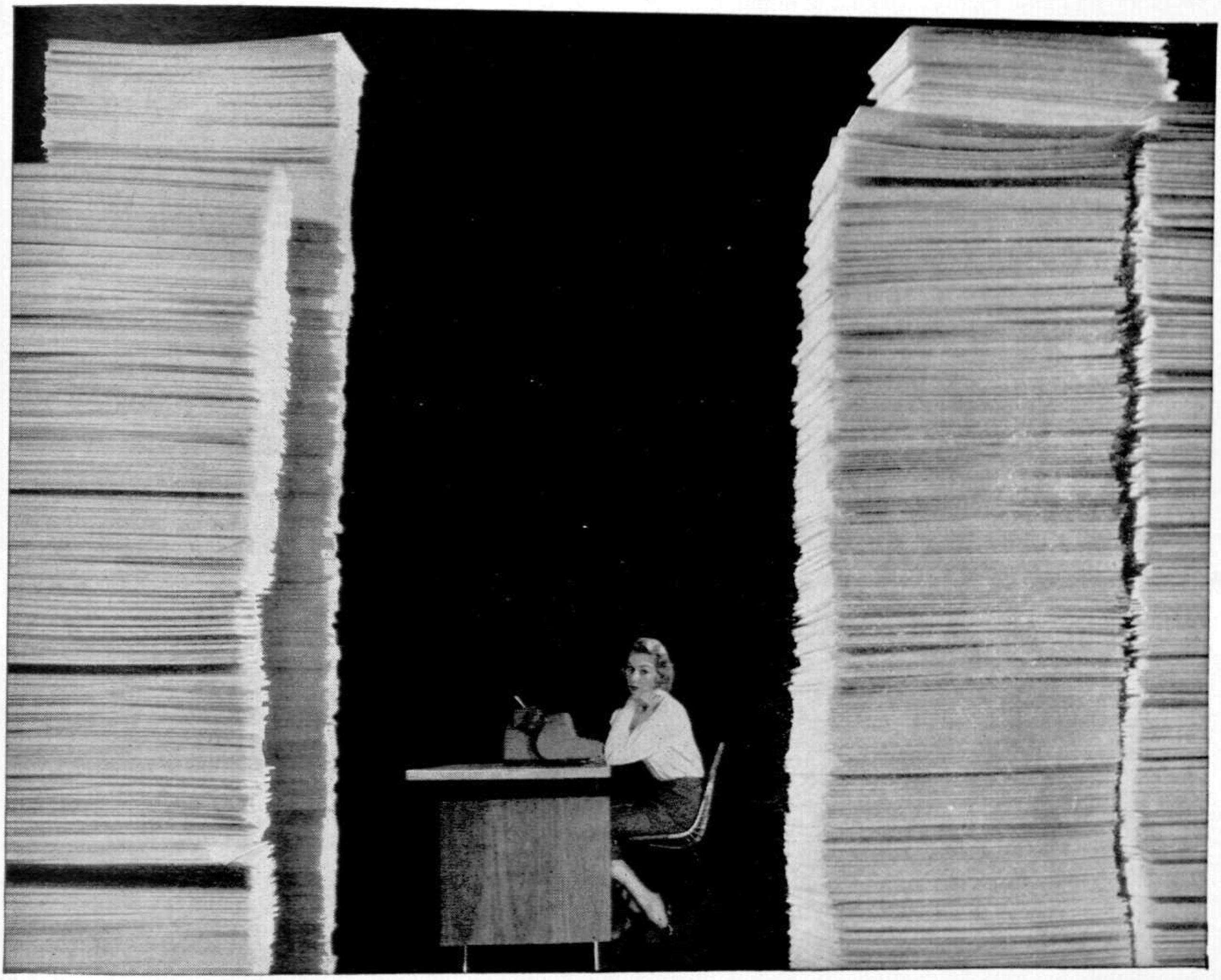

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The newest – and largest – electronic "brain" (more accurately, electronic data processing system) is Bizmac, developed by RCA.

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The leadership in electronic research that made Bizmac possible is inherent in all RCA products and services—to help make life fuller, easier, safer through "Electronics for Living." TMK(s) ®

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ELECTRONICS FOR LIVING

FOSSIL FUELS

(Continued from page 33)

enough we will be able to use our previously uneconomical reserves such as the oil shales. Also we may be able to recover oil from old wells which were not developed properly, leaving much of the oil in the well. These sources, due to the high cost of production, will probably never add more than a few billion barrels to our positive economically recoverable reserves and therefore would only extend the life of oil about 10 years.

Now, let's consider our natural gas reserves, and their life. So far the United States has used 175 trillion cubic feet. According to Putnam there are 180 trillion cubic feet of proven reserves in the United States. He believes that the total reserves known and unknown are about 600 trillion cubic feet. At the present time we are producing 10 trillion cubic feet annually. Production is increasing 8% annually. At this rate production in the United States will reach its peak in 1968 and will then begin to decline. There are no data for the rest of the world, but for every barrel of oil produced about 3000 cubic feet of gas are produced.

The last of our fossil fuels to consider is coal. Up to the present time coal has supplied 84% of the fossil fuel energy used in the world. Since it is not economical to transport coal long distances I will only consider the reserves of the United States. Crichton (1948) said there were 3.1 trillion tons of reserves of which 260 billion are economically recoverable. There are a number of reasons for the low quantity of economically recoverable coal. One is that much of our reserves lie at great depth or in beds less than two feet thick. At present only 7% of the coal in the United States comes from coal seams less than 3 feet thick because thinner beds are not economically mineable. Another reason for the small amount of economically recoverable coal is that the recovery from the average mine has often been as low as 50%. A tremendous amount of coal is left in pillars to support the mine. Also, some of our coal is high in sulphur and ash content and made unusable. Also, 75% of our coal reserves lie west of the Mississippi; our greatest reserves being in Colorado, Wyoming, Montana and North Dakota. 75% of these reserves are very low grade lignite and subbituminous coal, both of which are non-coking. They could only be used through processing since they decompose easily and undergoes spontaneous combustion. Such a low grade of coal isn't worth transporting and only about 10% of it could be used locally.

Production of good coal is increasing at a rate of 3% annually and will reach its peak in 1970. It is believed that the good coal will last to 1995. To increase our fuel reserves scientists have tried to make use of the deep and thin beds by making producer gas which is carbon monoxide. This is done by burning the coal in place with insufficient oxygen. The disadvantage of such gas is that carbon monoxide has a very low heat content. Russia is the only country which is now using it extensively. When depletion causes prices to go up, more of our coals will probably be considered economical to mine.

According to the relationships of the reserves of fuel, the demand, the production, and the level set on what is economically recoverable our fossil fuels will begin to go out after 1980. As fuels get scarce our economic framework may change bringing once uneconomical fossil fuels into production. Also our efficiency in consumption and production may increase, causing the date of decline to be moved ahead a few years. We may develop more economical methods of deep mining and more economical methods of distilling oil from oil shales. We may develop a more economical gas engine such as the gas turbine. But despite all these improvements, we are still going to run out of fossil fuels sooner or later and they will have to be replaced by something else.

