The Wisconsin engineer. Volume 63, Number 7 April 1959

Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

https://digital.library.wisc.edu/1711.dl/7P3DBZ6M5SIJV8I

APRIL

1959

The Wisconsin

engineer

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Space Materials

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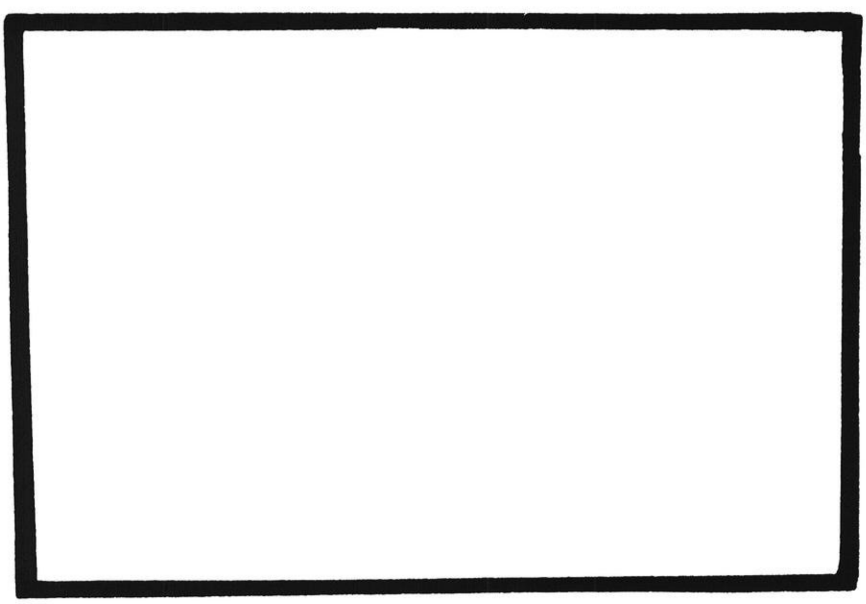
High School Section

Why did you bring your slide rule?

THE WISCONSIN ENGINEER??



No, this is not a polar bear in a snowstorm. It is a Greek engineer's test paper in Thermo during Hell week.

Volume 63 APRIL 1959 Number 7

WISCONSIN ENGINEER

The Student Engineer's Magazine

FOUNDED 1896

Features

Departments

Cover

Army missile crew fires Martin LACROSSE during training mission. LACROSSE is a swept-wing field artillery guided missile that is launched from a standard 2½-ton Army truck. This unique method of the missile age serves to illustrate advances made in defensive measures and space travel. For Articles see contents.

MEMBER OF

ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman:
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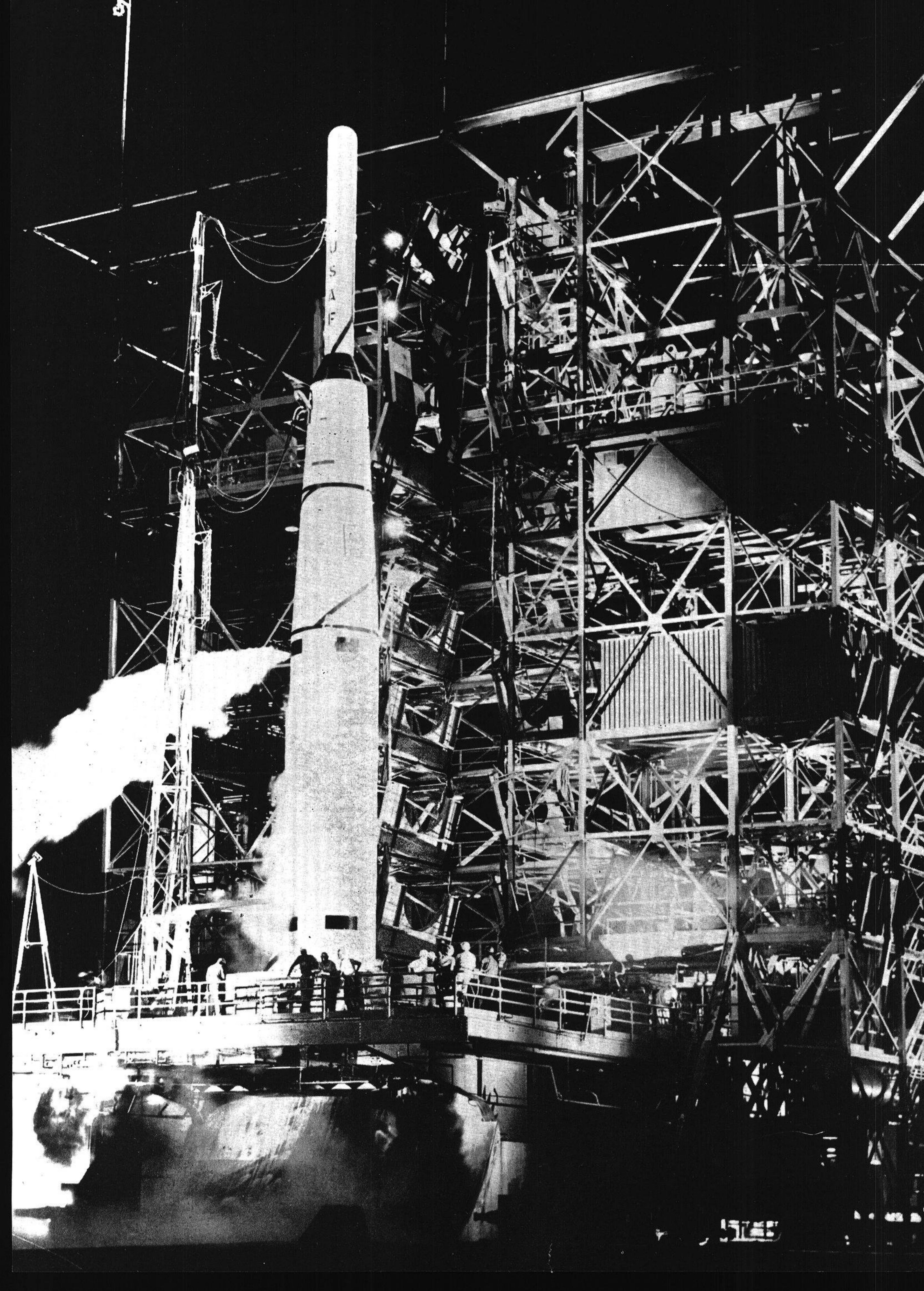
Publishers' Representative:
Littell–Murray–Barnhill, Inc.
369 Lexington Ave.
New York 17, New York

Second Class Postage Paid at Madison, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at a special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized Oct. 21, 1918.

Published monthly from October to May inclusive by the Wisconsin Engineering Journal Association, 333 Mechanical Engineering Building, Madison 6, Wisconsin

Subscription Price

$1.25 PER YEAR . SINGLE COPY 25¢


USAF

Rambling WITH THE EDITOR

It is quite needless to say that there is a tremendous demand for engineers today. Industry indicates its value of engineers when it absorbs every graduate from American colleges each year and places a graduate with a B.S. degree on a starting salary of $500. to $600. a month. The national government's defense and space-exploration programs are constantly calling for an increasing number of engineers.

In 1930 there were 261,000 scientists and engineers in the American labor force of 48.6 million—a ratio of 180 to 1. In 1956, of the labor force of 68.8 million, there were 950,000 engineers—a ratio of 73 to 1 or an increase of 2½ times in 25 years. Continuing technological advances will undoubtedly see a lowering of this ratio unless industrialists, educators, engineers, and upper class students realize more definitely their responsibility to encourage more young men to study engineering.

Last September there was a seven percent increase in the number of freshmen enrolled in colleges in the United States, but at the same time there was a 13 percent drop in the number entering engineering courses.

Several high school students will read this special issue of the magazine. The statistics above should indicate the almost urgent need to enter engineering or science courses in college, but present junior and senior engineers have a special opportunity to help emphasize these needs to all high school students with whom we come in contact.

Recently, the vice president of engineering services for ALCO Products, Inc., Wilson D. Leggett, told a group of senior engineering students "You are in the best of all positions to help. You are still in contact with young men entering college and probably know better than anyone why so many shy away from engineering." Seniors will soon be graduating into positions with various companies in various cities. They will live in various communities and participate in a variety of activities. Their enthusiasm about their engineering work can be shared with qualified high school fellows. Their influence upon them could perhaps do a great deal in helping the nation meet its need for engineers. Juniors will be stepping into the ranks of seniors soon. They may be even closer to the "guys back home" in high school or to other young men who are qualified to enter an engineering curriculum soon.

Leggett went on to say "I hope that you are as enthusiastic about your engineering course now as you were when you started, and that you will endeavor to impart this enthusiasm to as many qualified young men as possible."

Those of us who see these needs for engineers in our society and who are really interested in preparing ourselves to help meet them have a very definite responsibility to encourage those whose interests and abilities qualify them for engineering study. It becomes our responsibility to clarify the functions and goals of engineers, as we understand them, to anyone interested in this field. We owe it to him and to the engineering profession to give as clear and as objective a view of the profession as we can. We must be honest in pointing out the disciplines and difficulties necessary for adequate preparation and study, but, on the other hand, we must not sugar-coat the opportunities or give the impression engineers are indispensable creatures independent to scientists and others of different professions for the ideas and tools they work with.

Never has the need for properly trained engineers been greater. The intensity of the interests shown in this need by those already in the field and the interest that motivates high school graduates to enter engineering colleges determines the technology of the future and may determine in fact the whole future direction this nation takes.

Pre-Launch Lunar Probe #2 consisting of a Douglas Thor Air Force, IREM and Able rocket stages.

Space Materials

by Thomas F. Canny, me'60

One of the problems connected with space exploration deals with the materials necessary for outer environments. Here the author discusses these environmental problems and summarizes information on the properties of materials now existing.

THE subject of this article is Study of Space Materials. We have entered the space age. With it has come new methods of propulsion, new fuels, and most significant, new environments. Rapid advances in aircrafts, missiles, satellites, and long range plans for space flights have required a reappraisal of materials, fabricating methods, and design.

Paralleling these rapid advances is a need to develop improved capabilities in our common metals. Ideally, we need a metal with a high melting point, excellent strength, and ductility but with near zero density. Such a metal does not exist. The purpose of this article is to show where we stand in regard to and future prospects for practical space flight materials.

To read and fully benefit from this article, one should have a basic understanding of metallurgical terms.

The first part of this article is a general discussion of the environmental problems that will exist during space flight. Special emphasis will be placed on the problem of increased temperature due to frictional heat. Next, is a summary of information on the properties of materials, metallic and non-metallic, and a comparison of how each will be effected by thermal environment. Finally, there is a discussion of other alternatives, such as super alloys and composite materials.

SPACE ENVIRONMENTAL PROBLEMS

The needs of astronautics have been under close study for some time. By astronautics is meant flight at speeds, elevations, and distances beyond the capabilities of aeronautics, which by definition depends upon the presence of atmospheric air. What will be the future requirements of astronautic materials? A consideration of these requirements brings one to the study of the natural and induced environments which are unique to space or are important to space operations.

High vacuum probably typifies space more than any other single environmental factor. Vacuum is not expected to have any significant direct effects on most materials; however, indirect effects plus other environmental factors may be very important. Examples are the vaporization of liquids, removal of plasticizers from plastics, and sublimation of materials of high vapor pressure. On the other hand, oxidation and corrosion should be reduced if not entirely eliminated. Materials normally unacceptable because they oxidize and corrode may provide needed capabilities.

The degradation of organic materials by the sun's radiation is familiar to us as the weathering of plastics and paints, the weakening of fabrics and the discoloration of glass. Materials in space will be exposed to its full intensity and the effect will be greater.

Ozone forms by ultraviolet energy between 15 and 25 miles; however, it may exist over much wider ranges. Ozone is very reactive with many organic materials, such as rubber. It is fairly stable and may persist in harmful concentrations in the air drawn into vehicles operating in the 20 mile region. Since it is harmful to humans, ways of decomposing it may have to be found. In any event, it should not present a serious problem for vehicles which spend only a little time in the ozone layer.

