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Pellegrino

OCTOBER
1959
The Wisconsin
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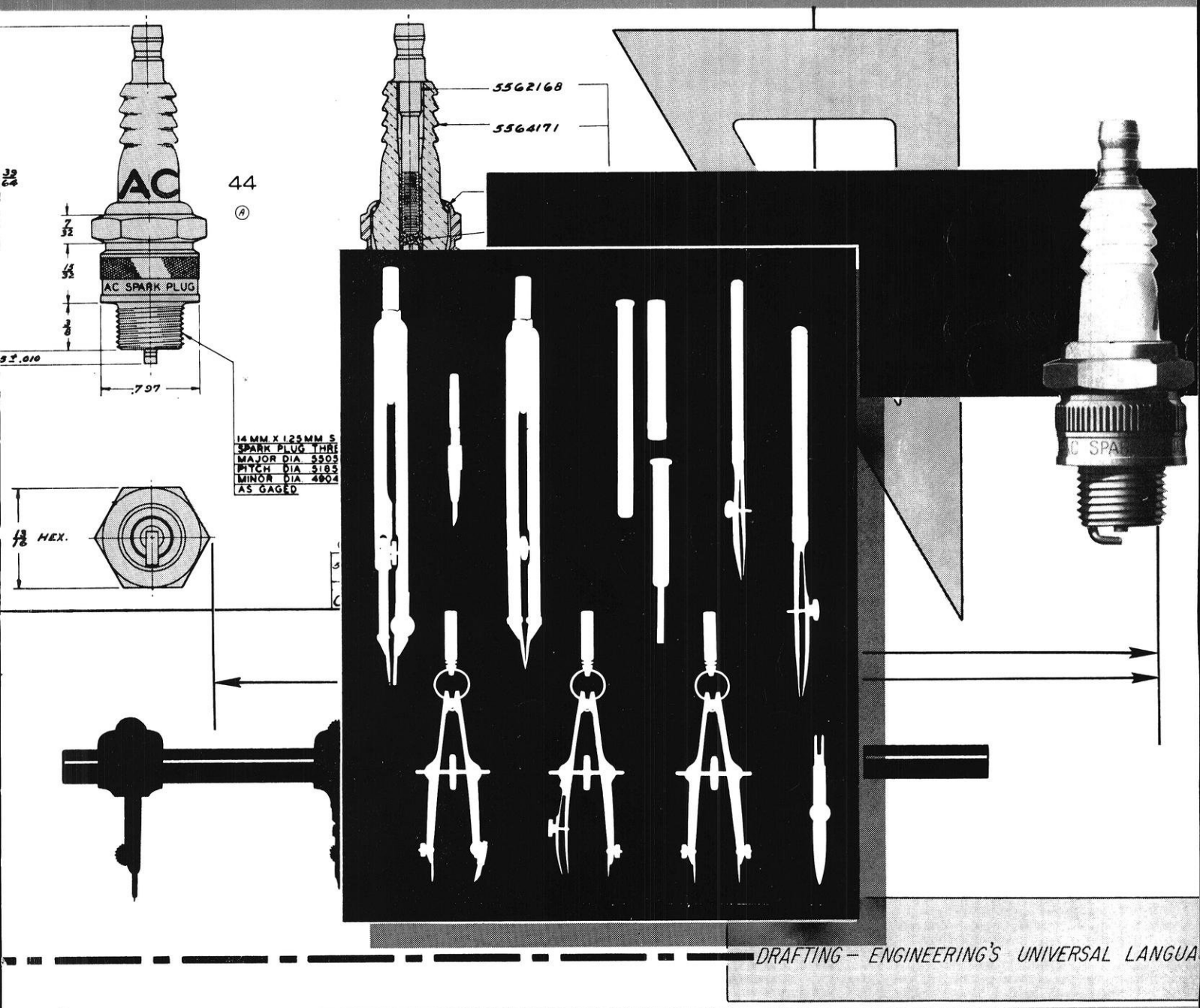
engineer



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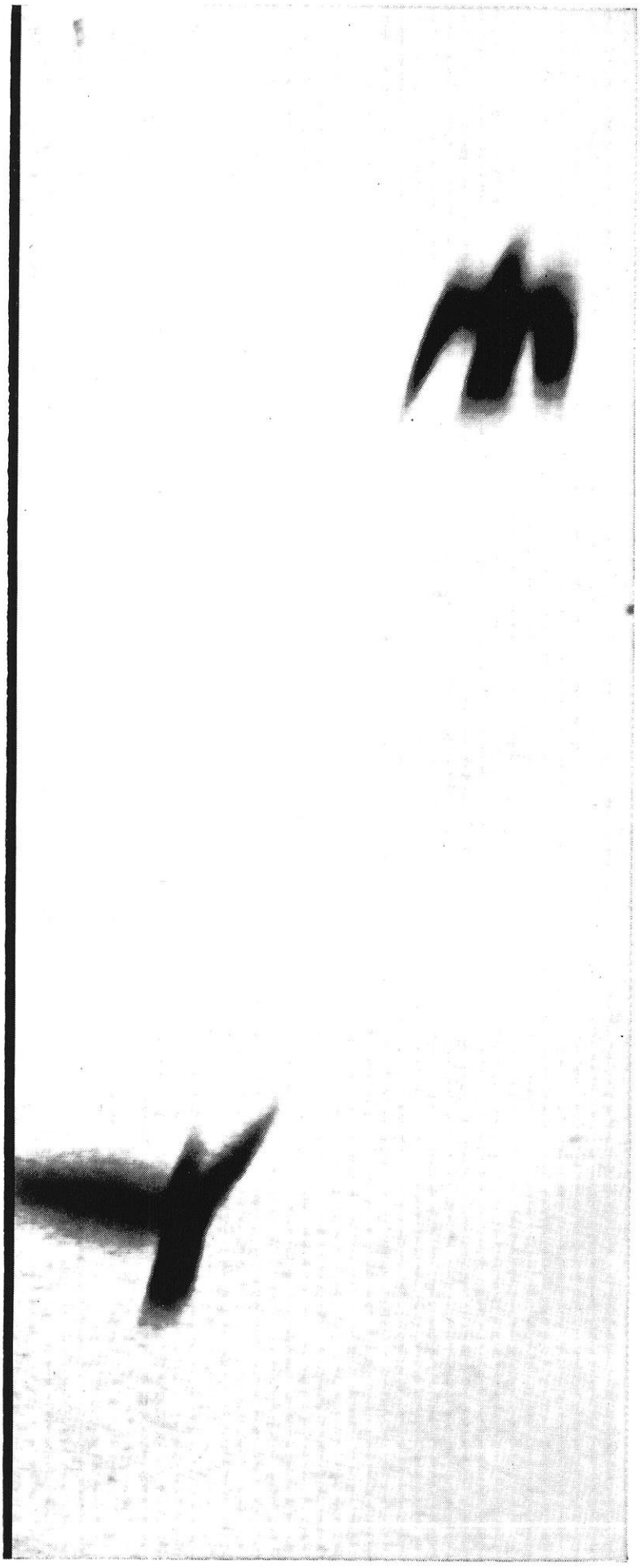

The shape of flight

The shapes of things that fly have always been determined by the materials they are made of. Feathers form wings that are basically alike for all birds—and membrane forms an entirely different wing for insects. It takes thousands of years, but nature improves its materials and shapes, just as technology improves the materials and shapes of aircraft. But here, the improvements in materials are so rapid that designs become obsolete almost as soon as they are functional.

Today, our aeronautical designers and missile experts work with types of materials that didn't exist just a few short years ago. Steels are probably the most important examples: United States Steel has just developed *five* new types of steel for the missile program. They are called "exotic" steels because they have the almost unbelievable qualities necessary for unearthly flights.

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Volume 64 OCTOBER 1959 Number 1

WISCONSIN ENGINEER

The Student Engineer's Magazine
FOUNDED 1896

Features

Departments

Cover

The competent engineer uses three languages—verbal, mathematical and graphical. His assignments sometimes dictate that he use one, or perhaps two, of these languages more often than another. Yet, all three must be at his command. For the engineer visualizes the forces of nature, he creates in his mind a product or process, and finally he must communicate his thoughts to others. The choice of his means of communication may be determined not by his preference but by the subject matter or by the recipient of the information.

In this issue's cover design by artist Richard P. Renius, the engineer's knowledge and use of graphical language is symbolized by a product assembly drawing, some drafting tools used for making the drawing, and the final product. [Courtesy General Motors.]

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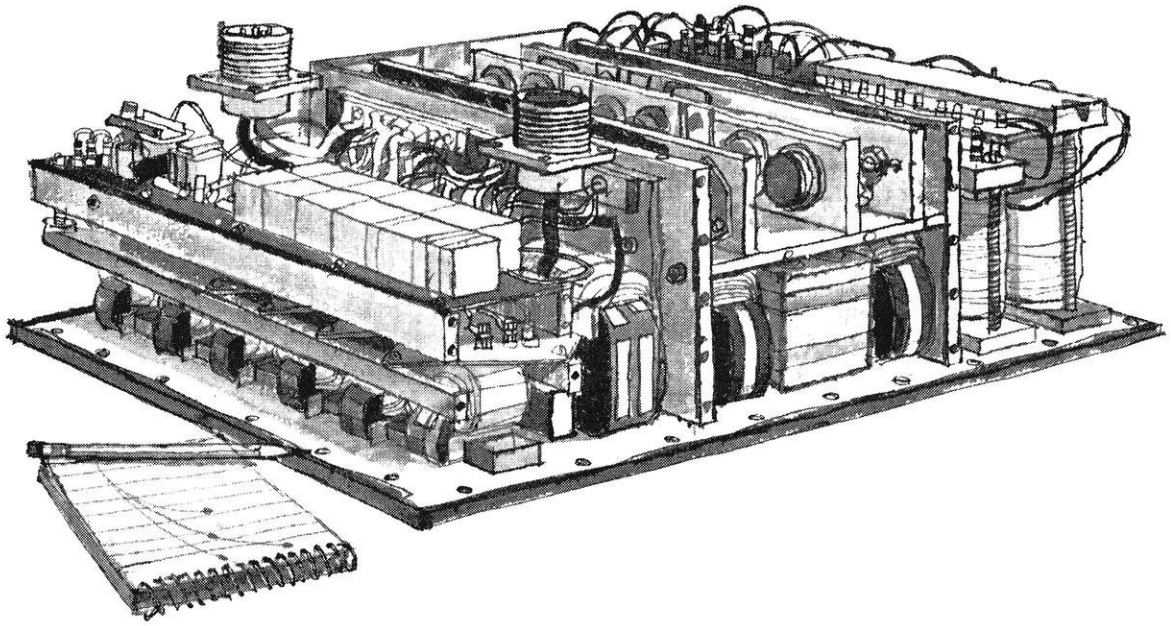

Shooting for the moon ...and beyond

The High Capacity Static Inverter, latest electronic achievement from General Motors, provides exceptionally stable and precise frequency control for power and guidance requirements of missiles and rockets.

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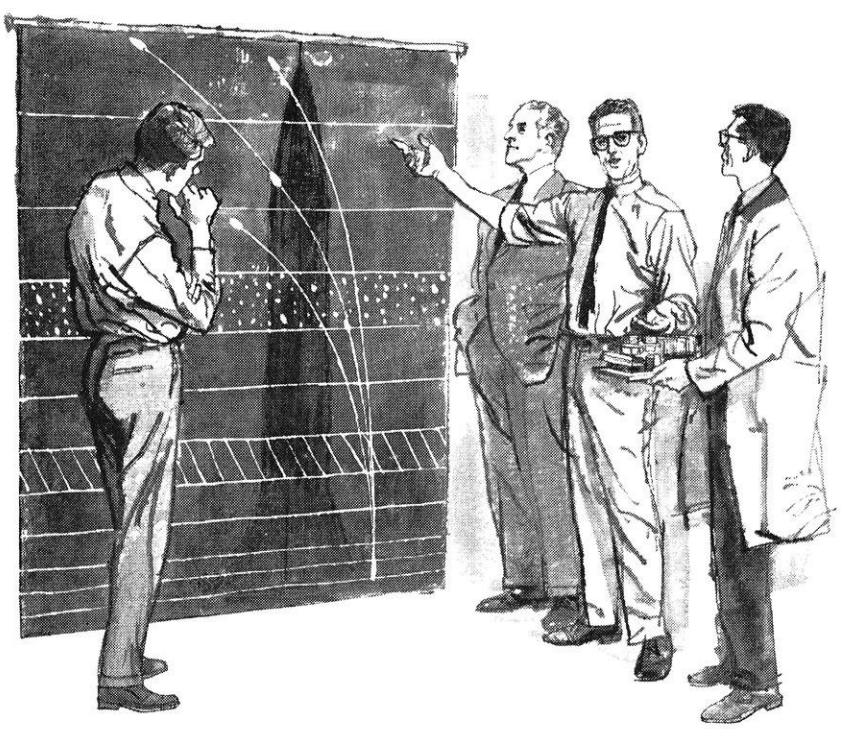

The minds of inquiring scientists and engineers are the spark that brings the wonders of tomorrow to the threshold of today. At General Motors the sky is the limit for men who work in these and other highly specialized fields.

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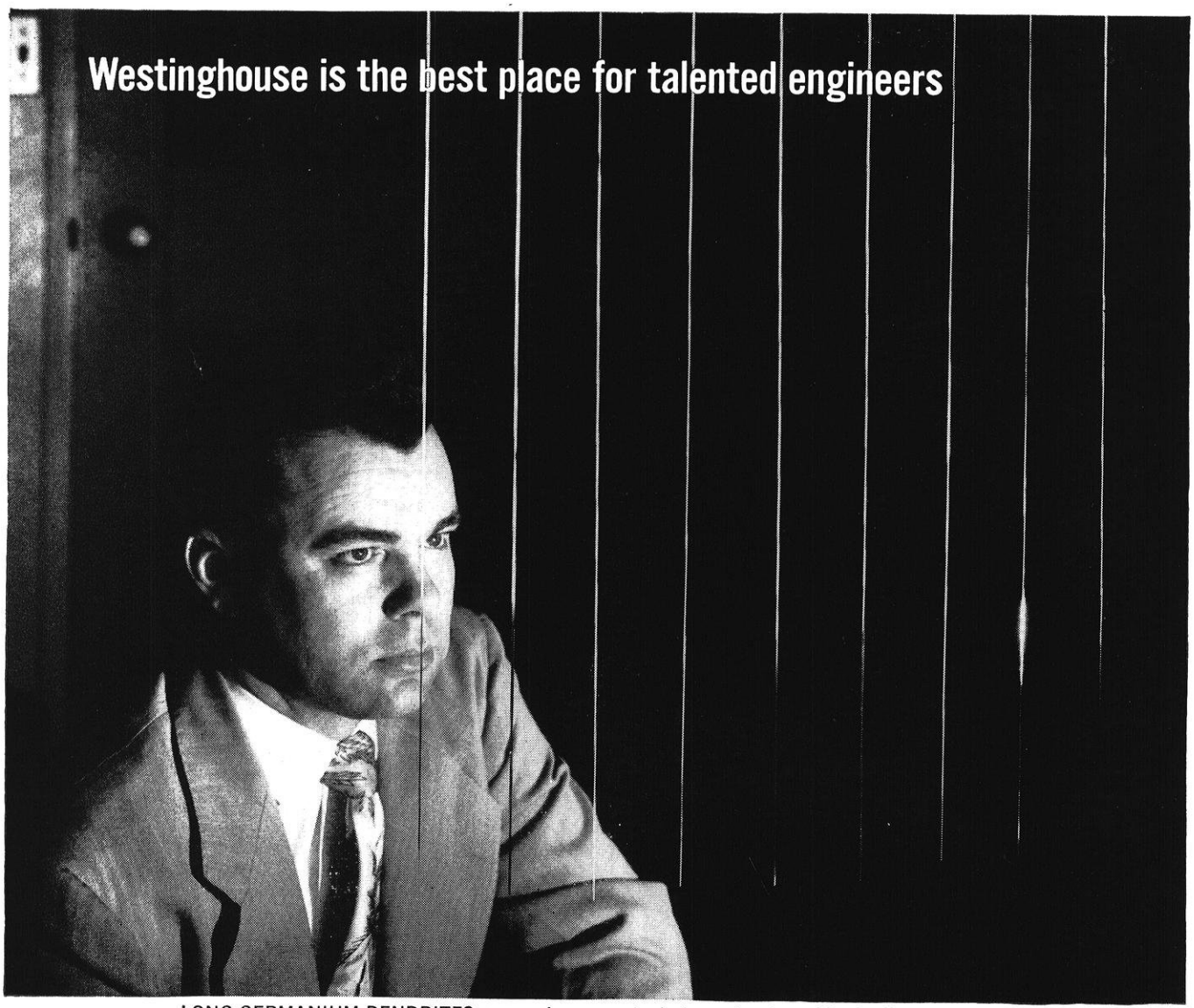
GENERAL MOTORS



LONG GERMANIUM DENDRITES, grown by a new technique developed in the Westinghouse Solid State Physics Laboratory, are here inspected by Dr. A. I. Bennett, research physicist.

The Solid State Lab helps you when your idea needs a new semiconductor

The Solid State Physics Laboratory helps Westinghouse engineers exploit the rich phenomena of the solid state. Problems are solved in low temperature and semiconductor physics, and magnetic and ferroelectric materials. If an engineer's idea requires a new kind of semiconductor, this group may be able to develop it for him.

This laboratory is staffed by 27 Ph.D.'s, 4 M.S.'s, and 7 B.S. junior engineers. Here's one way it ties in with work at operating divisions:

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Our Youngwood plant is designing the new devices needed for these systems

The Solid State Physics Lab is perfecting a method for growing the dendritic material needed to make these devices

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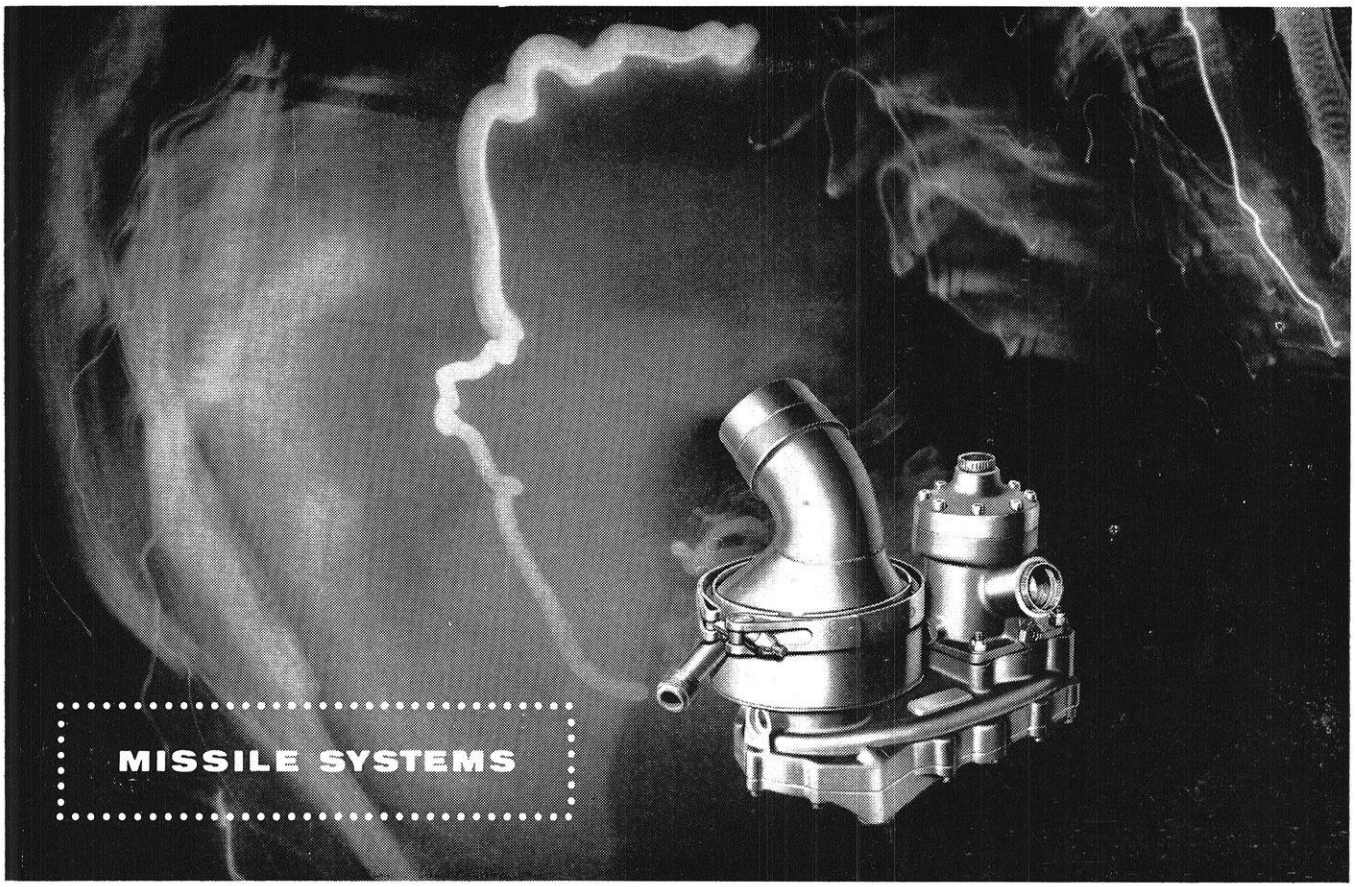

• A missile's main engine runs only for a few seconds. To supply electric and hydraulic power for control during the entire flight a second power plant is necessary. The AiResearch APU (accessory power unit) which answers this problem is a compact, non air-breathing, high speed turbine engine. The unit pictured above develops 50 horsepower and weighs 30 pounds. The acknowledged leader in the field, AiResearch has designed, developed and delivered more accessory power units than any other source.

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Rambling WITH THE EDITOR

You're in engine school now! Are you cut out to be an engineer? Can you make it through this semester? Won't the assignments ever stop coming? These are among the many questions that have been running through the heads of nearly all the new students and in fact many of the upper classmen, too. These queries should not go unanswered. The College of Engineering is not a school where four years of time entitles you to a degree. A great deal of effort lies ahead of you. Be alert and find out whether you have chosen the correct branch of engineering. Talk over your interests with your instructors and fellow students. After you are sure that the course you are following is best for your interests and abilities, your work begins.

You are attending one of the finest engineering colleges in the nation. It is now your challenge to make the best of your time spent here. There has been much talk of the necessity of a well rounded engineer. No . . . . I am not suggesting that you rush down to the Hasty Tasty and increase your waistline to 42 inches by pouring down the golden beverage. What I would like to emphasize is that there is more than one side to your college education. Industry acknowledges the fact that engineering students should broaden their horizons by participation in extracurricular activities. One thing, however, must be held first in mind. Your purpose in being here is to acquire the technical knowledge which you can apply as an engineer. The time necessary for scholastic endeavor should be set aside before considering any outside activities. Depending upon your scholastic ability you will have, believe it or not, some spare time. I hope you will give thoughtful consideration to your decision as to the use of this time. Those of you who do not work at a part time job, will find a myriad of activities at your disposal. I would like to suggest that you read the Campus News section of this issue on page 30 for information on the professional engineering fraternities, the engineering societies and other engine campus doings. The Wisconsin Union offers many hours of pleasant recreational activity. Meeting and participating with students of your own faith is an advantage of the many church organizations. Student publications offer a chance to use your journalistic talents. Staff positions are still open on the Wisconsin Engineer. The University assuredly offers many opportunities. . . I sincerely hope you will make the best of them.

DONALD D. ROEBER
Editor

North American Aviation's XSM-64 NAVAHO guided missile, developed by the company's Missile Division in Downey, California, was used to gather high speed high altitude data for SAC's newest weapon, the B-70 Mach 3 intercontinental bomber. This program was known as project RISE (Research in Supersonic Environment).

REAR ENGINE AUTOS

by David C. Gantenbein me'60

Rear engine autos are fast becoming Americas favorite. 2½ million of these small economical vehicles are on the roads today.

INTRODUCTION

IN THE past ten years a great number of small foreign automobiles have appeared in this country. The most common are the Renault and Volkswagen. These two are unique because each has the engine placed in the rear.

Because a car must have its weight fairly evenly distributed between the front and rear wheels for riding comfort and roadability, rear placement of the engine is practical only in small cars. This is true because in small cars the weight of the passengers is a larger percentage of tho total weight of the vehicle. The fact that the passengers are a large percentage of the weight of the vehicle enables us to use this weight to counter balance the engine.

DEVELOPMENT AND HISTORY

The development of the rear-engine motor car which has taken place in Europe during the past ten years may be surprising to many, but not to those who know the history of the industry. Rear-engine cars have always been built. If their numbers remained relatively small during the first half century of the motor car, it was because the slow evolution of the automobile did not permit drawing on all the advantages of the rear-engine formula.

With an increase in use of the internal-combustion engine the engine became more compact. As an inheritance from the horse-drawn vehicle, the front wheels were used for steering, so it was natural to place the engine as close as possible to the rear wheels which did the driving.

The problem of the gearbox itself was most easily solved by mounting the engine so that its axis was parallel to the rear axle. The rear wheels were then driven by means of belts, pulleys, or chains. Nearly all of the cars built between the years of 1880 and 1900 were of this type.

From this time on engines became larger and heavier, and had to be moved forward to achieve a weight balance. The only development on rear-engine cars from this time until the 1930's was done for racing purposes.

The great industrial expansion of the rear-engine auto began in 1938 with Dr. Porsche's Volkswagen. From 1938 until 1945 development was steady; however, immediately after World War II the popularitv of rear-engine cars skyrocketed. During the period from 1945 until 1956 European production of rear-engine autos increased from 5.2 percent to 38.3 percent of the market in Europe.

To have achieved such development in European mass production, the technique must have marked advantages for both customer and manufacturer.

DESIGN AND MANUFACTURING ADVANTAGES

The common rear-engined car is composed of a closed passenger package (the body) at the rear of which is fixed the engine. Because of the car's smaller size, the body is usually made in one compact unit. This unitized construction allows the manufacturer to eliminate an expensive frame. This type of construction is also used on all American Motor Company automobiles. The other mechanical units such as the engine, wheels, transmission, and steering gear are then fastened directly to this unitized body. Because this type of construction is so easy, it is obviously popular with the manufacturers.

Rear placement of the engine allows minimum overall length of the body for a given passenger space. It allows the front-seat passenger's feet to extend to the front

Renault Caravel

wheel centers, while the engine's farthest unit is located under the rear seat. Thus resulting in a minimum wheelbase for a given passenger space. In conventional cars comfort is possible only by increasing the wheelbase, thus increasing the passenger space. It is understandable that this increased wheelbase will also increase the weight and expense of an automobile; however, with a rear-engine car it is possible to have equivalent comfort without the increase in size or expense.