There are a number of possible sources of energy at least one of which we will someday have to use. There is one inexhaustible source. That is the use of the sun's rays or solar energy. If we could convert 10% of the solar energy falling on the earth at an efficiency of 10% we could supply heat power and nutrient to 17 billion people. That is about 6 or 7 times the present world population. Enough heat strikes each acre of ground each year to equal the heat of 800 tons of coal. One way of using solar energy is for solar space heating. It would be feasible where temperatures are not extreme and where there is a lot of sunshine. It would prove very feasible in the southern portion of the United States, but its use in the northern states would be doubtful. It is ultimately possible that solar space heating may provide one fifth of our comfort heating and 6% of our total energy at a cost no greater than 2 times the present cost. Solar heat could also be applied to heating water in the same geographical areas.

Another source of energy is water power. It now contributes 1% of the United States energy demands and it is doubtful whether or not it can provide more.

Another source of energy is fuel wood. It supplied the major portion of the world energy until 1880 when it was replaced by coal. By a maximum expansion of our forests we could eventually produce enough wood to supply a major part of our fuel. It is doubtful whether or not such extensive forrestration would ever be used.

Wind power is another potential source of energy. The energy of the wind is transformed into electrical energy by a windmill and a generator. An experimental windmill has been set up on Grandpa's Hill in Vermont. From it most of our knowledge on wind power has been derived. The windmill requires a continuous wind of at least 18 miles per hour to generate electricity. Thus the system would only prove useful in a few small windy areas.

Another source of energy is earth heat. More than 10 times the present yearly requirements for world energy flows from the earth each year. Its most noticable effect is in volcanoes and hot springs. In parts of Iceland volcanic steam has been used for heating purposes, but it seems doubtful as to whether or not we will ever develop this source of heat to any extent since the energy from it would be hard to collect and is not often found where it could be put to use.

The most likely source of energy for the future seems to be nuclear fuels. At present only a small amount of energy is being produced from atomic fuels. It is in the form of electricity and is being produced at a cost only slightly higher than that of coal. The Atomic Energy Commission believes that 70% of the electricity generating work load could be carried by nuclear energy. Nuclear energy could also be adapted to comfort heat in certain localities. In districts where severe heating seasons are combined with a dense population we could have heat supplied by a district steam plant whose energy was supplied by nuclear fuels. This type of heating could supply one-sixth of the urban comfort heating by 2000. So far we've been unable to adapt nuclear fuels to such things as home size comfort heating units and land and air transportation.

Possibly by 2000 we may be able to greatly modify our present energy system. One means of modification would be a greater expansion of electrification. We could have all our heating done by electricity. We could have all of our means of transportation operated by electricity. Possibly we will be able to develop small nuclear heating units suitable for houses and some sort of small power unit for vehicles. If such would become the case we could change nearly all of our energy requirements over to nuclear fuels. It is believed that such use of nuclear energy, with the exception of electrification, would result in a high cost of energy. Still, such costs would not be nearly as great as the present costs of solar heat if it were our only source of energy. According to the Atomic Energy Commission the earliest possible time that we could develop atomic energy to peace time use is 1970. So we would have atomic energy at least to some degree when we need a new source of fuel.

Although concentrated deposits of uranium are rare, uranium is a common constituent of the earth's

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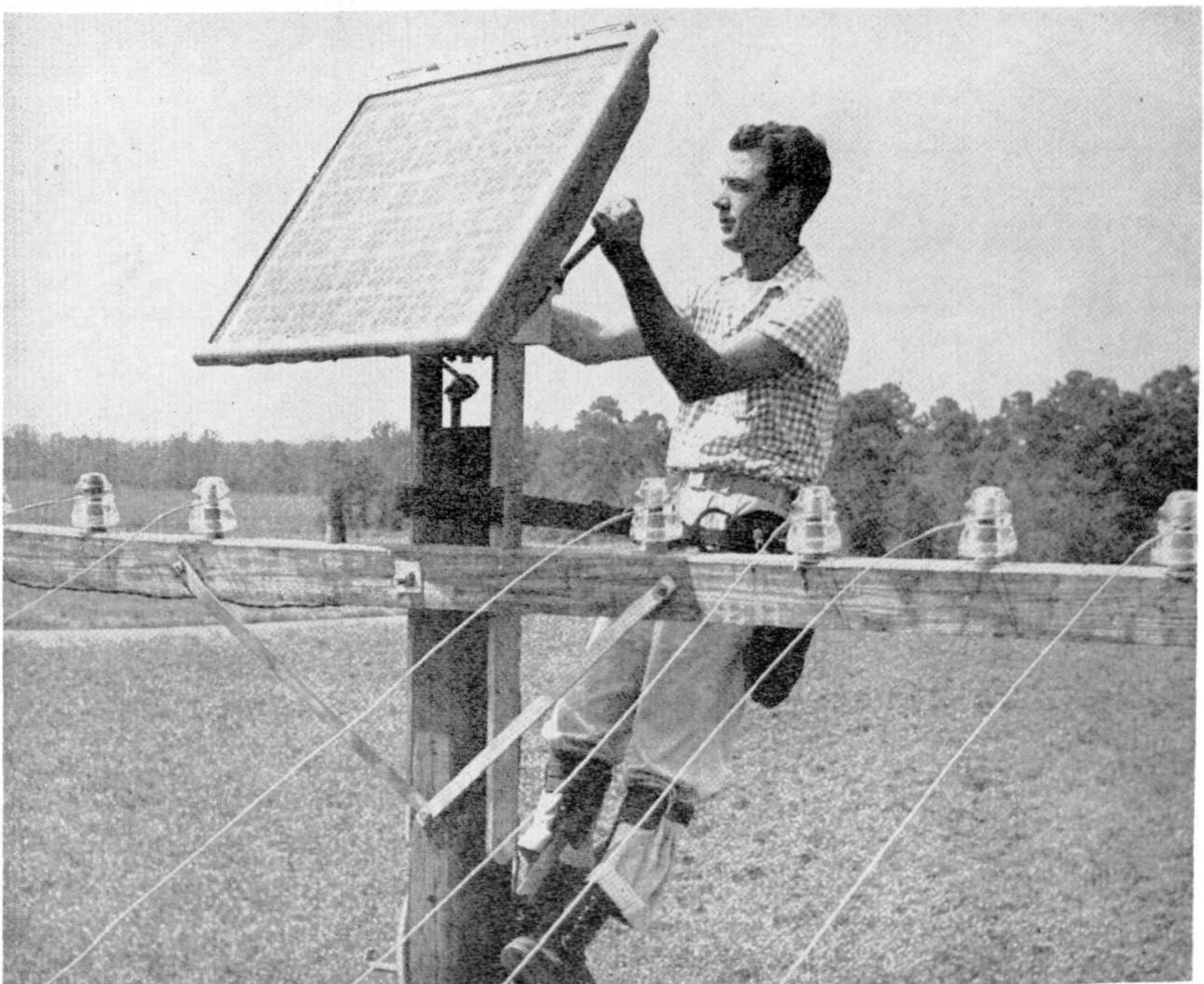

The Bell Solar Battery, being used in experiments near Americus, Ga., 135 miles south of Atlanta, to develop more and better rural telephone service. A Southern Bell Telephone Company cable repairman, is adjusting the device to pick up the prevailing light.