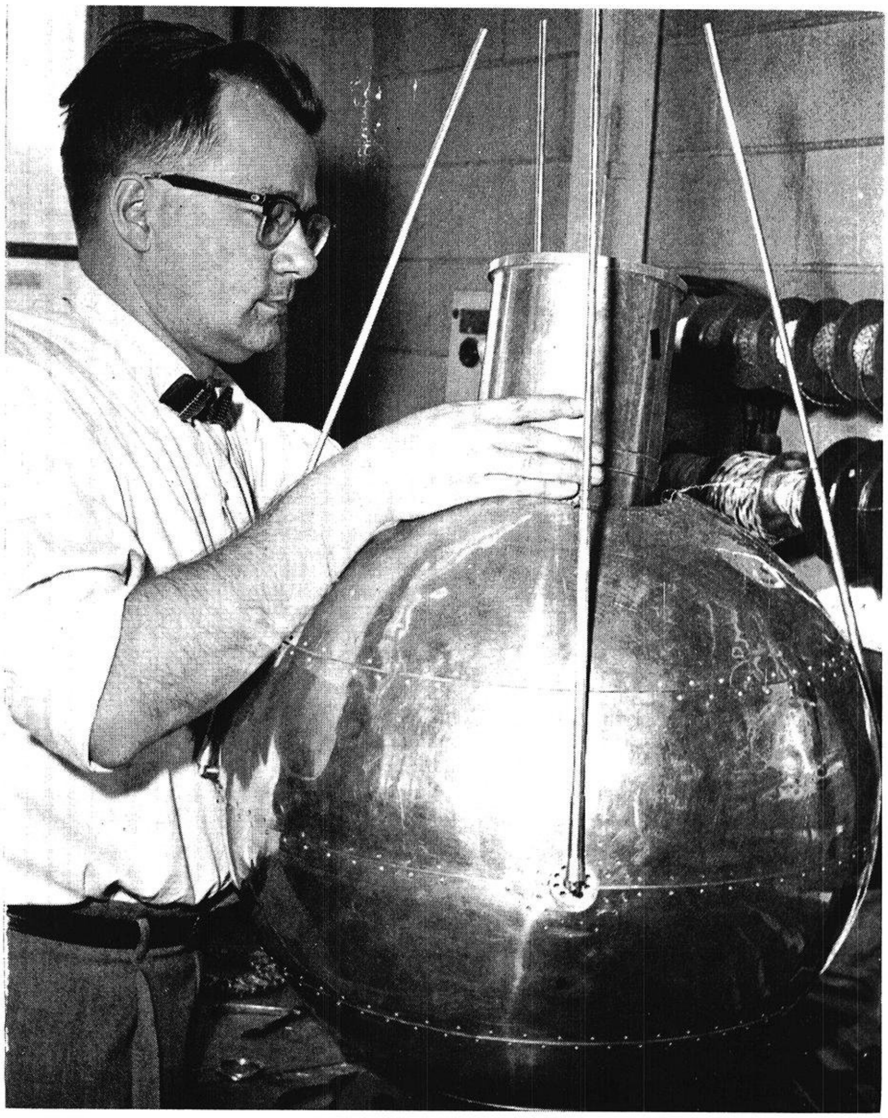
A significant number of particles of dust size will be encountered capable of pitting and eroding a surface. For long exposures, the effects may actually damage the material. The number of meteoric particles decreases with increases in sizes and the chance is small that a vehicle will be hit by a piece large enough to penetrate its skin.

Zero Gravity

No significant direct effects on materials is anticipated with zero gravity. Convection due to temperature differentials in liquids and gases will not occur. Cooling of hot spots and distribution of heat will be by radiation and conduction only and forced cooling may be necessary. This will result in local hot spots and steep temperature gradients. If the vehicle is rotating to induce gravity effects, the centrifugal loads will be very high. In fact, centrifugal loads plus the forces from internal pressurization will constitute the primary stresses acting on a satellite.

Probably no induced environmental factor has received more attention in recent years than temperatures. Heat resistance has come to be one of the controlling properties in material selection for both power plant and airframe construction. As a result, most of the research and development effort in aeronautics has been pointed in this direction. The question now arises as to whether this factor will continue to have dominant importance in astronautics. The problem of aerodynamic heating will remain severe as long as one portion of the flight leaves or enters the atmosphere of the earth or another planet. The equilibrium skin temperatures go up with increasing speed because of the friction encountered as the structure moves through the air. But what about the temperature of a vehicle in space?

The equilibrium temperature of an exposed surface depends upon a balance between the heat it absorbs and the heat it radiates. If not absorbing any heat from the sun, a material would cool by radiation to a few degrees above absolute zero. Fortunately, it is relatively easy to regulate surface absorption and emission by selecting the right material or treating its surface in order to maintain moderate temperatures in space.



—Photo by Martin Dean

Harry Miller of the University of Wisconsin faculty is placing components into the University's satellite. The outer shell is a multiple-plated alloy of magnesium.

How much the temperatures will change due to surface abrasion by meteoric dust remains to be determined. Internally generated heat from power plants and electronic equipment will also influence the heat balance. Likewise, the orbit time exposed to solar radiation will effect the temperature and whether or not the satellite is spinning will effect its distribution.

Summary of Anticipated Effects

After this consideration of various space environments, the conclusion is reached that they will certainly complicate the future requirements for materials. However, no insurmountable problems are foreseen. The bill of materials for satellites, space ships, and re-entry vehicles will undoubtedly be more varied than for customary aircraft. Each component and structural part must be made of the material best suited functionally for the job to be done.

The problem is now, can these future requirements be met with existing materials. The remainder of this article will give a reasonably full picture of high temperature metallurgy as it stands today. The word "metallurgy" is used to include properties of metals, nonmetals, super alloys, and composite materials. Each group will be considered individually.

(Continued on Next Page)

METALS

There would be no problem at all if there could be a material with a high melting point, excellent strength and ductility, and with near zero density. Such a material does not exist. We must rely to a great extent on classes of materials already developed to solve the current problems. Their metallurgical properties and fabricating characteristics must be improved as rapidly as possible and design with them until new materials can be discovered and developed. To begin, some metals practical for space use will be discussed; namely, aluminum, magnesium, steel, titanium, and beryllium.

Alloys of aluminum and magnesium have inherent properties which have made them useful in the past and which will make them useful in critical applications in the future. The most important of these is their low density. The penalties of weight are greatly multiplied when trying to break through the earth's atmosphere.

Since aluminum melts at 1220° F. and magnesium at 1202° F., their use in many future applications is out of the question. Some of the higher strength aluminum and magnesium alloys get their maximum properties through heat treatment, reheating would cause a severe loss of strength. Nevertheless, there are some encouraging points. The extreme temperature and loading conditions encountered in the leading edge and nose cone will probably not exist throughout the entire structure. Designs with cooling and insulation will undoubtedly be developed so that aluminum and magnesium alloys with superior elevated temperatures will be useful.

One proposed construction of this type uses an aluminum airframe to which very small pipes have been added to carry a water coolant. Another alternative is also possible; a thin, protective sheet of high temperature metal which is separated from the load carrying aluminum or magnesium structure by an insulating layer may permit an over-all design which is practical and lighter in weight.

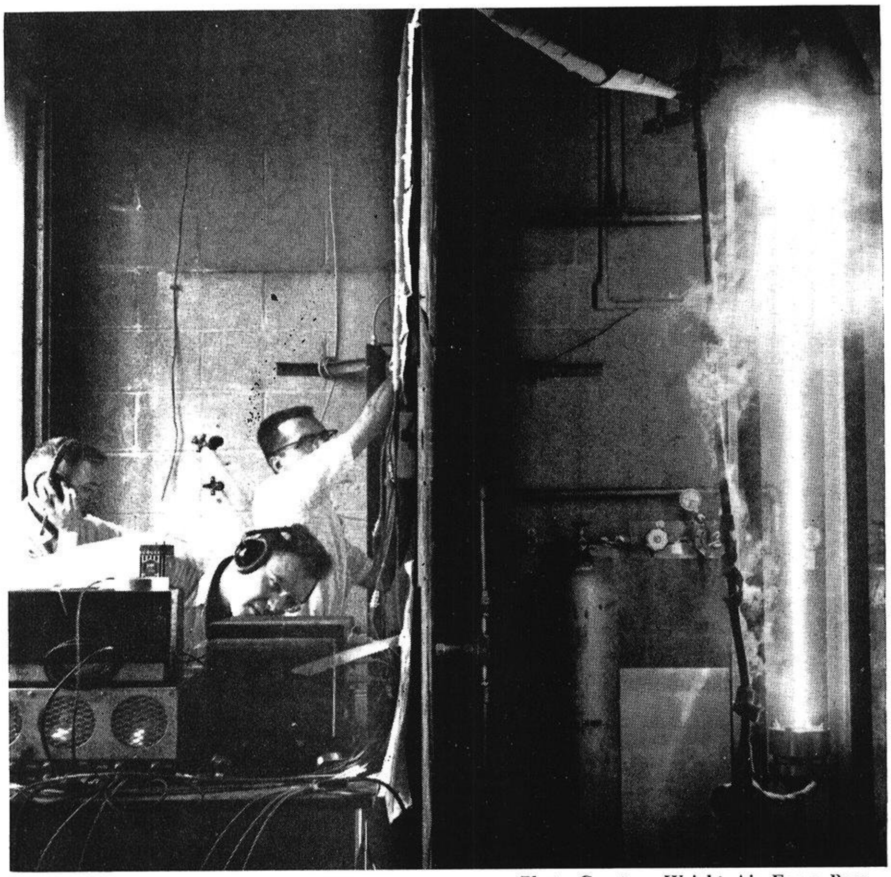
Alloy X2020 is a new alloy containing copper and lithium. Its room temperature properties are somewhat higher than has been true of the strongest standard aluminum alloy. Alloy X2020 has superior tensile strength properties in the lower temperature range, up to almost 400° F. for 1000 hours of exposure. For shorter exposure time, its superiority is extended over 400° F.

Alloy X2219 was developed for elevated-temperature service. It contains copper, magnesium, and small amounts of vanadium and zirconium. It comes into its own in the range of 400° F. to 600° F. At present, it is primarily a forging and extrusion alloy although it can be rolled into sheets and plates.

A significant aluminum development has been the sintered aluminum powder (SAP) type of product. These products utilize aluminum flakes containing various amounts of aluminum oxide. The properties of products vary with particle size and volume of oxide they contain. One composition, M 257 contains six to eight percent aluminum oxide by volume. These powder products are useable up to about 1000° F., and the creep and rupture properties up to 600° F. are superior to all conventional aluminum alloys.

Alloys containing thorium have pushed the useable temperature of magnesium up to 900° F., for short time, low stress applications. This is within 300 degrees of its melting point. Alloy AZ-31, the standard sheet alloy, has the highest room temperature properties, but it is exceeded in elevated temperature properties by HK-31 and HM-21. Alloy HM-21 is exceptionally stable at elevated temperatures. For example, exposure for as long as 100 hours at 700° F. has practically no effect on its properties.

Looking at the strength-to-weight ratios of the best aluminum and magnesium alloys for each temperature range, it is seen how low the ratios are at higher temperatures. The major challenge then is to improve property levels available at maximum usable temperatures.



—Photo Courtesy Wright Air Force Base

Cornell Aeronautical Laboratories graphite tube furnace is used as a general research tool for materials behavior studies, under hypothermal conditions. A high mass velocity gas (hydrogen) stream, heated to 5000° F, simulates leading environment for 30 seconds duration.

Steels

As already noted, materials already developed must be relied upon for solution to many airframe problems. High strength steels fit into this picture. They offer good strength to weight ratio and promising elevated temperature performance. They also show evidence of fairly good ductility and fatigue characteristics.

The properties of steels heat treated to high hardness levels are constantly being improved. Refinements in heat treating practice have increased ductility in the 280,000 to 300,000 psi range, for example, while studies of embrittlement have shown how to use alloys to best advantage.

Compositions classed as hot-work die steels have joined the ranks of metals receiving attention for moderate to fairly high temperature applications. Until recently, they were not considered a structural material.

One of the better alloys to date is the hot-work tool-steels which show impressive tensile- and yield-strengths up to one-thousand degrees F. Fabrication difficulties are hampering their use as structural materials. They are more susceptible to decarburization in heat treatment and welding is a ticklish operation. Machining in the hardened condition is also difficult.

Stainless steels are an important class of materials for airframe construction. Even though they do not come up to the elevated temperature strength of the tool steels, their improved resistance to oxidation and corrosion is an important factor. The martensitic stainless group comes closest to matching the strength of the tool-steels but lack oxidation- and corrosive-resistance and are plagued with fabrication problems. The precipitation hardening steels are easier to fabricate and are more heat resistant but they possess only about two-thirds of the strength of tool steels.

Titanium

The strength-to-density ratio of titanium is its most publicized property. In this respect, it is superior to many metals over a wide intermediate temperature range. On this basis, the hot-work die-steels are the most competitive materials. Beryllium, with its low density, will be competitive when it becomes more available. The new all-beta titanium alloy has the potential of being heat treated to over 250,000 psi ultimate tensile strength.

The maximum temperature for use of titanium appears to be about 2000° F. for very short-time exposure and 1000° F. for long-time properties. Creep strength is not necessarily the limiting factor at high temperatures. Above 1100° F., titanium absorbs oxygen and nitrogen at rates sufficient to effect its usefulness. Some producers consider 1000° F. the upper limit for continuous and 1500° F. for short-time service.