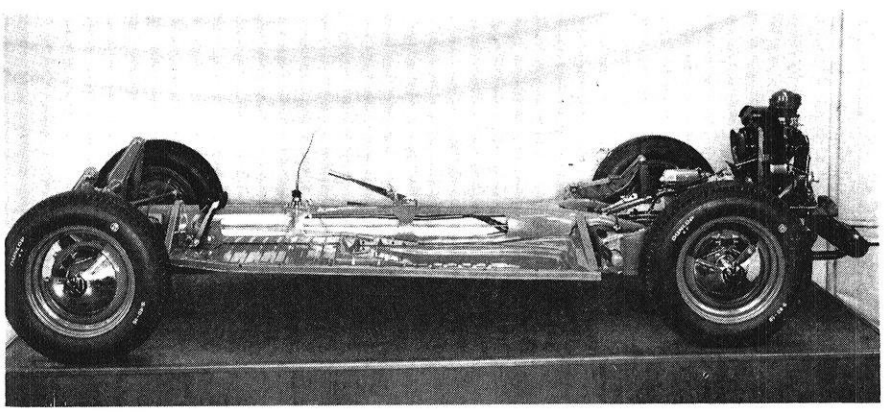
CONSUMER ADVANTAGES

Safety

Undoubtedly the most important question asked by the consumer is, "What does a rear-engine auto have to offer me?" The rear-engine car offers many advantages to the consumer. One of the most important is safety.

Rear-engine cars are much safer in a collision than conventional cars. In a conventional car the motor, which is in the front, has a large mass. It is interesting to note that statistics show 75 percent of all accidents involve the front of autos. It is a recognized fact that not the fall, but the sudden stop kills people. This same principle applies to a collision in an automobile. Because the engine is in the rear, the front of the car is able to deform, and the deceleration occurs less rapidly. In rear-engine cars, passengers do not have to worry about the engine being pushed into their lap. Because of rear placement of the engine, serious injury due to collision is greatly decreased.

Greater traction is possible with rear-engine placement. The weight of the engine pushes directly down on the driving wheels, and the effect is increased on a grade. Increased traction is very comforting when driving conditions are hazardous. In the conventional car the greater share of the weight is on the front wheels. This large amount of weight causes hard steering, and nose-diving when the brakes are applied.



Volkswagen Chassis

(Continued next page)

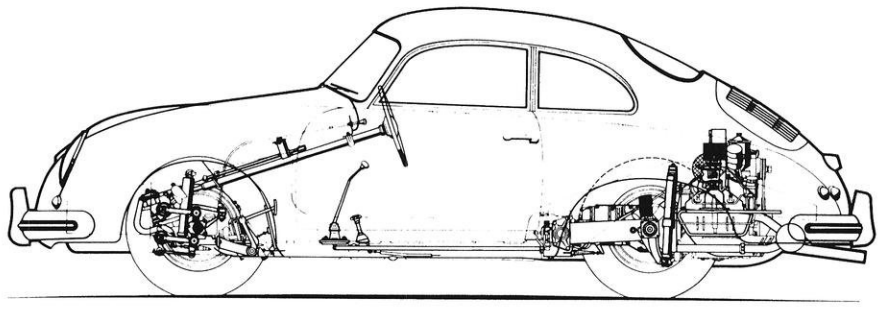
Comfort

Absence of engine heat in the passenger compartment is made possible by the placement of the engine in the rear. The engine is outside the passenger compartment and totally isolated from the passengers. Thus, the heated air does not flow over the floor of the body as it does in the front-engine car.

Rear placement of the engine also overcomes the problem of exhaust fumes. Because there are no pipes running under the car, it is not possible for fumes to leak into the car. In the front-engine car the exhaust pipes which run under the car drastically reduce the ground clearance. These pipes are also very vulnerable to damage on bad roads. Rear placement of the engine easily does away with all these problems.

In rear-engine cars the seats are located between the front and rear suspension. This reduces movement of the car at passenger level. As a result the riding comfort is increased. In most conventional cars the rear seat is placed nearly over the rear wheels, the back seat is then subjected to the movement of the rear wheels.

As was mentioned before, much of the weight is on the rear wheels of a rear-engine car, while in a conventional car a large share of the weight is on the front wheels. This decrease in weight on the front wheels results in easier steering, which is especially useful if a car does not have power steering. Not only is the steering easier, but the short wheelbase, which is inherent in cars of this design, permits a much shorter turning radius.



Porsche—coupé type 356A.

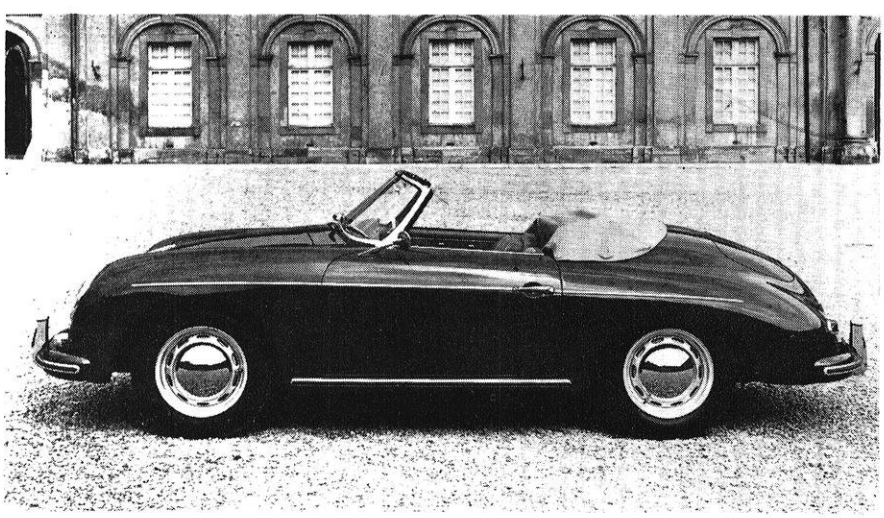
Economy

Because most rear-engine cars are small in size, one of their principle advantages is economy. As was mentioned before, rear-engine cars may be made lighter in weight without any loss of strength. It is obvious that lighter weight will produce an increase in economy as well as performance.

The drag coefficient is as much as 40 percent lower for cars of rear-engine placement. Cooling air for the engine enters along the side of a rear-engine car.

In a front-engine car it must enter under the front bumper of the car. Front entrance of cooling air results in turbulent flow of the air, and higher drag coefficients. Since the wind force produced on a car is the product of drag coefficient, cross-sectional area, and the velocity of the car; the force needed to overcome wind resistance is less, if the drag coefficient is reduced. The reduction in wind resistance shows up as an increase in economy.

The unit-type body construction used in rear-engine cars provides a stiffer front section. Because the front section is stiffer, the front wheels tend to maintain their alignment. It is a known fact that many of the conventional Detroit made cars have a considerable problem with maintaining wheel alignment. It is not only expensive to have the wheels aligned, but the increased wear on tires due to misalignment can be very expensive.



Porsche—convertible type 356A.

CONCLUSIONS

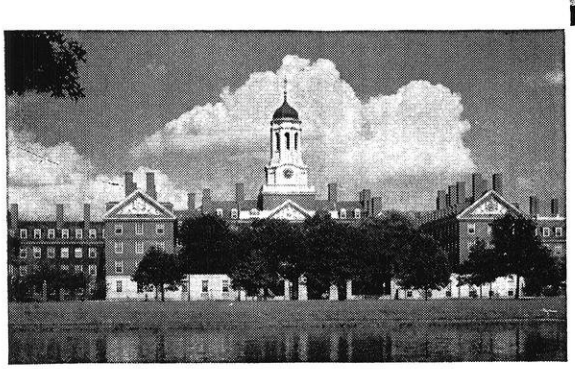
Has the rear-engine design a good chance to increase its popularity? I believe it has, as long as small economy type cars continue to remain popular.

We have seen that the advantages of this design are numerous. It offers advantages to the designer, manufacturer, and consumer. Now that 2,500,000 rear-engined cars are being driven on all continents and in all climates, customer acceptance is no longer a problem. We can, therefore, conclude that the rear-engine car will not only maintain, but improve its present position in the sales market.

THE END

Raytheon Graduate Program

FOR STUDY AT HARVARD MASSACHUSETTS INSTITUTE OF TECHNOLOGY AND CALIFORNIA INSTITUTE OF TECHNOLOGY IN 1960-61



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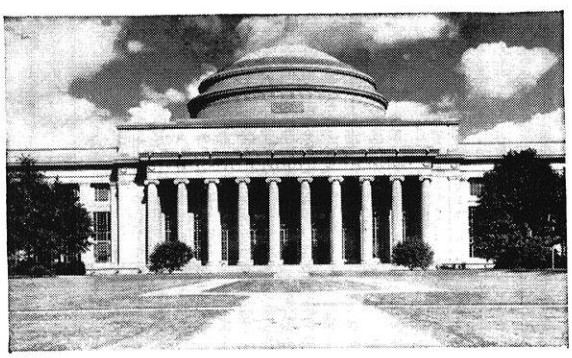

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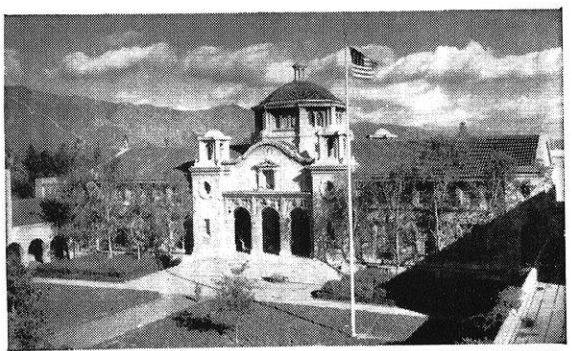

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The Raytheon Graduate Program has been established to contribute to the technical development of scientists and engineers at Raytheon. It provides the opportunity to selected persons employed by Raytheon, who are accepted as graduate students by Harvard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

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PLASTICS

A New Construction Material

by K. Stuart Vogel che'59

Plastics are the modern construction miracle of the present engineering age. The author discusses the problems in the varied use of these plastics.

PLASTICS are divided into two main groups: thermoplasts and thermosets. The thermoplastic resins are those which may be heated and reformed. Polyvinylchloride and polyethylene are examples of this group. The thermosetting resins are rigid at all temperatures, and will char and break down before becoming pliable. Examples of thermosets are the phenolics, urethanes and polyesters.

The advantages of plastics as materials of construction are numerous; the most important are listed below:

1. low density,
2. low heat capacity,
3. low thermal conductivity,
4. high dielectric strength,
5. ease of fabrication and good moldability,
6. high strength to weight ratio,
7. good resistance to impact,
8. maintenance of size and shape under extremes of temperature and pressure,
9. resistance to weathering, rot, fresh and salt water, chemicals, acids, oils and solvents.

Some of the shortcomings of plastics are:

1. they are not flameproof or self-extinguishing,
2. they deteriorate in sunlight,
3. they have low burst strength,
4. they have high creep rate.

The latter are characteristics of individual plastics and can usually be overcome by process modifications or by replacement with another resin.

The main problem with all plastics is their relatively low moduli of elasticity even when reinforced with materials such as glass.

The great variety of new resins today with improved mechanical properties (impact strength and tensile strength) have pointed out one fact. Plastics, regardless of the reinforcing materials used, have a lower elastic modulus than that of metals. The following table shows the moduli of elasticity (E) of the various structural materials used today.

MODULI OF ELASTICITY OF VARIOUS MATERIALS

Material	$E(10)^6$psi
General purpose phenolic	8 to 12
Polyethylene	1.5
Rigid polyvinylchloride	5
General purpose polystyrene	4 to 5
Polyester-glass laminate	20
Glass-reinforced phenolic	30
Glass-filled nylon	8
Glass-filled polystyrene	12
Epoxy-glass laminate	30
Unidirectional glass-epoxy laminate	60
Aluminum	100
Steel	300
Magnesium	60
White pine (air-dried)	22
White oak (air-dried)	18
Window glass	100
Concrete	20 to 50

The main design limitation of plastic materials is low flexural stiffness, which is indicated by stiffness factors. When usual design conventions are followed, specifications call for abnormally thick sections if plastics are used. This results in added weight in spite of the low density, and it also increases manufacturing and material costs. In this case the economic advantage over other material is lost,

even when strength considerations favor the resins.

The stiffness factor is the product of elastic modulus of the material, and the moment of inertia of the component part about its neutral axis. It can be seen that since the elastic modulus is constant, the only way to increase the stiffness is by increasing the moment of inertia. The method for doing this is illustrated below in figures (1) and (2).

The preceding figures show that by taking the section from figure (1), cutting it in half, and separating the halves, the moment of inertia can be greatly increased. In this case it has been increased thirty-seven times.

Plastics may be made into corrugated sheets. These have the disadvantage of low rigidity in the direction of corrugation. Where stiffness is required in only one direction these serve well, and give the added benefit of material savings.

The plastics industry is a newcomer to the American scene when compared to the steel and aluminum industries. Plastics have experienced a phenomenal growth over the past ten years, and are finding more and more uses as substitutes for metal, wood, cement, and other structural materials. The next few pages will show various applications of plastics as materials of construction.

Piping

By June of 1957 U. S. Rubber had produced over 6,000 miles of Kralastic, a resin rubber pipe, which is, chemically, an acryonitrile-styrene-butadiene terpolymer. Its main use is in natural gas lines, but it is utilized also in carrying salt water, crude oil, fruit juices, laundry cleaning compounds, leather tanning chemicals and battery acids. Kralastic is unaffected by chlorine, alcohol and gasoline.

Kralastic pipe comes in 30 ft lengths, and weighs approximately one seventh as much as steel. One man can handle 300 ft of pipe easily, as it weighs only 75 lb. It has high impact and tensile strengths, and its maximum operating temperature is 170 F. The lengths of pipe can be threaded or solvent welded. In the latter instance, a thin layer of the surface is dissolved with a solvent cement,

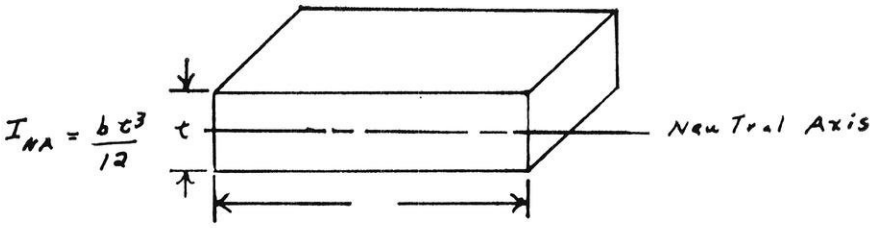


Figure 1

and the end is pushed into place to provide a leakproof joint.

Rigid (unplasticized) vinyl pipes find many of the same uses as Kralastic. They are used to transport petroleum and natural gas where corrosive soils attack metal, and also where paraffin accumulates on pipe walls. They are used at pressures under 75 psi where there are no line surges. They are used in oil fields for the disposal of brine and for transporting crude oil where immunity to galvanic corrosion and the effects of salt water are very important. Vinyl pipes are being used on the west coast to transport salt water for hotel swimming pools.

Vinyl pipes are used for underground wire installations, because they do not corrode. This makes it easier to remove the wires after many years of service. If an easier method of processing and greater temperature resistance could be developed, they also could be used in buildings for gutters, channeling and window frames.

It is estimated that over fifty million pounds per year of polyethylene are used for pipes and wire coatings. Eastman makes this pipe in 6000 ft extruded lengths, which means less than one joint per mile. It can be installed from a large spool into a ditch. It has the advantage of requiring no angle fittings, and it can be cut with a knife. Two difficulties to be overcome in polyethylene are weathering and stress-cracking. Polyethylene deteriorates in sunlight, but carbon black can be added to the resin to prevent this. Polyethylene also has low burst strength and high creep rate.

Transportation

The White "5000" highway tractor truck cab is now being made of 30 molded plastic parts, all of which are easily replaced. The metal cab used previously weighed 550 lb, while the plastic cab consists of 200 lb of resin and 100 lb of glass. Two of the main features are a molded-in fresh air duct, and a multiple ribbed roof. A repair kit for the cab costs $1.50; it consists of resin activator, resin impregnated glass cloth and requires only

(Continued on page 48)

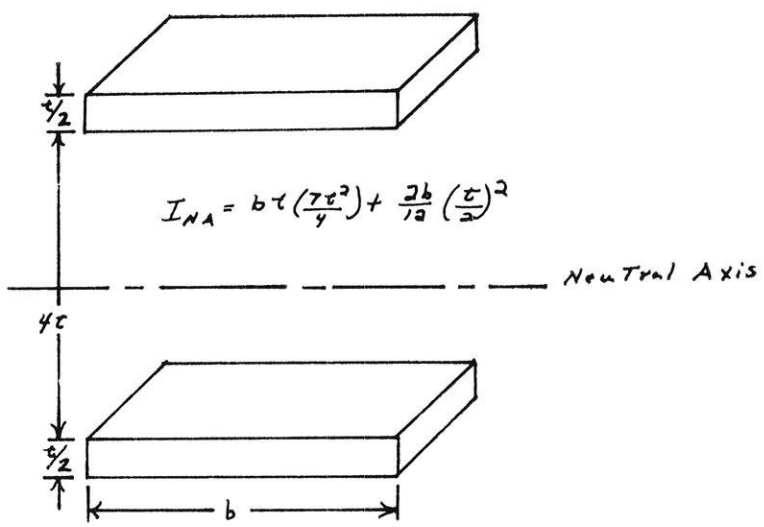


Figure 2

Direct Transformation of Heat into Electricity

by Dean K. Anderson me'4

Once a questionable and sometimes a disappointing risk, thermoelectric power generation is now a desirable choice for many applications and an inevitable replacement for some of them.

FOR some time engineers and technicians have searched for a way to efficiently produce electricity by the direct conversion of heat energy into electrical energy. The development of a class of materials with low electrical conductivity, which we now know as semiconductors, has produced an efficient means of converting heat directly into electricity.

There are two types of semiconductors used in a thermo-electric circuit, the n-type and the p-type. The n-type becomes positively charged at the end which is heated, and the p-type becomes negatively charged at the heated end. An electric current can be generated by connecting these two types of semiconductors with a metallic bridge at their hot ends, and by a conductor at their cold ends.

Efficient thermoelectric generation of electricity has been made possible by the development of thermionic converters. A thermionic converter produces an electric current when two electrodes are held at high, but different, temperatures and separated by a small gap. The heat has the effect of "boiling" electrons off the hotter electrode. These electrons are attracted by the cooler electrode and pass across the gap in a steady stream. This steady stream of electrons is the electric current.

The efficiencies of thermionic converters range from 8 per cent in a gas converter to a potential efficiency of 30 per cent in a vacuum converter. For small power requirements of only a few kilowatts of electricity, the efficiency of thermionic converters is comparable to the efficiencies of other methods of generating electricity.

DIRECT TRANSFORMATION OF HEAT INTO ELECTRICITY

In Berlin, Germany, in 1821, Thomas Johann Seebeck discovered that an electrical current could be produced by holding the junctions of two dissimilar metals at different temperatures. Because of the low efficiency of this thermoelectric effect at that time and because of Seebeck's incorrect interpretation of the effect, the direct transformation of thermal energy into electrical energy was given little attention. A renewed interest in this method of electrical generation has taken place in recent months because of discoveries of thermionic converters which have potential efficiencies in the range of 30 per cent.

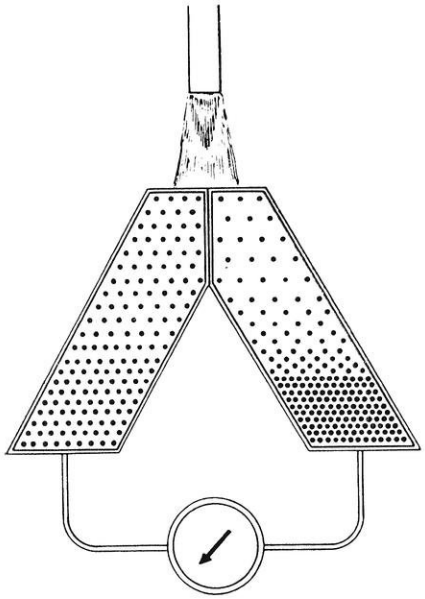
SEMICONDUCTORS

The possibilities of thermoelectricity remained undiscovered until during the 1920's when a class of materials with low electrical conductivity, which we now know as semiconductors, was discovered. Investigation of these materials showed that the thermoelectric effects are greater in semiconductors than in metals.

The explanation of why semiconductors have high thermoelectric advantages over metals and why semiconductors have made thermoelectricity a practical reality can be done by describing how a current is produced in a thermoelectric cell.

Current in a metal is thought of as the flow of electrons. In a metal each atom contributes at least one electron able to move freely within the metal. In semiconductors only a very few atoms release such electrons. The number of electrons available for current flow in a semiconductor is hundreds or thousands of times less than in a metal, and this accounts for the low conductivity of these materials.

When one end of a conductor is hotter than the other, negative electrons leave the hot end more



—Courtesy Westinghouse Electric Corp.

Complete thermocouple wherein the effect is seen to be the pumping of electrons with heat.

often than they do the cold end. These negatively charged electrons tend to flow toward the cold end which soon becomes negatively charged with respect to the hot end. Knowing that like electric charges repel one another and unlike charges attract one another, it can be seen that the negatively charged cold end will begin to repel the electrons flowing from the hot end. After a short period of time, the flow of electrons from the hot end reaches equilibrium with the return flow from the cold end. The charges no longer accumulate, but the cold end remains negatively charged. The fewer the electrons available for the return flow, the higher will be the voltage reached at the cold end before equilibrium is reached. Since the voltage is dependent upon the number of electrons in the return flow, a semiconductor will produce a greater voltage than a metal because of the much smaller number of free electrons in a semiconductor. This smaller number of free electrons is the fundamental principle of the thermoelectric advantage possessed by semiconductors.

P-type Semiconductor

Another thermoelectric advantage of semiconductors is not found in metals at all. In some types of semiconductor materials the voltage difference between the hot and cold end is not established by the flow of negatively charged electrons, but by the flow of positively charged "holes" vacated by electrons. These "holes" are formed when a semiconductr material contains an impurity with fewer electrons than it needs to satisfy the bonds to its neighboring atoms in the crystal. Electrons from neighboring atoms move in to satisfy the deficiency, leaving positive holes, which are in turn filled by other electrons. Therefore, the holes can wander through the crystal. Under an applied voltage their direction of motion is opposite that of the electrons.

The result of this action is that the cold end in the semiconductor becomes positively charged. A semiconductor which acts in this manner is called a p-type semiconductor.

N-type Semiconductor

The semiconductor that is positive at the hot end is called an n-type semiconductor. The n-type semiconductor is a crystalline material composed of an element like germanium which has tightly bound electrons, plus an "impurity" element which has loosely bound electrons that are free to conduct electricity. The free electrons are shown moving toward the right in the direction of the potential rise. Positive "holes" vacated by electrons are stationary.

When the p-type and n-type semiconductors are used in a thermoelement, they must have stability to chemical influences, in particular to oxidation. Good mechanical strength and elasticity are also necessary to prevent the thermoelement from cracking under the effect of thermal stresses.

A suitable material must also be found for the metallic bridge which connects the two semiconductors of the thermoelement. This material should neither create additional electrical resistances at the boundary of the metallic bridge and the semiconductors, nor additional thermal stresses.

CONSTRUCTION OF A THERMOELECTRIC CIRCUIT

By joining a p-type and an n-type semiconductor at their hot ends by a metallic bridge, a thermoelectric circuit can be constructed to generate an electric current.

The current produced in the n-type semiconductor, flows from the hot end at the left to the cold end at the right; while the current in the p-type semiconductor, flows from the cold end to the hot end.

Although the voltage that is produced by this thermoelectric circuit is less than one volt, voltages in the range of 100 to 200 volts can be obtained in a thermoelectric generator by joining hundreds of individual thermoelectric cells together.

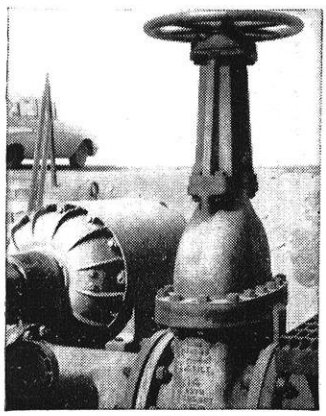
THERMIONIC CONVERTERS

A diode is a device which can be used for the direct conversion of heat energy into electrical energy. The diode operates on the phenomena of thermionic emission. When an electrode is heated in a vacuum, negatively charged electrons escape from the surface of the electrode and make the electrode positively charged. The electrons that have escaped are attracted by the electrode and form a "negative charge cloud" or "space charge" around the electrode. Equilibrium is usually quickly formed between the number of electrons escaping from the electrode and the number of electrons returning to the surface from the space charge. If a second electrode is placed nearby and maintained at a higher potential than the first, electrons in the space charge are attracted to it; and as long as the potential difference is maintained, there will be a steady flow of electrons from the first electrode to the second. The first electrode is called the cathode, and the second electrode is called the anode.

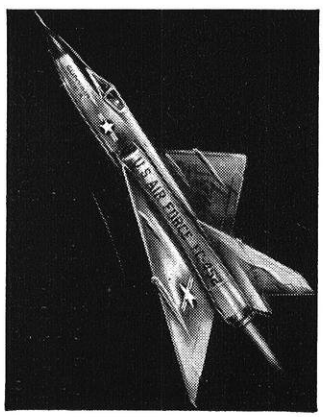
If the potential difference between the cathode and the anode is small, only a few of the emitted electrons reach the anode. Most of the emitted electron penetrate only a short distance into the space charge and then return to the cathode. As the anode potential is increased, more and more of the emitted electrons reach the anode, and with sufficiently high potential difference all the emitted electrons arrive at the anode. Further

(Continued on page 43)

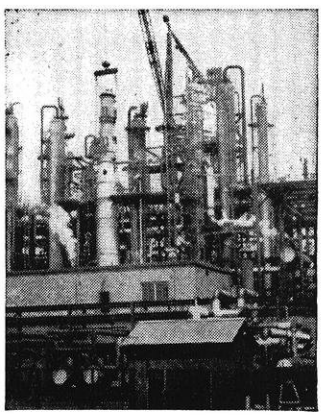
Metal quiz... you might have to take one like it again when you design equipment. Try your hand at it now. But remember to take advantage of the help INCO can give you when really tough metal quizzes come your way in your future engineering jobs.



☐ **Refinery valve**—Needed: resistance to attack from petroleum products, thermal and hydraulic shock. Which alloy . . . ?



☐ **Turbojet afterburner shell** — Needed: strength plus corrosion resistance at high temperatures. Which alloy... ?