FOSSIL FUELS

(Continued from page 59)

crust. Most of the world's reserves of uranium are in the low grade sources such as shale and marine phosphates. There are 26,000,000 tons of recoverable reserves of uranium. There is also 1 million tons of thorium, another nuclear fuel. These reserves are believed to have energy equal to 25 times that of the net recoverable fossil fuels. Much of the reserves are in the United States and at present the United States, Canada, Belgian Congo, Portugal and Australia are the biggest producers. The biggest producing area in the United States is the Colorado Plateau.

Based on our present knowledge nuclear fuels would never be capable of supplying more than 20% of the world's energy requirements, but if our energy system can be modified entirely to nuclear energy the 26,000,000 tons of reserves would last us for 3 or 4 centuries. Despite the present limitations, nuclear energy seems at present to be our best potential source of power. Perhaps we may use in part a number of the sources. Whatever the source may be, the world will have to begin using it by 1970 or 80 and by 2000 will have to depend on it almost entirely.

We can now ask the question: Will the world survive the crisis? It is doubtful whether or not this question can be answered positively. We know that the inventive genius of man has given us the modern world we have today and if this inventive genius of man makes as rapid strides in the future as it has in the past, we may survive the crisis unscathed. At the present we have not developed another source of energy, but when the need becomes more urgent and more men concentrate their inventive effort on this problem, we will surely solve it.

Gordon Utter, the author of "Fossil Fuels: How Long and What Then," is a senior majoring in geology. He is from Monroe, Michigan. Gordon is a member of Sigma Gamma Epsilon, the geology honorary, and Gamma Delta. His hobbies are hunting and fishing.

Next year Gordon plans on working for his Masters Degree in Geology here at Michigan State.

"Heard you were moving a piano, so I came over to help."

"Thanks, but I've already got it upstairs."

"Alone?"

"Nope, hitched a cat to it and drug it up."

"You mean your cat hauled that piano up two flights of stairs? How could a cat pull a heavy piano?"

"Used a whip!"

My parents taught me not to smoke;
I don't.
Nor listen to a dirty joke;
I don't.
They make it clear I must not wink
At pretty girls, nor even think
About intoxicating drink;
I don't.
To sew "wild oats" is very wrong;
I don't.
Wild youths chase women, wine and song;
I don't.
I don't kiss girls, not a single one,
I don't even know how it's done,
You'd think that I wouldn't have much fun;
I don't.

Student: "To whom was Minerva married?"

Professor: "My boy, when will you learn that Minerva was the Goddess of wisdom? She wasn't married."

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CLUBS AND SOCIETIES

KNIGHTS OF ST. PATRICK

Last spring during the intermission of the May Hop, fifteen outstanding junior and senior engineering students passed under an arch of slide rules to be dubbed Knights of St. Patrick by the beautiful Queen of Engineering. Thus another in a long history of traditions in the Engineering School and at M.S.U. began.

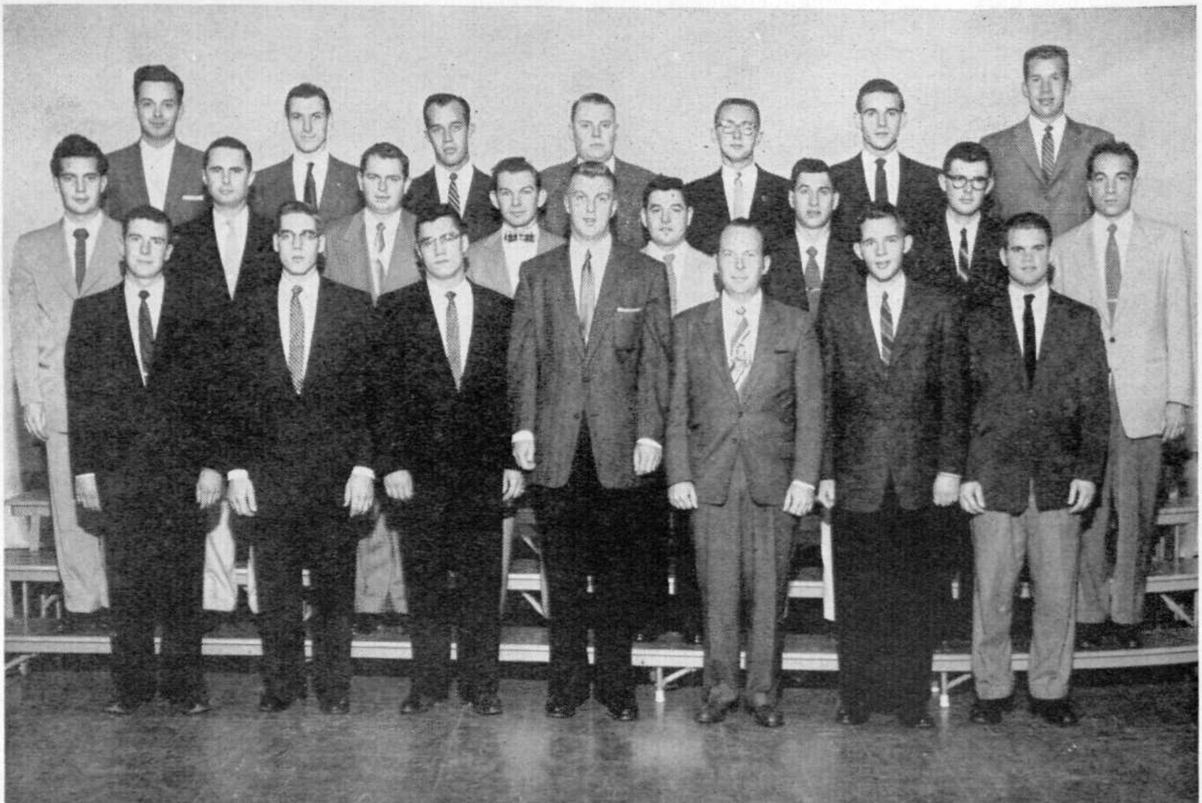
These five seniors and ten juniors had been chosen on the basis of their extra-curricular activities, demonstrated leadership ability, character, and service to their school as the first official members of the Knights of St. Patrick at Michigan State.

The Knights exists nationally as an engineering honorary and is active on several mid-western university campuses. It was organized last year on this campus on a suggestion by Dean Ryder as a means of bestowing honor on those junior and senior engineers who have made outstanding contributions in Engineering and campus-wide activities. To be eligible these students must also perform satisfactorily in the classroom.

Since the Knights is composed of members active in all phases of campus activity, the function of the organization is primarily that of an honorary. They meet once or twice each term in Old College Hall for informal get-togethers and to discuss future plans.