Beryllium

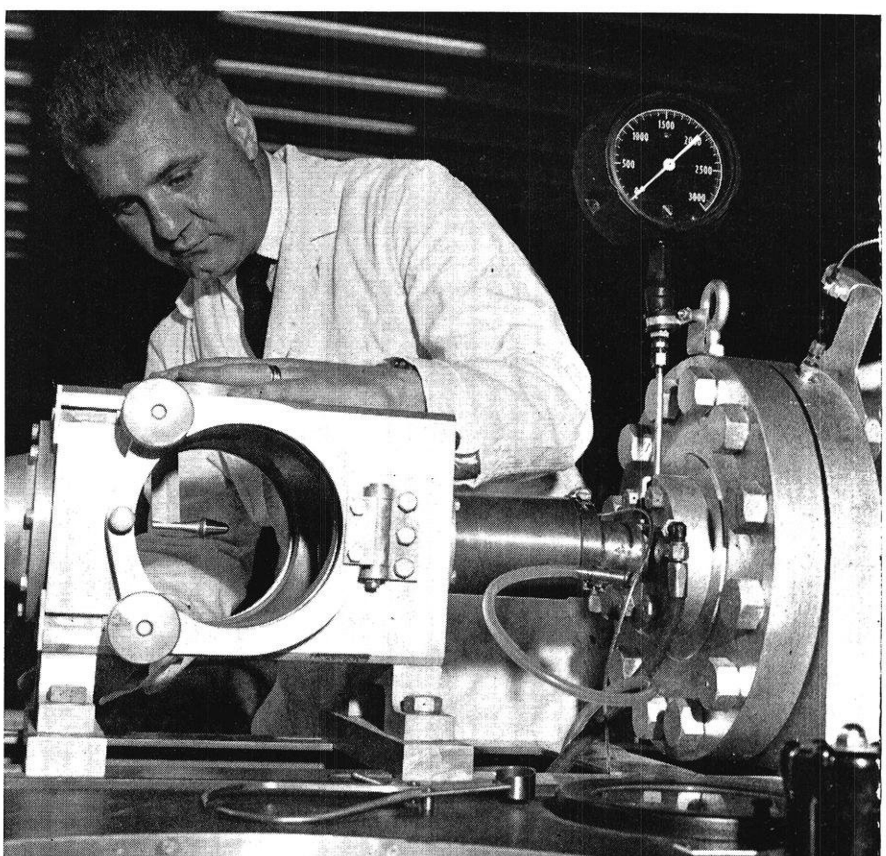
During the past year, progress made to develop beryllium has been tremendous. Today, it is no longer a laboratory curiosity. Instead, it is a metal which can be made into needed shapes and utilized in limited, but important, applications.

A unique advantage of beryllium is its great stiffness. It has a modulus of elasticity of $42x10^6$ psi, topping many other metals including the steels. The thermal properties of beryllium make it highly desirable for heat-sink applications. Its melting point of 2343° F. gives a degree of optimism for high temperature use. Also, its strength-to-weight ratio is extremely high; few metals can approach it.

Because of these advantages, beryllium is being proposed for a number of applications and is already being used in several components. A proposed application which utilizes the unusual thermal properties of beryllium and at the same time reduces weight, is aircraft brake disks. Here the metal would be a heat sink for the enormous amount of heat given off. Another proposed use is in missile nose cones and re-entry bodies. The thermal properties of beryllium, combined with lightness, would permit a weight saving which could be translated into either a range increase or fuel savings.

Joining beryllium to itself and to other metals presents a problem. The metal is toxic, and special equipment is required when working with it. Its cost is high. However, other factors such as weight saving, fuel saving, and range in-

(Continued on page 54)



—Photo Courtesy Wright Air Force Base

Anthony Fiore, Aeronautical Research Laboratory, places a test model into the hypersonic test stand. Speeds of Mach 18 (about 12,000 miles per hour) can be reached with the device.

Flight to the Moon

by A. J. Slifka, me'59

Recent probings of outer space and the near-successful attempts to place a satellite in Lunar orbit lead to the prediction that soon man will be making that flight to the moon heretofore contained only in science fiction.

WITH the progress of time we have seen the invention of the automobile, the steamship, and the airplane, and now we have successfully launched space-probing satellites. In the future, we will be landing unmanned laboratories on the moon to send back information, which will then be followed by man's landing on the moon. Space travel, once inconceivable to practical men, has now become a reality. Our era is the beginning of a space age.

Beginning of the Space Flight

Satellites have traveled as far as 79,000 miles into space. Rockets have traveled as far as 100 miles in space. All these probes have brought back valuable information pertinent to radiation, density and temperatures of gases in the immediate vicinity of the earth, distribution of micrometeorites, and magnetic fields in space. Soon, miniature television systems will be installed in the satellites.

At the present time efforts are being made to hit the moon with a missile containing a warhead such as TNT. Nuclear weapons will not be used because they would contaminate the moon with artificial radioactivity. The light from the flash, in case of a hit, would be helpful for analyzing the chemical nature of the surface layer of the moon.

Recently, as hot at the moon was attempted by the Air Force's 88-foot Pioneer moon-probe missile. Pioneer's main objective was to reach the gravitational field of the moon and orbit it. But the missile had shot up at too steep an angle and could not reach the velocity of 24,900 miles per hour necessary to escape the earth's gravitational. field.

Drawing a bead on the moon is something like shooting a duck from a spinning merry-go-round, using a bullet that takes two days to creep near its target.

The Pioneer had to be fired at a precise time to pass into the moon's gravitational field. This time occurs only three days out of each month, and during 18-minutes of each of these days.

The moon revolves about its own axis at the same rate as it revolves about the earth. Therefore the other side of the moon has never been seen. A rocket, orbiting the moon, carrying a television system could relay information back to earth.

Next, rockets will land on the moon and robots, with television heads, will explore the moon. The robots will take temperatures and analyze the dust and rock layer formations.

Manned Rockets

There will be three types of space ships. The first type will be a multi-stage rocket with a winged final stage. This rocket will be used to orbit the earth and other planets atmospheres that possess. It will return to the earth or planets by atmospheric braking.

The second type will be the lunar spaceship. It has no wings and is used for landing on smaller planets without atmospheres; therefore, it uses rocket braking. The lunar spaceship would not have to be built as strongly as the first type, since the moon has a smaller gravitational field than does the earth. This rocket will have to be built in space.

The third type would be the deep-space ship which would never land on any planet. It would just go from orbit to orbit. This spaceship would have to be built in space and would not have to be built very strongly because no excessive accelerations would be required of it.

The first rockets will go all the way to the moon and back. They will probably have five stages with a winged final stage for landing in the earth's atmosphere.

A comfortable environment will have to be provided for the crew. Temperature, humidity, and pressure will have to be maintained. Food will have to be carried in the spaceship. The crew will be living in a world all by themselves with no help from the outside.

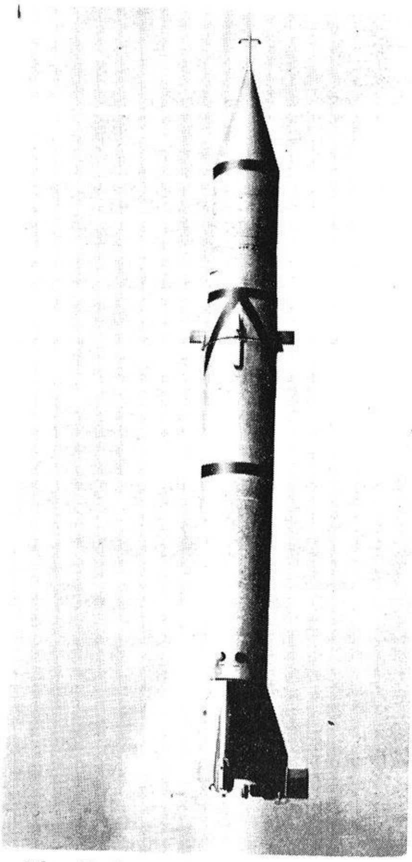
The spaceship will have to be strong to withstand pressurized cabins. In space, there will be pressure on the inside and not on the outside of the spaceship. On earth, our bodies are subjected to an atmospheric pressure of 14.7 pounds per square inch. The atmospheric air is made up of 21 per cent oxygen and 78 per cent nitrogen by weight. The human body can withstand a reduction in pressure to a certain extent, provided the available oxygen is increased. If the pressure is reduced to eight pounds per square inch, the oxygen content must be increased to 40 per cent by weight. This reduced pressure will make the construction of the spaceship easier because the bursting strength will not have to be quite so high. Also, the nitrogen will be replaced by helium. Helium is lighter, and the case of an accidental reduction in pressure, helium will not produce the bends.

Good air ventilation must be provided. Some means must be used to remove the carbon dioxide and replenish the oxygen. Green plants, which absorb carbon dioxide and liberate oxygen, would solve this problem although this would be an awkward solution. Also, filters added to the air cycle will be necessary to remove objectionable materials and offensive odors. The helium would be recycled as it would not be changed in the breathing cycle.

Exhaled CO_2 A Threat

When there is gravity, warm air rises because of a decrease in density, but this will not be the case in a spaceship. Therefore when relatively warm air comes out of a person's nostrils it will not circulate. It will just hang there and the carbon dioxide will be breathed in again. So, an efficient means of circulation must be provided.

In a flight to the moon, temperature will not present an insuperable problem. The only source of heat from the outside will be the sunlight. If the surface material of the spaceship is a reflector, not much heat will be transferred inside. If



The Redstone Missile, produced by Chrysler Corporation soars upward in flight.

it is like a black body (absorber), it will absorb all the heat. Some optimum condition between the two extremes of absorption and reflection will be used. Only one side will face the sun. In order to have a uniform distribution of heat, the material used will have to be a good conductor, or the spaceship will have to rotate slowly so all of the surfaces are equally heated.

Since there is a lack of oxygen in space, huge fuel tanks carrying the liquid oxygen, which is necessary for fuel to burn, will occupy the greater part of the spaceship. Some rocket engines will also use solid fuel propellents. Engines will have to develop 2,000,000 pounds of thrust. One pound of liquid fuel can produce 200 pounds of thrust per second. So one can see the necessity of extremely large fuel tanks.

Liquid oxygen must be handled with great care. It must be kept under great pressure and 300° below zero. If a person placed his finger in liquid oxygen, retracted it, and then bumped it gently, it would shatter like glass. Above the 300° temperature, oxygen will vaporize and expand more than 800 times. Therefore valves and pipes must be leak proof.

Mixing the fuel, which is usually kerosene or alcohol plus the liquid oxygen, is a precision operation. The fuel and liquid oxygen do not explode spontaneously when they come together, but form a gelatin blob. This blob will explode at the lightest touch. If a person stepped on a blob the size of a marble, it would blow his foot off. The liquid oxygen and fuel are sent through nozzles and mixed together a split second before they enter the combustion chamber. If they were mixed before, vibrations would cause the whole mixture to explode. The fuel and liquid oxygen must be mixed in exact proportions. They must be sucked out of their tanks at a high rate of speed. This is accomplished by a small turbopump that sucks out 10,000 gallons of fuel and liquid oxygen in three minutes.

When this mixture burns, a high temperature of 6000° is obtained. Because presently known metals cannot withstand this high temperature, the combustion chamber will have to be cooled.

After the rocket leaves the ground, the guidance system takes over. This system is composed of three gyroscopes which can detect a change in direction. When there is a change in direction, instruments tell the ship which way to turn. Computers figure out the velocity at all times and must be very exact because an error in velocity can cause the rocket to miss its target.

Flight to the Moon

To escape the earth's gravitational field, a spaceship would have to attain a speed of 24,900 miles per hour. At this speed it would reach the moon's orbit in 116 hours. If the spaceship exceeded its initial speed, it would drastically reduce its time in reaching the moon. If it were traveling at a rate of 27,000 miles per hour, it would reach the moon's orbit in 19 hours. But the object is to just reach a point where the earth's and the moon's gravitational fields will balance. This point is 24,000 miles from the moon. It takes only a matter of

(*Continued on page 56*)

Satellite Tracking

by John Spooner, ce'61

This is a report on the electronic and visual methods that are used by professionals and amateurs in the tracking or recent satellites.

INTRODUCTION

ON JULY 29, 1955, the White House announced "The United States, as part of its contribution to the International Geophysical Year, will launch an unmanned Earth–circling satellite vehicle." On the last day of January, 1958, the United States army fulfilled this prediction with the launching of Explorer I.

Several other successful U. S. launchings have followed—Vanguard I in March, and Explorers III and IV in June, and July, 1958. Recently, in February, 1959, Vanguard II began circling the earth in an attempt to survey the world's cloud cover.

Many problems connected with these undertakings had to be resolved. Not among the least of these was the problem of proving that the satellite was actually in orbit—not as simple as it would appear at first thought. It was like trying to locate a golf ball, sixty-thousand feet away, traveling at supersonic speed.

In this article, an attempt will be made to summarize the methods used by the United States in the tracking of satellites. A primary problem is the information needed to determine an orbit for an artificial moon. Then the three types of tracking methods selected for use in the United States program and the reasons for these choices will be discussed. The three methods are: electronic tracking, professional optical tracking with a camera, and amateur visual tracking. As shall be seen, each phase of the program has its specific purpose. The success of the entire program depends upon the success of each operation. Finally, the coordination of activities and the computations derived from the data collected will be considered.

SUMMARY

There are two basic methods of tracking artificial moons. The first is electronic. Both amateurs and professionals are engaged in this work. Minitrack stations are built on both continents of the Western hemisphere. These stations conduct complex operations, needing trained technicians and costing much to construct. Most of the information used in determining the orbits is obtained by these stations. Amateurs are doing their part, however, using simplified equipment. The results obtained from these installations are sent to Washington, where they are evaluated.