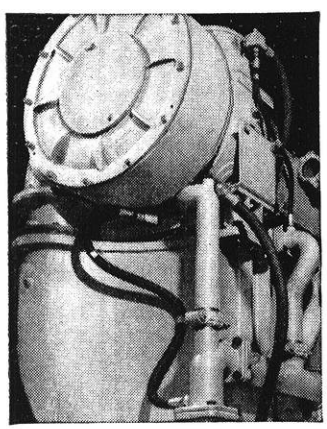


☐ **Recovery tower**—Needed: resistance to hot coke oven gases and aromatic chemicals, long service life. Which alloy... ?

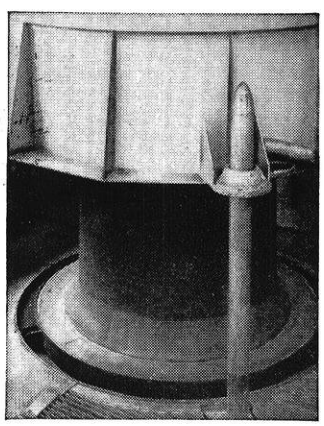
See if you can tell which of these nickel-containing alloys proved to be the answer to these problems. Put the right number in the right box.

1. Ductile Ni-Resist*
2. Nimonic "75"* nickel-chromium alloy
3. Nickel-aluminum bronze
4. Ductile iron
5. Monel* nickel-copper alloy
6. Inconel* nickel-chromium alloy
7. Type 316 chromium-nickel stainless steel

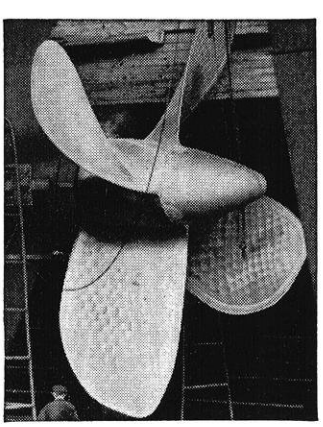
See answers below



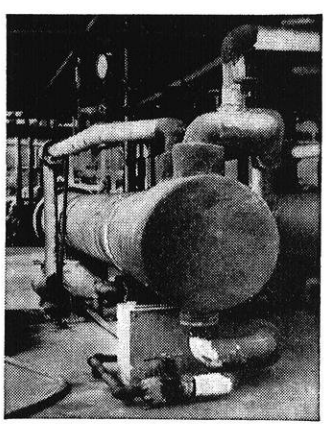
☐ **Diesel manifold** — Needed: scaling and oxidation resistance at 1200°F, resistance to thermal shock. Which alloy ?



☐ **Heat treating retort**—Needed: light weight, ability to endure destructive heating-cooling cycles. Which alloy... ?



☐ **Ship's propeller** — Needed: lighter weight and resistance to erosion and salt water corrosion. Which alloy... ?



☐ **Regenerator pre-heater** — Needed: trouble-free service handling hot caustics, fabricating ease. Which alloy... ?

When you start to design equipment, you'll have to select the proper material to meet given service conditions... a material that might have to resist corrosion, or wear, or high temperatures, or a combination of these conditions.

Over the years, Inco Development and Research has gathered information on the performance of materials in many such problems. Inco's List "A" and List "B" contain descriptions of 377 Inco publications which are available to you, covering applications and properties of Nickel and its alloys. For Lists "A" and "B", write Education Services.

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

*Registered trademark

ANSWERS:

- Refinery valve... Ductile iron
- Turbojet afterburner shell... Nimonic "75"
- Recovery tower... Type 316 stainless
- Diesel manifold... Ductile Ni-Resist
- Heat treating retort... Inconel alloy
- Ship's propeller... Nickel-aluminum bronze
- Regenerator pre-heater... Monel alloy

Inco Nickel

makes metals perform better, longer

Hoover Dam Construction

by Richard E. Herget, ce'61

Hoover Dam, America's greatest dam structure, provides the method and details of construction for most any type of dam. Yet this dam is different because of height and overall vastness.

BUILDING Hoover Dam was one of the most tremendous and interesting pieces of construction undertaken in the United States up to 1935. Power lines, roads and railroads had to be built from Las Vegas, Nevada to the dam site before any construction at the site could begin. Also Boulder City, a small city that still exists today, was built to house men working on the dam. Today the town is inhabited by the men who maintain the dam.

Construction at the dam site was started on April 20, 1931 and the last concrete was placed on May 29,, 1935. The contractors, Six companies Inc., did such a magnificent job that they finished two years ahead of schedule. This is truly amazing considering the large amount of rock excavated and the huge amounts of cement, steel and other materials that had to be gathered from all parts of the United States and put into the dam.

CHOOSING THE DAM SITE

After the decision was made to build a dam somewhere on the Colorado River the very important job of choosing the correct site was begun. The site not only had to have solid rock to support the dam, but it also was required to have a large enough reservoir capacity to control floods. Surveys and geological studies were made to find a suitable location.

First a topographic survey of 100 miles of canyon was made to find all possible locations that would satisfy the requirements. In taking this survey three men lost their lives. The rodmen had to be let down the canyon walls on ropes and many times they had to swing pendulum-like to reach otherwise inaccessible points. To indicate the unevenness of the canyon and the exactness of the survey, over 4,000 transit shots were taken in a horizontal area 320 by 660 feet. The maximum difference in elevation was 600 feet.

After the surveys were completed and all possible locations chosen, geological studies narrowed the sites down to five in Boulder Canyon and two in Black Canyon. These seven sites were then drilled to study bedrock under the river. From the seven, drilling eliminated all but one site in each canyon.

It was finally decided that the Black Canyon site was the best one for the following reasons:

(1) Rock at Black Canyon had fewer seams and appeared a little stronger than at Boulder Canyon.
(2) It had a greater reservoir capacity.
(3) It was located closer to the railroad at Las Vegas.
(4) The dam if located in Black Canyon would be below Collidle and Las Vegas Washes, thereby intercepting a larger drainage area.
(5) The same height dam built in Boulder Canyon would have submerged Overton, the principle town in Muddy Valley.

Up to 1947 the dam was called Boulder Dam, but it was then changed to Hoover Dam. Had this been done back in 1931 it would have avoided a lot of confusion. Books and articles discuss the main sites as Black and Boulder Canyons. The dam was then called Boulder Dam which gives one the impression that the dam was built in Boulder Canyon. But this is not true, it is in Black Canyon.

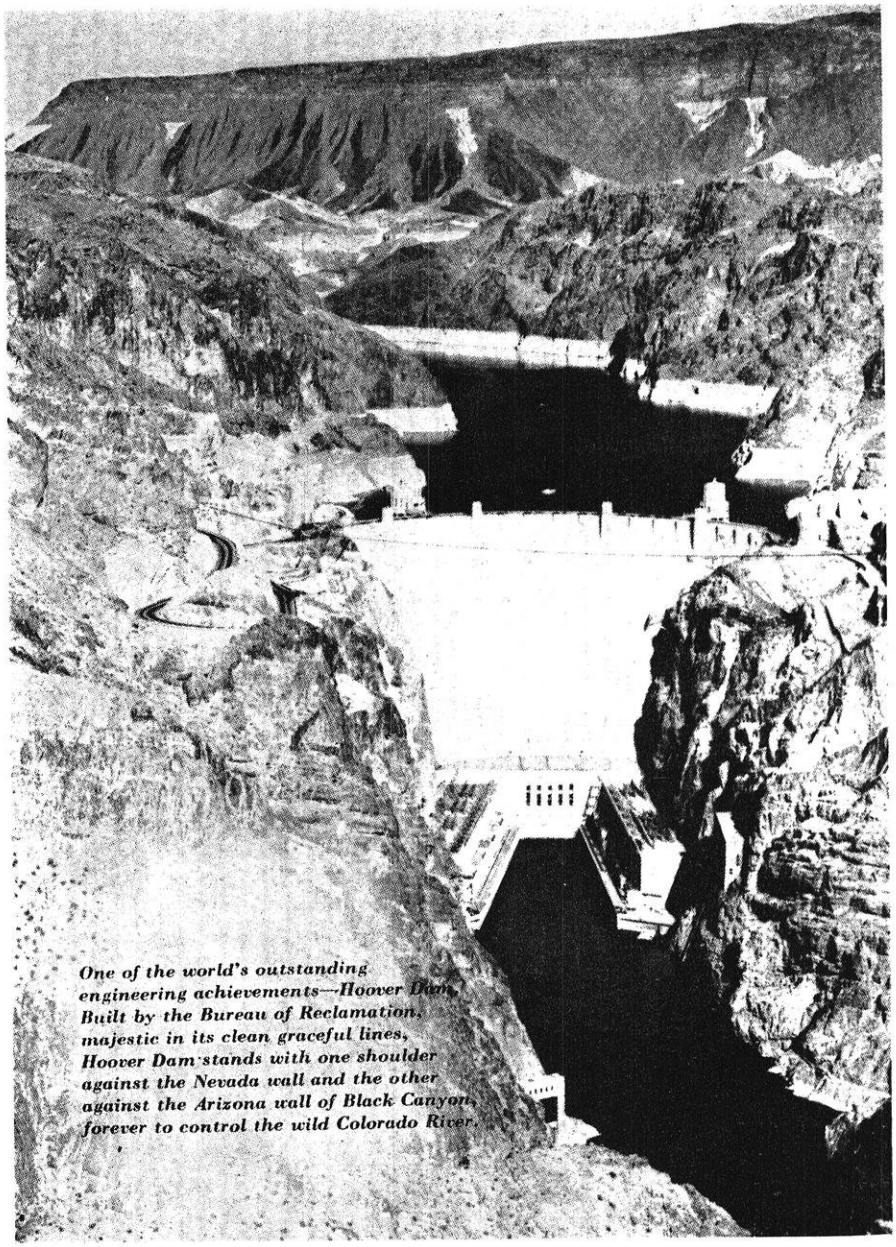
RIVER DIVERSION WORKS

Before any work on the dam could begin the Colorado River had to be diverted around the dam site. Because the site is in a deep can-

yon, the only way to do this was through large tunnels blasted through solid rock. The diversion system had to be safe and adequate because it would be used for several years. To protect the contractors from unforeseen floods the Government agreed to bear all expenses due to flood damage after they approved and accepted the diversion works.

The design used had a capacity of 200,000 second-feet. This would have been able to handle the largest flood ever recorded on the Colorado. The plan called for construction of four tunnels (two on each side of the river) of a combined length of 15,909 feet and two cofferdams. A capacity of 200,000 second-feet means that water can flow at the rate of 200,000 cubic feet per second.

Driving the diversion tunnels was a major operation involving blasting and disposing of thousands of cubic yards of rock. The tunnels enter the cliffs, which are 800 to 1000 feet above the water, about 2,000 feet above the dam site and come out about 2,000 feet below the dam. They follow roughly a semicircular path. The tunnels vary from 3,500 to 4,300 feet in length and they are 50 feet in diameter after being lined with three feet of concrete. The quality of rock is evident from the fact that no timber shoring was needed in any of the tunnels.



One of the world's outstanding engineering achievements—Hoover Dam. Built by the Bureau of Reclamation, majestic in its clean graceful lines, Hoover Dam stands with one shoulder against the Nevada wall and the other against the Arizona wall of Black Canyon, forever to control the wild Colorado River.

Excavation of the Tunnels

In digging these huge passageways, first a 12 by 12 feet hole called the "top heading" was removed. Then the main part, or "bench", was taken out and last to go was the invert section. The wing sections were removed along with the bench. All of these sections had to be drilled and blasted. To do the drilling a carriage arrangement which had several drills was built on a truck body. Then after each shot was made and the loose material cleared away all they had to do was back the truck into place, hook up the air and water hoses and they were ready to drill again. On the bench it only took 20 minutes to be prepared to drill after the mucking shovels got out of the way.

Mucking (removal of waste) was done by eight 100 ton electric shovels equipped with 3½ cubic yard rock diggers loading into about 100 dump trucks ranging from 7 to 16 c.y. capacity. As soon as the blasting was done the shovels would move up and begin loading rock. It took approximately seven hours to remove 860 c.y. of rock, which was the amount loosened by the average dynamite blast. Total time for drilling, blasting and mucking averaged out to about 14.5 hours.

Disposing of this tremendous amount of material, nearly 1,500,000 cubic yards, was a very difficult task because no material could be dumped where it might block the river. Some was used to widen the railroad grade going into the canyon, but much of it was hauled 3½ miles to the Hemenway Wash dump grounds.

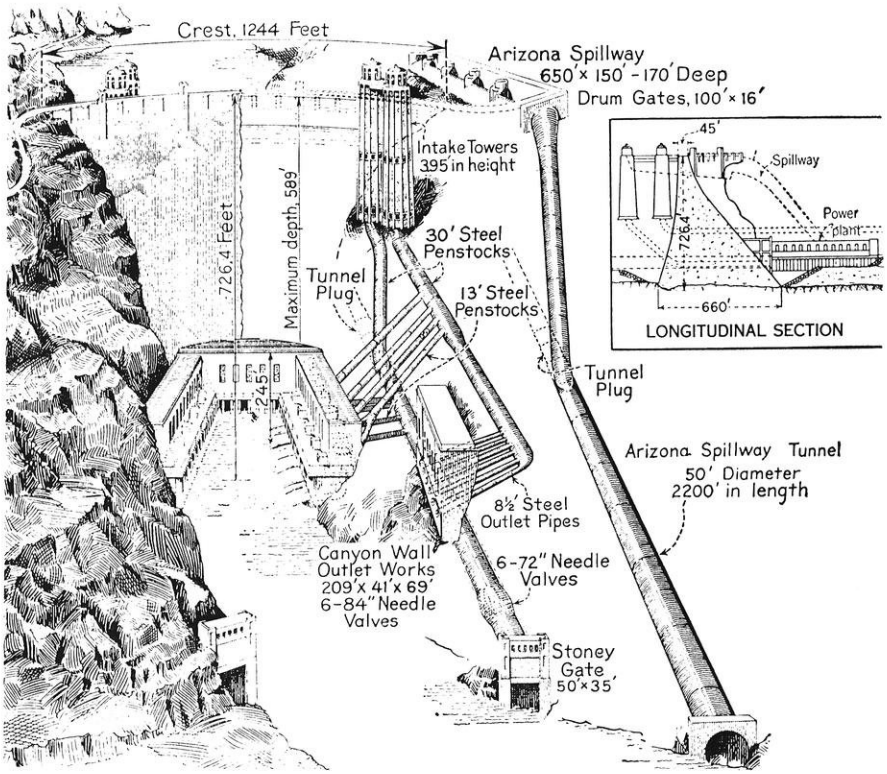
Lining the Tunnels with Concrete

The tunnels were cut roughly to 56 feet in diameter and then lined with three feet of concrete with a minimum thickness of 24 inches. Three sets of forms were needed for the lining operation. One set for the invert section, the bottom 74°, which was poured first; a set for the side walls, 88° on each side, which was poured next; and for the last pour, a set was needed for the top 110°. These forms were made of timber and 2,000 tons of steel at a cost of $325,000.

Concrete for the tunnels was mixed at the low-level mixing plant located 2,000 feet upstream from

the Nevada portals. The concrete was placed in the invert and side wall sections by chutes and hoppers, but it had to be blown in the top with concrete guns. After the concrete had set, grout (a mixture of cement and water) was forced into holes under a pressure of 50 to 100 pounds per square inch. This was done to fill any space between the lining and the rock wall. A total of 122,000 feet of grout holes were drilled and 200,000 cubic feet of grout was used in the diversion tunnels.

The primary use of the tunnels was, of course, to divert the river around the dam site during construction. But this is not their only use. The two nearest the river were closed off above the dam with concrete plugs and below the dam they were installed with needle valves. They serve, through the penstock pipes, as outlets for regulating the flow of the river below the dam. The outer pair of tunnels were also plugged above the dam and are connected with the spillways to form outlets for any overflow of water.



Some of the major details are shown above.

Cofferdams

Cofferdams were built to get the river to flow into the diversion tunnels. Because of the importance of these dams, they were built permanent in nature. After all, they were the only thing between the construction crew and the mighty Colorado. If they ever fell apart a great deal of damage would have been done to the big dam along with the loss of many lives, so it was necessary to do a good job at this phase of construction.

The temporary cofferdams were made of rock and earthfill with no particular care as to the quality. They were just built to hold back the water long enough to build more permanent structures. On the permanent cofferdams much more care was taken to be sure and use only good quality material. A mixture of silt, sand, and gravel was found in Hemenway Wash which was ideal for the earth-fill part of the dams. The earth-fill was covered with a rock blanket of a maximum size of one cubic yard in volume. On all of this was placed a layer of concrete.

Before anything could be done two temporary dams of earth and rock had to be thrown across the river in a hurry. This was done in less than 24 hours. The area between them was then pumped dry and excavated to get a good foundation for the permanent cofferdams. After a good base was reached, layers of rolled earth, not more than 12 inches thick after rolling, was laid down until the proper elevation was reached. Each layer of earth was thoroughly moistened to secure maximum compaction before the next layer was added. On top of the earth a three feet thick blanket of rock was placed to protect it from the terrific pounding of the river. The upper cofferdam was then covered on the upstream side with a six inch layer of reinforced concrete. The lower dam was not covered with concrete, just the rock. The lower temporary cofferdam was widened with rock to form a protective barrier to keep back-wash from the diversion tunnel outlets from washing away the permanent cofferdam.

The cofferdams had only one use. They were to keep the area around the dam site free from water during construction.

Building of the Dam

Building Hoover Dam consisted of three phases: first excavation of the foundation; second grouting the foundation; and last, building the dam itself. These three parts constitute the major portion of the whole Boulder Canyon Project. The dam is of arch-gravity type construction in which the water load is carried by both gravity action and horizontal arch action. The maximum pressure at the base of the dam is 45,000 pounds per square foot.

This was perhaps the most important part of the whole dam-building project because the dam had to have good solid rock for support. Excavation was done in two separate parts; first scaling the canyon walls and second digging to bedrock in the river bed.

The job of stripping the loose and unsatisfactory rock from the abutments was done as much as possible by barring. Some blasting was done, but it was kept at a minimum to keep from damaging the solid rock that the dam would rest against. Also only the least amount of material to reach good rock was removed because tests showed that the quality of the canyon walls was such that it was stronger than the concrete that would replace it.

(Continued on next page)

More than 137,000 cubic yards of waste was taken off the canyon walls. Waste was allowed to fall into the canyon and hauled away with the muck from the river bed.

Excavation of the canyon floor was carried on at the same time as stripping the canyon walls and building the cofferdams. To fully utilize the equipment and complete the job sooner, the contractors had the trucks haul material to the cofferdams then pick up a load of waste from the river bed. They hauled the rock back to the same railroad cars that brought earth-fill from Hemenway Wash. The trucks would then load up on fill there and start the cycle over again. This worked very well because the waste dumping grounds were in Hemenway Wash near the same place where they were getting cofferdam fill. In doing this they saved a great deal of time and money.

Digging of waste was done by the same electric shovels previously used in the diversion tunnels. They were equipped with 3½ cubic yard shovels and loaded 70 to 80 trucks, ranging from 7 to 16 yards capacity, at the rate of five per minute. A total of 1,636,500 cubic yards of rock, silt, sand, and gravel was removed from the canyon floor in about seven months. This material was not all from excavation for the dam foundation. Some was from the canyon walls and some from the diversion tunnels.

Preparing the foundation consisted of removal of all loose material from the bedrock and pressure grouting the seams and springs. As I have already talked about waste removal I will dispense with that and begin with grouting.

Grouting had two objectives: one to form a barrier to prevent water seepage under the dam, and second to form a good solid base for the dam to rest upon. Grout holes were drilled with diamond-tipped drills and then filled with a mixture of cement and water. Most of the holes were filled from portable grouting plants mounted on 5 ton trucks. These trucks were needed for their mobility because of the wide area that had to be grouted. The portable plants consisted of a grout mixer, a sump, a water tank and two air driven pumps. For most of the grouting, pressure ranged from 100 to 750 pounds per square inch. The exception was the springs where the pressure went as high as 1000 pounds per square inch. A total of 130,000 lineal feet of holes were filled with 116,600 cubic feet of cement.

Construction of the Dam Itself

Construction of the dam posed a great problem because of the huge amount of concrete that went into it. The amount of concrete used in Hoover Dam would pave a 16 feet wide highway from San Francisco to New York; or it would build a monument 100 feet square 2½ miles high; or if placed on an ordinary city block it would rise higher than the Empire State Building. If this concrete was allowed to cool by itself it would have taken 100 years or more. Normally concrete dams require either radial or circumferential expansion joints. But because of its great height and thickness Hoover Dam took both type joints. The dam is 726.4 feet high and 660 feet thick at the bottom.

The dam was built in blocks or columns because of its immense thickness and width. Each block on the downstream face of the dam is about 25 feet square. On the upstream side they are about 60 feet square. The forms used were made of timber covered with sheet steel and were used over and over on the same column. The blocks were poured in five foot vertical sections with a maximum difference in height between adjacent columns of 35 feet. Also not more than a five feet thick layer could be poured in 72 hours in any one block and not more than 35 feet high could be placed in 30 days. To allow for cooling an eight feet wide slot was left vacant down the middle of the dam. As soon as each 50 feet high section was cooled and grouted the slot was filled.

Placing of the 3¼ million cubic yards of concrete, at the rate of 138,000 yards per month, was done for the most part with four 20 ton cableways. Where the cableways could not reach, some cement was placed by derricks mounted on the canyon walls. The buckets used were bottom dump buckets that could only be opened by men at the dam or by setting them down on a solid object. This was a safety precaution to protect workers from having concrete fall on them from above because the cableways carried it over quite a few men before reaching its destination. The cableways had selfpropelled head and tail tower so that material could be moved almost any where it was needed. In the restricted areas or where a slow rate of flow was needed, concrete was placed by 4-cubic yard agitators or 2-cubic yard hoppers.

There were quite a few restrictions as to the placement of concrete. No concrete could be placed without the presence of a government inspector. Also the top of each block had to be washed and covered with a layer of mortar to insure a good bond between layers. And no concrete could be dropped over five feet.

The concrete for the dam was mixed at both a high-level and a low-level mixing plant. Both plants were located on the Nevada side of the river; the high-level one about 700 feet upstream from the dam on top of the canyon and the low-level one about 4,000 feet upstream from the dam down in the canyon. Concrete from both batching sites was loaded into the eight-cubic yard buckets. The buckets were then placed on railroad cars and hauled to the cableways where they were taken from the cars and moved to the dam for placement. The operation of the cableways was very difficult because the operator was a long way from the point of placement and had to have signalmen to give him directions. The signalmen had to determine the exact point on the cable, a quarter of a mile above, where he should stop the carriage so that the bucket, dangling 700 feet below the cable, would complete its swing over the point of use. At the moment the bucket reached the end of its swing the carriage had to be brought directly overhead to stop the pendulum action. This required a great deal of skill and coordination between the operators and signalmen.

Because of the mass of concrete poured in the dam, cooling had to be done artificially or it would have cracked. To do this cooling a large cooling plant was set up to first circulate air-cooled water and

(Continued on page 54)

René Descartes...on the light of reason

"Hence we must believe that all the sciences are so interconnected, that it is much easier to study them all together than to isolate one from all the others. Therefore, if anyone wishes to search out the truth of things in earnest, he should not select any one special science; for all the sciences are conjoined with each other and interdependent: let him think only about how to increase the natural light of reason, not in order to solve this or that difficulty of a scholastic nature, but that his understanding may direct his will to its proper choice in every contingency of life."

—*Regulæ ad Directionem Ingenii, 1629*

THE RAND CORPORATION, SANTA MONICA, CALIFORNIA

A nonprofit organization engaged in research on problems related to national security and the public interest

SIX PERTINENT QUESTIONS TO ASK THE ALCOA RECRUITER WHEN HE VISITS WISCONSIN

Here's What You May Want to Ask About Opportunities at Alcoa

1. Where can I go in Alcoa with my type of degree?
2. In what part of the country would I be located?
3. What kinds of training programs will I participate in at Alcoa?
4. What are my starting salary prospects?
5. Will Alcoa pay my moving expenses?
6. What are my chances for advancement with Alcoa?

And Here's What We Answer:

1. There are openings at Alcoa each year for graduates with many types of degrees. Graduates in mechanical, metallurgical, electrical, industrial, chemical and civil engineering have a wide choice of opportunities in engineering, production, research, development or sales engineering. There also are openings for chemists for research and for business administration and liberal arts graduates in accounting and sales.

2. Geographical location will depend on your field. New engineering, production and accounting employees are assigned to one of 30 Alcoa operating locations throughout the nation. New sales engineering and sales administration employees, after completing a six-month training program, go to one of Alcoa's 72 sales offices. If your field is sales development or process development, you will be located in New Kensington, Pa., or Cleveland, Ohio. Main research laboratories are located in New Kensington, with branches in Cleveland, East St. Louis, Ill., Massena, N. Y., and Chicago.

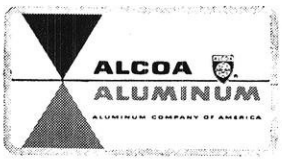
3. Alcoa has a training program for each new employee. Engineering and production training involves orientation and rotation of assignments for approximately one year. Sales training is conducted in sales offices and in nine plant locations over a six-month period. Accounting training calls for rotation of assignments for 18 to 24 months.

4. Alcoa's starting salaries are competitive with those of other companies. An initial salary is established for a basic four-year degree. Additional credit is given for outstanding personal qualifications, advanced educational training, military service and previous work experience. Future salary progress is based on your own performance and growth potential.

5. Alcoa pays transportation and moving expenses for you and your family. This applies to your first and all subsequent assignments.

6. Alcoa personnel policies assure individual recognition for you. They include regular performance appraisals, individual opportunity for advanced management training, confidential and individual salary consideration and promotion entirely from within the company.

If you'd like to find out more about employment opportunities with Alcoa, contact your placement officer to arrange a campus interview. Mutual interest will result in further interviews at an Alcoa location. For more details immediately, write Manager, College Recruitment, 810 Alcoa Building, Pittsburgh 19, Pa., for the new booklet, *A Career for You With Alcoa.*



Your Guide to the Best in Aluminum Value

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

SCIENCE HIGHLIGHTS

Tom Sobota ee'60

NEW TOOL MANUFACTURING PROCESS PROMISES TO SAVE AMERICAN INDUSTRY $35 MILLION ANNUALLY

A radically different tool 'make-up' process gives every indication of saving American Industry an estimated $35 million a year in initial and replacement tool costs. This estimated saving has been calculated by Spiral Carbide Tool Co. on the basis of a new manufacturing process for cutting tools. The method, as developed by Spiral, uses a new approach to tool construction and eliminates a number of basic machining operations previously used in the manufacture of cutting tools. The new method is applicable to many types of tools, including carbide and HSS types. Besides the cost savings advantages, the method is also said to improve tool performance.

In addition to initial tool-purchase cost savings, the new process also slashes tool replacement costs up to 50%. Substantial tool savings are also visualized through the lower inventory levels necessary for the new tools.