(*Continued on page 64*)

PHI LAMBDA TAU

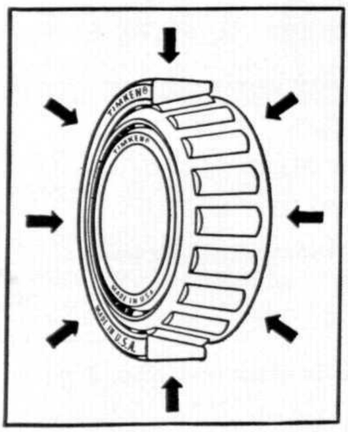


1st row: Alfred Murry, Carl Talaski, Kent Johnson, William Stanke, Melvin Anderson, Neal Saunders, Norman Gill.
2nd row: Dean Orr, Richard Tillotson, Richard Forrest, William Florac, Duane Dolph, Francis Izzo, Joe Lake, Pat Paone.
3rd row: Curtis Richmond, Loren Foote, Philip Mielock, James Wood, Richard Hertzler, Harold Mawby, James Clock.

Tear out this page for **YOUR BEARING NOTEBOOK...**

How to keep the world's biggest mouth chewing

This gigantic power shovel bites off 90 tons, lifts it ten stories, and moves it 290 feet. The engineers who designed the shovel had to provide for the tremendous loads, from all directions, placed on the hoist sheaves and swing machinery. To take the combination radial and thrust loads, keep wheels and shafts turning smoothly under punishing operating conditions, the engineers specified 34 Timken® bearings at all critical points.



Tapered design lets Timken® bearings take both radial and thrust loads

Some bearings can take loads from the sides—some from above. Because of their tapered design, Timken bearings take *both* radial and thrust loads or any combination. And because the load is carried along a full line of contact between rollers and races, Timken bearings have extra load-carrying capacity.

Want to learn more about bearings or job opportunities?

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

TIMKEN TAPERED ROLLER BEARINGS

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

CLUBS AND SOCIETIES

(*Continued from page 62*)

However, spring term finds the Knights working hard on the Miss Engineer contest and the selection of new members.

Right now the Knights are busy interviewing coeds representing the women's living units as candidates for Miss Engineer. Through a series of teas, the Knights will select the five finalists on the basis of beauty and personality. From these five charming girls, one will be elected Miss Engineer by the votes of all engineering students. She will be crowned at the May Hop to reign over the Engineering Week festivities including the Exposition and Auto Races. Miss Engineer will also have a chance for more fame as our representative in the Miss M.S.U. contest next year.

Present active members of the Knights of St. Patrick are Roland Brown; Bob Fox, vice-president; Mary Ann Hafke, secretary; Pete Kondo; Jim Leigh, president; Dave Lee; Frank Paganini; Ike Shepard, treasurer; Bill Stanke and Bob Warner. They have been ably assisted by their advisors, Dean Ryder and Professor Boyd Ringo.

Submitted by Donald Rodgers

Four ohms and seven volts ago, our farads brought forth into this great capacitance a neutralization dedicated to the power that all condensors are created equal.

At this great inverse feedback when all oscillators are consuming the power of electricity is when a current of great dissipation is achieved.

When the great electrons have the right to short out all circuits and blow fuses, etc. Here have gathered the great powers of inductive and capacitive reactance who are fighting a very high signal strength to obtain resonance.

Whereby we dedicate this day to our electrons who have been lost in the vast field of ionization. So let us aim our inductance, minimize our impedance, increase our voltage in our effort to defeat this great amount of distortion. Let us generate our harmonics to such a scale that our neutralization will forever be of pure resistance.

We therefore dedicate this day to the Elecrtical Engineers of Michigan State University.

ENGINEERING EXPOSITION

(*Continued from page 19*)

20 times. A rigorous safety inspection will be held prior to the race and all cars will feature roll bars, and safety belts.

Saturday night, May 11, is the big night of the "May Hop," an all-university semi-formal dance, sponsored by the engineering council. The dance will be held in Kellogg Center from 9 to midnight. Tickets are available from the various engineering societies and at the Union Concourse ticket window for $3.00 a couple. During the intermission, the Engineering Queen will be crowned "Miss Engineer for 1957." The Engineering Queen will be picked from five finalists who are: Rosemary Meyer, Lansing; Clara Christopher, Muskegon; Joan Loveless, Grosse Pte.; Rhea Raymond, Livonia; and Pat Heiland, Chicago, Ill. These coeds were voted on by all engineering students and the one receiving the highest number of votes will be crowned Engineering Queen. The other four coeds will serve as her court at the dance.

The staff of the Spartan Engineer hopes that all those who attended the "1957 Engineering Exposition" found their visit here both enjoyable and educational. Many members of the School of Engineering, both student and faculty, put many long hours of hard work into making this year's exposition a success. The only measure of their success or failure, however, is the public's opinion of the exposition. Any comments that you, the public, would like to make would be greatly appreciated. Please send your comments to:

The Spartan Engineer
P. O. Box 468
East Lansing, Michigan

ENGINEERING QUEEN FINALISTS

One of the girls above will be crowned "Miss Engineer" at the May Hop, Saturday, May 11. On floor, left to right, Rosemary Meyer, Lansing, Mich.; Clara Christopher, Muskegon, Mich. Sitting, left to right, Joan Loveless, Grosse Pte., Mich.; Rhea Raymond, Livonia, Mich.; Pat Heiland, Chicago, Ill.

JETS

(*Continued from page 23*)

project is assembled, and he is anxious to test it. He tries it out. If he is lucky and has made all of his calculations right, it will work like he predicted. If this is the case, he is eager to demonstrate it for his friends, and to show them its good qualities.

Usually this is not the case. The young engineer, like many of his seniors, may not have made the necessary allowances for work under certain conditions. Maybe his device doesn't work smoothly enough or maybe it doesn't work at all. Again a searching process begins. Somewhere, sometime, someplace, he made one little mistake. With more checking and experimentation, he usually finds the "bug" he has been searching for. This may possibly be eliminated by increasing the voltage or by a little change in some part of the device. The Exposition is now just around the corner. Can he get his project done for the judging? The young engineer is persistent and also lucky, because he usually gets it done just before the Exposition.

As far as his project is concerned, the JETS club member has one thing left to do. Like many engineers, he feels that making a device is only part of the job. The other part is to "sell" it to the consumer, industry, or anyone who may have a use for it. At the Exposition the student will try to "sell" his project to the judges. If he has done a good job he may get a cherished prize. The prize will be some tool of the engineering profession. These will be awarded May 10th at the general meeting of the JETS clubs in the afternoon.

The JETS expect about 150 projects for competition this year. Reports from the various clubs show that there are many new ideas. One member has made a magnetic T-square, which he feels should help the draftsman do his work. Another member claims he has a new type of differential. This, coupled under the right condition in one's automobile, should give maximum starting and stopping ability on slippery roads. All the projects will not necessarily have new ideas, but most will make use of some engineering principle.

The display of the JETS club at last years Exposition. Shown are many projects, typical of their display.

A loving-cup will be presented to the most outstanding JETS club. It is given to the club which the judges feel has contributed the most to furthering the interest of the youth in the engineering profession. Last year this award was given for the first time, and the Traverse City club was the winner of the initial contest. Various industries and organizations have provided gifts for club members and pilots. These will be given to them during the Exposition. All club members will receive a packet of some small articles of the engineering profession.