The second method, visual tracking, also employs both amateurs and professionals. High precision cameras have been designed for professional use. These cameras need approximate information on the orbit if they are to be of value. Once this information is obtained, they provide very precise results as to the satellite's location. Amateurs, through operation Moonwatch, are providing a valuable service. If the satellite's radio transmitter should fail, the amateurs provide the only information on the satellite. Also, during the final few hours of the satellite's life, the amateurs are the only group which can track it.

All the information collected is evaluated in Washington by using electronic calculators. The calculators can provide instantaneous information as to the position of the satellite.

SATELLITE ORBITS

A knowledge of the factors determining the orbit of an earth-circling satellite is necessary to see what information is sought through tracking.

Broadly speaking, everything in the universe is a satellite, is part of one, or is held to one by the force of gravity. Tiny atoms, like frantically spinning solar systems, have electrons spinning around their nuclei. Everything in the solar system travels in some sort of orbit around the sun, or around bodies which themselves travel around the sun.

In most cases, the orbits which these bodies follow are ellipses. There are some bodies which follow parabolic or hyperbolic orbits, but they are of no interest in the present discussion.

Orbits of any type always lie in a plane. Any deviation of velocity changes the orbit. Slowing down reduces, and speeding up increases, the size of the orbit. Any departure from the plane changes the orbit, which is said to be inclined to its former plane. It is possible to prove that a satellite's orbit has to be in a plane with the center of gravity

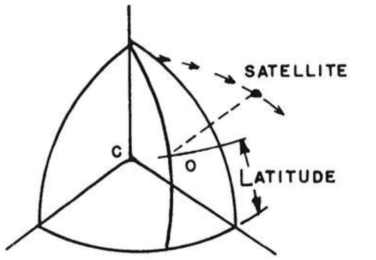


Fig. 1.—The coordinate system within which a satellite's orbit is calculated.

of the body around which it is to rotate. This is of importance, for it is known that an earth satellite is bound to pass over a tracking station set on the equator of the earth.

If the orbit of a satellite is to be defined, there must be some framework to which it is related. Since the earth satellites rotate around this planet, the center of the earth is a good hub of reference. If point 0 is located by its latitude and the time of the observation of a satellite from 0 is known, the distance and angle from the center of the earth to the satellite can be determined.

If there are several such points 0, and at each the distance and angle to the satellite are determined, an orbit can be calculated. There are several methods which can be used to determine these distances and angles.

METHODS USED FOR TRACKING

Electronic Methods

The requirements of a tracking system were considered in great detail. In the early hours after a launching, it was imperative that the location of the satellite be determined quickly. If the artificial moon should have a short life span, such as would happen if the angle of launching were too low, and the satellite plunged back into the atmosphere, as much information as possible should be quickly determined. One of the requirements of the tracking method, therefore was that the satellite's presence be determined immediately with no previous information as to the path, time of arrival, or speed. In addition to this, since the satellite would circle the entire globe in a short time, continuous operation of the tracking method, day or night, rain or shine, is imperative.

With these requirements established, radio was chosen as the method of tracking most likely to meet with success. There are two types of radio systems which could be used: passive and active. The passive system, where a signal is transmitted from earth, reflected from the satellite, and reflected back to earth, was considered and then rejected. The system would have depended upon the size and shape of the satellite and would have taken extreme power. The second alternative was chosen. In the active system, a small transmitter would be placed in the satellite, and ground stations would be built to receive the signals. This system came to be known as Minitrack.

Minitrack. The name "Minitrack" was derived from the use of a minimum weight transmitter in the satellite emitting the signal which is tracked on the ground.

The transmitter in the Explorer I is contained in a package weighing thirteen ounces and is in the shape of a cylinder five inches by thirteen inches. The transmitter uses transistors and printed circuits to conserve space, weight, and power.

The transmitter emits a signal of twenty-milliwatts power (two ten-thousandths of the power of the 100-watt light bulb) on a frequency of 108 megacycles. This frequency is about the same as the frequency at which television is broadcast. The 108 megacycle band was chosen because it would permit the use of transistors and the signal would penetrate the ionosphere easily. The ionosphere is a layer of electrified particles high in the atmosphere. Radio waves of a frequency in the normal broadcast range are reflected by this layer and bounce back to earth.

The ground receivers are equipped with huge antennas arranged in what is called a Mill's Cross, a plus shaped pattern of grids, each of which vaguely resembles a television antenna. There are eight or twelve of these grids in each Mill's Cross. Unfortunately, these arrays are very expensive. The stations require ten technicians and cost $120,000 each to construct.

How does this system work? In ordinary human experience, an individual locates the source of a sound by virtue of the slight differences in time it takes the sound waves to reach each of his ears. This difference is known as the phase difference. Similarly, the listening "ears" of the Minitrack stations are pairs of receiving antennas set a measured distance apart.

If the radio waves arriving at the two antennas are out of phase by one-third of a wave length, the extra distance that the wave has to travel to the farther antenna can be found, and, from this, the angle from the base line to the satellite can be found.

Unfortunately, the system is not as simple as this, for the wave may be out of phase by two-thirds, one

(Continued on Next Page)

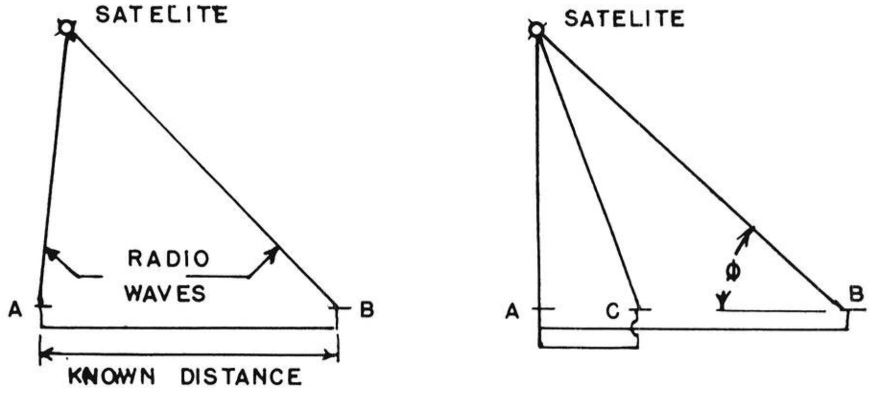


Fig. 2a, b.—Diagrams showing the use of phase differences to determine the angle to a satellite.

and two-thirds, or two and one-third, etc. Thus another pair of antennas must be added. By combining the two different phase readings obtained, the true angle can be established.

In practice, radio readings are obtained by means of an electric circuit which amplifies, mixes, and then compares the signals from an antenna pair, and finally produces an electric output which is proportional to the phase difference. This output is fed to a recorder which reads directly in degrees. Greater accuracy is provided by another recorder which records the phase difference to within one-one thousandth of a second. From this, figures can be computed which will fix the direction angle within 1/180 of a degree.

Also in practice, supplementary antennas are placed at ninety degrees to the original pair, so that two angles can be found and thus the satellite can be fixed in three dimensions. In these stations, more than two pairs of antennas are provided in each direction. The antennas cover an arc of one-hundred degrees by ten degrees in the sky; thus, if the satellite passes anywhere within this range, its signal can be picked up.

For the station to function accurately, its position on the surface of the earth must be determined. For it is only through its position that the satellite can be fixed with relation to the center of the earth. The baselines have to be exact north-south and east-west lines. This is hard to accomplish in practice, so a correction factor is computed for each station.

An ingenious method was devised to determine this correction factor. An airplane, carrying a small light, was equipped with a transmitter such as is used in the satellite. A telescope was set up at the intersections of the baselines of each station. When the plane flew over the station, its direction was determined by the station from the transmitter in the plane, and at the exact same time, a picture of the light in the plane, superimposed against the background of stars, was taken by the telescope. The correction factor was then computed from the plane's radio direction and its actual direction as shown by the picture.

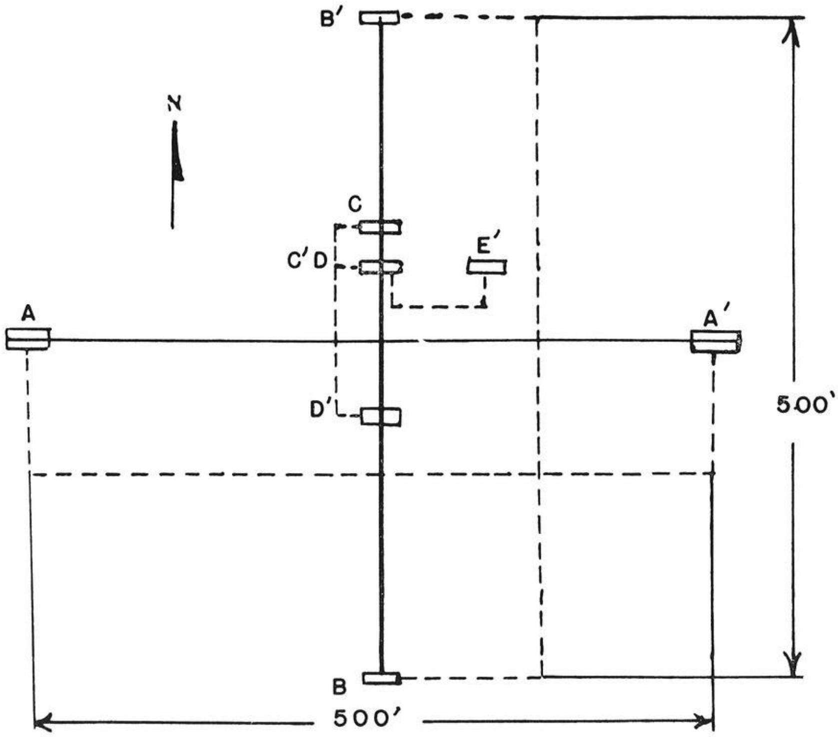


Fig. 3.—The ground plan of a typical Minitrack station.

Approximately twelve of these stations have been built along the general line of the seventy-fifth meridian extending from Maine to Chile. They have lived up to the designers best expectations, providing accurate information on the satellites which the United States has sent aloft.

An interesting sidelight occurred when Russia launched her Sputniks. Their transmitters were on a frequency of 20.005 and 40.002 megacycles, which is much lower than the frequency around which the United States had planned the stations. One can imagine the frustration caused as the Minitrack antennas were hurriedly converted to handle these much lower frequencies and makeshift equipment was flown to the stations. However, the task was accomplished, and the Minitrack stations succeeded in determining the orbit.

Amateur Contribution to Electronic Tracking. There are in the United States many amateur radio operators. The "hams" have always been interested in experimentation and helping where they are needed. It is only natural that the "hams" would want to take part in the satellite tracking program.

When the Russians launched their first Sputnik, the amateur radio operators were among the first to report its signals. The average "ham's" equipment includes a receiver that will pick up the signals from the Russian satellite, while the professional Minitrack stations could not.

From the above discussion of the Minitrack setup, it is obvious that the equipment is too expensive for the amateurs. However, a simplified system has been designed. Its cost is still quite prohibitive, but groups of amateurs, aided by grants from local industry, could cross this obstacle. Provision is made for the amateurs to record the signals they receive. These recordings are then sent to Washington, where professionals evaluate them.

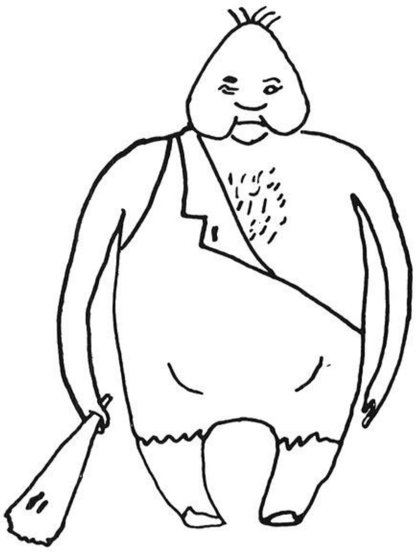
Visual Tracking

While radio tracking is the best method of tracking, the satellite, the entire operation depends upon

(Continued on page 61)

Marvin Ook Discovers Rolling Friction

by Charles H. Veen



THE discovery of rolling friction has often been attributed to primitive man. But now there is conclusive proof that the man who first utilized rolling friction was Marvin Ook.

Marvin made this astounding discovery while transporting his furniture from Caveville to a small plot of land near the big swamp. It seems that Marvin was involved in a "back to the farm" movement.

Public opinion was one of the reasons Marvin had to move to the country. This situation arose when a biological experiment conducted by Marvin failed. The failure which Marvin suffered was from an attempt to breed a larger and better Scorpion. Not that Marvin's endeavors did not produce results. But when 755 of the twelve foot Scorpions escaped and went roaming loose through Caveville, Marvin was definitely considered persona non grata.