These 'new-type' cutting tools are made up using a pre-formed metal wafer construction. These wafers are fabricated with the major geometrical configurations of cutting tools already incorporated into their design. They are then assembled on arbors of various sizes corresponding to standard sizes, lengths and styles of tools already in use. Either HSS or carbide cutting tips are placed into appropriate cutouts and the entire assembly is then brazed into a solid mass.

The improved tool performance is due to the increased density of the new tool. This increased density acts as a vibration dampener, with a tendency toward the elimination of tool chatter caused by vibrations developed by the machining operations. Tool chatter can fracture the ultra-hard cutting tips. Tool life is also improved because the construction allows for a better dissipation of heat at the cutting edges, a major cause of tool breakdown.

FIVE REVOLUTIONARY TRANSPORTATION IDEAS

Two thousand mile an hour airliners possible by 1965 will combine with monorail airtrains, new "limocopters," vertical takeoff aircommuters and fast regional airliners to revolutionize larger cities' mass transit systems in the sixties, a Lockheed transportation engineering study has predicted.

Tomorrow's travel will be so voluminous and so keyed to speed that an entirely fresh approach—involving five basic vehicles—will be needed to move the masses of people "to, within and from" modern cities, according to Robert A. Bailey, chief engineer of Lockheed's California Division.

"Long-trip travelers using supersonic airliners will demand a way to get to and from airports free of surface traffic restriction," Bailey declared. "The faster, off-the-ground vehicles for this purpose can also give wings to today's strap-hanger, lone-wolf motorist and car-pool rider.

"It is time to junk our piston-age, surface-tied concepts of public transit," the engineer continued. "We must prepare to airlift the many millions who in a few years will be thoroughly frustrated by stop-and-go lights, clogged highways and old-fashioned rolling vehicles."

Bailey listed these prime reasons why cities must look forward—and use five basic vehicle types—for public transit in the sixties:

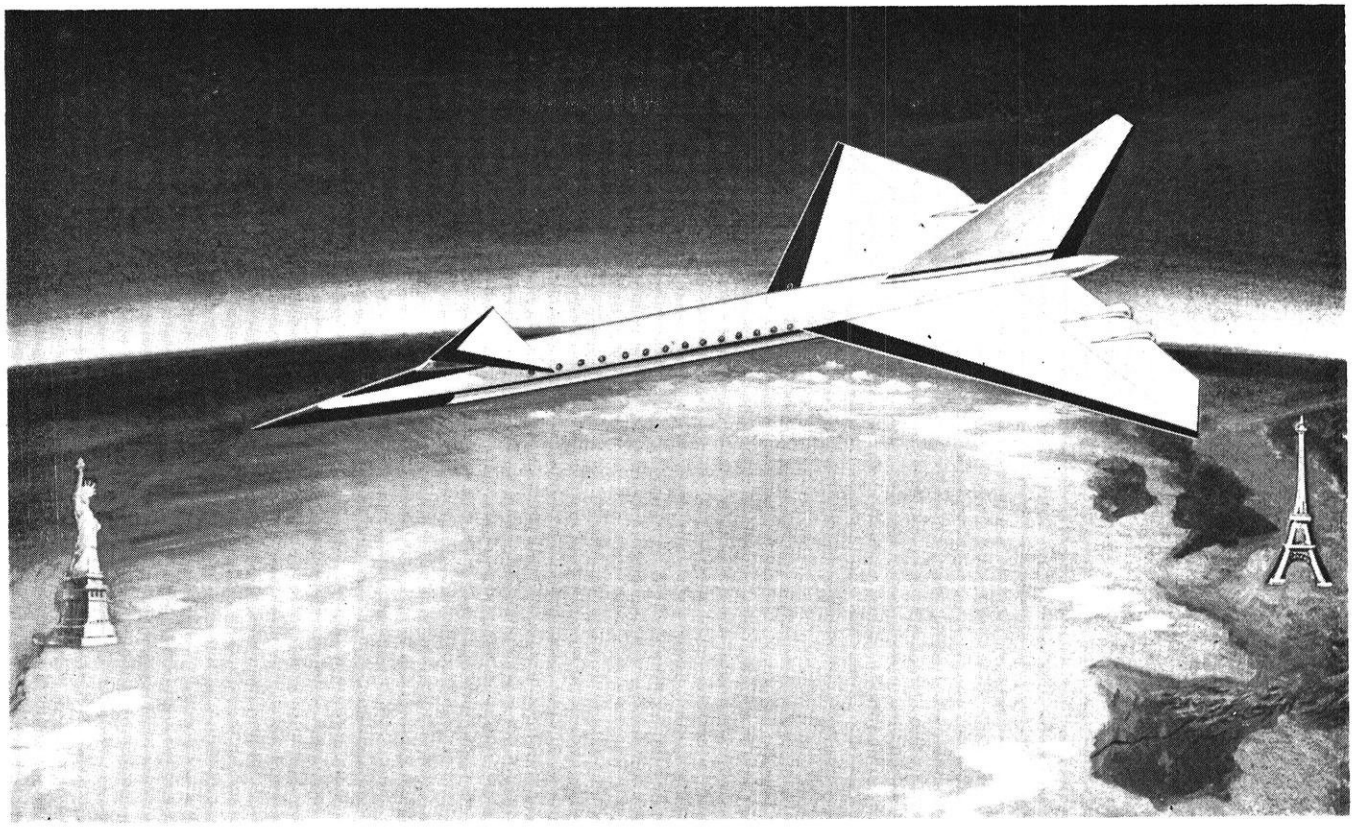
1. It will be "ridiculous" to spend two to four hours getting to and from a triple-sonic airliner that crosses the nation in 80 minutes or spans the Atlantic in 2 hours.

2. Recent technological strides are bringing closer the day when aircraft that take off and land vertically can operate into the heart of a city.

3. Any travel improvement always increases travel volume.

4. Faster, more modern vehicles, some requiring only a rooftop or vacant lot as a base, must be integrated with feeder systems such as monorails or helicopters.

5. As cities spread out and suburbanism grows, more persons must travel farther and longer—with increasing ground traffic congestion.



Here is Lockheed design of 2000-m.p.h. airliner, flying three times speed of sound, which future transportation planners predict will cut long-distance travel time so drastically that revolutionary overhaul of supporting transit systems will be mandatory in major cities. Powered by chemically fueled jet engines, it would carry around 80 passengers and could operate from standard-length metropolitan runways. It would cross U.S. in 80 minutes, fly New York–Paris in two hours, enable Londoner to have breakfast at home, do business in Los Angeles same morning and return for dinner in London.

Cities can solve their traffic dilemmas by lifting transit systems off the ground and utilizing new vehicles already available or soon to materialize, Bailey urged.

"We have to get up to go," he summarized.

"Today's streets are nothing but long obstacle courses—and freeways or expressways often are little better."

Bailey said the 2000-m.p.h. airliner will so obsolete present supporting transit systems that the need for modernization will be "dramatically apparent" starting perhaps by 1965.

Carrying around 80 passengers and powered by chemically fueled jet engines, such supersonic transports will be economical on routes of 1500 up to 3500 miles, the Lockheed executive reported. Models have been wind-tunnel tested and designs are being presented privately to both airlines and military agencies.

Second in the five-vehicle complex would be a 475-m.p.h. prop-jet airliner linking small and medium cities with metropolitan centers. This type could carry up to 100 passengers. It would fill flight needs up to 1500 miles—and even more—yet could provide unmatched economy and speed on mass-haul routes of 200 to 500 miles.

This regional airliner might be a follow-on version of todays Electra prop-jet, which cruises 410 m.p.h. More powerful engines are being developed for potentially faster speed.

Third would be a so-called "air-commuter," designed either to take off straight up and land straight down or use a runway as short as 500 feet. Capacity: 40–50. Speed: 300–350 m.p.h. Range: 25 to 200 miles.

Bailey said such aircraft are possible in about seven years. They could feed main trunk airlines or, as a businessman's special, land on a downtown rooftop. They may be powered by advanced prop-jet engines or new turbofan engines.

"Now in preliminary design, this vehicle may prove one of the most important developments in commercial aviation history," Bailey said.

Fourth basic vehicle would be a limousine-type helicopter, or limocopter, for trips within large cities, to nearby suburbs, or to transit terminals. It would carry about 10 persons. It would be more economical than helicopters now flying because of simplified mechanical techniques recently developed, Bailey emphasized. Tenth-scale models have been successfully flown.

Fifth—and probably the most widely used—would be a new type monorail, similar to the system Lockheed will build at Seattle to run from a downtown shopping area to the Century 21 Exposition scheduled for 1961.

Seen as best for heavy-volume metropolitan travel routes, the monorail plan would utilize multi-car airtrains riding atop supported rails 16 feet above ground. They could move 200 or more passengers per train at 60–75 m.p.h. in densely populated regions or connect population centers with major business and shopping districts, airports, sports arenas and recreation areas.

"Air travel progress is moving rapidly," Bailey said, "but support-

(Continued on next page)

ing transport systems to match them in speed and efficiency are being neglected. In no city in the world is there a fully coordinated tie-in between main airlines and the myriad systems of taxis, buses, trains, helicopters and feeder airlines supporting them.

"It is time now to recognize that a transportation revolution is certain sometime during the next 5 to 15 years. It is time now to plan to think big—and think in terms of faster travel—to avoid sinking millions in some conventional surface facilities that might soon be a waste of money, a waste of time—and a step backward."

SAVANNAH FORERUNNER OF FUTURE ATOM-POWERED OCEAN LINERS

The future role of atom-powered commercial surface vessels rode with the N.S. Savannah and her nuclear core when the 21,000-ton merchant ship was launched on July 21.

The fact that heat from fissioning atoms of uranium can be controlled in a reactor and removed by a liquid coolant, such as water, to form steam has been established for many years. The submarine Nautilus was first to take the atom to sea in a pressurized water reactor more than five years ago. Her performance record proved that nuclear propulsion is both practical and safe.

The lag between military and commercial application of nuclear power reactors is a result of cost justification. Cost of military applications is more easily justified than commercial applications which must be competitive. The gap is steadily closing. While cost of nuclear power plants runs high, their obvious advantages in terms of the small amount of fuel needed to operate them over long periods of time has made the atom an increasingly attractive source of energy.

In the Savannah, nuclear power will get its first test as a practical means for commercial marine propulsion. Close study of the Savannah's reactor and propulsion system will be made by marine specialists and nuclear industry's scientists and engineers. This study will continue during the 3½ years the ship is expected to operate under nuclear power before her original atomic core needs to be removed for refueling.

The Babcock & Wilcox Company, designers and builders of the advanced nuclear reactor that will power the Savannah, has estimated that its version of the pressurized water power reactor will propel the sleek, stackless ship more than 350,000 miles on its initial charge of uranium fuel.

Less fuel burn-up per unit of power is just one of many advances incorporated by B & W's nuclear specialists in the design and development of the Savannah reactor. Metallurgical research has led to new metal alloys and techniques that have increased efficiency of heat extraction and transfer. This translates into more shaft horsepower for every calorie of heat generated in the fission process.

Improved shielding makes possible access within the containment vessel in a matter of minutes after shutdown. The Savannah represents the first, large scale, practical use of polyethylene plastic as a biological radiation shield. The containment vessel that surrounds the reactor system will have a six-inch layer of polyethylene over a six-inch layer of lead.

Although the nuclear power plant for the Savannah is considered an advanced design, it is conservative in that it purposely incorporates maximum shielding, control and protective features to assure optimum operational reliability and the safety of her crew and passengers.

Following sea trials scheduled to start in the spring of 1960, the experience gained under varied operating conditions expected during the initial 3½ year run under nuclear power will undoubtedly lead to dramatic refinements in future marine reactor plants. Reactors should become more sophisticated and may well become economically competitive as well as preferred over conventional methods of marine propulsion.

Thus, in addition to being an atomic ambassador for the United States, the Savannah will help bridge the economic gap between fossil fueled and nuclear fueled ships, that someday may take Mr. and Mrs. Average America on an atomic cruise.

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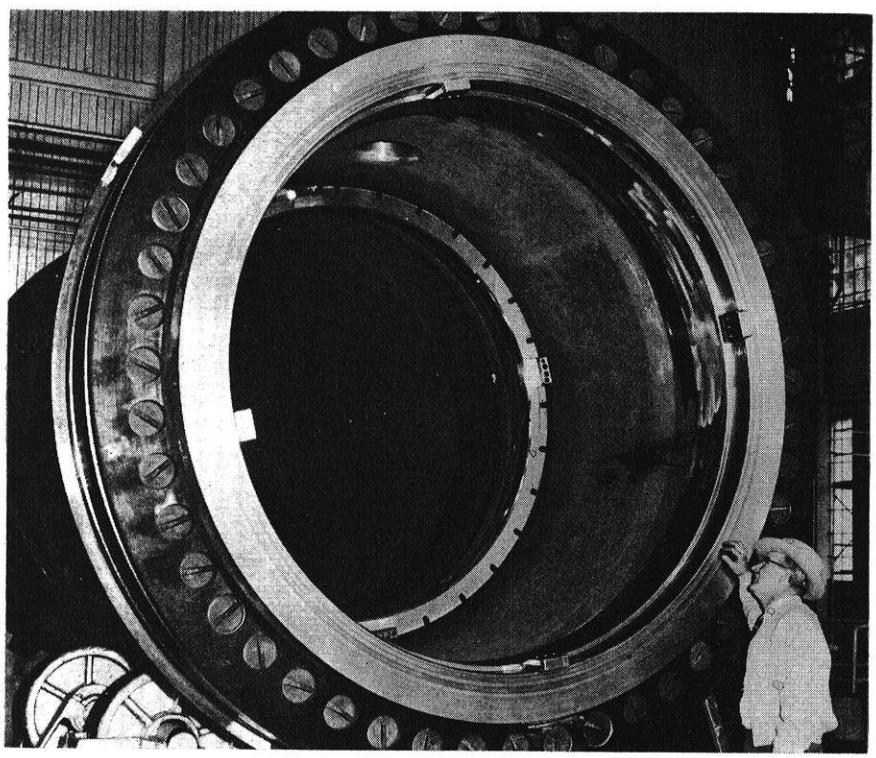
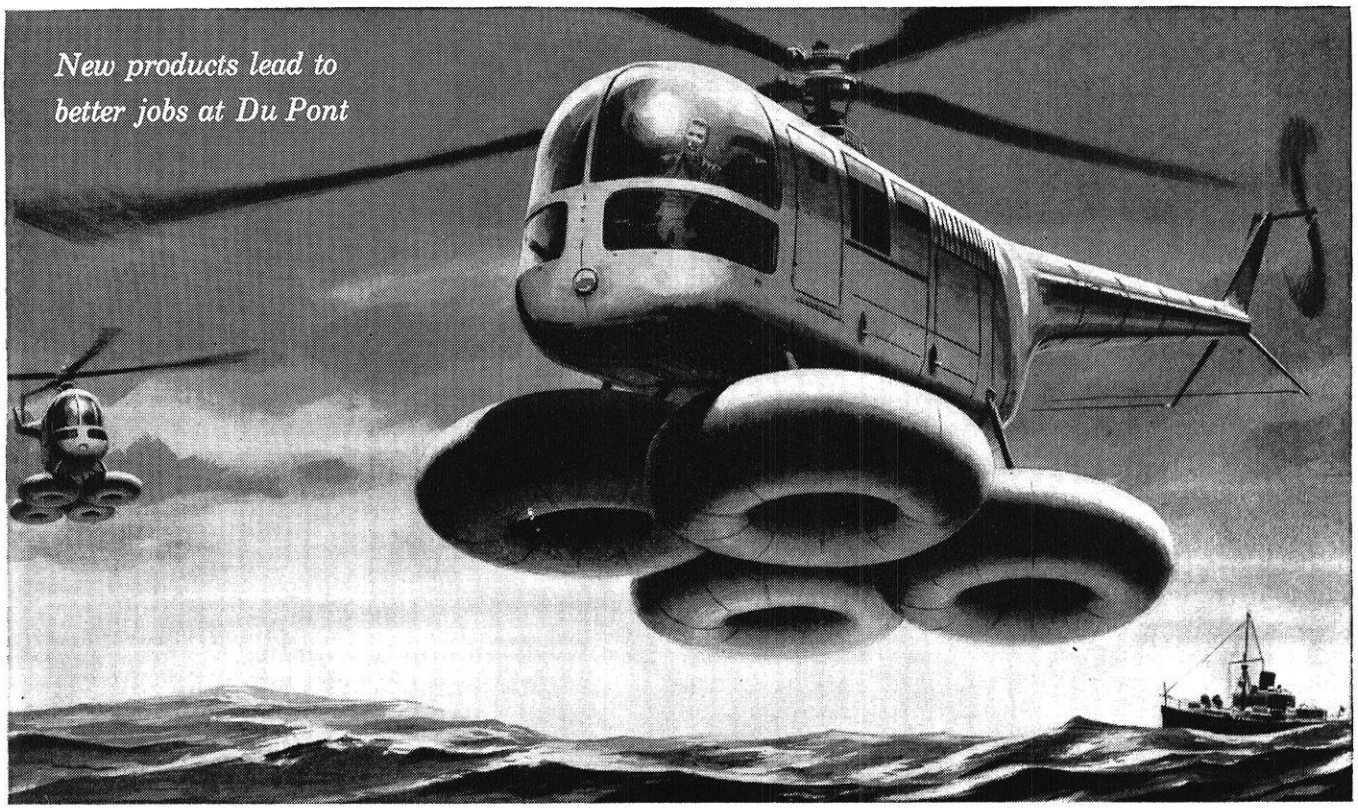


Shown here is the interior of the "atom furnace" in which nuclear fuel will be "burned" to propel the N. S. Savannah, world's first cargo-passenger ship to be fueled by atomic energy. Because corrosion is a particularly pressing problem in nuclear reactor pressure vessels, the entire inner surface is cladded, or bonded, with a thin layer of stainless steel. When she begins her first cruise in 1960, the Savannah will be capable of traveling 355,000 nautical miles on one atomic core.



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This year nylon, product of Du Pont research, is 20 years old. Since its discovery, hundreds of new jobs have been created. To improve it in the laboratory. To make it in the plant. To find new uses. To advertise it across the nation. To sell it in world markets. These new jobs range from trainee to administrator.

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At the bottom rung of the technical graduate's ladder, you are given an actual project assignment almost at once and begin to learn your job by doing it. All training is personalized—tailored to your background and interests. It permits periodic evaluation of your performance. Our promotion policies are based on the conviction that you should work at the top of your ability. It stands to reason, then, that the better your training, the more rapid your rise is likely to be . . . and the brighter your future.

If you would like to know more about career opportunities where growth through research has been the history and continues as the objective, see your placement officer for literature, or write E. I. du Pont de Nemours & Co (Inc.), 2420 Nemours Building, Wilmington 98, Delaware.

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Better Things for Better Living . . . *through Chemistry*

ENGINE EARS

by Bob Helm ce'61

TRIANGLE FRATERNITY

Triangle, carries on a social program which is adjusted to the spare time of its engineering members. Parties are held after football games and approximately every two weeks thereafter. Extracurricular activities include participation in volleyball, football, softball, basketball, and bowling, membership in the engineering societies, positions on the Wisconsin Engineer, and Parent's Weekend tours.

Why be a fraternity man? Or more specifically what has membership in Triangle Fraternity to offer to an engineering student? This is a question that many students have asked themselves. The answer to this query can be gleaned from what the fraternity strives to attain and from what the fraternity offers to its members.

Triangle, as a fraternity, has always sought to mold its members into individuals who will be a true asset to society. Towards this end, it strives to inculcate in the member a sense of real brotherhood through mutual social and extracurricular activities, while at the same time to impress upon the student the genuine value of scholastic achievement.

Scholastic achievement is realized through time spent in studying together or with help from upperclassmen in addition to the individual effort which is so necessary to an engineering education.

Triangle has much to offer its members. First of all, there are the opportunities of personal improvement which are had by living in brotherhood with fellow students all seeking to attain the aims of the fraternity. Secondly, there is the asset offered by all fraternities, the cultivation of close and lasting friendship, which is, in the case of Triangle, magnified by reason of Triangle being a professional fraternity, one in which the membership is drawn from a specific field of achievement. By this selectivity a member is kept in a close relationship with men in his chosen field of endeavor. This is of incalculable professional value to the member since it is certain that one will find at least one brother, often in key positions, in practically all technical or scientific organizations and firms.

Thirdly, Triangle offers its members the comforts and pleasures of living at the chapter house together with their friends and brothers.

The chapter house is located at 438 North Frances in the heart of the campus community. Plans are being made for a new chapter house on Breese Terrace where we will be closer to engineering school yet still in contact with the campus.

Each year Triangle welcomes into its ranks many new members.

The procedure to be followed in the acquisition of new members is specified in the National Constitution. Students interested in Triangle are encouraged to attend all rushing smokers and after the prospective member signifies by his actions a sincere interest in Triangle, the fraternity strives to help in every way possible to aid the student to get to know the fraternity better. It can justifiably be said that if you are interested in Triangle, Triangle is interested in you.

Once the desire of the student has been recognized and he has been found to measure up to the standards demanded by Triangle, he is pledged. His pledgeship is "a period of testing, some reworking, and considerable tempering." If during his period of pledgeship, the student exhibits that he is truly acceptable and desires to become a member, he is initiated into the fraternity as an active.

Triangle as a fraternity is a living organization and as such can be counted as worth no more than what its members are. The worth of Triangle has been, is and will continue to be of the highest because it demands much of its members and aids greatly in the realization by its members of its chosen ideals.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The student chapter of the American Institute of Chemical Engineers is a professional engineering society open to all chemical engineering students, both undergraduates and graduates. Its purpose is

(Continued on page 32)

FRESHMEN - SOPHOMORES - JUNIORS

The Wisconsin Engineer offers you an opportunity for new and interesting activities while serving the engineering students and faculty of Wisconsin as a member of the Business and Editorial staffs of this magazine.

CONTACT:

DON ROEBER
Editor
AI 5–6252

OR

SALLY TRIELOFF
Business Manager
CE 3–3674

WISCONSIN ENGINEER STAFF BANQUET—SIMON HOUSE

Left to right, Prof. Sell, chairman of board of directors; Prof. Asmuth, faculty advisor; Wayne Rogers, retiring editor; Prof. Carbon, main speaker; Sally Trieloff, business manager; Don Roeber, new editor.

Campus News

(Continued from page 30)

to present the professional as well as the technical side of chemical engineering to its members in order to assist them in achieving a better understanding of their chosen profession.

This purpose is accomplished through monthly meetings at which chemical engineers presently working in industry speak to the group on a variety of topics ranging from technical subjects to a description of their own work as an engineer. The meetings are always followed by an informal discussion period with the speaker over beer and chips.

Through these monthly meetings, the open house in the fall and the annual spring picnic, the members become better acquainted with their fellow students, the members of their faculty, and, most important of all, with chemical engineering.

The dues for student chapter membership are only $2.00 per year. An undergraduate who is a member of the student chapter after graduation may join the national chapter of A.I.Ch.E. as an associate member at which time the entrance fees of $5.00 are automatically waived.

This article is a personal invitation to all chemical engineers to join A.I.Ch.E. Remember, being affiliated with your professional society is a widely recognized indication of interest in your profession.

Officers for 1959–60:

President—Warren Haug
Vice President-Treasurer—Rod Higbie
Treasurer—Gerald Tice
Polygon Board Representative—Larry Dodge

SOCIETY OF AUTOMOTIVE ENGINEERS

SAE, the Society of Automotive Engineers, is an organization where leading engineers and those just entering the engineering field meet to exchange information on new developments in the automotive field. Most people have the impression that the automotive field means Detroit and passenger cars. On the contrary, although passenger cars are included, SAE has many other lines of interest. Among them are the following.

1. Air transport
2. Aircraft
3. Diesel Engine
4. Engineering material
5. Tractor and Farm Machinery
6. Trucks and Buses

The SAE Student branch meets once each month to provide excellent speakers from industry on the above topics, and movies and slides to assist the speakers. The first meeting of the school year, 1959–1960, will be Wednesday, September 23, 1959 at the Memorial Union. This meeting will consist of movies on racing, and an excellent speaker on some of the aspects of racing. All the engineers are invited to this meeting, and memberships can be obtained at the meeting if desired.

Attending the meeting will also give you a chance to meet the new officers for the year. They are as follows:

Chairman—Don Willam
Vice-Chairman—Cliff Torason
Corresponding Secretary—Mike Thomas
Recording Secretary—Jim Walker
Treasurer—Jim Donovan
Polygon Representatives—Dave Salzman and Dennis Witte

For further information about SAE, or for membership, please feel free to call on any of the above officers.

ALPHA CHI SIGMA

Alpha Chi Sigma Fraternity is composed of men who have chosen chemistery and its related fields as their professions. The fraternity was founded at the University of Wisconsin in 1902 by nine young men who felt the need for an organization capable of providing not only the ordinary benefits of fraternal affiliation, but also the comradeship of striving toward a common goal. In the years since its beginning, Alpha Chi Sigma has fulfilled the hopes of its founders and expanded from Wisconsin to become a national organization. It now has nearly 30,000 members, through sixty-six collegiate chapters at the major universities of the country.

Scholarship—Scholastically, Alpha Chi Sigma has always been among the very top of the all-fraternity list, with an undergraduate average that generally runs over 3.0. House quiet hours encourage an atmosphere of study which is contagious. At the house an up-to-date file is kept of notes and exams in chemistry and engineering courses. This file is handy for reference and review. If a prof didn't make something quite clear in lecture, there is always a classmate or graduate student who is willing to help.

Social Activities—Even the most ardent chemist or engineer occasionally leaves his lab or slide rule to join the merry-making. Any week end may find the chapter house decorated for a "Night in Greenwich Village", for a minstrel show, or for the annual pajama party. In adition to theme parties, several informal parties round out the Saturday night socializing at AXE. Occasionally, beer suppers and listening parties with sororities serve to keep the members busy. Also there are a few "special" social events each year—the annual hayride, the Spring Formal, and the spring picnic.

Athletics—Ample opportunities are provided for AXE men to flex their muscles as part of the fraternity's participation in the interfraternity athletic program. All the intramural sports are entered each year.

Professional Activities—The distinguishing feature of Alpha Chi Sigma, that which makes it unique among the many fraternities on the Wisconsin campus, is its Professional program. The sponsoring of campus speakers and films, and the performance of chemical "magic shows" for high school students stimulate interest in the fields of chemistry. The promotion of safe practices and procedures in the chemical laboratories provides an aid to the campus community. An annual competitive examination in chemistry provides recognition for scientifically inclined freshmen enrolled in chemistry courses.

The advantages which are available to members of Alpha Chi Sigma are tangible and they certainly bare your consideration. If you are interested in learning more about the Fraternity, please consider this a personal invitation to inquire further at Alpha Chi Sigma, 621 North Lake Street.