At the Exposition the members will have the opportunity to visit with members from other clubs. They will go on tours of the engineering buildings and inspect various displays of the Exposition. They will be able to talk with representatives from the colleges and also some industries. The Engineering Council, Tau Beta Pi, and JETS Alumni will act as hosts and guides. These organizations will be in charge of setting up the JETS exhibit and other activities for the clubs during the Exposition. Arrangements have been made to house members in the short course dormitory for the weekend.

Many of us probably feel that most engineering displays are strictly of interest to the engineer. This should not be the case with the JETS exhibit. There will be an element of interest present for almost anyone. The engineer will have the opportunity to compare young ideas with some of his own. The educator will be able to see how eager young minds can grasp theories, and put them to practical everyday use. The Philosopher will be able to find elements of how the young man of science feels about the future. Almost everybody should find an interest in the JETS exhibit. That interest may range from strictly science to just seeing how young men of tomorrow are working and adjusting today to make that tomorrow a better one for everybody.

The JETS exhibit will be in Room 110 in Olds Hall. You can't miss it! You might find it quite interesting, and even if you don't, it isn't a bad way to waste time.

The young man was practicing on his saxophone in the wee hours of the morning when the landlord came in.

"Do you know there's a little old lady sick upstairs?" asked the landlord.

"No," answered the musician. "Hum a little of it."

Englishman No. 1: "Terribly sorry you buried your wife the other day."

Englishman No. 2: "Had to—dead you know."

KEY TO MODERN PROGRESS

(Continued from page 17)

mass production of Zirconium, was reported in 1946. Previously Zirconium has been considered one of the uncommon or rare metals even though it is more abundant than nickel, copper, zinc, and lead. The high cost of extracting the metal from the ore, chiefly Zircon, which is plentiful in our Florida beach sand, has been the primary deterrent to its use.

The era of nuclear reactors has commercialized the metal Zirconium because its excellent corrosion resistance and low neutron capture cross section make it most useful in this field.

In 1953 the production of Zirconium metal sponge totaled 75 tons for the year. In 1956 the rate was more than 300 tons per year and the estimated production for 1957 is in the order of 2,000 tons. Thus Zirconium, in the short space of 10 years, has changed from a laboratory curiosity to a vital material for the nuclear age. The largest application of Zirconium at the present time is in nuclear reactors where it is used for the permanent structure, to clad the radioactive fuel, and to alloy with the fuel for altering its characteristics. The design of nuclear reactors utilizes four characteristics of Zirconium: corrosion resistance; low neutron capture cross section; workability into desired shapes; and necessary strength under operating conditions.

Lesser applications of Zirconium include its use for high-temperature alloys, and as a degasing agent and grain refiner for certain magnesium and aluminum alloys.

Closely related to Zirconium in chemical properties is the metal Hafnium. In fact, most commerical grades of Zirconium metal contain about 2% Hafnium. This occurs because Hafnium is found in the Zirconium ores. In contrast to Zirconium, Hafnium has a very high neutron cross section. Thus reactor grades of Zirconium metal are required to have a maximum of 0.02% Hafnium.

The ability of Hafnium to absorb neutrons did not escape the attention of the metallurgist, however, and when the nuclear propulsion plant of the USS Nautilus was designed the control rods were made of the little-known metal, Hafnium. Manufacture of these rods required extensive development of the metallurgy of this new metal.

New metals and alloys promise to open up entire new technologies and to expand the frontiers of the old—providing the manpower shortage can be solved.

The United States today faces a desperate shortage of trained metallurgists for its jet-engine, atomic-energy, and guided-missile research and production programs. Dr. J. H. Hollomon, internationally known metallurgist, recently stated that the demand for metallurgists with advanced degrees will be at least twice the available supply during the next few years. In the years since 1950 the professional manpower situation in metallurgy has deteriorated. Of the 520,000 professional engineers in the nation in 1950, only 5% were working in metallurgy. In 1953 this figure dropped to 3.8% and in 1954 to 3.1%. In 1955 it was 2.3%.

United States colleges graduated 657 metallurgists in 1956 and careful projections indicate that fewer than 500 students will be graduated in the fields of metallurgy in 1957.

LAGRANGE'S EQUATIONS

(Continued from page 27)

certainly this sum is not sufficient for determining the originating system. In exact analogy, Lagrange's equations are satisfied by sets of variables with certain properties, but are *not* sufficient for determining the original set of equations which establish the properties of these sets of variables.

It is possible to show that the variables associated with linear graph theory satisfy Lagrange's equations. However, the mathematical detail necessary to prove this statement precisely is not given here. Rather, the conclusions reached by the authors at MSU are indicated.

In the Lagrangian formulation, the energy functions are evaluated in terms of what is referred to in graph theory as the "element" variables. It can be shown that if the energy functions required for the Lagrangian formulation can be evaluated, the linear graph can be drawn.

In the Lagrangian formulation the dynamic equations are obtained by taking the partial derivatives of the energy function with respect to a set of coordinates or variables. Although, there may be many sets of generalized coordinates with which to differentiate, *no method is available for systematically establishing even one set.* However, when the linear graph is used as the basis of formulation, *this information is systematically supplied.*

Even when one supplies the information as to what constitutes an independent set of generalized coordinates, the derivation of the final system of equations using Lagrange's equations is far more formidable than by the use of properties of graphs. The former involves integration with subsequent partial differentiation, as well as matrices quadratic in form. The latter technique involves simple matrix substitution of variables.

The weakness of the Lagrangian formulation as compared with the use of graphs has been evidenced in part by a continued effort in the profession to establish electrical analogs of mechanical systems. Unfortunately, the electrical analogue, as normally applied, requires that the equations of the mechanical system be formulated first by other means. The real simplification comes when the physical systems are all viewed as a problem of correlating observations and the same basic properties of linear graphs used irrespective of the type of meter to be associated with the *through* and *across* variables.

Arne Steivang and Charles Baumann of Federal Bakery Co., Winona, Minnesota, receive engineering service and product data from Stan Nelson (left), of Standard Oil, to help keep maintenance costs low on Federal's truck fleet.

How to write a success story

STANLEY NELSON, automotive engineer, is typical of many young men we like to tell about in the Standard Oil organization. He keeps proving to be the right man in the right job as he advances with us.

Stan likes engineering, of course. He graduated from the University of Minnesota with a B.S. degree in Mechanical Engineering in 1950.

He likes people. He especially likes to get into business problems with them where he and his company can help. Truck maintenance, lubrication, and fuel consumption are big items to fleet operators, large and small, who have found that help from Stan pays off—for them.

And he likes selling. He functions frequently as a key man for the sales department. His intelligent analysis of a problem in his field may either improve our service to a valued customer or help us to secure a new one.

He likes to keep moving, too, and he's done that. He held several sales positions in Minnesota and attended Standard's intensive Sales Engineering School in Chicago before being promoted to his present position in which he works out of the Mason City, Iowa, division office.

As men like Stanley Nelson earn their way upward in our organization we have frequent openings for ambitious college men to follow them. You might find a career in engineering, research or sales with this stable and progressive company rewarding, too.