After the third attempted hanging, Marvin's keen mind perceived that he was not wanted in Caveville. So we find Marvin and the little woman, Matilda Ook, dragging eighty-two tons of stone furniture on a wooden sled. Now the popular contention is that Marvin rolled the sled over a log. However, this is untrue. The little woman, who was quite portly, accidently fell in front of the sled. Marvin felt the strain on the rope lessen. Looking back, he found that the sled was rolling over Matilda. Being quiet shrewd at deducing the reasons for natural phenomena, Marvin realized that by continually throwing the little woman in front of the sled his work would be reduced appreciably.

After three hundred miles, Matilda went a bit flat and began to roll eccentrically. So Marvin decided to replace her with a more sturdy object, namely a log. This is the manner in which Marvin discovered the rolling log as an expedient mode of reducing friction. This was truly one of the greater discoveries made by Marvin and for which he has not received fair and just recognition.

STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Co., Inc.

Here at Douglas we're involved in a greatly accelerated missile and space program. This requires one of the most intensive engineering and research efforts in our history.

The problems are great ones as we move into the new dimension of unmanned and manned space vehicles. They require specialists in almost every engineering field. But their solution will result in great benefits not only to our own nation but to all mankind.

If you're interested in tackling these problems with us... in giving your best in an all-out drive to solve them... we're interested in you!

Please write to Mr. C. C. La Vene
Douglas Aircraft Company, Box P-600
Santa Monica, California

Here's how PPG research put more FUN in boating

Take your pick—water skiing, skin diving, or just skimming along the surface. Afloat, boats mean fun. But there's a big difference ashore. Some boats demand wearisome hours of work—caulking, repainting, replanking. And here's where PPG•research comes in. Thanks to hulls made from PPG Selectron® and Fiber Glass, boat owners never have to worry about upkeep and costly repairs. PPG Fiber Glass hulls can't peel, can't rot or corrode. And what a beating their one-piece construction can take! There are no seams. No nails. No screws. No rivets to rust or loosen. There's new styling freedom, too. Boats of PPG Fiber Glass can take any shape, yet they're strong, light and durable.

Fiber Glass and Selectron polyester resins are just two of a long roster of products developed from the many facets of PPG's research. Every day, the scientists and engineers at PPG work toward developing new products and new applications for established products to benefit our living in countless ways. Right now, long range research is being directed toward finding new uses for Selectron resins and Fiber Glass, toward screening and improving original ideas and molding them into practical applications. The possibilities are endless.

PPG's versatile products offer exciting career possibilities. So, if you want a career with challenging opportunities and a real and rewarding future, find out about your place at Pittsburgh Plate Glass Company. Write to: Manager of College Relations, Pittsburgh Plate Glass Company, One Gateway Center, Pittsburgh 22, Pennsylvania.

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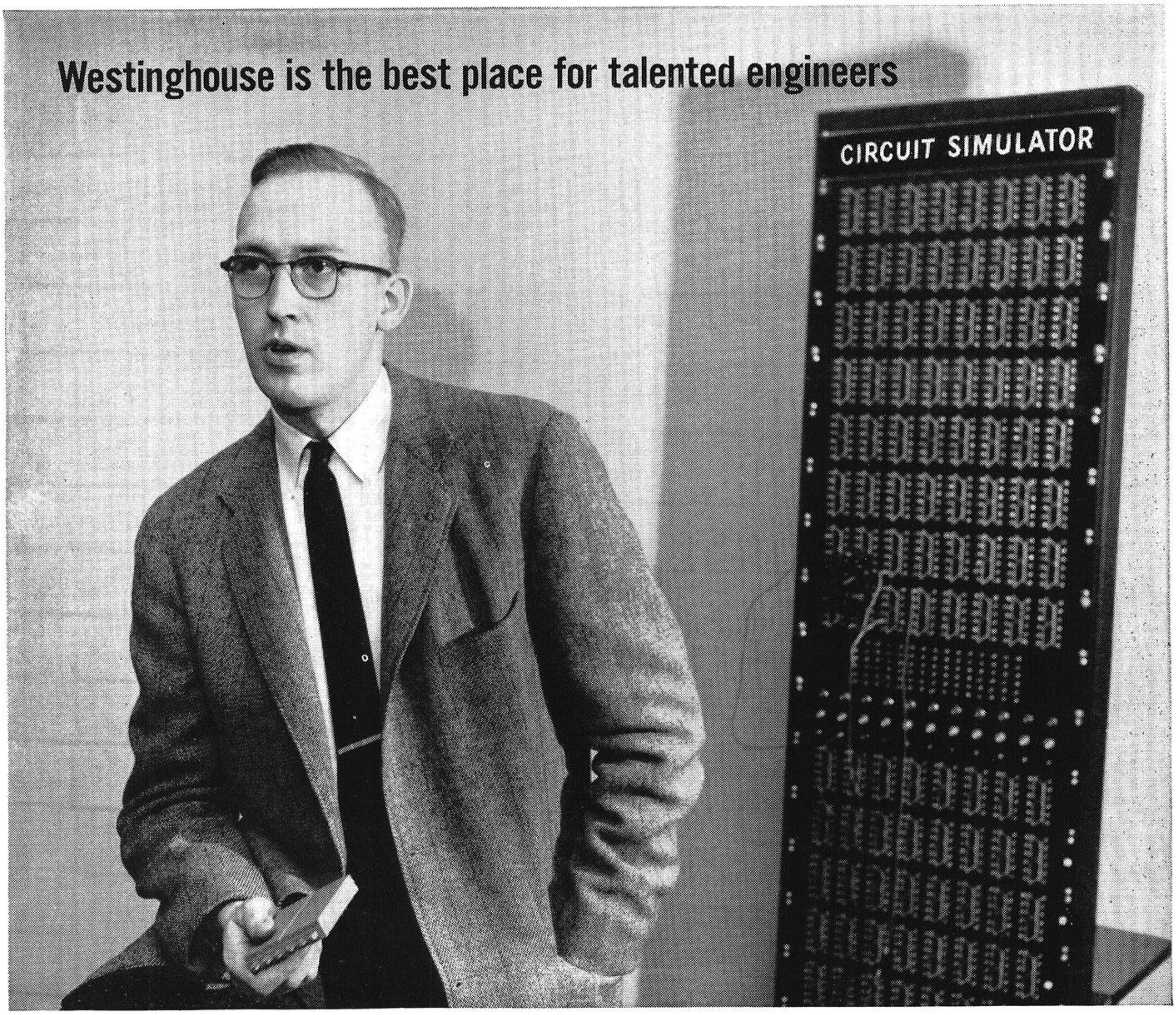

Frank Willard joined Westinghouse in 1954—now designing punched card control systems

At 28, Frank G. Willard, a 1953 BA and MSEE graduate of Dartmouth College, is already one of very few experts in an entirely new area in electrical engineering. Now a development engineer in the Westinghouse Control Division at Buffalo, N. Y., Frank is specializing in advanced industrial control systems. He helped to develop PRODAC* control, the first programmed digital automatic control system for heavy industry; he was responsible for the first industrial application of computor-type magnetic core information storage; and, through major creative work in logic circuits, he was a key man in the team which designed the first completely automatic blooming mill control system for the steel industry.

Most important, *Frank Willard is doing exactly what he wants to be doing.* Upon completion of the Westinghouse Student Training Course, he was assigned to the Control Division and, soon thereafter, was selected to attend the Westinghouse Advanced Design Course at the University of Pittsburgh. He has submitted 12 patent disclosures; and he has 8 U. S. patents pending.

Frank Willard is one of many talented young engineers who are finding rewarding careers with Westinghouse. You can, too, if you've got ambition and you're a man of exceptional ability. Our broad product line and decentralized operations provide a diversity of challenging opportunities for talented engineers. Guided missile controls, atomic power, automation, radar, semiconductors, and large power equipment are only a few of the fascinating career fields to be found at Westinghouse.

Why not find out now about the opportunities for *you* at Westinghouse? Write to Mr. L. H. Noggle, Westinghouse Educational Department, Ardmore & Brinton Roads, Pittsburgh 21, Pennsylvania.

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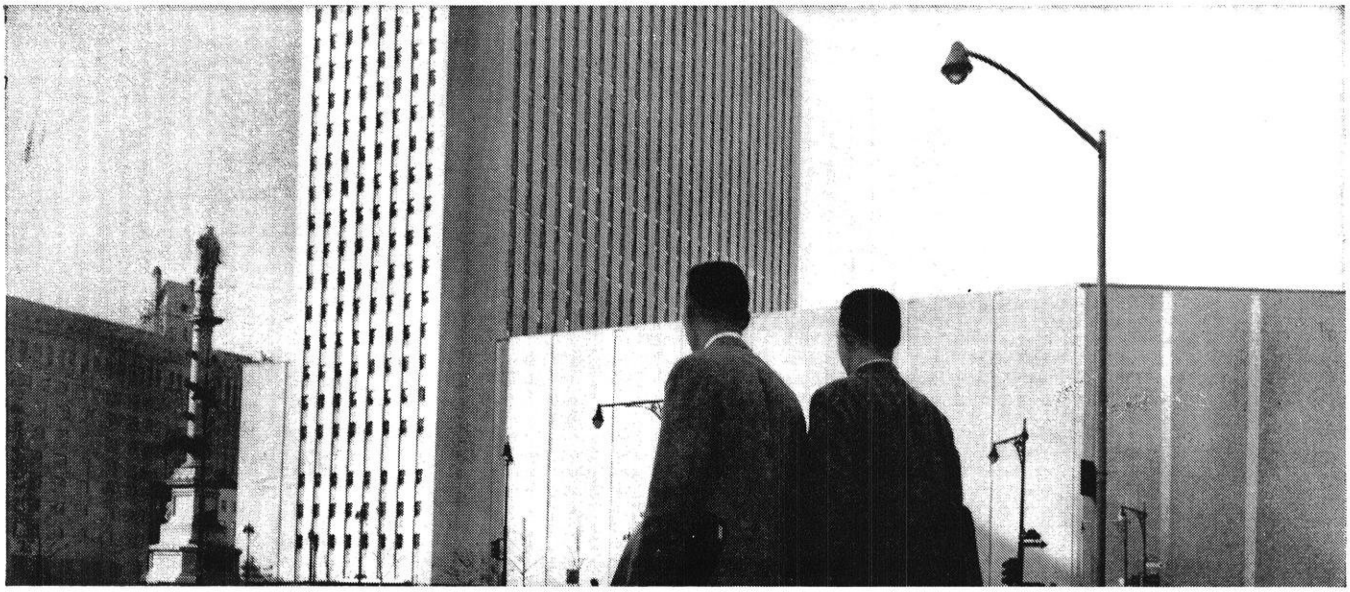
YOU CAN BE **SURE**...IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI-ARNAZ SHOWS"
CBS TV MONDAYS

New "post-grad" program helps engineers move ahead at Western Electric



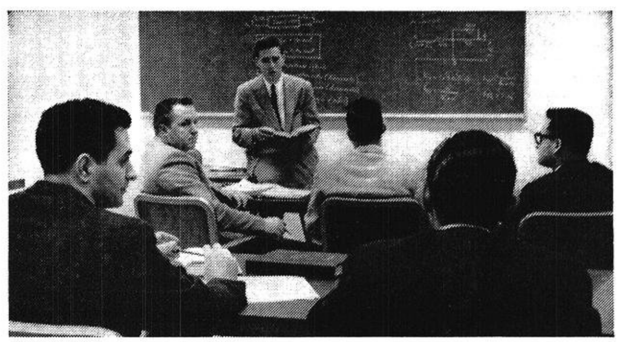
MANHATTAN'S COLISEUM TOWER building houses Western Electric's New York training center. Here, as in Chicago and Winston-Salem, N.C., Western Electric engineers participate in a training program that closely resembles a university graduate school.

Careers get off to a fast start—and keep on growing—at Western Electric.

One big help is our new Graduate Engineering Training Program. This unique full-time, off-the-job study program starts soon after you join Western Electric . . . continues throughout your career. Students are offered courses in various fields including semiconductors, computers, feedback control systems, and problem solving techniques. What's more, they study methods for improving skills in communicating technical information and the art of getting ideas across.

You'll find the work at Western Electric stimulating, too. As manufacturing and supply unit of the Bell System, we pioneered in the production of the transistor, repeatered submarine cable, and the provision of microwave telephone and television facilities spanning the country. Engineering skills can't help developing—careers can't help prospering—in the lively, exciting technical climate at Western Electric.

Western Electric technical fields include mechanical, electrical, chemical, civil and industrial engineering, plus the physical sciences. For more 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.



CLASSROOM SESSION at one of the centers takes up the first part of the three-phase program, Introduction to Western Electric Engineering. During this initial nine-week training period, new engineers are provided with a better understanding of Western Electric engineering methods and technical practices.

TECHNICAL TALK often continues after class. The free and easy informality of the new Western Electric training program offers plenty of opportunity for the stimulating exchange of ideas.