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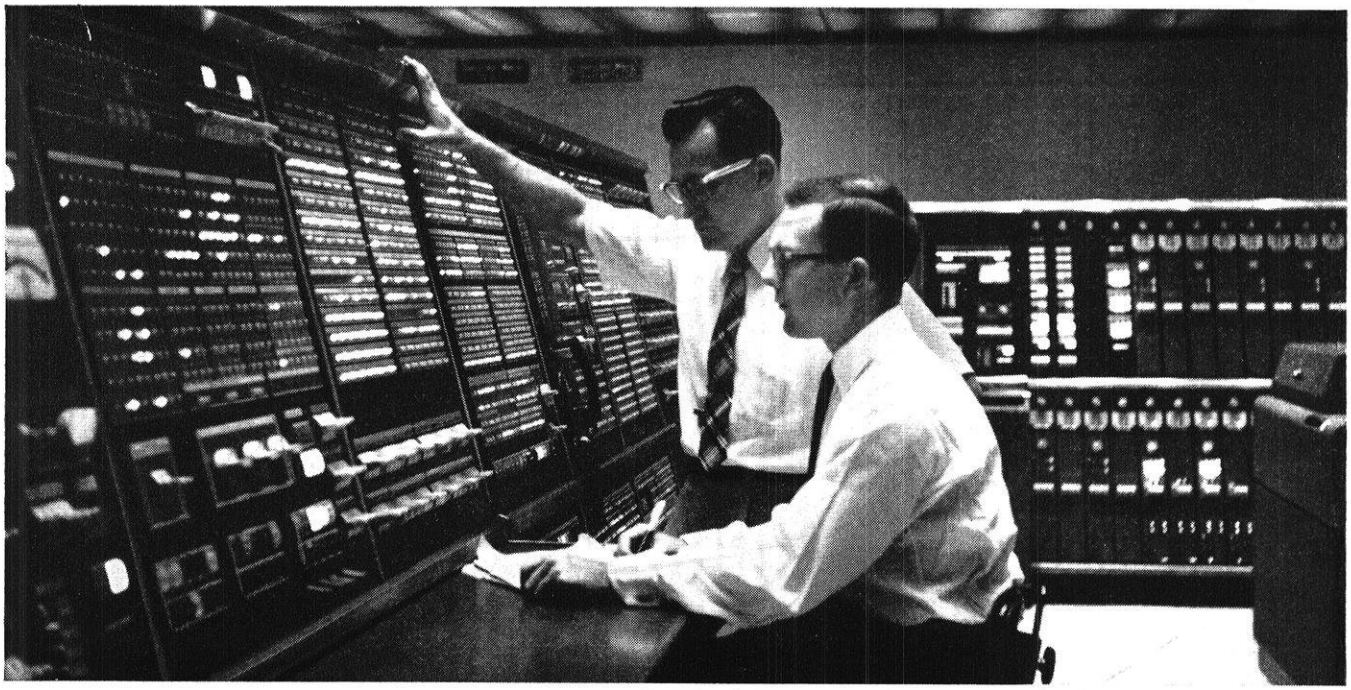

W.E. DEFENSE PROJECTS ENGINEERS are often faced with challenging assignments such as systems testing for the SAGE continental air defense network.

ENGINEERS explore exciting frontiers at Western Electric

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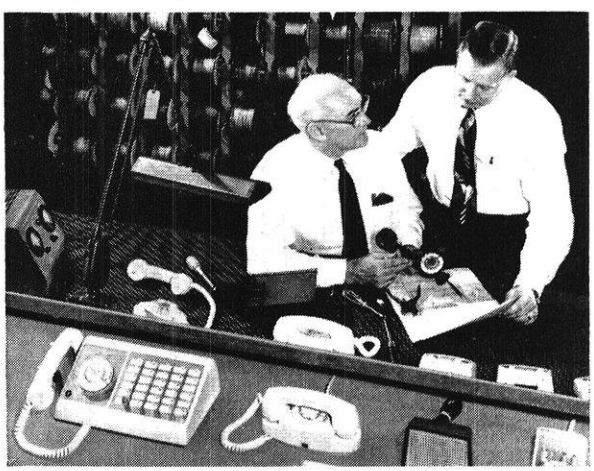
In our main job as manufacturing and supply unit of the Bell System, Western Electric engineers discover an even wider range of opportunity. Here they flourish in such new and growing fields as electronic switching, microwave radio relay, miniaturization. They engineer the installation of telephone central offices, plan the distribution of equipment and supplies . . . and enjoy, with their defense teammates, the rewards that spring from an engineering career with Western Electric.

Western Electric technical fields include mechanical, electrical, chemical, civil and industrial engineering, plus the physical sciences. For more detailed information pick up a copy of "Consider a Career at Western Electric" from your Placement Officer. Or write College Relations, Room 200D, Western Electric Company, 195 Broadway, New York 7, N. Y. And sign up for a Western Electric interview when the Bell System Interviewing Team visits your campus.



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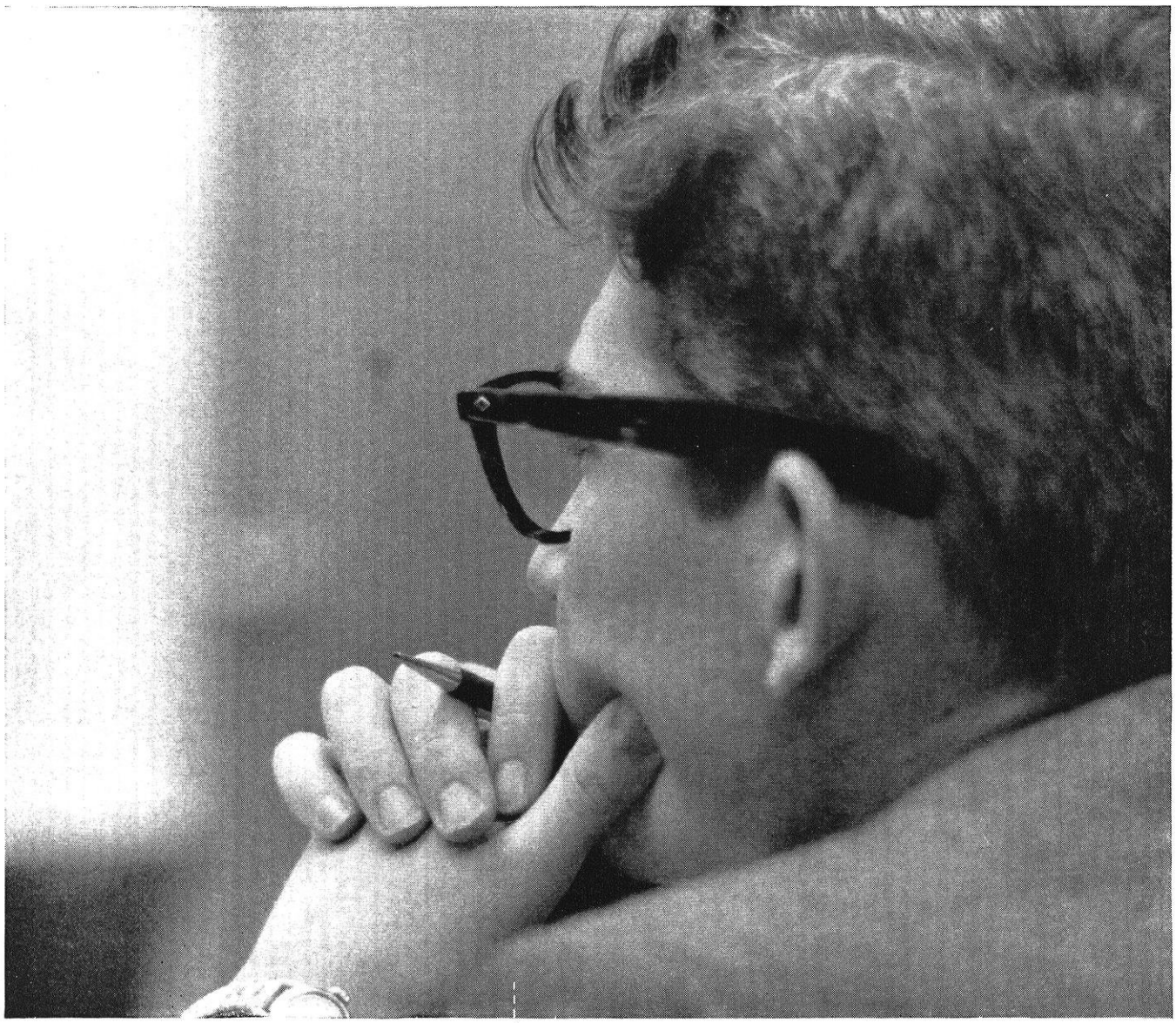

THE HUMAN FACTOR in today's technology

Scientists have long been preoccupied with the technological problems of Man and the Machine. The increasingly complex nature of advanced systems has created an urgent need to enhance man's contribution to effective systems performance. The complicated nature of this relationship requires the skills of psychologists, social scientists, mathematicians, and engineers.

At Ramo-Wooldridge, human engineering, personnel selection, individual and system training, display design, and communications are successfully integrated into systems design and development by the technique of large-scale simulation.

Simulated inputs enable scientists to observe a system as it operates in a controlled environment and make possible the collection of data on performance, training, human engineering, maintenance, and logistics and support. Scientists and engineers use this data to assure the design, production, and delivery of a unified system capable of high performance and reliability.

Expanding programs at Ramo-Wooldridge in the broad areas of electronic systems technology, computers, and data processing have created outstanding opportunities for scientists and engineers. *For further information concerning these opportunities write to* **Mr. D. L. Pyke.**

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YOUR TASK FOR THE FUTURE

Since its inception nearly 23 years ago, the Jet Propulsion Laboratory has given the free world its first tactical guided missile system, its first earth satellite, and its first lunar probe.

In the future, under the direction of the National Aeronautics and Space Administration, pioneering on the space frontier will advance at an accelerated rate.

The preliminary instrument explorations that have already been made only seem to define how much there is yet to be learned. During the next few years, payloads will become larger, trajectories will become more precise, and distances covered will become greater. Inspections will be made of the moon and the planets and of the vast distances of interplanetary space; hard and soft landings will be made in preparation for the time when man at last sets foot on new worlds.

In this program, the task of JPL is to gather new information for a better understanding of the World and Universe.

"We do these things because of the unquenchable curiosity of Man. The scientist is continually asking himself questions and then setting out to find the answers. In the course of getting these answers, he has provided practical benefits to man that have sometimes surprised even the scientist.

"Who can tell what we will find when we get to the planets? Who, at this present time, can predict what potential benefits to man exist in this enterprise? No one can say with any accuracy what we will find as we fly farther away from the earth, first with instruments, then with man. It seems to me that we are obligated to do these things, as human beings."

DR. W. H. PICKERING, *Director, JPL*

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CALIFORNIA INSTITUTE OF TECHNOLOGY

JET PROPULSION LABORATORY

A Research Facility operated for the National Aeronautics and Space Administration

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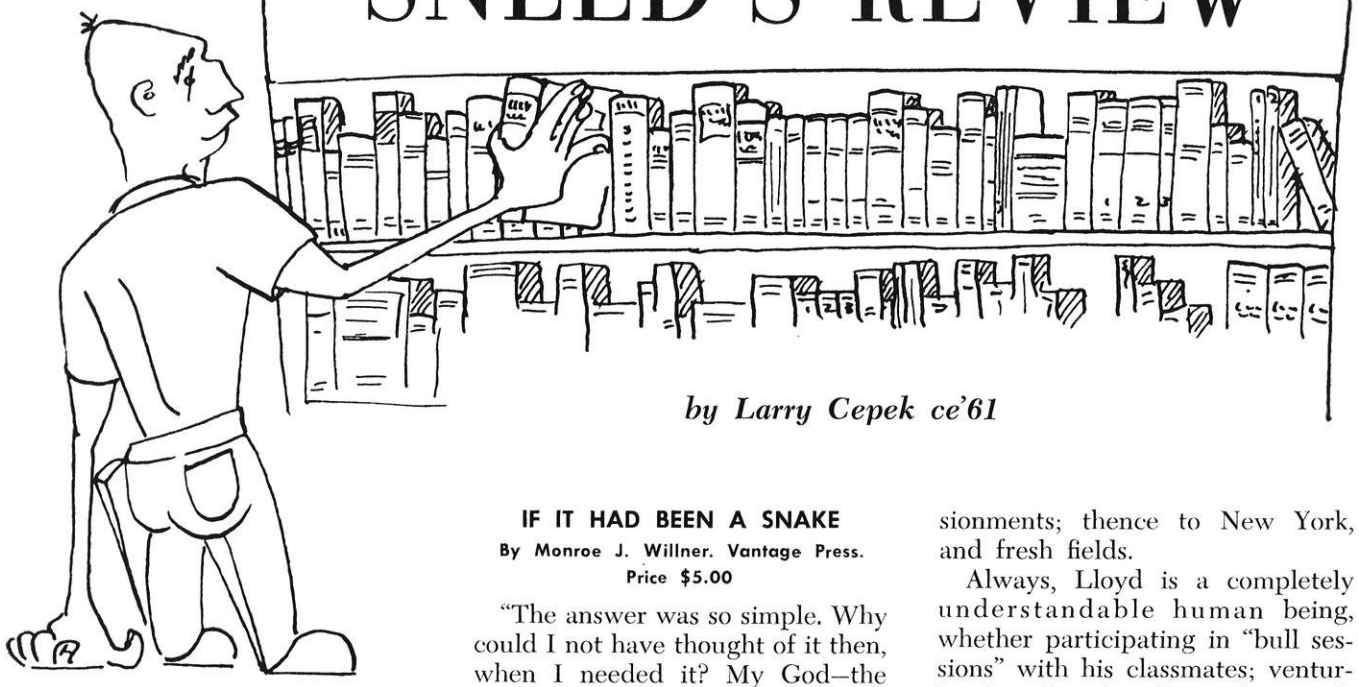
Send professional resumé for our immediate consideration. Interviews may be arranged on Campus or at the Laboratory.

SNEED'S REVIEW



by Larry Cepek ce'61

NEW ELECTRONICS GUIDE

By Robert Hertzberg. Price $2.50

For most of us the word electronics has taken on a new meaning. Just a few short years ago the term was considered the exclusive property of the graduate engineer. Not so any longer; for today's hobbyist and experimenter electronics is a workaday word, a practical one. The brand new guide, "Practical Electronics", by Robert Hertzberg, has helped to make it so.

Mr. Hertzberg—long an acknowledged authority—has made another significant contribution to the literature of electronics. In "Practical Electronics" he presents, in simple, clear text, instruments and their uses, and feature articles on microwave. He has analyzed critically the newest test equipment and assembled and reported on construction-kit projects of recent vintage. There is a wealth of information for the amateur radio operator as well as the audiophile.

This complete new guide is clothbound, has 136 pages, is fully illustrated with hundreds of photographs and drawings, and sells for the low price of $2.50. It may be ordered direct from the publisher, Arco Publishing Company, 480 Lexington Avenue, New York 17, N.Y.

IF IT HAD BEEN A SNAKE

By Monroe J. Willner. Vantage Press. Price $5.00

"The answer was so simple. Why could I not have thought of it then, when I needed it? My God—the solution was so close! If it had been a snake it would have bitten me!"

So speaks Lloyd Fraser, successful young engineer, as he thinks back to the start of his career, and pauses, at a climatic moment, to consider what the future holds.

In this engrossing novel Monroe J. Willner dramatizes, with penetrating insight and communicative warmth, the life of that little-understood professional man—the American engineer.

Do you know what an engineer is really like? Have you wondered about the real reasons for the so-called engineering shortage? Do you know how it feels to be a dedicated young engineer in these changing, challenging times? Can you envision the mass of obstructive trivia he must encounter as student, as employee, as executive? This book gives you a vivid "inside" picture. . . .

We meet Lloyd Fraser at Georgia Tech—an impecunious Florida farm youth with a driving ambition; we learn of the grinding study essential to preparation for this demanding profession; we see Lloyd returning from Army service, a bit more mature, and with undiminished zeal for his chosen field; and we travel with him to California, to his first job, in an aviation plant—and his first disillusionments; thence to New York, and fresh fields.

Always, Lloyd is a completely understandable human being, whether participating in "bull sessions" with his classmates; venturing into the wherefores of sex with soft-voiced Georgia beauties; questing, with a more seasoned eye, as a young bachelor-about-town; or reacting to the varied personalities inhabiting what seems, at times, to be the jungle of the engineering business.

Books have been written about doctors, lawyers, clergymen. This novel brings forward a member of another profession—a field of inestimable importance to every one of us, caught in the dynamics of a scientific age. And this story of Lloyd Fraser, tracing his development from acquisition of technical know-how through progress toward mental, emotional, and sociological maturity, could well apply to the seekings, the inner conflicts, and the achievements of countless professional men today.

Lloyd Fraser is very real. As you read this book you will get to know him well.

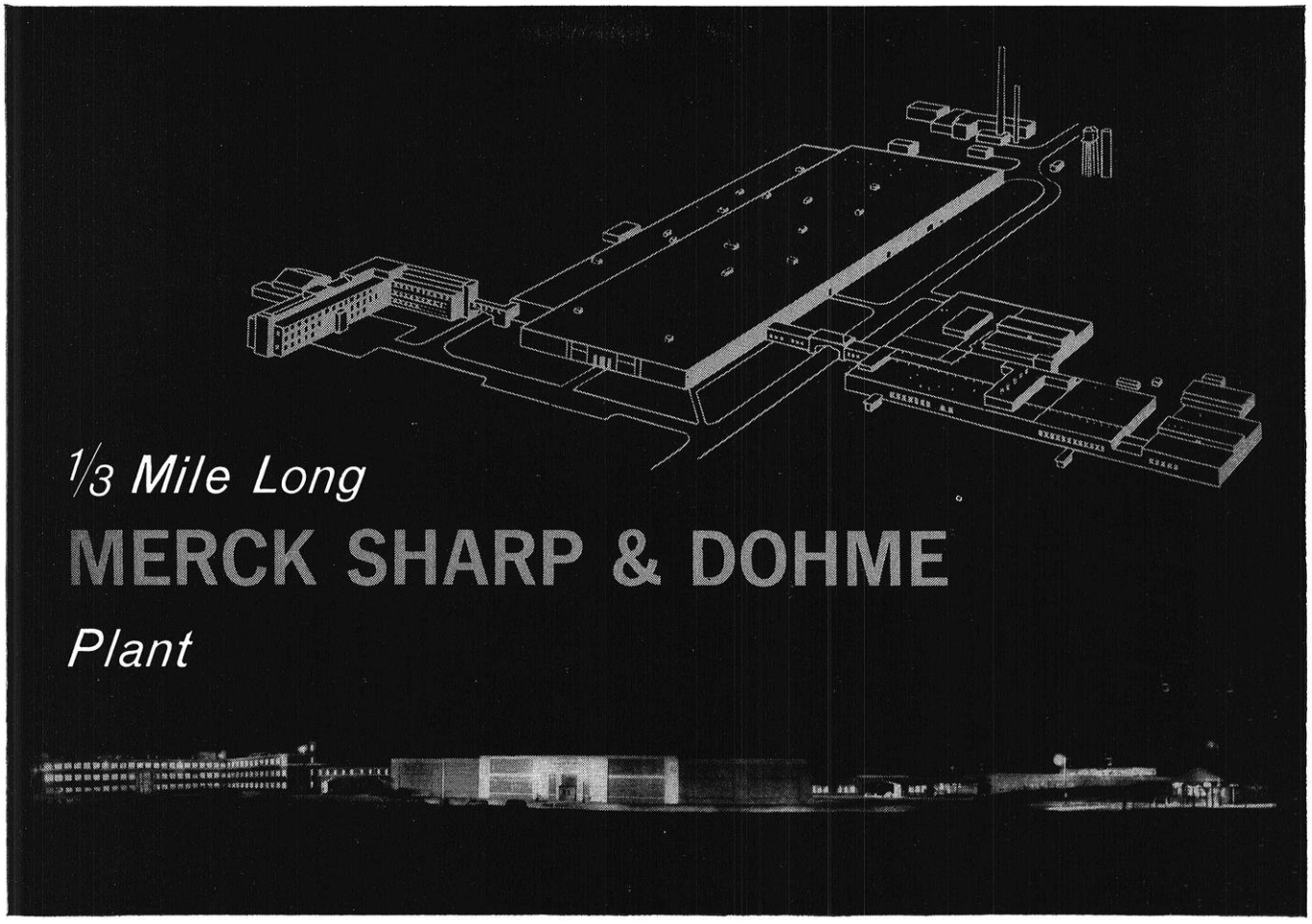
FIFTEEN MINUTES TO STEREO

By General Electric Company

A new 26-page booklet, "Fifteen Minutes to Stereo," has been published by General Electric as a layman's complete basic guide to stereo hi-fi.

In non-technical language, the booklet covers such subjects as the

(Continued on page 41)



where dependability of pipelines is a must, control is entrusted to JENKINS VALVES

World famous Merck Sharp & Dohme, division of Merck & Co., Inc. not only knows pharmaceuticals and biologicals; they know a lot about valves. They need to! Control of pipelines must be *unfailing*.

That's why you'll find Jenkins Valves on all process pipelines in this West Point, Pa. plant . . . as well as on plumbing, heating and air conditioning lines.

The Jenkins name is not new to Merck Sharp & Dohme. They have been using Jenkins Valves extensively for the past twenty years. The unusually large number of valves installed in the company's seventeen domestic and foreign plants represents a big investment. So you can be sure this experienced valve buyer has found Jenkins Valves both dependable and maintenance free.

Jenkins dependability can save money for any plant or building. What's more, you can specify or install Jenkins Valves at no extra cost. Jenkins Bros., 100 Park Avenue, New York 17.

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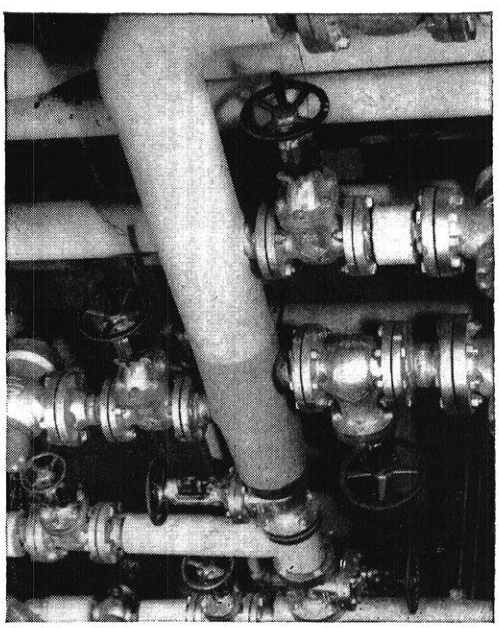

Jenkins Valves on main steam lines serving the Biological buildings

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
JENKINS
SINCE 1864
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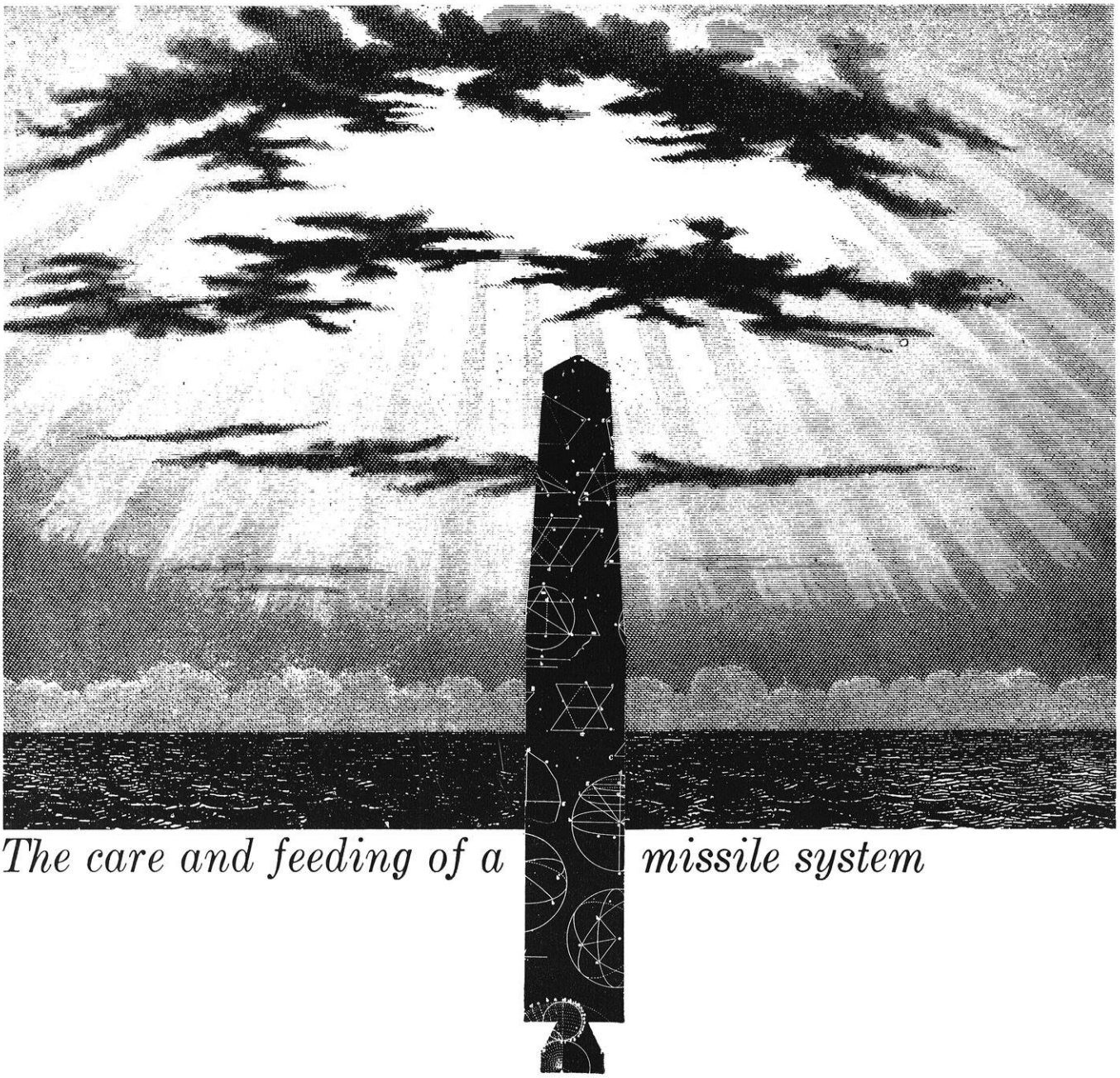

The care and feeding of a missile system

It takes more than pressing a button to send a giant rocket on its way. Actually, almost as many man-hours go into the design and construction of the support equipment as into the missile itself. A leading factor in the reliability of Douglas missile systems is the company's practice of including all the necessary ground handling units, plus detailed procedures for system utilization and crew training. This complete job allows Douglas missiles like THOR, Nike HERCULES, Nike AJAX and others to move quickly from test to operational status and perform with outstanding dependability. Douglas is seeking qualified engineers and scientists for the design of missiles, space systems and their supporting equipment. Write to C. C. LaVene, Box P-600, Douglas Aircraft Company, Santa Monica, California.