Standard Oil Company

STANDARD

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FERMI POWER PLANT

(Continued from page 25)

neutrons used in the reactor are fast neutrons. The neutrons come out of a fission with speeds of about ten thousand miles per second. In some types of reactors they are permitted to collide many times with atomic nuclei, and in each such collision they lose some of their speed. Usually their speed is reduced to about one mile per second. Then they are called thermal neutrons, and reactors in which this process goes on are called thermal reactors (the reactor on the U.S.S. Nautilus is a thermal reactor). In a thermal reactor most of the fissions are caused by thermal neutrons, and only a very few neutrons are able to cause fissions while they are fast. (Fissions are the processes whereby large nuclei are split into two parts by a neutron collision. In this case the large nuclei is that of the U-235 atom.) The substance used to slow the neutrons down from ten thousand to one mile per second is called the moderator. The best moderators are materials which contain many nuclei of low atomic weight such as hydrogen or carbon. In a reactor, materials like water and graphite are used as moderators.

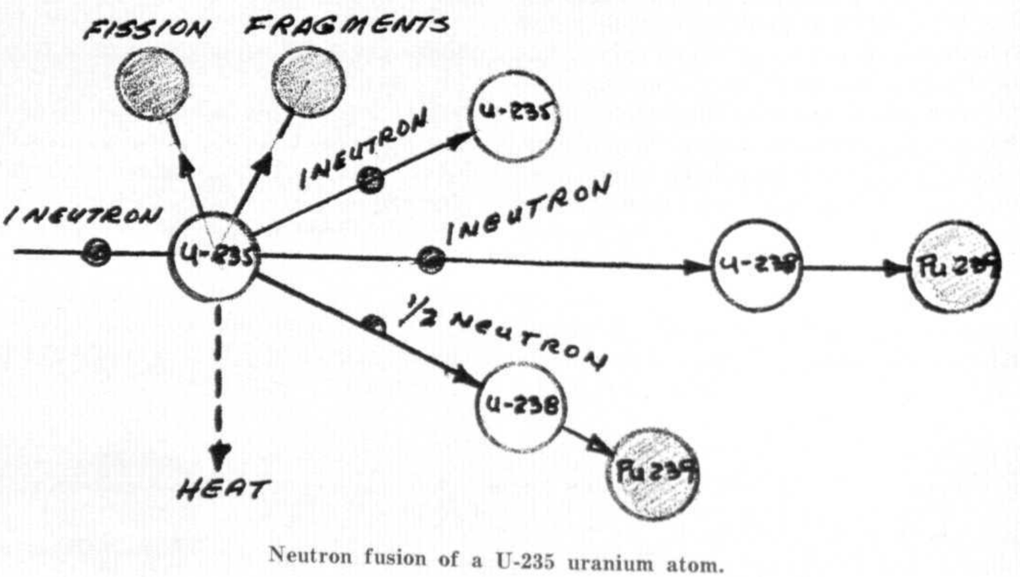
In a fast reactor the use of a moderator is avoided as far as possible. Then the neutrons remain fast and will make fissions while their speed is still several thousand miles per second rather than one mile per second. In order to accomplish this all materials containing hydrogen are kept away from the reactor core.

Suppose we examine the reactor core of the Enrico Fermi Atomic Power Plant. The original fuel for the breeder reactor is the fissionable isotope of uranium that was mentioned previously—U-235. The fuel material is contained in cylindrical pins thirty inches long, assembled to form the reactor core. A total of 450 kilo-grams will make up the fuel charge of the reactor. Power, in the form of heat energy, is produced in the reactor by means of neutrons which cause fission of the U-235 nuclei. Additional neutrons and large amounts of heat are released with each fission. The amount of heat produced is directly proportional to the rate of this fission. When no neutrons are present in the reactor, no power will be produced.

Surrounding each fuel pin subassembly (there are 91 subassemblies, 144 fuel pins to a subassembly) is the breeder "blanket." The blanket is made up of a non-fissionable isotope of uranium. This isotope, U-238, will not undergo fission but will react with the neutrons to form plutonium. Plutonium is a fissionable material. The actual mechanism of the reaction, starting with the fission of an atom of U-235 is shown in diagrammatic form below. The neutron strikes the U-235 nucleus causing fission to occur. As a result of this fission, two new substances called fission products are formed. Along with the fission products a quantity of heat is emitted and two-and-a-half neutrons are formed. These neutrons are now free to cause more fissions or be absorbed by the breeder blanket. Let us assume that only one neutron collides with another U-235 nucleus. That leaves the other 1.5 neutrons free to be absorbed by the U-238 surrounding the core. When the U-238 absorbs a neutron it is transformed into an atom of plutonium. So in one fission, one atom of U-235 has produced 1.5 atoms of fissionable plutonium. In the future when plutonium can be used as a fuel for a fast reactor, the probable ratio of fuel consumption to fuel production will be about 1 to 1.5. Such a breeder would then be like a coal furnace which makes more coal than it uses up.

In the example below, the one neutron that struck another U-235 nucleus will in turn cause another fission and another 2.5 neutrons to be emitted. If on the average, one of the neutrons emitted in each fission

(Continued on page 72)



Neutron fusion of a U-235 uranium atom.

FARAWAY PLACES

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Rick is the Mobil marine engineer in Hong Kong. His counterparts work in every major Free World port—more than 400.