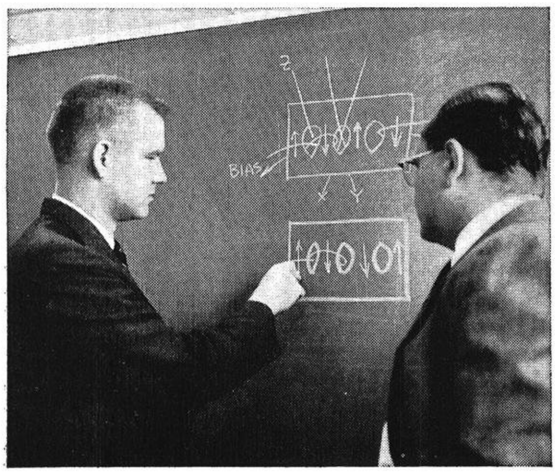
Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Western Electric Graduate Engineering Training Centers located at Chicago, Winston-Salem, N. C., and New York. Principal manufacturing locations at Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Burlington, Greensboro and Winston-Salem, N. C.; Buffalo, N. Y.; North Andover, Mass.; Lincoln and Omaha, Neb.; Kansas City, Mo.; Columbus, Ohio; Oklahoma City, Okla.; Teletype Corporation, Chicago, Ill. and Little Rock, Ark. Also Western Electric Distribution Centers in 32 cities and installation headquarters in 16 cities. General headquarters: 195 Broadway, New York 7, New York.

Product Development at IBM

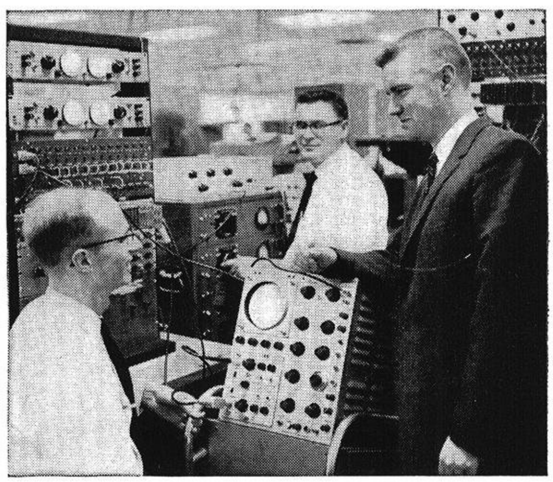
IBM Engineer Richard R. Booth
explores electronic frontiers
to develop new, faster and
larger storage devices
for tomorrow's computers.



Computing time cut from six months to one day

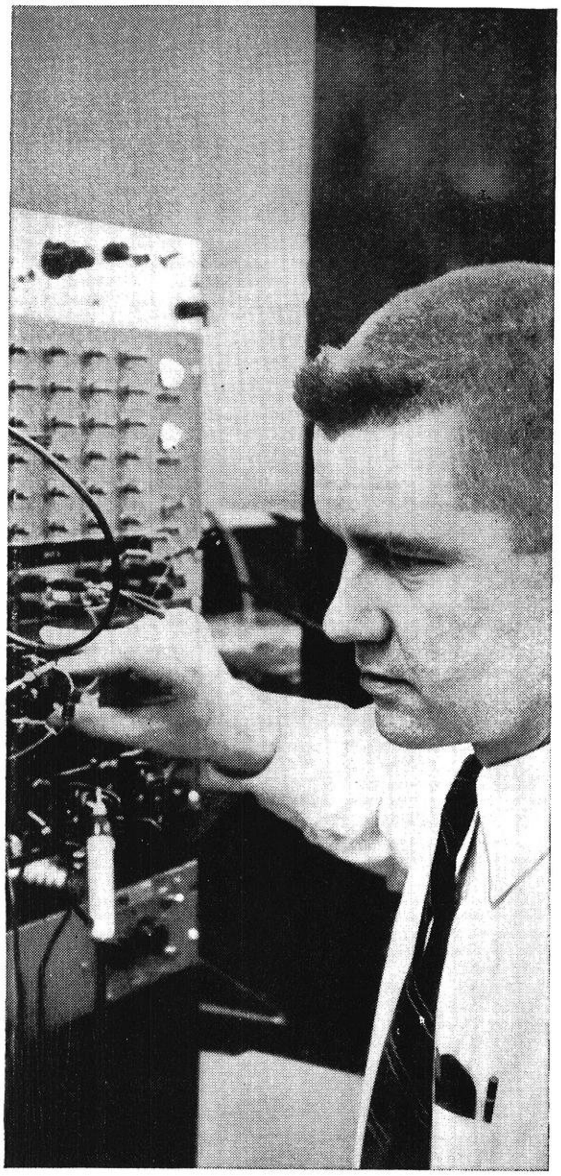
"My job is to design and develop new, high-speed storage devices for a powerful new computer that will perform, in one day, operations requiring six months on present equipment," said Dick Booth as he began a typical day recently. A product development engineer at the IBM Laboratories in Poughkeepsie, N. Y., he started his morning with a conference on a product of great interest to him: a magnetic core storage device with a nondestructive read-out feature. For an hour, he discussed with circuit design engineers the logical devices needed for the register—such as magnetic core drivers and sense amplifiers. Should such devices not be available, the group would work on designs for new ones.

Dick Booth next met with members of the Magnetic Materials Group to establish specifications for the magnetic core memory elements to be used in the register. He also discussed with the group the development of equipment to test the memory elements. "This magnetic core register is based on an original idea of mine," he explained. "When you have a worthwhile idea, you will be given a free hand in proving it out, backed by IBM's resources — plus the assistance of skilled specialists."



Increasing responsibility

At 10:30, Dick Booth reviewed the status of the entire project with the two engineers, two technicians, and one logic designer who make up his team. "My present position is staff engineer," he explained. "It's the second promotion I've had since I joined IBM three years ago with a B.S.E.E. degree from the University of Illinois. I know that there are plenty of other opportunities to move ahead. Furthermore, parallel advancement opportunities exist for engineers in either engineering development or engineering management."



Preparing for the future

In the afternoon, Dick Booth went to the 704 Computing Center to supervise some complex precision computations. "You see how quickly the 704 arrives at the answers," he said. "The computer being developed is expected to multiply more than 500,000 fourteen-digit numbers a second and add them at the rate of one million a second. The computer may be used for design computations for reactors, as well as calculations of satellite behavior. Of course it should have hundreds of other applications."

At 3:30 P.M., Dick Booth attended a weekly class on Theoretical Physics that lasted until 5:00. Afterward, he commented, "You know, IBM offers excellent educational opportunities both in general education and for advanced degrees. One of the engineers in my group has just received his Master's degree from Syracuse University, after completing a postgraduate program given right here at the IBM Laboratory."

A chance to contribute

As he was leaving for the evening, he said, "Yes, I'd recommend an IBM career to any college graduate who wants to exercise his creative ability. IBM will appreciate his talent and he'll have the opportunity to work with specialists who are tops in their fields. I doubt that he'd be able to find a more sympathetic and stimulating atmosphere. Furthermore, he'll have the added incentive of contributing to vitally important projects . . . projects that will take him to the frontiers of knowledge in computer electronics."

* * *

Talented college graduates will find exciting, rewarding careers at IBM. Excellent opportunities are now available in Research, Development, Manufacturing, Applied Science, Sales, and Administration. Find out from your College Placement Office when our interviewers will next visit your campus. Or, for information about careers of interest to you, write to:

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ENGINE EARS

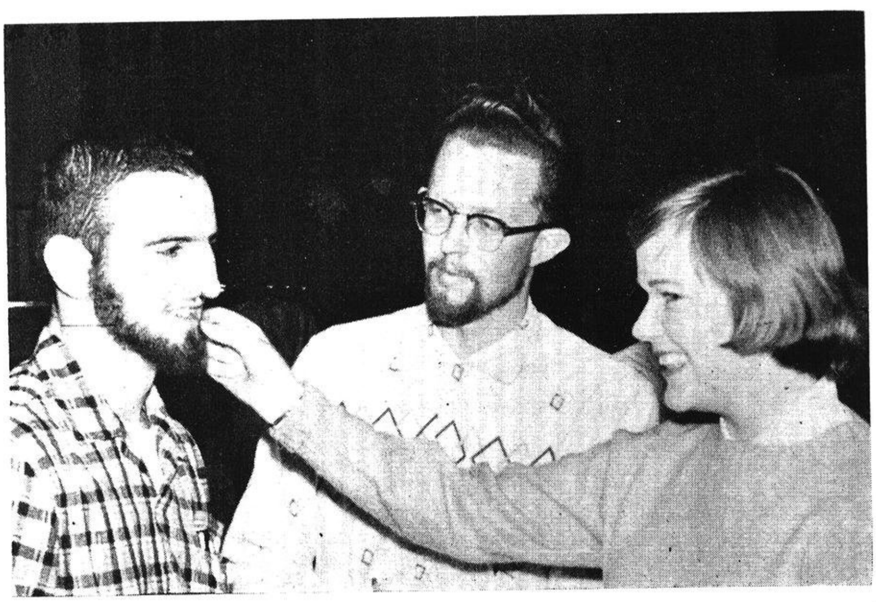
by Tom Corth, ee'60

ST. PAT HONORED AT GALA EVENT

The annual celebration in honor of St. Pat, the engineers' patron saint, was held on Saturday, March 14, at the Memorial Union. The highlight of a series of events, which took place during the preceding week, was a semi-formal dance held in Great Hall. One of the candidates from the eight professional engineering societies was named St. Pat and reigned as "king" of the ball. The winner of the St. Pat contest was based on a total number of points accumulated by selling tickets and buttons, the button design contest, beard growing contest, decorations contest, and basketball tournament.

The beard judging is probably the biggest event leading up to the dance. This took place on Thursday evening, March 12. Awards were given for the bushiest, most colorful, most devilish, most Lincoln-like, and longest beard. The winners in each division received a trophy. To further increase the competition, the Remington Company sponsored a shaving contest to see who could shave his beard off in the shortest time. Several electric shavers and other valuable prizes went to the winners.

Gerald Lesiecki and Roger Cannell winners of the most colorful and bushiest beard contests.



Bill Hable, winner of the most devilish beard contest, Richard Mann, Polygon Board President and Judge Teddy Christenson.

A.S.T.E. PRESENTS EDUCATION NIGHT

Professor Max Carbon of the UW mechanical engineering department emphasized the variety in occupational opportunities for the engineer in a talk delivered to a gathering of the American Society of Tool Engineers at the Top Hat Supper Club. Each year the area A.S.T.E. chapter presents a program directed to word the area students who are interested in engineering as a part of their annual Education Night. High school students and faculty members from area high schools and the University were guests at the meeting. Professor Carbon used his college training and practical experience to give the students a better view of what lies ahead of them in an engineering career. A highlight of the evening was a question and answer period in which Professor Carbon

A group of high school student-faculty representatives at the ASTE Education Night Banquet.
Front row: Mr. Lynch, Edgewood; Mr. Vasaitis, Central; Mr. Ritter, Middleton; Mr. Eisner, West; and Mr. Benedict, Wisconsin High.
Second row: Mr. Erpenback, Middleton; Mr. Ritter, Middleton; Mr. Richter, East; Mr. Leffon, Monona Grove; Mr. Teskoski, Edgewood; Mr. Barnes, West; Mr. Dhein, East High; Mr. Mergen, Chairman of Chapter 75, ASTE Professor Max Carbon.

answered the questions of high school students concerning the engineering curriculum and job opportunities.

NEWS FROM TRIANGLE FRATERNITY

Triangle Fraternity is now a professional engineering fraternity on the Wisconsin Campus. Formerly a member of the Wisconsin Interfraternity Council as a social fraternity, Triangle now enjoys professional status. Wisconsin's Triangle Chapter felt that concentration of scholarship and service to the engineering campus should be placed above participation in I. F. activities designed for students with more free time than the average engineering student.

Scholarship is evident in the present Triangle pledge class which compiled over a three point average last semester. Pledge study halls are being held at the Chapter House with tutoring available to them. Members of the pledge class include: Thomas Niccum, Jack Mercer, Thomas Roth, Wayne Johnson, Dennis Pitts, Larry Cepek, Ken Kluge, Roger Pasch, and James Vierbicher.

Service to the engineering campus is rendered in speakers sponsored by the Chapter, displays on engineering in the Electrical Engineering building and our main project for the spring semester, Parents Weekend guided tours through the engineering campus.

Our change in status has not however led to the neglect of social life as this is considered as a necessary part of our college life. A faculty tea for Triangles their dates and faculty members on March 14 before proceeding to the St. Pat's Dance, a pledge party on March 21, and our annual founders day banquet and spring formal on April 25, attest to the aforementioned fact.

Athletically, we still compete with other fraternities in softball, football, basketball, and bowling, with plans for volleyball next fall. On April 10 and 11, Triangle was represented at their National Basketball Tournament at Northwestern University with nearly 20 Triangle chapters competing. A stag party on Saturday, a "chug-a-lug" contest, and the crowning of a National Triangle Sweetheart at the annual Basket Ball at the Crystal Ballroom of the Edgewater Beach Hotel filled out the weekend of fun and frivolity.

NEWS FROM THETA TAU

Theta Tau, a national professional engineering fraternity, selecting the recipient for its Outstanding Sophomore award. The award is made on the basis of scholarship, outside activities, and degree of self-support. The formal presentation was at the St. Pat's Dance, March 14. The award consisted of an engineering handbook and the recipient's name be engraved on the plaque that hangs in the lobby of the new engineering building.