Alfred J. Carah, Chief Design Engineer, discusses the ground installation requirements for a series of THOR-boosted space probes with Donald W. Douglas, Jr., President of DOUGLAS

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He has confidence born of knowing where he's going and how he's going to get there. The graduate training program at Allis-Chalmers helped him decide on a *specific* career — and he had a choice of many. He knows his future is bright because Allis-Chalmers serves the growth industries of the world . . . produces the widest range of industrial equipment. He is confident of success because he is following a successful pattern set by Allis-Chalmers management.

Here is a partial list of the unsurpassed variety of career opportunities at Allis-Chalmers:

Types of jobs

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Construction
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Nuclear Power
Paper
Petroleum
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Equipment

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Switchgear
Transformers
Electronics
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Kilns
Crushers
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Earth Movers
Motors
Control
Pumps
Engines
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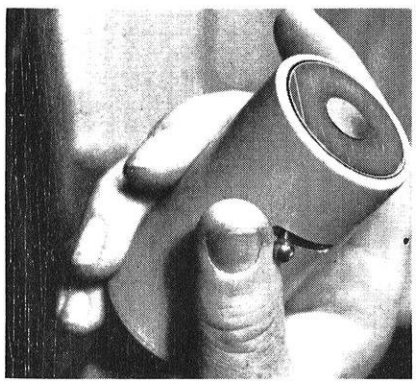
The graduate training course helps you decide on your "Very Important Position," by giving you up to two years of theoretical and practical training. This course has helped set the pattern of executive progress since 1904. For details write to Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.

Science Highlights

(Continued from page 28)

NEW ARTIFICIAL LARYNX UNDER DEVELOPMENT MADE POSSIBLE BY TRANSISTORS AND MINIATURIZATION

A new artificial larynx for persons who have lost their voices through surgical removal (laryngectomy) or paralysis of their vocal cords has been described by three Bell Telephone Laboratories scientists at a meeting of the Acoustical Society of America. Still in the experimental stage, it is the result of a considerable background of research in an interdisciplinary field of of science known as psychoacoustics.



New electronic artificial larynx utilizes a modified telephone receiver which transmits sound through flesh into person's throat.

Great impetus to development of the device was given by some of the nation's foremost surgeons connected with the National Hospital for Speech Disorders. They felt that, what with the great advances in electronics brought about by the transistor, specialists in acoustics research could devise a far better artificial larynx than any presently available.

With a minimum of difficulty and training, laryngectomees can use the new electronic larynx to speak conversationally. It is especially effective when conversing over the telephone.

By means of a finger-operated combination push-to-talk switch and inflection control, the user can easily control the pitch of his artificial voice, thus giving his speech a natural sounding quality previously unobtainable.

The underlying principle of the new artificial larynx is a vibrating driver (transducer) held against the throat. Completely self-contained and cylindrically shaped, it measures only 1¾ inches in diameter by 3¼ inches long—thus acceding to plaints of laryngectomized people for an unobtrusive device. Included in this one small package is a modified telephone receiver serving as the throat vibrator, a highly-efficient transistorized pulse generator with pitch control, and a battery power supply. In order to miniaturize the new artificial larynx, experimental units were built using modular techniques. However, by employing printed-circuit techniques it is anticipated that an even more compact unit can be built.

To use the unit, the laryngectomized person presses the vibrator against his throat. Switching on the pulse generator with his finger, he transforms vibrations transmitted into his throat cavities into speech sounds by normal use of the articulatory mechanisms—i.e., throat cavity or pharynx, tongue, mouth, teeth, and lips—in his vocal tract.

Output speech volume obtained with the artificial larynx is equal to that of a person speaking at a nor-

mal conversational level, though the sound is a bit buzzy and mechanical. Nevertheless, the frequency spectra of vowel sounds show that the frequency range transmitted into the person's throat is sufficient for satisfactory production of such sounds. And while intelligibility tests give results lower than those of normal speech, they are superior to those of any other artificial larynx. Users of the new artificial larynx can achieve a sentence intelligibility of 97 per cent or more, depending on their experience.

Because the artificial larynx requires an economical, self-contained power source, circuit parameters had to be adjusted to yield maximum acoustic output with a minimum of current drain. Accordingly, two transistors are used in a relaxation oscillator whose frequency is controlled by a variable resistance, and whose pulse width is determined by a feedback network. The output is a negative pulse which occurs at a frequency of about 100 cycles per second. This repetition frequency may be varied from about 100 to 200 cycles by a rheostat which the user operates by pressure on the push-to-talk switch—or inflection control—while speaking, thus changing the pitch of his voice. For use by women talkers, the frequency range is adjusted to 200 to 400 cycles, to correspond with the normal range of pitch of a woman's voice.

A third transistor acts as a single-ended power output stage that amplifies the pulses applied to it from the relaxation oscillator. A diode serves to isolate the multivibrator from the power amplifier input impedance during the period between pulses, and is necessary for stable operation. Because a large pulse is required for sufficient acoustic power output at low frequencies, the relaxation oscillator drive circuit has heavy current requirements.

Two 5.2-volt mercury cells in series provide the power necessary to operate the artificial larynx continuously for a period of approximately 12 hours. These batteries have a 250-milliampere hour rating with a maximum permissible current drain of 25 milliamperes. With push-to-talk operation such as the laryngectomized patient requires, 12 hours of continuous operation should be equivalent to several days or even weeks of normal talking.

Sneed's Review

(Continued from page 36)

"why" and "how" of stereo hi-fi, stereo components, and typical component system arrangements for varied home settings. It also includes a glossary of stereo hi-fi terms and a basic stereo record guide.

Illustrations include simplified diagrams showing recording and reproduction of stereo records, explanatory pictures of components, and diagrams showing speaker placement for best stereo perspective.

The booklet is priced at 25 cents, and is available from authorized General Electric hi-fi components dealers.

HANDBOOK OF TV REPAIR

By Robert Hertzberg. Arco. Price $3.50

"For the sum of about $3.18—less, if you can find some of the required parts in your 'junk box'—you can make a simple 'continuity checker' for electronic circuits." Thus begins a new book, designed to release you from your technical and economic bondage to the repair man.

Robert Hertzberg, in clearly written and illustrated terms, initiates you into the mysteries of tubes and antennas which prove to be not so mysterious at all. In 144 pages, well-bound and attractively jacketed, the average set-owner can learn to master the intricacies of Circuits, Ghosts and that infamous bugaboo, Interference. Hot Tips on Soldering, the Adjustment of Ion—Trap Magnets, Earphones—for Quiet Listening and Aeriel information, are only a few of the subjects elaborated in language anyone can understand and apply. Handbook of TV Repair supplies you with all the know-how necessary so that your entertainment is not killed when your television set goes dead.

Thermionic Converters

(Continued from page 17)

increase of the anode potential does not increase the anode current which is then said to be saturated.

The magnitude of the saturated current increases when the cathode temperature is increased. This saturated space current is called the "emission" from the cathode.

Although an electric current is used to heat the cathode in a diode, it should be realized that other heat sources can be used to heat the cathode in other types of converters based upon the phenomena of thermionic emission.

Gas Thermionic Converter

A gas thermionic converter can be made by constructing a glass tube that contains two electrodes which are held at high, but different, temperatures and separated by a small gap. The heat has the effect of "boiling" electrons off the hotter electrode. These electrons are attracted by the cooler electrode and pass across the gap in a steady stream.

Cesium vapor is used in the converter to coat the electrodes, thus affecting their work functions (The amount of energy needed to free an electron from the electrode and release it into the surrounding space). The difference between the work functions of the two electrodes is the key to the successful operation of the thermionic converter, because this difference provides the voltage that drives the electrons through the circuit.

The cesium vapor partially ionizes and is used to reduce the internal resistance caused by the space charge effect. If the space charge effect is not reduced it will block the flow of electrons from one electrode to the other. Another way of reducing the internal resistance is to place the electrodes very close together, as is done in the vacuum converter.

Vacuum Thermionic Converter

The vacuum converter is similar to a gas converter in that two electrodes are held at high, but different, temperatures. Electrons are "boiled" out of the hotter cathode and collected by the relatively cool anode. The electrons can then flow through an external circuit and do work.

FACTORS AFFECTING THE ELECTRICAL OUTPUT

Temperature is an important factor in the electrical output of a thermoelectric cell. The higher the temperature of a cell, the greater its electrical output.

Two other factors that are important in the electrical output are the electrical and thermal conductivity. If the voltage produced is to be delivered as useful current, then it must have high electrical conductivity. Also, if a thermoelectric cell is to convert a high percentage of the heat energy into electrical energy, it must have a low thermal conductivity. The principal deficiency of thermoelectric cells is that much of the heat supplied to the hot end flows directly and wastefully, by heat conduction, to the cold end. Therefore, the ratio between the useful electrical output and the heat input in a thermoelectric cell is low, and consequently, the efficiency is low.

The efficiency of Seebeck's first thermoelectric cell was 3 per cent. This efficiency has been improved to 8 per cent in the gas thermionic converter, and the potential efficiency of the vacuum thermionic converter is 30 per cent.

The comparison of these efficiencies with the 35–40 per cent efficiency of a steam-turbine generator makes the possibilities appear quite small that electricity will be produced for commercial use by thermoelectric generators. However, the 35–40 per cent efficiency can be obtained only from very large steam generators. The efficiency of small steam generators may be 10 per cent or even lower.

Electricity generated directly from heat operates this light bulb shining on the face of Dr. Volney C. Wilson, inventor of a new thermionic converter which changes more than eight percent of applied heat energy into electric power.

—Courtesy General Electric Research Laboratory

Therefore, for small power requirements of only a few kilowatts of electricity, thermoelectric generators can compete with steam generators. For the very small power requirements, as in telegraph and telephone communications, thermoelectric generators provide a good engineering solution. It should also be remembered that efficiencies will increase significantly if materials are developed that will permit the use of high temperatures in thermionic converters.

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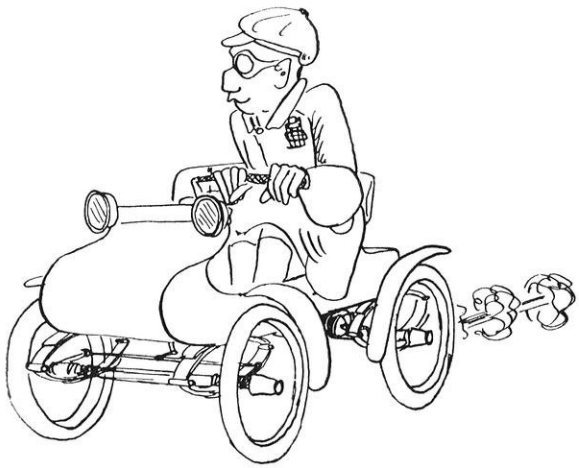
THE END



THE ENGINEER OF YESTERYEAR

Floyd Gelhaus ee'61

TO ALL ENGINEERS

From an article by W. A. Baehr, 1903

I WISH to appeal as strongly as I can to the college men who are studying engineering, whether civil, mechanical, mining, electrical, or any other of the numerous special developments of our science. We are living in an age of rapid progress, of constantly widening and broadening views, and of greater and more generous impulses toward each other. The future will see the great body of all engineers laboring in unity, endeavoring to secure the greatest good to the greatest number, and recognized by their fellow men as the real benefactors of mankind. Therefore I appeal to all to strive to encourage each other, to let each field have its utmost possibilities developed, and by thought, word and deed to help your fellow engineer whenever you can.

THE NEW IS NOW THE OLD— "VIEWS IN BOILER HOUSE"

December, 1897

The University Boiler House is considered a model plant, being equipped with all modern appliances including a mechanical stoker, fuel economizer and temperature regulator. The equipment is so well arranged and so complete, that, although the plant is about 1,200 horse-power, two men can handle it with ease. All of the University buildings, with the exception of those of the College of Agriculture, are heated from this plant. It also supplies the steam for the engines in the steam laboratory, those in the machine shops and dynamo laboratory and for the pumps at the pumping station. The steam is carried to the various buildings through covered pipes placed in underground tunnels. The condensed steam is all returned to the boilers.

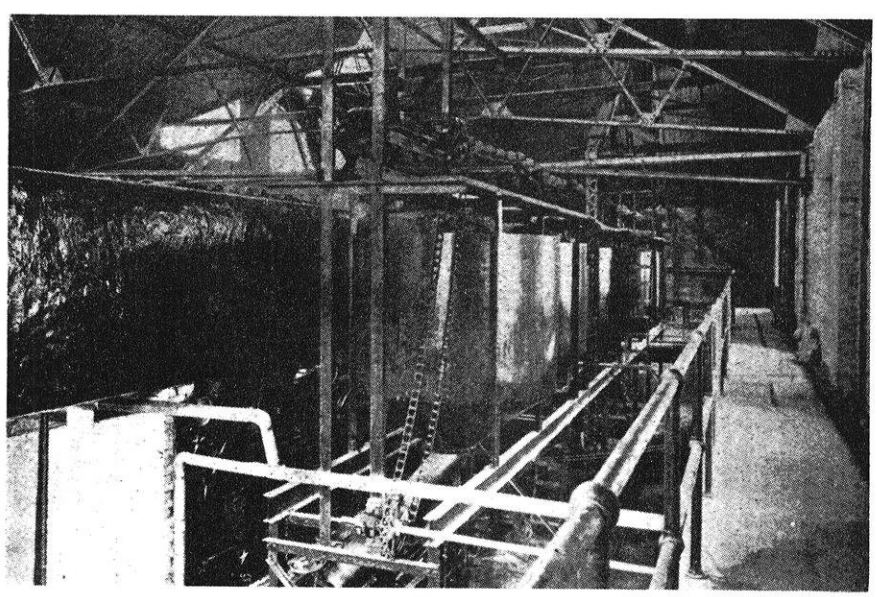
The first of the two accompanying half-tones shows the conveyor for elevating the coal from the coal pit at one end of the building and conveying it to the hoppers. The cal pit holds about 1,000 tons, and the coal is dropped into it from the delivery wagons through holes. As shown in the cut there are seven hoppers, each of which holds from three to six tons, and supplies the fuel for one and some for two of the boilers.

The second cut illustrated the ash car and the elevator for elevating the ashes into a wagon outside. The Nagle engine is also shown, which runs the conveyor and elevator. This engine is started at intervals during the day and the coal goes on the next one and so on until all are filled. The coal conveyor and ash elevator were installed by the Link Belt Machinery Co., Chicago.

LESS HOURS BUT MORE WORK

September, 1901

The work in the freshman and sophomore years in the College of Engineering has been reduced from the twenty-one-hour schedule of the current catalogue to nineteen hours in the first semester of the freshman year, and to twenty hours for the remaining part of these two years. This reduction has been made in mathematics, one fifth; in chemistry, one fifth; in descriptive geometry, one fifth; in technical German, one



Coal elevators and hoppers.

fifth, and in mechanics or in machine design, one fifth. In the electro-chemical course there has been added four fifths chemistry in the sophomore year in place of an equivalent amount of shop work and machine design.

AN UNDERGROUND CAMERA

June, 1907

(J. T. Atwood, U of Wis.)

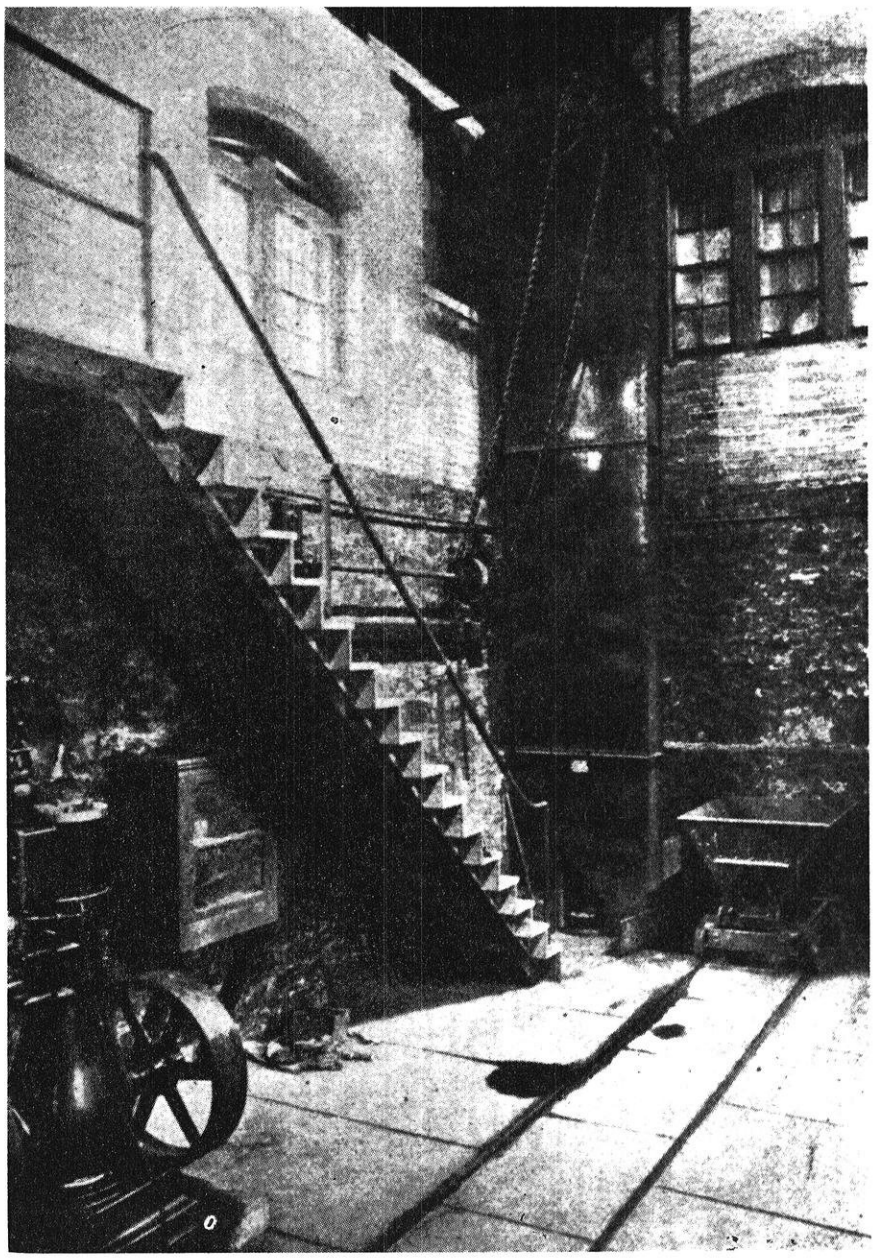
An underground camera for photographing the sides of well holes, so far as the writer knows, has never been made. However, it seems probable that such a camera has been used because of the value of photographs of the earth's foundation at levels reached only by drill holes. With the belief that such photographs would be of value in scientific research and in commercial mining work, the camera herein described was designed and built.

The camera is mounted in the lower end of a water tight tube. This tube is 5 inches outside diameter, and 43 inches long. Near the upper end of the tube is a plate glass window with a mirror back of it, so mounted as to reflect the image of an object placed before the window directly down the tube and into the camera. On either side of the mirror is mounted an electric lamp with a reflector, which sends the light through the window, and also prevents any light from shining directly into the camera. This iron tube or camera bute is lowered and raised in the well by a cable winding on the lower of the two drums shown in the photograph. The upper drum carries an electric cable to operate the lamps and to turn the camera film.

The field work done with the camera has been necessarily limited to a little over a week's time. Because of unexpected difficulty in effectively drying the air in the tube, the results obtained are incomplete, but satisfactory in showing that good photographs can be taken in a well hole both above and below water.

The first attempt in taking photographs under water resulted in securing good photographs. The camera was filled with dried air by forcing the air through a bottle of sulphuric acid. Calcium chloride was desired to aid in the drying, but could not be secured. After lowering the camera tube into the water it was raised to the surface to see if in cooling any moisture had been precipitated on the inside of the window. The window was found dry and clear, and upon lowering it the second time the exposures were made without any regard to the location of ore bodies.

The important information which the photograph may give about ore deposits, which cannot be secured in the sludge record, is as follows. First: The nature of the deposit, whether it be sheet or disseminated ore and Second: In case or a sheet deposit, the exact thickness and pitch. Such information as given by a photograph is important, and consequently the possibilities offered in the camera are of great value to the prospector and mining engineer.



Ash car and ash elevator.

HUGHES MASTERS FELLOWSHIPS. The Hughes Masters Fellowship Program offers unusual opportunities for academic training leading to a master's degree . . . and, in addition, provides each fellow with practical experience in the professional field of his choice.

Approximately one hundred new awards will be made by Hughes in 1960 to qualified applicants who possess a bachelor's degree in science or engineering. Additional awards are open to qualified applicants interested in business administration and education.

Hughes conducts extensive research and development in the scientific and engineering fields. Each fellow may elect an assignment while working for Hughes during the summer in such areas as: microwave power tubes, microwave devices, parametric amplifiers, masers, precision frequency sources, infrared detectors, infrared search and track systems, microminiaturization, switching devices, antenna arrays, phase shifters, ferrites and garnets, simulation methods, propagation, language translation, advanced data handling systems, information processing, human factor analysis, and alpha-numeric displays.

Two different Hughes Masters Fellowship Programs are offered. In the **FULL STUDY PROGRAM** applicants will receive fellowships that permit them to attend an outstanding university on a full time basis during the regular academic year with a substantial stipend.

In the **WORK STUDY PROGRAM** award winners will attend a university sufficiently near a facility of the Hughes Aircraft Company to permit them to obtain practical experience, in a professional field of their choice, by working at the company part time each week. An appropriate stipend will also be awarded.

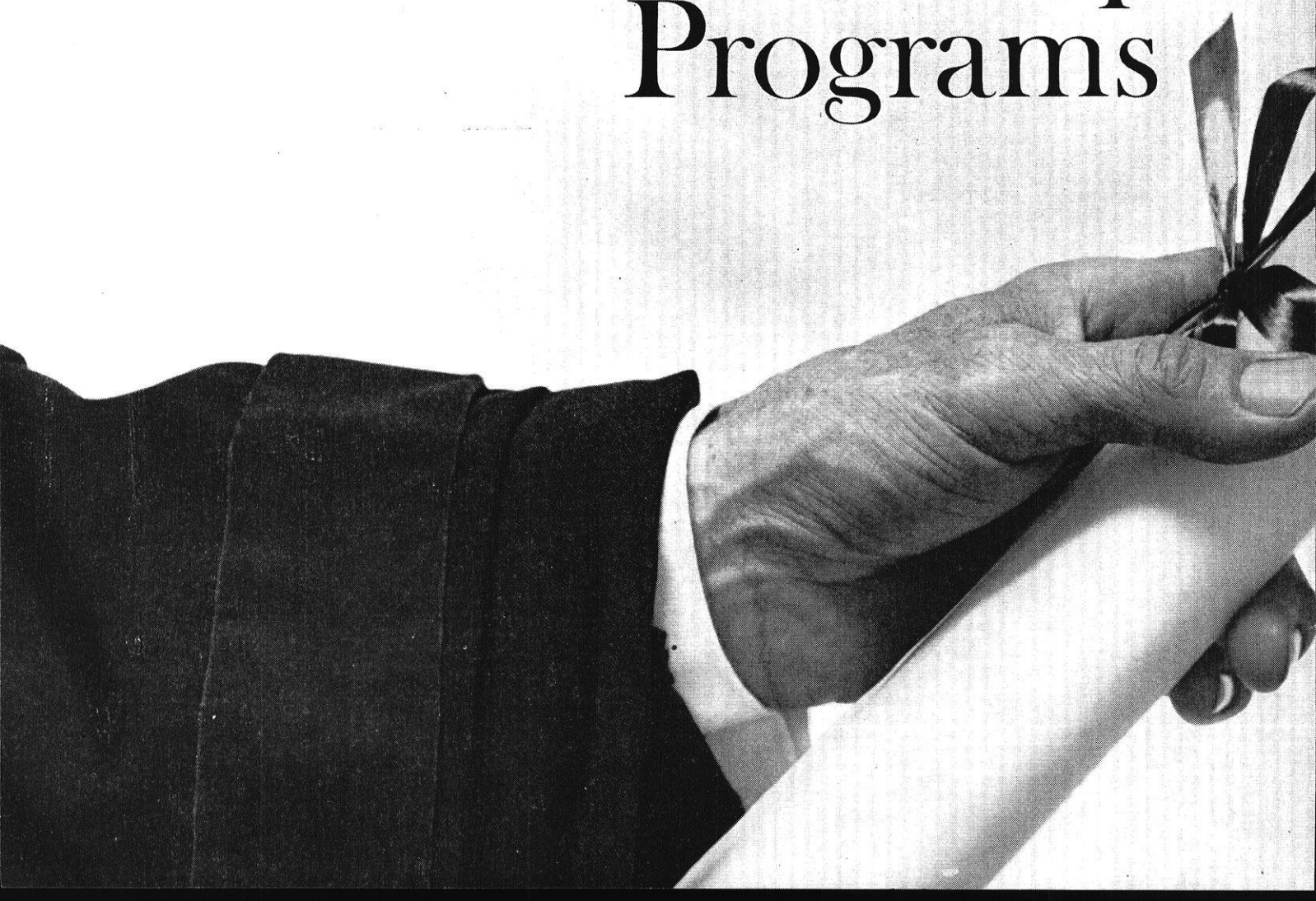
After completion of the Master's Program, fellows are eligible to apply for HUGHES STAFF DOCTORAL FELLOWSHIPS.

The classified nature of work at Hughes makes eligibility for security clearance a requirement for nearly every applicant.

Closing date for applications: January 15, 1960.

How to apply: Write Dr. C. N. Warfield, Scientific Education, Hughes Aircraft Company, Culver City, California.

Hughes Fellowship Programs



IOWARD HUGHES DOCTORAL FELLOWSHIPS. If you are interested in studies leading to a doctor's degree in physics or engineering, ou are invited to apply for one of approximately 10 new awards in the 960 Howard Hughes Doctoral Fellowship Program.

This unique program offers the doctoral candidate the optimum ombination of high-level study at an outstanding institution plus ractical industrial experience in the Hughes laboratories.

Each Howard Hughes Doctoral Fellowship provides approximately $8,000 annually. Of this amount $1,800 is for tuition, books, fees, hesis and research expenses. The remainder is the award of a cash tipend and salary earned by the fellow.

Hughes conducts extensive research and development in the scientific nd engineering fields. Typical programs include: network analysis nd synthesis, semiconductor materials, plasma electronics, commuications, computing... and solid state physics, atomic and nuclear hysics, tests of the general theory of relativity, chemistry, physical hemistry and metallurgy, information theory, mechanics of structures, electro-mechanical propulsion systems, and systems analysis.