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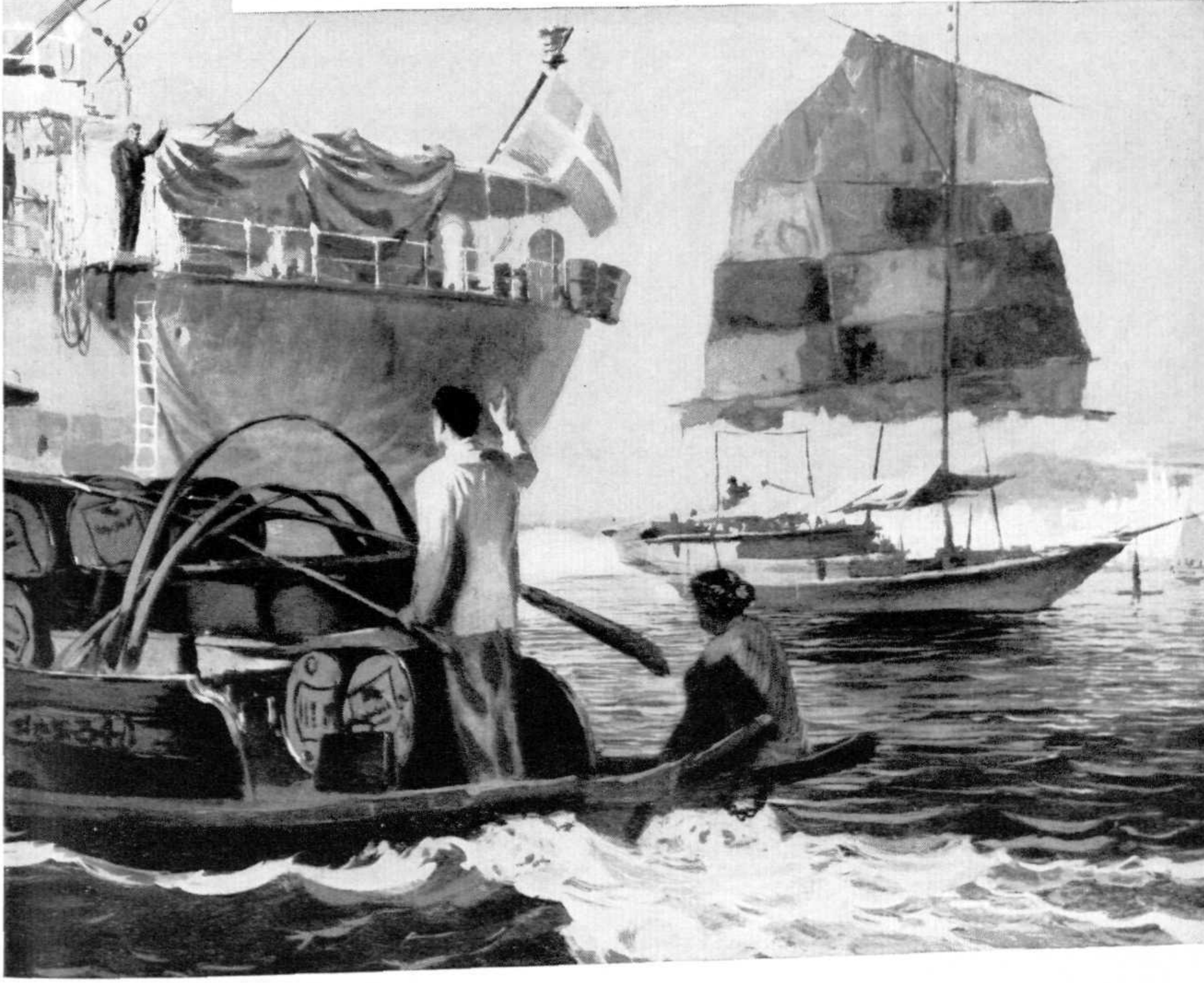


FERMI POWER PLANT

(Continued from page 70)

causes another fission, then a chain reaction will be the result. If more than one neutron from each fission strikes another atom of the fuel, then the total number of neutrons in the reactor will increase. Consequently more heat energy will be produced until the temperature reaches a point where everything melts. Then the reaction will stop. An incident of this type can happen within a matter of seconds and the reactor is no longer operable. Obviously, some method for controlling the rate of production of neutrons must be devised if the reactor is to operate properly.

Actually there are three methods available for controlling the reaction in a nuclear reactor. The first of these is to vary the amount of fuel in the reactor. This can be accomplished by installing movable fuel rods that can be removed or inserted as the situation demands. The second method is to have movable rods installed that are made of a substance which absorbs neutrons easily. (Rods of this type are called poison rods.) Finally, part of the neutron reflector (around the core assemblies) may be made movable. This would tend to control the amount of neutrons "leaking" from the reactor.

The PRDC reactor is utilizing the poison rods for control purposes. A total of ten control rods will be used to control the reactor. These rods contain the nuclear poison boron carbide. Insertion of the rods into the reactor core will cut down the number of free neutrons in the core. With this decrease in the number of neutrons, a comparable decrease in the number of fissions will follow. This in turn will tend to decrease the number of neutrons, since additional neutrons are emitted as a result of fission. When the rods are removed, the process will gain in momentum again until it reaches a desired level. The control rods work just like a combination brake and accelerator in an automobile. Just as a car can be accelerated and decelerated at will, so the power of a reactor can be increased or decreased by the control rods.

That explains how the neutrons are taken care of, now let's consider the heat produced by the fission of U-235. This heat must be removed from the reactor compartment before it can be put to any use in the production of electrical power. Remembering that in order to keep the neutrons fast, all substances containing hydrogen must be kept out of the reactor core, let's consider what liquids can be used to absorb the heat and transfer it somewhere else. Water is immediately ruled out because of its hydrogen content. The type of liquid needed is one that is not corrosive at high temperatures; one that will not develop extremely high pressures under high temperatures, and one that is free of hydrogen or carbon.

Extensive research was carried out at the Knolls Atomic Power Laboratory in Schenectady, N.Y., and it was decided that liquid sodium would fill the bill. So liquid sodium is pumped through the reactor core and the heat is absorbed. The sodium is heated to 800 degrees F through contact with the hot surfaces of the closely spaced fuel and blanket elements. The sodium is then pumped to an intermediate heat exchanger, where the heat is transferred to a second liquid sodium system. The secondary liquid sodium system then carries the heat into a boiler where steam is produced. The boiler is so designed that water is flowing in one end and superheated steam is flowing out the other end. The steam is then passed thru a conventional turbine to produce electricity. The second liquid sodium system is provided for safety reasons to prevent radioactive sodium from coming into contact with water in the event of a boiler tube failure.

When the starting switch is thrown, putting the Enrico Fermi Atomic Power Plant into operation, a new giant will be born. It will not be big as far as power plants are concerned, producing only 100,000 kilowatts of power, but it will be a giant in the field of nuclear power development. It is one of the first big steps towards restoring to the United States the leadership in this important section of the atomic power program. Remember, the breeder reactor is an essential part of any large scale program for the development of economical nuclear power.

SILICONES

(*Continued from page 21*)

"Lustergrip," a new process for coating paper bags has been developed to prevent skidding and slipping of the bags when piled on top of each other. This antiskid coating gives paper bags made out of smooth kraft paper, such as those used for suger, approximately the same degree of slip-resistance as rough kraft paper printed with so-called noskid inks. Smooth kraft paper stays cleaner and prints better than rough kraft. This insures a more attractive package. Dupont, "Ludox," the same substance that adds the antiskid property to your safety floor wax, is the source of friction. Have you ever run your hand over sandpaper? That is how "Ludox," works. Submicroscopic particles, so small that they don't mar the apparent smoothness of the kraft paper, acts like ultrafine sandpaper. This increases the surface friction and stops skiding.

Mixed with a filler, "Ludox," is applied to the front and back of the finished multiwall bags. This coating prevents the ink from smearing when the bags rub together, as well as providing a nonskid surface. This product can be of great value to industries.

Slippery bags are a safety hazard. When a bag slips and breaks, it also represents a lose of money and time.

Another very important use of silicones is for special lubricants that must be used at extreme temperatures. It is also useful for surfaces, such as rubber or plastics, that are adversely affected by conventional oils or greases. High temperature oven conveyors and chutes or molds of glass forming machines are examples of where this special lubrication is needed. Silicone lubricants have been found to be much more superior than conventional lubricants.

One special grease is called red or strawberry grease because of its distinctive color. This grease contains a substance called estersil. It is a white fluffy material consisting of fine silica particles. More than ten billion of these tiny particles are needed to cover the head of a pin. These particles are joined together in a sponge like structure which is capable of holding great quantities of oil. Greases made with estersil are resistant to water as each of these may be thought of as wearing a chemical raincoat. The silica repels the water. In tests that were made estersil grease functioned exceptionally well when water was present. Conventional greases that had soaps as thickeners did not lubricate the parts properly. One of the big advantages of estersil grease is that it is extremely stable at high temperatures. Ordinary greases, with soap thickeners, become quite thin at temperatures that do not even begin to effect estersil greases. Because this grease is special, they decided to make it look different than other greases. The red or strawberry color from which the grease gets its nickname is just a red dye that has been added to give it a distinct identity.