Inspired by the national convention which was recently held at the Edgewater Hotel here in Madison, the Wisconsin XI chapter has started off the new semester with a full head of steam. The officers this semester are William Kellenberg, Jr., Regent; Sherman Ansell, Vice Regent; Robert Brauns, Scribe; Neil Brunner, Treasurer; Delbert Towne, Financial Secretary; William Luedke, Corresponding Secretary; and Robert Bensman, Historian.

Many other activities are being carried out by the chapter. A building fund is being established to purchase a fraternity house along Breese Terrace, where it will be convenient to the engineering campus. Programs lined up for after meetings include movies and speakers. The chapter advisor, Dr. G. A. Roblich, will talk on Sanitation Engineering at one of the coming meetings.

(Continued on page 51)

Mr. Hussa, Harnath Kapoor, Professor Max Carbon, Don Roeber and Jim Wise at the ASTE Banquet at the Top Hat Supper Club.

SCIENCE HIGHLIGHTS

Jim Mueller me'59

THE SEVEN MONTH "DISK"

The largest glass telescope mirror blank made since completion 25 years ago of the 200-inch disk for the Hale Observatory was recently cast.

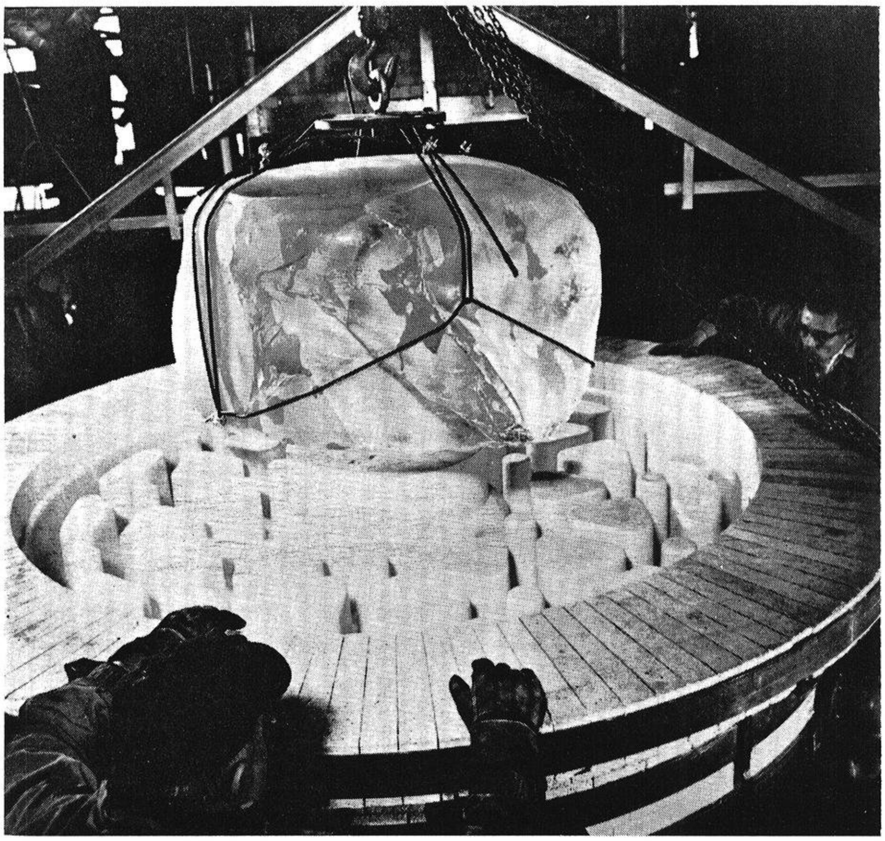
Designed as the giant reflective piece for a new national observatory, the disk is 84 inches in diameter and weighs over 3500 pounds. It is 13 inches thick and has a center hole 26 inches in diameter.

Melted down at temperatures reaching approximately 2300° F., the molten blank was transferred from the furnace to a specially-built annealing kiln for scientific cooling which will continue for seven months. The regulated cool-down is necessary to eliminate internal stress in the glass.

The disk was formed by a sagging process in which separate chunks of glass are placed on the mold and melted to shape. It is the largest piece of glass ever produced by this method. The 200-inch disk, world's largest, was cast by ladling molten glass into the mold.

The new mirror is being made for an observatory under construction atop Kitt Peak, 40 miles southwest of Tucson, Arizona. The observatory will be operated by The Association of Universities for Research in Astronomy, Inc. (AURA), under the direction of Dr. A. B. Meinel. Participants include the universities of California, Chicago, Michigan, and Wisconsin, and Harvard, Indiana, Ohio State, and Yale Universities.

Nine separate pieces of glass were melted down to form the big blank The largest piece weighed 2,796 pounds. Glass used is a hard, low expansion borosilicate composition selected because of its mechanical strength and resistance to temperature change. The mirror must retain its shape to prevent distortion of images.



Carefully lowered onto the mold, the giant piece of glass used in making an 84-inch telescope mirror blank is set atop the center core, reinforced by a steel plate. The glass is a hard, low expansion borosilicate composition.

Like the 200-inch disk, the new blank is of ribbed construction on the back face. It is the first large-sized ribbed disk made by sagging. The honeycombed pattern was engineered to reduce weight while retaining necessary strength and rigidity. The pattern was formed by use of ceramic cores, bolted and cemented to the floor of the mold.

With completion of the annealing cycle, the disk will be crated and shipped to Tucson where it will be ground and polished before being hauled to the observatory site, a 6,875 foot mountain peak.

The finished mirror will serve as the primary reflective piece in the larger of two telescopes being built for astronomical research. The second telescope is 36 inches in size.

The project is being sponsored by the National Science Foundation. Along with the National Radio Astronomy Observatory at Green Bank, West Virginia, the Arizona observatory will be the first in the United States to be constructed with federal funds for use of all qualified astronomers.

Hi-Lites in Short Shorts

BUBBLES FROM BREAKWATER

A wall of bubbles controls the waves at the entrance to the inner harbor of Dover, England. The installation consists of two parallel submarine rows of air-bubble distributors placed across the 300-foot gap between two jetties. When incoming waves become heavy, air bubbles are released at regular intervals. The created turbulence sets wave energy working against itself. Result is a 50 per cent reduction in the height of the waves.

HEALTH-GIVING BULLETS

Sheep in Australia are healthier because they are getting shot with bullets. The bullets are thimble-sized pieces of cobalt shot into the esophagus and gullets by a tube-like gun. The cobalt helps the sheep produce vitamin B–12, which is essential to blood formation. The bullets apparently remain in the digestive tract for some years, releasing a steady stream of cobalt into the animals system.

RUSSIAN ROBOT 'READS'

One million pages per hour can be read by a robot library developed by Soviet scientists. The machine is a book depository with a device for mechanical reading and reviewing of texts in accordance with requests of readers. A special section translates foreign language text. The machine can be linked by wire to readers who have special TV sets for reading. By dialing the "address" of a desired text, they will immediately have it on their screens.

FIVE-PURPOSE LAMPPOST

New York City plans to replace its 120,000 lampposts with a five-purpose fixture. The new lampposts, now in the design stage, will provide street lighting, traffic signals, police telephones, fire alarm boxes and street signs in a single installation. New York hopes eventually to replace all of its 64 different types of ornamental lampposts with the new model.

DIRT-CHEAP HOUSES

Low-cost houses, literally built of dirt, are now under construction in New Zealand. Their eight-inch thick walls are made of "terracrete," a mixture of 12 parts dry sandy soil to one part cement. Reinforced concrete columns are first placed at every change in wall direction. Then the relatively dry-mix terracrete walls are built and capped with a continuous band of reinforced concrete.

Giant Bearing Rolls Along

Transporting the world's largest ball bearing to a Nike–Zeus radar site proved a problem for its builders. The 14-foot ring, containing 88 four-inch balls, had to be rotated constantly enroute to prevent corrosion from road vibration. Resting at a 30-degree angle, the bearing had to be shipped on a flat truck, while a small gasoline engine kept it spinning.

Seeable Street Signs

Lakeside, Virginia, makes the motorists' task of finding street markers much easier. This suburb of Richmond uses four-foot high street signs, just about the eye level of drivers. The signs save neck-craning, put letters within headlight range and are not hidden by tree branches.

Cutting 500,000 Tin Miles

Every year, in opening food for the American table, can openers cut half a million miles of tinplate; a distance to the moon and back.

Air Pillow Drives Elevator

The Czechs claim to have developed the world's first elevator that operates without a cable system. It rides on a pillow of air. Ventilators are used to create a sufficiently strong air beam under the elevator to press the cage upward. When descending, the cabin compresses the air underneath it, insuring a soft downward glide.

NEW PLASMA ARC TORCH

A radically new method for fabricating shapes and applying coating that will withstand temperatures above 5000° was recently announced. The process, which harnesses the highest controlled temperatures ever used in industry, up to 30,000° F, makes possible the fast and accurate mass production of ultra-hard materials that have been virtually unworkable by any conventional means in the past.

The key to the method is the Plasma Arc Torch (product of Linde Company, Division of Union Carbide Corporation), a small device less than two inches in diameter that can melt the toughest materials known to man without being itself consumed by the intense heat it generates.

In addition to experimental rocket and missile parts of pure tungsten or tungsten-coated graphite, the new torch has already been used to produce high density tungsten crucibles for metallurgical purposes, special parts for nuclear work, sensitive electrical contacts, and electronic components and x-ray targets of superior density.

So flexible is the method that pure tungsten, molybdenum, zirconium, and tantalum; all metals in the highest temperature range; the hard carbide materials, and even precious metals, including platinum and palladium, have all been used successfully.

There are no known limitations on size or complexity of shape. Accuracy on the order of plus or minus two-thousandths of an inch can be maintained at will. And where formed parts are not required, the Plasma Arc Torch can be used to coat virtually any material. including reinforced plastic, with a widest variety of metallic or refractory platings.

Two Torches Used

The basic principle of the Plasma Arc Touch is quite simple although many unique design problems have arisen during its development. The torch works this way:

The metal or substance to be worked is prepared in either wire or powder form and is then passed

(Continued on page 63)

Why metals corrode...and how to prevent it

The equipment you will design most probably will have to stand up against one or more of these 6 different forms of corrosive attack:

1. General tarnishing or rusting with occasional perforations in highly affected areas.
2. Highly localized attack by pitting.
3. Cracking induced by a combination of stress and corrosion.
4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.
5. Corrosion of one of an alloy's constituents leaving a weak residue.
6. Corrosion near the junction of two different metals.

HOW CORROSION OCCURS

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

The electrolyte in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

The plates of the battery correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

Briefly then, for corrosion to occur, there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

When you plan against galvanic corrosion it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

GALVANIC SERIES TABLE

•
Magnesium
Magnesium alloys
•
Zinc
•
Aluminum 25
•
Cadmium
•
Aluminum 17ST
•
Steel or Iron
Cast Iron
•
Chromium-iron (active)
•
Ni-Resist*
•
18-8 Chromium-nickel-iron (active)
18-8-3 Chromium-nickel-molybdenum-iron (active)
•
Hastelloy "C"
•
Lead-tin solders
Lead
Tin
•
Nickel (active)
Inconel* (active)
•
Hastelloy "A"
Hastelloy "B"
•
Brasses
Copper
Bronzes
Copper-nickel alloys
Monel*
•
Silver Solder
•
Nickel (passive)
Inconel (passive)
•
Chromium-iron (passive)
•
18-8 Chromium-nickel-iron (passive)
18-8-3 Chromium-nickel-molybdenum-iron (passive)
•
Silver
•
Graphite
Gold
Platinum

HOW TO USE THE CHART

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

When you plan against local action, keep in mind that the corrosion process is similar to galvanic action . . . a movement of electrons from one point on the metal to another. Naturally, the easiest way to avoid local action is to use a metal with little or no impurity . . . or an alloy with constituents that are listed closely on the galvanic series table. Local action on other metals, however, can be controlled by stopping any flow of electrons . . . such as with protective coatings. Environment, too, is a factor for consideration.

FILM ON CORROSION AVAILABLE TO ENGINEERING CLASSES

Inco's full-color sound film — "Corrosion in Action" – gives a graphic explanation of corrosion and how to control it. The film is in three parts: The Nature of Corrosion, 20 minutes running time; Origin and Characteristics of Corrosion Currents, 26 minutes; Passivity and Protective Films, 17 minutes. 16mm prints can be loaned to engineering classes. For details, write Inco for descriptive folder on "Corrosion in Action."