Howard Hughes Doctoral Fellowships are open to outstanding students qualified for admission to graduate standing. A master's degree, or equivalent graduate work, is considered very desirable before beginning the Fellowship Program.

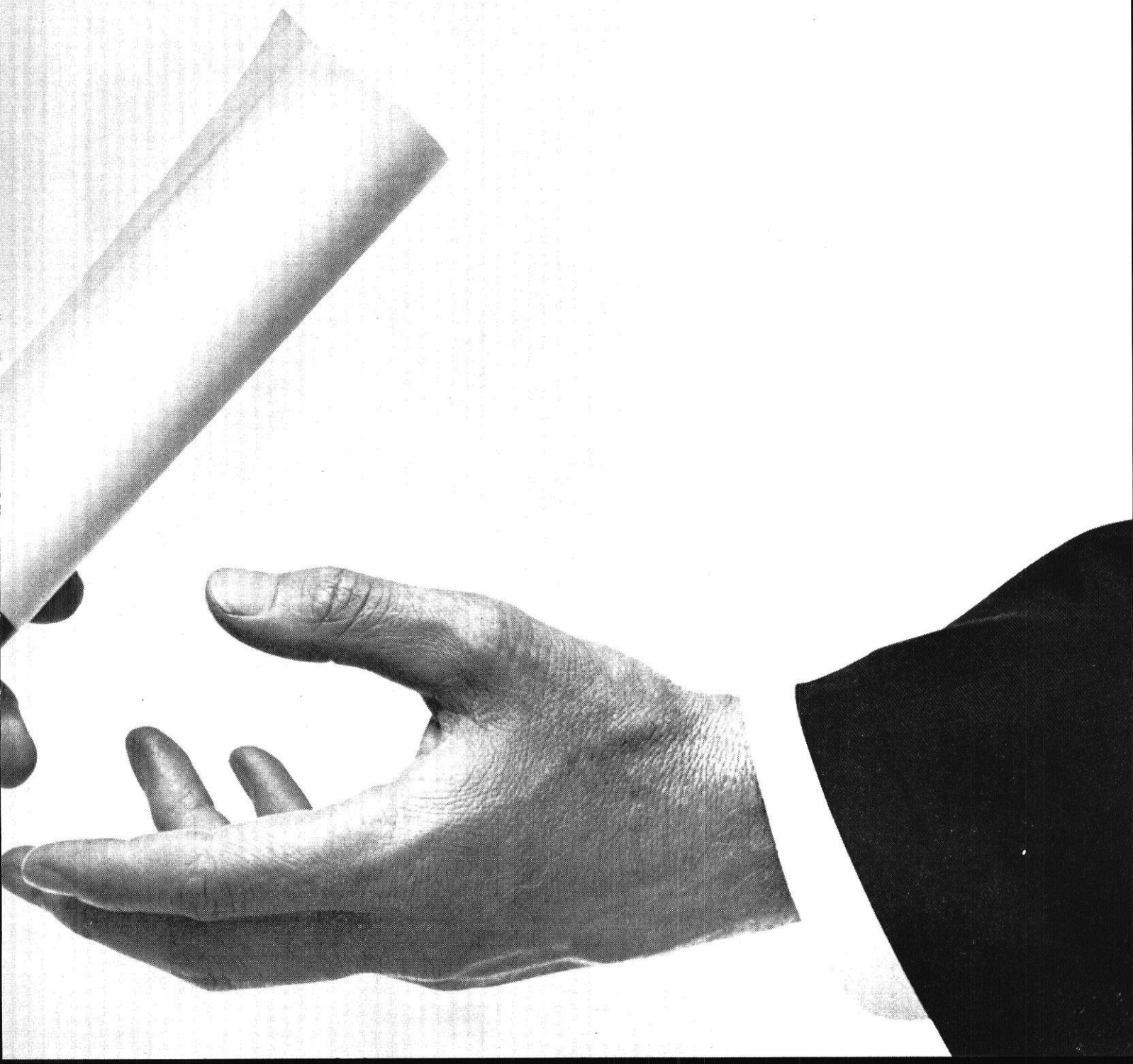
The classified nature of work at Hughes makes eligibility for security clearance a requirement for nearly every applicant.

Closing date for applications: January 15, 1960.

How to apply: Write Dr. C. N. Warfield, Scientific Education, Hughes Aircraft Company, Culver City, California.

Creating a new world with ELECTRONICS

HUGHES



Plastics

(Continued from page 15)

simple tools. White officials give the following reasons for switching to the plastic cab: the complex shapes are more easily molded; there are fewer actual parts; the lower thermal conductivity increases driver comfort in both winter and summer; there is less noise, because the plastic does not reverberate like metal does; the cab is unaffected by rust, salt and road chemicals; and the repair cost is low.

A reinforced resin carrier has been made which holds seven tons of meat. It was designed for use by railroads to provide ease and speed in handling. It is also 50 per cent lighter than previous carriers. The sandwich construction provides ease of assembly, and has excellent insulating properties. The panels are bonded with a resin adhesive which keeps out moisture which deteriorates insulation. It has a continuous plastic surface which facilitates cleaning, and there are no metal fasteners which would provide short circuits for heat loss. The design of the carrier is such that it will absorb a shock equivalent to running into a solid wall at ten mph.

Plastics are continuing to find more uses in the automobile industry. In 1957 the Thunderbird was equipped with a one-piece plastic hard-top, and the Studebaker Golden Hawk had a plastic hood overlay to provide space for a supercharger. Today whole automobile bodies are being molded of reinforced plastics.

Boats

An LCVP, Navy landing craft, weighing 18,000 lb when loaded, is dropped 20 ft into rough water, and usually hits the side of the ship before it gets underway. This is a normal launching for this boat. The U. S. Navy Bureau of Ships conducted tests for years (and still may be doing so) on construction materials which are immune to attack by fungi, worms, dry rot and salt water, to be used in building small crafts. In 1957 they had two reinforced plastic LCVPs built for testing. These were made mainly of a honeycomb structure with external laminations, while the hull was made of a sandwich type construction. The whole craft was painted with a pigmented epoxy resin. The results of the tests were apparent in 1958 when the Navy specified that all of their boats under 50 ft in length would henceforth be made of reinforced plastics.

Swimming Pools

In 1956 33,000 swimming pools were built, and there were 44,000 more in 1957. This represents one of the biggest booms for any individual industry. It is also a great opportunity for the manufacturers of reinforced plastic pools, who have the unique advantage of factory fabrication under quality control conditions. The pools can be molded in sections, and later constructed at the building site. This is a very young industry, and has had to contend with the "bugs" present in early models. The consumer is still wary of the plastic pools due to the presence of opportunists in this field, who are not too particular about fabrication and construction methods.

Some unnecessary failures have been due to thin wall sections. Of the pools made by reputable firms, the only recognized failures have been due to the owners emptying the pools, which were then lifted by hydrostatic pressure in the ground. A distinct disadvantage of the plastic pools is they are not a do-it-yourself project. They also must be sold on the basis of top quality instead of the lowest price. They have low maintenance costs, will not rust and never need painting.

Recently the Paradise-Delorich Company built a pool that measured 92 ft by 36 ft. It was made of plastic panels reinforced with epoxy resin. Estimates were made of construction costs for this pool when made of various available materials. The basis was a steel pool at an index of 100 per cent; the results are tabulated below.

Construction material	*Cost, per cent*
Aluminum	85
Sprayed reinforced gunite concrete	75
Reinforced plastics	55
Dry-packed concrete	55

Aircraft

The speeds of aircraft and missiles are rapidly approaching the thermal limits of present day materials. Manufacturers are turning to plastics to try to solve some of their problems, which are mainly extremes of temperature and impact.

The shock a missile encounters when it re-enters the earth's atmosphere has been compared to that of driving a car into a solid wall at 60 mph. Temperatures of 20,000 F to 30,000 F are encountered by the nose cone for short periods, and the blast tube must be able to withstand temperatures of 5,000 F to 8,000 F for several minutes.

The star in the missile field is phenolic, which is holding up under conditions which would vaporize most metals. It accomplishes this by what is defined as "erosion". The plastic material is thought of as being composed of three layers.

The outer layer, which is the hot side, disintegrates or "erodes" under high temperatures. The inner layer remains intact to insulate layer, which is the actual structural element.

Through this process of "erosion", filled phenolic nose cones have successfully re-entered the earth's atmosphere, withstood temperature extremes for more than 20 seconds and kept the instrument payload within its safe operating temperature of 250 F.

The main producer of missile parts is Haveg Industries in Wilmington, Delaware. There is no size limit to the parts Haveg makes. Assemblies have been molded with a diameter of 12 ft and weighing 42,000 lb.

Haveg is doing research on an all-plastic missile also, which, if successful, could be built for one-half to one-tenth of the cost of some of today's missiles.

Manufacturers say that the reason phenolic is used so much in missiles is because it has been around for a longer time. Some companies are doing research with other resins and some epoxies and silicones are also being used.

Buildings

The past few years have seen a large advance in plastics used as building materials. Some of the reasons behind this growth are:

(1) The current trend in the building industry is to transfer as much work as possible from the building site to the shop. Lighter materials are being requested, and this calls for panels, most of which incorporate some core material.

(2) Plastic panels can be constructed at the plant under strict quality control conditions, and these have lower installation and maintenance costs. Plastics allow sizeable reductions in the weight of structures, and also reduce transportation costs.

(3) Plastics have a longer life span than most building materials, and today they have greater availability and design flexibility.

Polystyrene foam slabs are used as an outside layer for foundations to control moisture and heat loss. For more complex shapes polyvinylchloride sheeting is used as a water stop, and also for expansion joints between slabs. Glass-reinforced polyester panels are used in flat and corrugated forms for skylights and open roof areas. Regular roof sections are being made of sandwich constructions with reinforced plastic skins and resin-impregnated honeycomb cores. Styrene foam slabs find use in joints and between sheets of roofing paper as an insulating material.

The new three-story Research Center for the Monsanto Chemical Company's Inorganic Chemicals Division has made use of 80 different commercially available plastic materials. The building has a frame of steel girders, but almost everything else is plastic.

Monsanto also has built an "all-plastics" home, which was designed by three professors from M. I. T. It consists of five sections of 16 square feet floor space. The main section is on the foundation, while the four wings are cantilevered from it. An idea was borrowed from aircraft manufacturers in that the central floor section and cantilevers are built of a continuous form, which eliminates undue stresses on the core. This is the same principle whereby airplane wings are extended through the fuselage. The floor and roof sections are also designed to carry loads vertically, so they do not transfer stresses to the columns. The weight of the house rests on the core, but the core is not subjected to lateral bending loads.

The limiting design factor was, naturally, stiffness and not strength. Box girders were decided upon to give both material savings and increased moment of inertia.

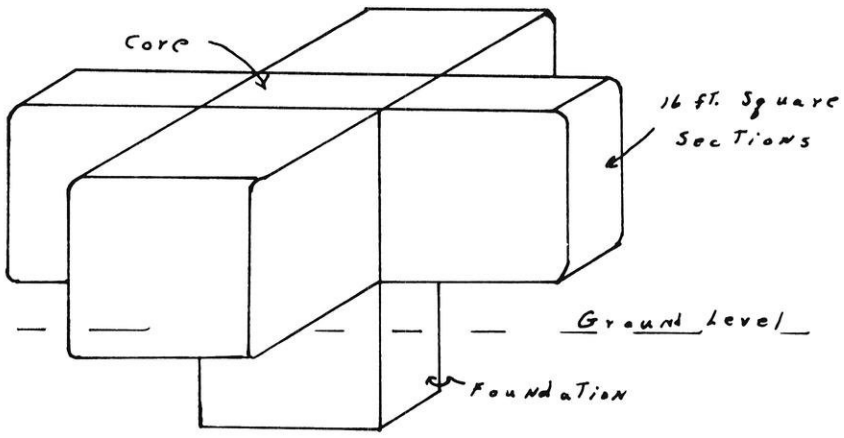
Considerations in the choice of construction material were weathering, resistance, ease of fabrication, flamability, strength of the finished laminate and cost. The resin selected was polyester with woven roving cloth for reinforcement.

In a design of this type the materials must meet severe requirements. Monsanto engineers conducted extensive tests on the structure to satisfy themselves that the building would hold up under use. A framework which simulated the core was constructed, and used in conjunction with bents from the same mold as the actual house parts. Gauges were installed at critical points, and the tests began.

First the lower bent was tested alone. Progressive loads of 10.8, 20, 30 and 50 psf were applied, and deflection of the outer end was only 0.75 inches, which is what was expected. The load of 50 psf was maintained for six weeks, and no measurable creep was recorded. This test showed that the design was very conservative as to working stress levels.

Later the roof bent was attached, and the bents were tested by methods common to many building codes. The floor and roof were loaded to 110 and 80 psf respectively, which is equivalent to having one hundred fifty people in the room plus the furniture, and about five feet of snow on the roof. This load was maintained for about 48 hr; there was no measurable creep, and the stresses were as expected.

Lawn sprinklers were installed over the roof to spray water at 186 F, and this set-up was then enclosed to prevent heat losses. The average temperature differential between the roof and the inner surface was 60 F. Elongations and stresses were obtained, and the largest stresses were only five per cent of the ultimate stress of the material. This again emphasized the conservative design.



Design of an "all-plastics" home.

The tests conducted so far have shown that the structure is much stronger than it needs to be. The house is presently located at Disneyland where hundreds of people will tour it every day; this should show whether or not it will stand up under use.

The plastics industry, though relatively young by modern standards, has a tremendous capacity, and a future of great expansion and progress.

THE END

Campus News

(Continued from page 32)

MINING AND METALLURGY CLUB

The Mining and Metallurgy Club is the University of Wisconsin's student chapter of the American Institute of Mining and Metallurgical Engineers (AIME). All students in the Department of Mining and Metallurgical Engineering automatically are members of the Club. No dues are collected from its members. Its means of support are the Engineering Exposition and rebates from the AIME.

Meetings of the Club are held once a month in room 226 of the Mining and Metallurgy Building. The starting time of the meetings is usually 7:30 p. m. The exact time and date of each meeting is posted on the M&ME department bulletin board.

The objects of the Mining and Metallurgy Club include:

(1) Acquainting the new students (freshmen or transfers) and continuing students in the department with their fellow students and the members of the Mining and Metallurgy faculty.

(2) Providing guest speakers from industry to discuss current aspects and trends in mining and metallurgical engineering.

Special activities of the Club include the annual Christmas banquet and spring picnic. Members are also invited to attend the Student Night of the Chicago Chapter of the AIME each fall.

Any questions concerning the Mining and Metallurgy Club may be directed to: Tom Roth, president; at ALpine 5–0772.

KAPPA ETA KAPPA, YOUR PROFESSIONAL ELECTRICAL ENGINEERING FRATERNITY

Kappa Eta Kappa is a national Electrical Engineering fraternity composed of active chapters at various colleges and universities, alumni associations, and a National Executive Council. It is a service organization, serving the student, the school, and the Electrical Engineering profession.

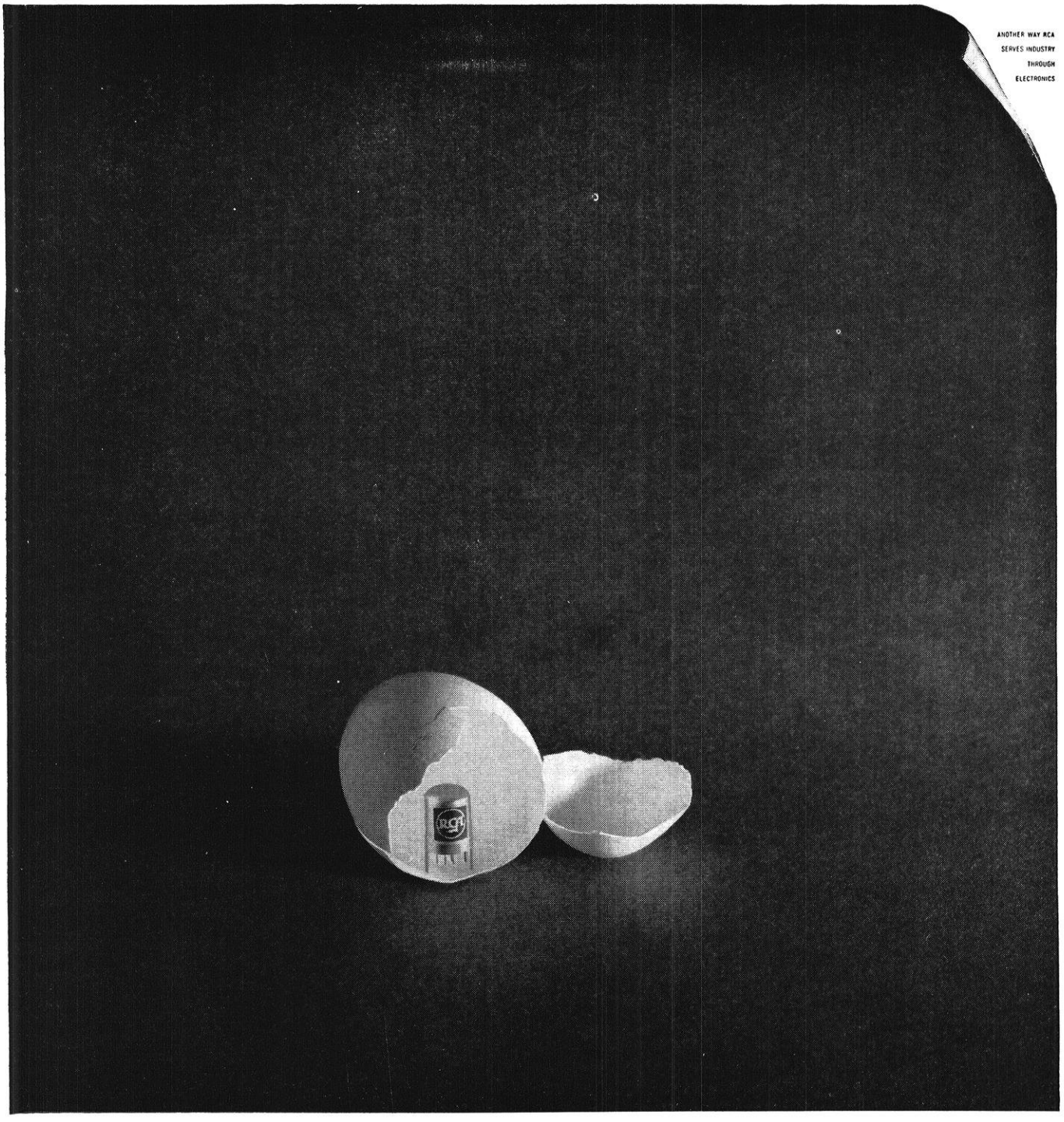
Kappa Eta Kappa is governed locally, for the most part, as each chapter's governing body administers its affairs in accordance with its own and the national Constitution and By-laws. The National Executive Council, which is elected each year at the annual convention of the fraternity, administers the national affairs of the organization and supervises the local chapters.

Membership in Kappa Eta Kappa, since it is a professional fraternity, is limited primarily to electrical engineering students. This is further outlined in excerpts from the National Constitution. Membership in Kappa Eta Kappa is not in any way affected by association with any other fraternity, social or honorary; in fact, we, of Kappa Eta Kappa, are proud of our members who are also members of honorary organizations and the part they have played in making these organizations what they are.

Delta chapter's fraternity house is located at 204 N. Murray Street here at the University of Wisconsin; conveniently located near the Wisconsin Union, library, lower campus, and the engineering buildings. The members have a variety of social functions including banquets, picnics, and house parties. As an aid to obtaining a well integrated education, KHK has a regular speakers program with authorities in such fields as law, medicine, religion, economics, and engineering. KHK is one of the most active fraternities in the engineering school and each semester places men in positions of importance to the entire engineering school. Its men are prominent participants in St. Pat's campaigns, AIEE and IRE, Polygon Board, EE building tours, and the Engineering Exposition. Also, KHK's pledge training program is held to a sane and educational level befitting any professional fraternity.

Membership in Kappa Eta Kappa offers several advantages. First, the opportunity of developing the ability to meet new people with ease and secondly, the opportunity of making new friends. Both of these are offered in any organi-

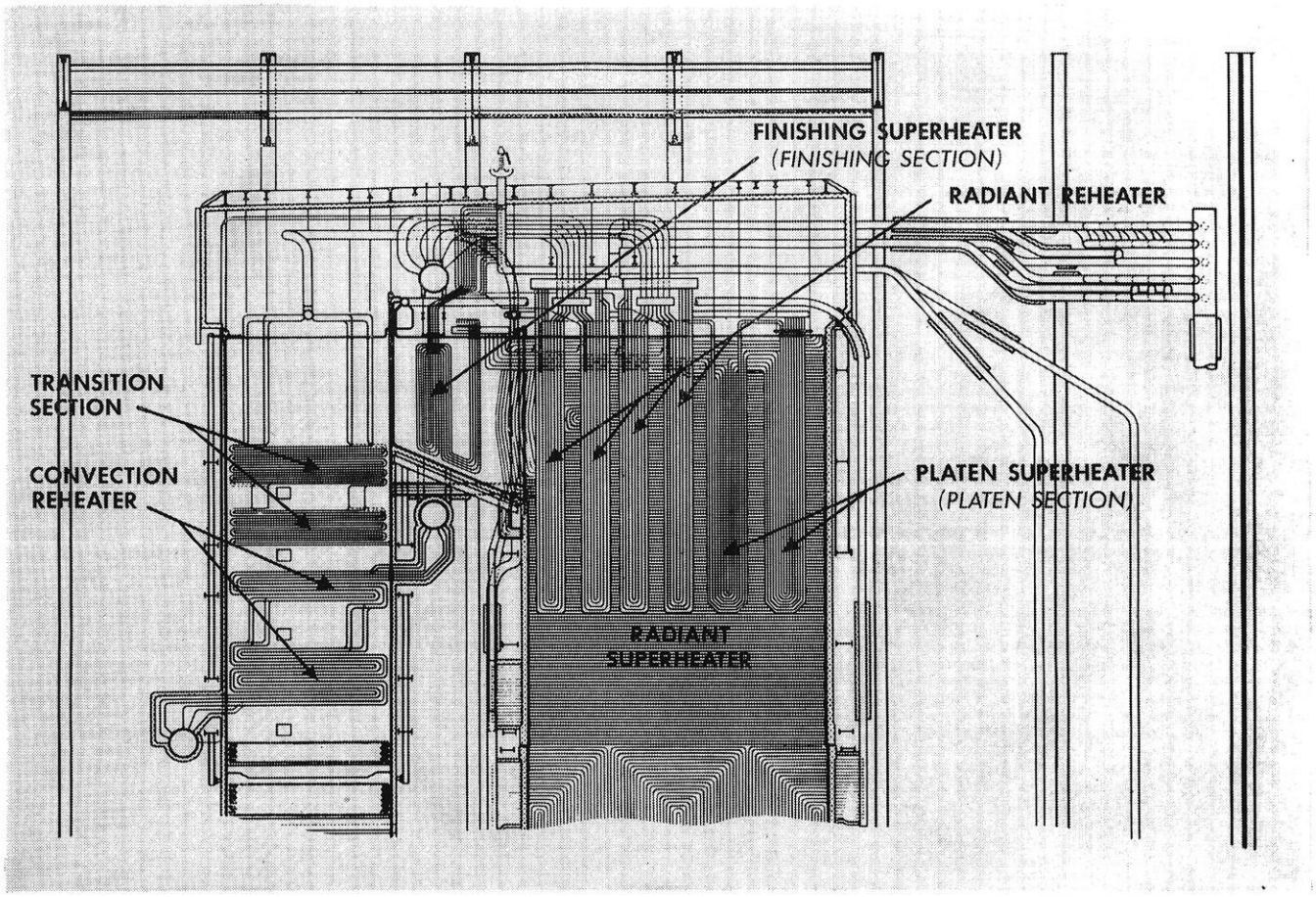
(Continued on page 59)



RCA Electronics introduces the tube of tomorrow

Called the Nuvistor, this thimble-size electron tube is likely to start a revolution in electronics. RCA engineers scrapped old ideas—took a fresh look at tube design. The result will be tubes that are far smaller, perform more efficiently, use less power, can take more punishment, are more reliable. Developmental models now being tried out by designers will have a profound effect on the size, appearance, and performance of electronic equipment for entertainment, communications, defense, and industry in the future. It is another example of the way RCA is constantly advancing in electronics.

RADIO CORPORATION OF AMERICA



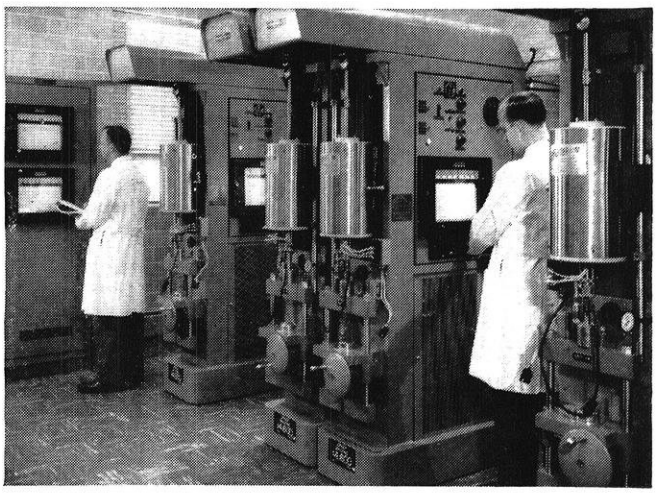
How to get steel tubes to harness highest steam pressures and temperatures

IN constructing Philadelphia Electric Company's revolutionary new Eddystone power plant, engineers had to harness the highest combination of pressure and steam ever achieved in a central station with 5,000 psi at 1,200° F. This called for superheater tubes (see diagram above) of a special stronger steel never before used in steam power plants. No one had ever succeeded in piercing this tougher steel to make seamless steel tubing.

The problem was given to Timken Company metallurgists, experts at piercing steels for 40 years. And they turned the trick. They made the steel for the platen and finishing super-heaters with the alloying elements in just the right balance for perfect piercing quality. They pierced *20 miles* of tubes free from both surface and internal flaws.

Timken Company metallurgists and Timken steels have solved all kinds of tough steel problems. They can help you on problems you may face in industry.

And if you're interested in a career with the leader in specialty steels . . . with the world's largest maker of tapered roller bearings and removable rock bits . . . send for free booklet, "Better-ness and Your Career at the Timken Company". Write Manager of College Relations, The Timken Roller Bearing Company, Canton 6, Ohio.



Creep-Stress Rupture Laboratory in our new Steel Research Center. Here we test the resistance of steels to deformation at temperatures as high as 1800° F.