Another use for silicones is for coating glass containers such as bottles and jars. When the surface of these containers is treated with liquid silicones they do not break as easily. The silicone reacts with the glass surface and forms a very hard coating. Containers treated with the silicones do not scratch as easily as regular containers that have been coated. This coating also increases the mechanical handling by increasing the ability of the container to slide more easily.

Silicones are a specialty product. As with most specialty products the price is not the important factor. What is important is that silicones can do some jobs much better then conventional products. In the long run it is often more economical to use the more expensive silicone products than the cheaper standard materials. Silicones often last longer and do the job more efficiently. These factors usually mean savings in time and money.

Silicones cost from three to four dollars a pound, about one half of the cost ten years ago. Even with this big reduction in price many industries try to engineer their products so that the use of expensive silicones will not be necessary. Silicones are not used unless they are shown to be far superior or as economical in the long run as conventional materials. Two industries that have found that silicones do the job better are the asbestos siding industry and the auto tire branch of the rubber industry. The siding industry uses them to waterproof the siding. The rubber industry uses them for mold release agent in their auto tire branch. Both of these industries have completely converted to silicones use. They have found silicones so superior that they have eliminated the former methods that used conventional material.

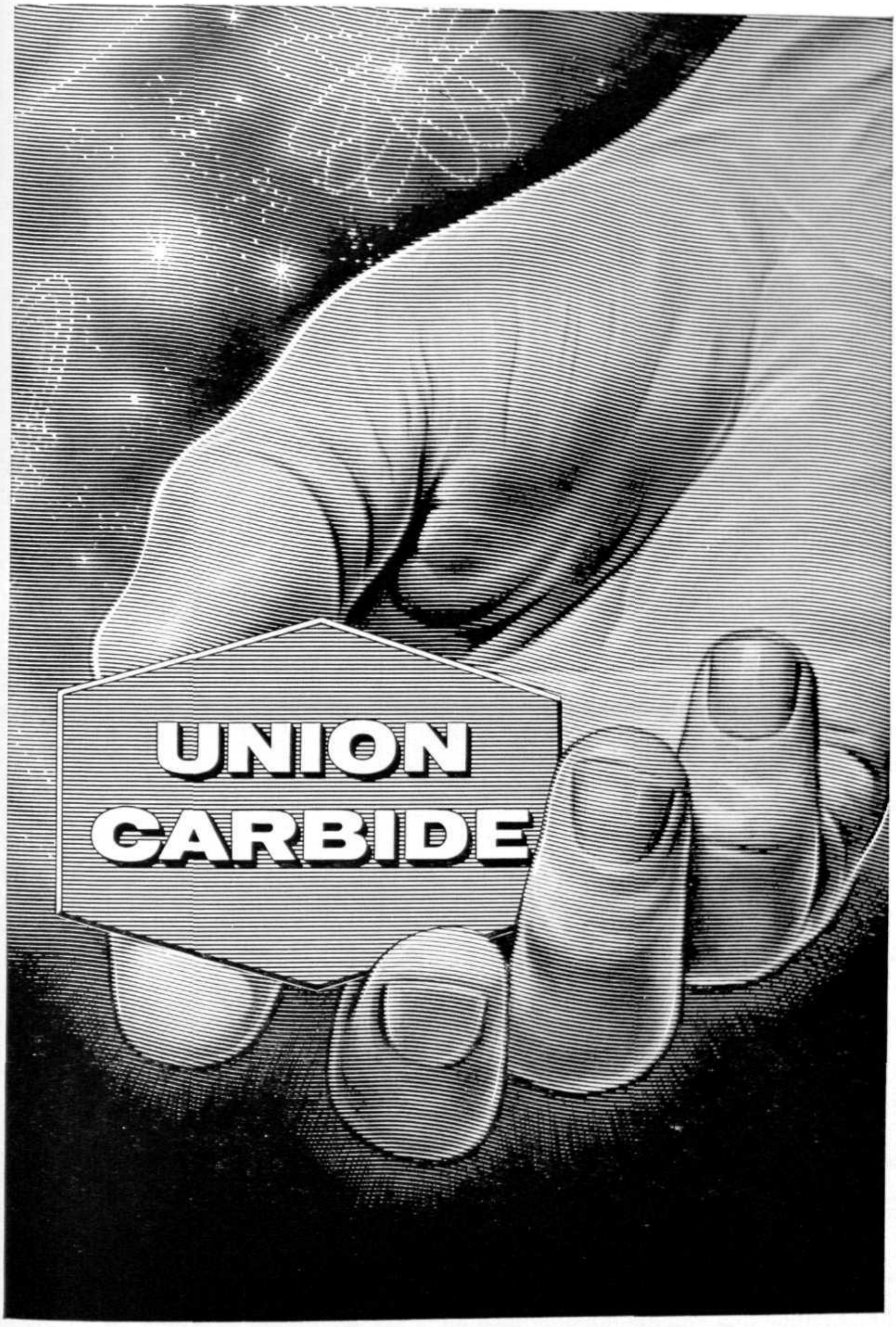
The silicone industry must make its own market. Except for special uses they can't compete economically with conventional materials even if the price of silicones were reduced to half of what they now cost. The silicone industry is meeting this problem by first looking for places to apply the use of silicones and then they try to make a silicone that will do the job. They also provide a technical service to industries to help them solve some of their problems by using silicone.

A beautiful girl was walking along the sidewalk one evening on her way to the movie. She noticed a small bird lying at the side of the walk with a broken wing. Instead of going to the movie, she took the bird home, bandaged its wing, and fed it. In a week the bird was well enough to fly away.

Now let's see you guys find anything dirty in that.

First Little Boy: "I don't like the new little girl in our block. Her's neck's dirty."

Second Little Boy: "Her does?"


UNION
CARBIDE

INDEX TO ADVERTISERS

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

PHOTOGRAPHY AT WORK—No. 27 in a Kodak Series

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Thom McAn ends ten-day hand-copying jobs with Kodak's Verifax Copier—now gets complicated sales, size and style data off in a day.

BEFORE, when Thom McAn's merchandise manager or stylist needed word on sales or style trends in certain stores, it took as much as ten days to hand-copy the records.

But today, when headquarters located in New York requests information on any shoe style or store, the New England merchandising center gets the latest facts and figures away in that night's mail. And styling, buying and distributing functions get 24-hour—instead of ten-day—service on vital stock allotment statistics.

This is because the facts, kept on files of removable panels and cards, can be slipped into a Kodak Verifax Copier and copied, photographically accurate, in a minute.

Photocopying is just one of hundreds of ways photography works today for all kinds of businesses, large and small. It helps with product design, takes kinks out of production, increases sales, improves customer and personnel relations.

Thom McAn calls the Verifax Copier *"the kingpin of the allotment control system."* It copies a store's style allotment records and width breakdowns and in less than 60 seconds has a dry print ready for the mails.

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.

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