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SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Hoover Dam

(Continued from page 23)

then refrigerated water. A total of 592 miles of one inch 14 gauge tubing was put into the dam to carry the cool water. The pipe was laid in coils beginning at the cooling slot, running out to the abutments and returning to the center of the dam. They ranged from 220 to 1340 feet in length with the average 513 feet long. They were placed five feet apart vertically and 5 feet 9 inches apart horizontally. The cooling system worked very well as there are very few cracks in the dam. In all, 159 billion Btu's of heat was removed from the dam with the cooling system. After they (the cooling tubes) finished their job they were filled with grout at the same time as the joints.

SPILLWAY CONSTRUCTION

There are two spillways 740 and 660 feet long, one on each side of the river, capable of discharging 200,000 second-feet each. They are made up of a side channel, an overflow weir and inclined tunnels. The tunnels connect the two outer diversion tunnels with the downstream end of the side channels. Part of the spillway construction involved closing off the diversion tunnels with huge concrete plugs. The main phases of spillway construction are: excavation and placing concrete.

Excavation consists of two parts; the open cut for the side channels and the tunnels. Rock in the side channels was removed in 20 feet thick layers by blasting and loading waste into trucks and hauling it to dumping grounds. Care was taken to get the correct shape without damaging the solid rock that supports the spillways. The tunnels were driven in much the same as they were for the diversion works. First a pioneer top heading was dug from the diversion tunnels up to the spillways. Then the top heading was widened out to the required diameter. To get rid of the rock from the inclined tunnels, it was dumped into the diversion, loaded by electric shovels and hauled to washes and side canyons. All rock from excavation of the side channels and tunnels amounted to about 726,000 cubic yards which required about 1.2 pounds of powder per cubic yard of rock.

Before any concrete could be poured, all surfaces were cleaned, washed and sandblasted, if necessary. Then anchor bolts were grouted into the canyon walls every 5 feet vertically and every 7 feet horizontally. While concrete was being poured reinforcing steel was hung on the bolts. The rock walls were grouted to fill all seams and make a good solid foundation for the spillways.

Mixing the concrete was done at the high-level plant and hauled to the Nevada spillway on railroad cars. To reach the Arizona side, concrete was taken across the canyon by cableways which were used to pour most of the spillways. The parts that could not be reached by cableways was poured by cranes and in the most inaccessible places by two-wheeled buggies. The forms used were made of 1 by 6 inch flooring nailed on 2 by 6 inch timbers. Pouring concrete for the spillways posed no special problem other than handling a lot of concrete.

Placing concrete in the tunnels was more of a problem because they are inclined. At first concrete was dumped into a hopper at the top of the tunnels and was allowed to flow through a 14 inch pipe into another hopper at the bottom or the point of placement. This proved unsatisfactory because it impaired the quality of the concrete. Then an inclined track was used with a railroad car on which was mounted a four yard agitator. The car was lowered by a cable to whatever point it was needed. Concrete was distributed in the tunnels by chutes and conveyors. About 150,000 cubic yards of concrete went into the spillways and tunnels.

The spillway system is used to make sure that the dam will never be over topped by flood. It has a capacity of 400,000 second-feet which taken together with the powerplant and outlet works give a protection of 520,000 second-feet. This will handle any flood that is ever expected on the Colorado River. Anytime water gets too high in the reservoir it flows into the side channels, goes down through the diversion tunnels and out into the river downstreams of the dam.

INTAKE TOWERS, PENSTOCK AND OUTLET SYSTEM

To secure water to turn the turbines in the power plant, four intake towers were built above the dam. Water comes in to the towers, down through 30 feet in diameter penstock pipes and then goes in 13 feet penstock pipes to the turbines. The excess water that does not go to the turbines flows to the outlet works on each side of the river.

The first part of the intake tower construction was excavation for the foundation. This was done at the same time as the excavation for the dam. Work was started at the top of the canyon with layers taken off until the correct depth was reached. The rock was dumped into the canyon and removed by electric shovel along with the removal of waste from the dam foundation. About 360,000 cubic yards of material was removed from the walls for all four towers.

The towers were built of 12 equally spaced buttresses which support the trashracks, cylinder gates and gate houses. These buttresses were very heavily reinforced with steel to protect against earthquakes. About 4,000,000 pounds of steel went into the four intake towers; or about 160 pounds per cubic yard. The towers are 82 feet in diameter at the base and 64 feet in diameter at the top with a total height of 395 feet. All 94,000 cubic yards of concrete was placed by derricks mounted on the canyon walls.

The intake towers are used mostly for securing water for the generating turbines. They are also used for letting water bypass the dam if the reservoir is filling up to fast or if water is needed down the river.

Construction of the Penstock and Outlet System

The penstock and outlet tunnels were driven in a manner very similar to the previous tunnels. They were drilled, blasted and the waste hauled away to disposal grounds. Some were a little difficult because they were inclined but little trouble was encountered. Part of the mucking involved loading rock onto a conveyor that dumped into waiting trucks. A total of 216,800 cubic

yards of material was excavated and hauled away from the penstock and outlet tunnels.

Because of their enormous size, 30 feet in diameter, and weight, a fabricating plant had to be built near the dam site to make the penstock pipe. They were too high and too heavy to be transported from a regular plant in the East. Some weighed as much as 190 tons and a special trailer was built to haul the pipe to the dam. The trailer was 22 feet wide, 37 feet long and was mounted on 16 rubber-tired wheels. The trailer alone weighed 41 tons. The cableways took the pipe from the top of the canyon, and moved them as close to the tunnel openings as they could. At the canyon floor the pipe was placed on special cars that rode on railroad tracks and were pulled into place up the tunnels by cables. When they were in place and fastened securely, the pipes were tested for leaks with soap suds under pressure.

The penstocks and outlet tunnels are used to house pipes that carry water to the turbines and around the dam. In case of flood or irrigation need, outlet pipes carry water from the reservoir around the dam and dump it back into the river.

SOME STATISTICS CONCERNING THE DAM

The grand total cost of Hoover Dam was $141,752,919.39. This includes the dam, the power plant and appurtenant works. This is a tremendous amount of money for the American taxpayer to have to spend for one dam. But it has more than payed for itself many times over from the taxes off the crops raised on the land irrigated from Lake Mead, the dam's reservoir. Revenue from the sale of water and electricity to many cities and industries in southern California will be enough to pay for the dam before the year 2000.

Table I on the next page contains yardage figures and cost figures of waste excavations and concrete used in the five main phases of construction. The difference between the total cost in the table and the actual total cost is made up of power production cost, cost of building Boulder City and the Denver and Washington offices cost. Engineering and inspection of the dam cost almost $3,000,000 alone.

There are many strange and interesting statistics concerning the dam. Some of the more amusing ones are: 86,968 hacksaw blades, 96 fishing poles, 588 police whistles and 32,664 canvas bags are just a few of the many diversified articles used in the dam. Six Companies Inc. bought; 5,000,000 gallons of gasoline, 750,000 pounds of grease, and 495 miles of manila rope. Between February 1931 and February 1935, 27,092 carloads of material arrived at Boulder City and was put into the dam. This material came from all parts of the United States.

TABLE I.—SUMMARY OF EXCAVATION AND CONCRETE, COSTS AND QUANTITIES

Part of Dam	Excavation in Cubic Yards		Cost of Excavation	Amount of Concrete Cubic Yards	Cost of Concrete	Other Costs
	Rock	Common				
Diversion Works	$,874,345.4	524,361.5	$15,803,436.98	325,833.8	$ 5,202,584.79	$ 8,247,655.03
The Dam	426,282.0	650,364.0	4,832,333.80	3,250,000.0	17,925,177.97	1,993,760.92
Spillways	740,118.3	.....	2,720,988.36	152,271.1	2,196,403.41	951,400.03
Intake Towers	358,743.0	.....	789,234.60	93,766.6	1,349,816.60	1,541,989.61
Penstock and Outlet System	419,468.2	.....	2,748,144.76	251,091.6	2,784,970.90	7,123,429.34
TOTALS	3,818,956.9	1,174,725.5	$26,914,138.51	4,072,963.1	$29,458,953.67	$19,858,234.93

Achievements of the Dam Since Completion

Hoover Dam is a excellent example of a multi-purpose project. Its benefits cover the whole concept of river control: protection from floods, water conservation for irrigation and other purposes, power generation, recreation and preservation of fish and wildlife.

The dam, being the highest in the Western Hemisphere, creates the largest man-made reservoir in the world. It was named Lake Mead in commemoration of Dr. Elwood Mead, Commissioner of Reclamation during the greater part of construction of the dam. Lake Mead is 115 miles long with 550 miles of shore line and holds 31,047,000 acre-feet of water. An acre-foot is that water that will cover one acre one foot deep. Its fishing, boating and other recreational facilities attract over 2,000,000 persons a year. It has been estimated that a total of 135,000 pounds of bass alone is taken from the lake each year.

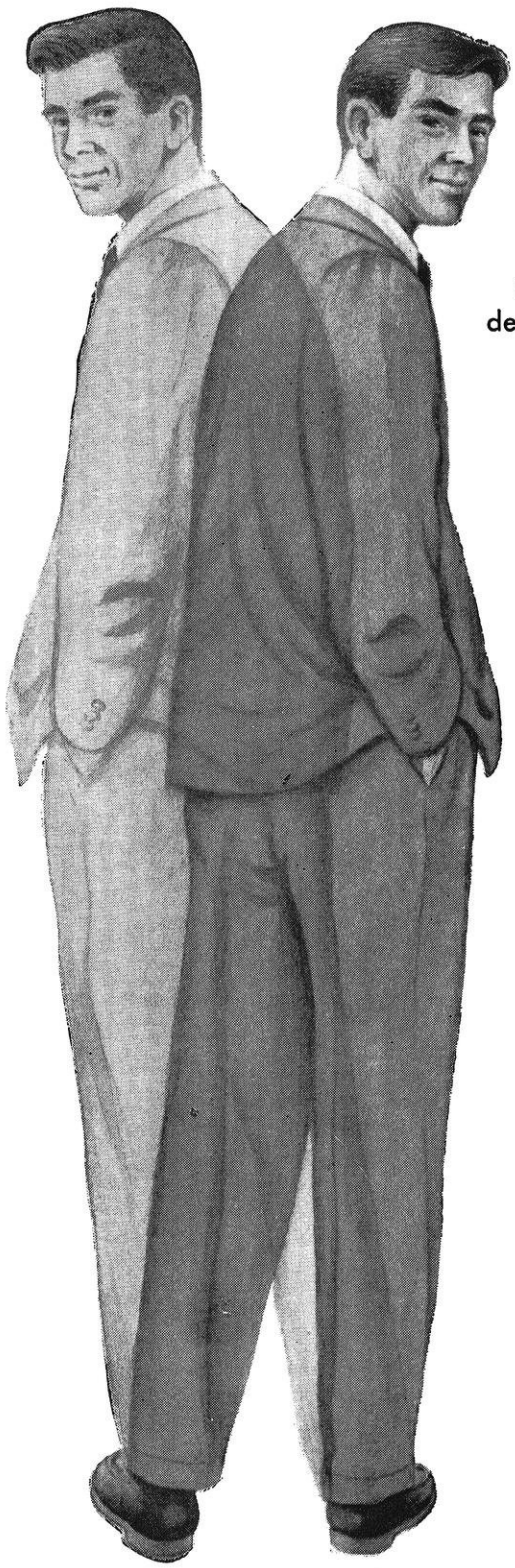
Water stored in Lake Mead assures a dependable supply for irrigating some 750,000 acres of land in southern California and southern Arizona, and over 400,000 acres in Mexico. These lands produce a large variety of crops in a year long growing season. The crops find their way to tables in all parts of the United States.

During World War II, Hoover Dam's power plant supplied more than half the energy for war plants in southern California, southern Nevada and Arizona. Today's peace-time energy requirements have caused outputs to be much greater than even the war-time peaks. It now has a total capacity of 1,249,000 kilowatts, which is enough to supply the normal domestic needs of 2,000,000 people. In the future it will have a capacity of 1,354,300 kilowatts. This tremendous amount of availble power has been a major contributing factor in the rise of a great new industrial region in the Pacific Southwest.

Even today with our many great structures, Hoover Dam remains as one of the greatest pieces of construction ever undertaken by man. It is the largest dam of archgravity type construction, and the second highest of all dams in the world. Hoover Dam is truly an amazing achievement which will reap benefits on us for many years to come. I heartily recommend that if you ever get a chance to visit the dam (as I have done) that you do so, as it will be well worth the time spent there to see what many consider America's greatest structure.

THE END

MEN ...who are Engineers, **look twice** at the many advantages CONVAIR-POMONA offers



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If personal interview is not possible send resume and grade transcript to B. L. Dixon, Engineering Personnel Administrator, Dept. CM500 Pomona, California.

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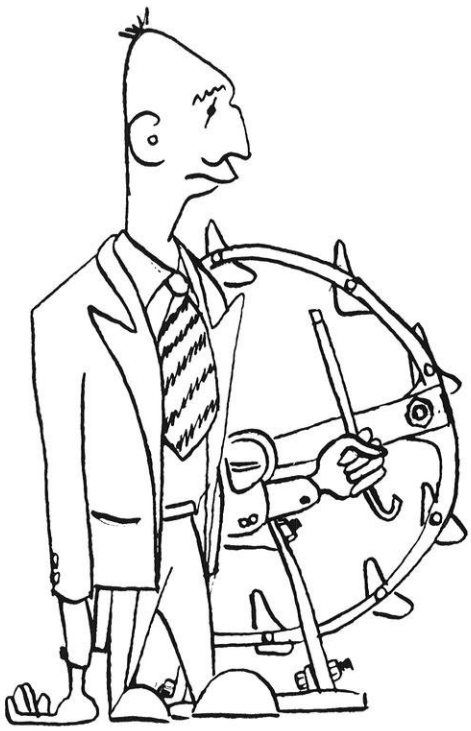


THE FERROUS WHEEL

by Chuck Veen me'60

Ode to a freshman:
Youth must be served. . . . Then carried out.

* * *

When the teacher asked little Jackie how he enjoyed Easter Sunday he came across with the following tale:

"Pop and Mom painted some pretty eggs for sis and me and hid them in the hen house so we wouldn't find them About that time, Bob, our rooster came along and took one look, dashed over the fence into the next yard and kicked hell out of the peacock over there."

* * *

A young lady, with a touch of hay fever, took with her to a dinner party two handkerchiefs, one of which she stuck in her bosom. At dinner she began rummaging to right and left in her bosom for the fresh handkerchief. Engrossed in her search, she suddenly realized that conversation had ceased and people were watching her, fascinated.

In confusion, she murmured, "I know I had two when I came."

* * *

If it's funny enough to tell, it's been told; if it hasn't been told it's too clean; and if it's dirty enough to interest an engineer, the editor gets kicked out of school.

Then there was chemical engineer who wouldn't let his wife feed their kid milk before it went to sleep because he reasoned that the kid would toss from side to side; that milk turns to cheese, cheese turns to butter, butter to fat, fat turns to sugar, sugar turns to alcohol; therefore, the kid would wake up with a hangover.

* * *

She had been dancing with a stranger and left the floor with him. Her fiance finally found her and pulled her away. As they returned to the dance, he said, "I saw that stranger kissing you. Who is that guy?" I'll teach him a thing or two."

"Ah, darling," she sighed, "I don't think you could."

* * *

I had twelve bottles of whisky in my cellar, and my wife told me to empty the contents of each and every bottle down the sink, or else! I promised to do so and, without further ado, proceeded with the unpleasant task.

I withdrew the cork from the first bottle and poured the contents down the sink, with the exception of one glass which I drank. I extracted the cork from the second bottle and did likewise, with the exception of one glass which I drank. Then I withdrew the cork from the third bottle, and emptied the good old booze down the sink, with the exception of one bottle which I drank. I pulled the bottle down the glass which I drank. I pulled the bottle from the cork of the next, and drank one sink cork from the fourth sink, and poured of it, and poured the rest down the glass. I pulled the sink out of the next glass and poured the cork down the glass, and drank the bottle. Then I corked the sink with the glass, bottled the drink and drank the pour.

When I had everything emptied out, I steadied the house with one hand, and counted the bottles, corks and glasses with the other, which were twenty-nine. To be sure I counted again when they came around, and I had seventy-four and as the house came by I counted them all again, and finally I had all the houses and bottles and the corks and the glasses counted, except one house and one bottle, which I drank.

* * *

Statistics show that Vassar graduates have 1.7 children, while Yale gaduates have 1.4 children on the average. This proves that women have more children than men.

...day after finals, a disheveled Ch.E. walked into a psychiatrist's office, tore open a cigarette, and stuffed tobacco up his nose.

"I see that you need some help," remarked the startled doctor.

"Yeah," agreed the student. "Do you have a match?"

* * *

The Kinsey Report proves just one thing: women like to talk.

* * *

The kindergarten teacher was trying to teach her class how to count money. Placing a half dollar on the desk, she said sharply, "What is that?"

A small voice from the back row: "Tails."

* * *

Engineer on the telephone: "Doctor, come quick, my little boy just swallowed my slide rule."

"Doctor: "Good heavens man, I'll be right over. What are you doing in the mean time?"

Engineer: "Using log tables."

* * *

And then there was the Mechanical Engineer who took his nose apart to see what made it run.

* * *

Fellow to blind date: I never really believed in reincarnation—but what were you before you died?"

* * *

"Here, here, don't spit on the floor."

"Why, does it leak?"

* * *

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

* * *

"Please remember I'm a lady," she snapped.

"Girlie," replied the EE, reassuringly, "your secret is safe with me."

* * *

The only thing worse than being a bachelor is being a bachelor's son.

Campus News

(Continued from page 50)

zation but in Kappa Eta Kappa these have more meaning, for these friends are men of your profession with which you have common interests and with whom you will be in contact the rest of your life through your professional experiences as well as socially.

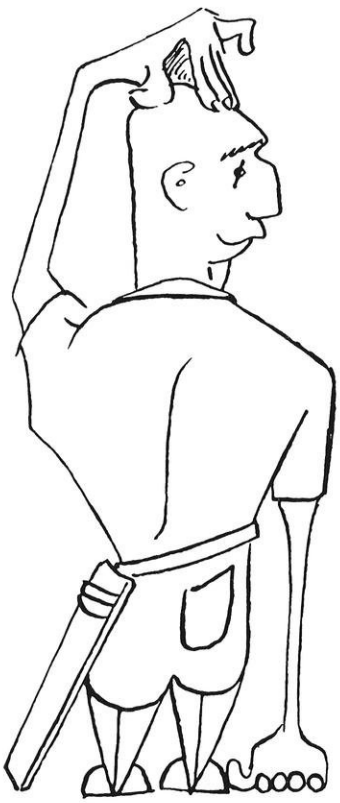
This relationship of men with common interests points out another advantage; that of knowing several with whom to discuss your problem at hand and these several being men who have had similar problems. Whether it is in school and the problem is of scholastic nature or whether after you are in the professional world and the problem is one such as trying to decide upon a new piece of equipment or the solving of a maintenance problem; whatever or whenever, the acquaintance of those that have sometimes before faced the same or similar problem and especially acquaintances so well formed that they are happy to make your problem theirs and assist in whatever way they can is a great asset.

In the field of leadership development, Kappa Eta Kappa offers other advantages. Men with natural leadership traits are encouraged to develop and use these abilities, whose qualities for leadership have and by their example, the men whose qualities for leadership have not been tested are given more opportunities to develop them. Nearly every fraternity offers the above advantages but in KHK, leadership is directed toward professionalism, service, and integrity.

In summary, Kappa Eta Kappa has a plan for every man who becomes a member; a plan of living together that helps men learn how to get along with other people, to assume leadership naturally, and to accept the social obligations that every educated person has for the preservation, welfare, and growth of our nation.

Men who live and study within the walls of a Kappa Eta Kappa house leave upon graduation with qualifications they never could have had without their opportunity of membership in our fraternity.

THE END



So You Think You're SMART!

by Sneedly bs'60

WELCOME to Sneedly's Hideaway, way way out here on the back page of the "Engineer." For the benefit of the freshmen and other generally uninformed persons, I will present each month for you super intellects three sweet problems. And to the sender of the complete set of correct answers with the earliest postl mark I will give ten sweet dollar bills. So wake up and read on!

Yes, read on, especially you freshmen, and learn well from my sad story. This article is one of the finest examples of procrastination you will ever see. The date is August first. In the deep recesses of my memory is a scene in the "Engineer's" spacious suite of offices on a humid May day. The editor, affectionately known to all the staff members as "Little Al Capone," is speaking.

"Sneedly, boy," he snarls, "get your article in before finals start."

The scene changes. It is a beautiful sunny day in June. Finals are over. A close friend and I lie on the sands of the Vilas Park beach thoughtfully drinking a six pack of Bud. I am thinking, of course, of my article. I did a tremendous amount of thinking on this article.

Another day in June. I arrive back at my room from another tough day in the lab. On a table there is a short not from "Little Al." It reads, "If your article isn't in by August first, you won't be in any shape to start school in September." But Al is miles away. August first is in the distant future. I'm not worrying. Not yet anyway.

But now I am worried. A friend sits outside racing up the motor in his Mercedes 300 SL, waiting to rush these words to Madison. If he doesn't make it by 12:00 I'm finished.

The lesson for you freshmen—Get Organized!

Now for this month's problems:

If your bureau drawer contains ten red and sixteen blue socks, and you reach into it in the dark, how many socks must you take out to be sure of getting a pair?

Sally went to vote. Asked by the clerk how old she was, she replied eighteen.

"You can't be serious," said the clerk.

"Of course not," said Sally. "I gave myself the benefit of a year less than a quarter of my real age."

The clerk let her vote. What is Sally's age?

Here's one for you logical thinkers. If $\frac{\text{PORK}}{\text{CHOP}}$ equals C, and C is greater than two, what different numbers do PORK and CHOP represent? None of the letters stands for zero.

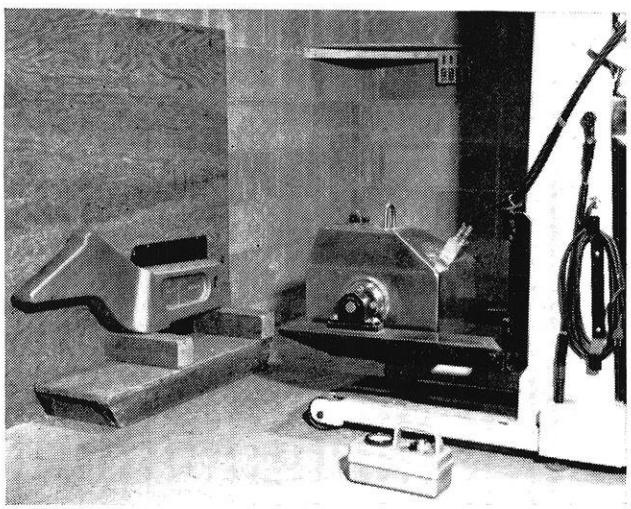
Get your solutions in fast. The ten dollars won't last long. Send your answers and any comments to

SNEEDLY
c/o The Wisconsin Engineer
Mechanical Engineering Bldg.
Madison, Wisconsin.

Caterpillar D8 Tractor with ripper tearing through road material

Rippers really rough it—

So radiography checks their stamina



Ripper shank being radiographed with cobalt 60 projector

RIPPER SHANKS and clevises at the business end of a high-powered tractor lead a torturous life as they tear through overburden and rock.

No place here for a flaw to ruin performance! So Caterpillar makes sure of their stamina—has them radiographed at the foundry that casts them. This is the place for any imperfection to be shown up. For here Radiography can do two things. It can make sure that only sound castings go out. It can point the way to improving casting technique so that a consistently better yield can be had.

Radiography is but one branch of photography that is working day in—day out for the engineer. It is saving time and cutting costs in research and development, in production, in sales and in office routine. You will find that in whatever field you choose, photography will be ready to serve you too.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

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TRADEMARK

One of a series*

Interview with General Electric's Charles F. Savage Consultant—Engineering Professional Relations

How Professional Societies Help Develop Young Engineers

Q. Mr. Savage, should young engineers join professional engineering societies?

A. By all means. Once engineers have graduated from college they are immediately "on the outside looking in," so to speak, of a new social circle to which they must earn their right to belong. Joining a professional or technical society represents a good entree.

Q. How do these societies help young engineers?

A. The members of these societies —mature, knowledgeable men— have an obligation to instruct those who follow after them. Engineers and scientists—as professional people—are custodians of a specialized body or fund of knowledge to which they have three definite responsibilities. The first is to *generate* new knowledge and add to this total fund. The second is to *utilize* this fund of knowledge in service to society. The third is to *teach* this knowledge to others, including young engineers.

Q. Specifically, what benefits accrue from belonging to these groups?

A. There are many. For the young engineer, affiliation serves the practical purpose of exposing his work to appraisal by other scientists and engineers. Most important, however, technical societies enable young engineers to learn of work crucial to their own. These organizations are a prime source of ideas — meeting colleagues and talking with them, reading reports, attending meetings and lectures. And, for the young engineer, recognition of his accomplishments by associates and organizations generally heads the list of his aspirations. He derives satisfaction from knowing that he has been identified in his field.

Q. What contribution is the young engineer expected to make as an active member of technical and professional societies?

A. First of all, he should become active in helping promote the objectives of a society by preparing and presenting timely, well-conceived technical papers. He should also become active in organizational administration. This is self-development at work, for such efforts can enhance the personal stature and reputation of the individual. And, I might add that professional development is a continuous process, starting prior to entering college and progressing beyond retirement. Professional aspirations may change but learning covers a person's entire life span. And, of course, there are dues to be paid. The amount is graduated in terms of professional stature gained and should always be considered as a personal investment in his future.

Q. How do you go about joining professional groups?

A. While still in school, join student chapters of societies right on campus. Once an engineer is out working in industry, he should contact local chapters of technical and professional societies, or find out about them from fellow engineers.

Q. Does General Electric encourage participation in technical and professional societies?

A. It certainly does. General Electric progress is built upon creative ideas and innovations. The Company goes to great lengths to establish a climate and incentive to yield these results. One way to get ideas is to encourage employees to join professional societies. Why? Because General Electric shares in recognition accorded any of its individual employees, as well as the common pool of knowledge that these engineers build up. It can't help but profit by encouraging such association, which sparks and stimulates contributions.

Right now, sizeable numbers of General Electric employees, at all levels in the Company, belong to engineering societies, hold responsible offices, serve on working committees and handle important assignments. Many are recognized for their outstanding contributions by honor and medal awards.

These general observations emphasize that General Electric does encourage participation. In indication of the importance of this view, the Company usually defrays a portion of the expense accrued by the men involved in supporting the activities of these various organizations. Remember, our goal is to see every man advance to the full limit of his capabilities. Encouraging him to join Professional Societies is one way to help him do so.

Mr. Savage has copies of the booklet "Your First 5 Years" published by the Engineers' Council for Professional Development which you may have for the asking. Simply write to Mr. C. F. Savage, Section 959-12, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: Salary • Why Companies have Training Programs • How to Get the Job You Want.**

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