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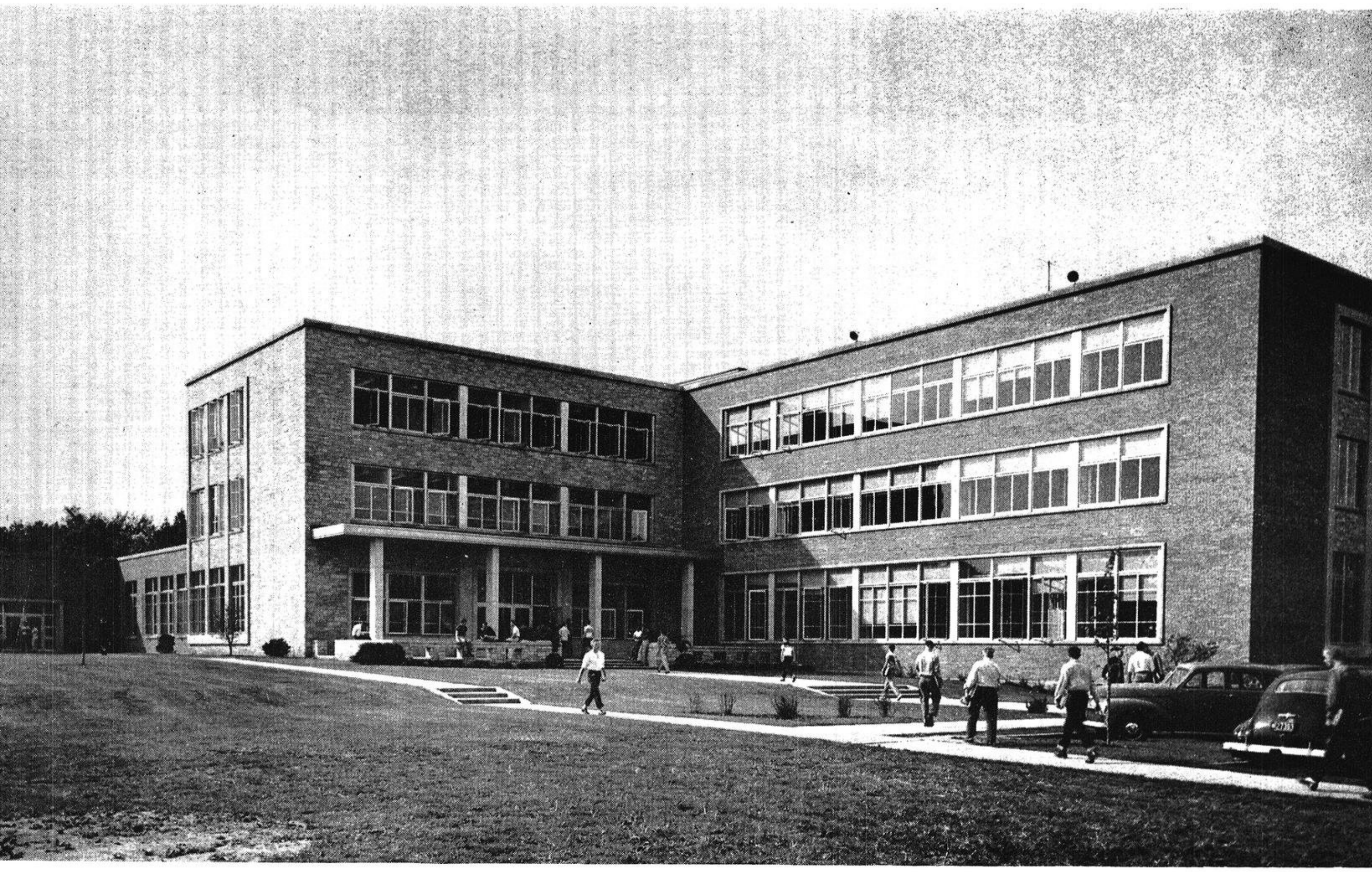


High School Section

compiled by Donald Roeber (me'60)

We of the Wisconsin Engineer Staff want to extend a greeting to all high school students, many of whom we hope to see in the University of Wisconsin College of Engineering next year. With the advent of the space age, there are unlimited opportunities in engineering. In an effort to acquaint you with these opportunities, we have published this High School edition. In this edition, we include articles from top educators in the five fields of engineering offered at the University.

In addition, we have comments by the Dean of Engineering, the Directors of Engineering Education Research, the Engineering College Placement Director, and the Assistant Dean who will be your freshman advisor.

We hope that these articles plus the sample class schedule and the Question and Answer section at the close of this high school section will assist you in choosing engineering as a career and the University of Wisconsin as your Alma Mater.

Engineering — Opportunity for You

by ***Kurt F. Wendt***
Dean, College of Engineering

IT IS a pleasure, through this High School issue of the *Wisconsin Engineer,* to extend greetings to all students in our Wisconsin high schools. Those of you who are interested in the field of engineering are invited to visit us, to see our laboratories, and to discuss your plans for the future. This year you have a special opportunity. Tours of the engineering campus will be held on May 16, during parents' weekend. You are welcome to take the opportunity of inspecting our facilities at that time.

During the past 100 years, engineering has made great strides and its many contributions to our high level of economic well-being are universally recognized. You need only look around to see the products of engineering on every hand. Automobiles, airplanes, trains, ships, bridges, buildings, roads, electric light and power, radio, television, water and sewer systems, machine tools, refrigerators, and heating systems, to mention only a few, all are the result of engineering design and production. Today, engineers are making substantial contributions in the fields of nuclear power, rockets, missiles, and satellites.

You may well wonder whether there is anything left to develop for the future. Actually, the discoveries and applications in engineering are increasing at a rapid rate and it is the considered opinion of scientists, engineers, and industrialists that we will see many more developments in the future than we have in the past. We have just began to realize the potential in the fields of nuclear and solar energy, in solid state physics, in communications, in plastics, and in automation. The problems of space are only beginning to emerge. A great challenge and a most interesting future lie ahead for young men and women in all engineering fields.

Every week we receive many questions and among the most frequent are: What engineering courses are available at Wisconsin? Which courses are most popular? What does the engineer do? Shall I be an engineer?

The profession is divided into five major fields: chemical, civil, electrical, mechanical, and mining and metallurgical engineering, each with many subdivisions. Wisconsin has curricula in all of these fields. This fall a new curriculum in engineering mechanics will be introduced. Both undergraduate and graduate work are available in each area, and graduate training is also offered in nuclear engineering.

At the present time, electrical and mechanical engineering are about equally popular and together account for about two-thirds of our total enrolment. The demands of industry are high, however, in all areas of engineering and it behooves you to investigate the entire field to determine your special interests before choosing a particular branch.

Manufacturing and processing of substances from raw materials through carefully controlled chemical and physical changes comprise the field of chemical engineering.

Civil engineering, the oldest branch, at one time included all engineering of a non-military character; today, the main divisions are structural, sanitary, hydraulic, and transportation engineering.

Electrical engineering has two main divisions: power engineering, which is concerned with the generation, transportation, and application of electrical energy; and the broad field of communications and electronics which includes telegraph, telephone, radio, radar, television, and control.

The mechanical engineer deals chiefly with the design and construction of machines for the generation or transformation of power, the design and production of machine tools, and industrial planning and management.

The mining engineer searches for and extracts all classes of minerals

(Continued on page 58)

Be Prepared!

by Lois B. Greenfield
Director, Engineering Education Research

AS A high school student planning for your future, you are probably bombarded with advice from all sides. Here is more in two important words: be prepared. This motto, so familiar to all, offers the key to intelligent and successful planning.

(1) *Be prepared* to choose your career with the best information and most realistic self-knowledge you can obtain. Ask yourself questions. What would you most like to do? At what would you be most happy? How can you best prepare for the future?

High school should be a time for exploration of your interests, aptitudes, and skills. Read about the vocational fields that interest you or excite your imagination. Talk to men and women working in these and allied fields. Try to visit schools, factories, shops, plants, and cities where you can talk to people working at the careers that interest you. See what these men and women do; note the kinds of people they are. Use your eyes and ears and brains to observe, compare, and contrast people and occupations. Look, listen, and read. Explore new fields and developments that might prove interesting to you. Talk to your parents, friends, teachers, and guidance couselors. See if you can take a vocational interest inventory to give yourself new leads about your future vocation.

If you plan to become an engineer, find out what engineering is and what you have to do to become an engineer. Learn about the diverse opportunities open to the engineering college graduate. Do you know that an engineer can work in such different areas as teaching, design, sales research, administration, or production?

(2) *Be prepared* to enter college with the best academic background you can get. Even if you do not as yet know what college you want to enter, nor what courses you wish to take, plan your high school career so that you are prepared to enter any college you choose or take any course. The basic requirements for entrance into *any* college include 3–4 credits in English, 2–4 credits in a foreign language, 1–2 credits in social studies or history, one credit each in physics and chemistry, and four credits in mathematics, distributed as follows: algebra, 2; plane geometry, ½, and trigonometry, ½. Write for the catalogues of colleges you are considering to make sure that you will meet their entrance requirements. Entering with scholastic deficiencies is sometimes possible, but involves loss of time, your time. If your high school does not offer a course you need, inquire about the possibilities of taking the course through Correspondence Study.

Be prepared, in addition, to enter college with the ability to write and speak effectively. Learn to read with speed and comprehension. These skills are needed by engineers as much as are skills with numbers and quantities. Remember, if you cannot communicate, you cannot direct the building of a bridge, plan for the synthesis of a compound, nor design a machine. Take as much preparation in English, foreign languages, speech, journalism, and grammar as your school offers.

(3) *Be prepared* to study effectively when you get to college. Many talented students have great difficulty when they come to college because they do not know how to utilize their talent, to study effectively. While you are still in high school, learn to work with concentration, learn to prepare for and take examinations, learn to

(Continued on page 58)

A Typical Freshman Schedule

by K. G. Shiels
Assistant Dean and Freshman Adviser

ARE YOU considering engineering as a career? Perhaps you would like to view a typical weekly class program of a freshman engineer.

On Monday morning, at 7:45, John reports to his class in English 1a where he will continue his training in composition. This is one of the most important courses in engineering and in college. John elected Air Science as his branch of basic Reserve Officers training so he reports to this class at 8:50. His friend Tom satisfies the ROTC requirement by playing in the Cardinal Band which practices at 3:30 on Monday, Wednesday, and Friday. At 9:55, John attends Speech 9 class. He welcomes this opportunity to develop fundamental skills in direct public speaking. At 11:00, he has a free hour, which, if he is wise, he will devote to study.

John took four years of mathematics in high school and passed the placement test in algebra and trigonometry given during registration period; so, at 1:20, he reports to Mathematics 60 to develop the concepts of calculus and analytic geometry. If he had not been adequately prepared, he would have been assigned to Mathematics 6 for one semester without credit toward graduation. At 2:25, John attends the interesting and inspiring Chemistry 2a lecture on general chemistry and, on Tuesday afternoon, he spends two hours in the chemistry laboratory. Although John had chemistry in high school, he soon realizes that the course demands good application and that his advantage over the students without previous chemistry is short lived.

On Tuesday morning, John spends two hours in an engineering drawing class where he learns to read and write the language used in all engineering work. On Thursday, at 9:55, all the freshman engineers attend an orientation lecture on engineering. Here John meets some of the key members of the faculty of the College and learns much about the functions that engineers perform in the various fields.

John is a good student who has chosen to carry the full 18 credits and he realizes that a minimum of thirty hours per week outside of class must be spent in diligent study if he is to maintain a satisfactory college record. To accomplish this he has prepared a weekly schedule of study hours, including about 10 hours for mathematics. His friend Tom must earn part of his way through college and was not as strong a student in high school, so he is carrying only 15 credits. He plans to spend more than four years in college to complete his course. John finds that his civil engineering friends are taking surveying instead of Speech 9, while those in chemical engineering carry five credits of Chemistry 4a and only one credit of shop work.

The freshman adviser office is at all times available to John for consultation on special problems or just for a friendly visit. John finds the life of a freshman engineer busy and demanding, but also full of interest. He told us that he thought prospective engineering students who are now in high school might enjoy this view of his week.

Freshman, John H. — M.E. 1 — K. G. Shiels

Last Name (Please print) — First name — Initial — Course and Year — Signature of Adviser

201 Richardson House, Adams Hall — 3287

Madison Address — Telephone No.

STUDENT STUDY LIST
STUDENT COPY

4

PLEASE READ — CARDS NOT PROPERLY PREPARED WILL NOT BE ACCEPTED.

Fill in all fixed hours and no others. Fixed hours include all hours not under control of the Assignment Committee. See time table for assignment committee subjects.

In filling in study lists, always use the name of the department or sub-department, such as History, English, French, Latin, etc. NEVER USE THE TITLE OF THE COURSE.

Each student is held responsible for meeting degree requirements in proper order.

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
English 1a Thomas 302 Bascom	Drawing	English 1a	Drawing	English 1a	Drawing
Air Sci 1a 105 M.E.	12 DOKE 11 T-24	Air Sci 1a	12	Air Sci 1a	12
Speech 9 Cleary 226 M&M		Speech 9	Fresh. Lect. Shiels Agr. Hall	Speech 9	
	Phy Ed Masley Gym		Phy. Ed.		
					MODEL ENTRIES
←		Math 60 Evans 259 M.E.		→	Botany 1 Clarke 102 BIRGE
Chem 2aL. Holt 100 Chem.		Chem. 2aL.		Chem. 2a Quiz 310 Chem.	Drawing 12 Staff T 24
					Math. 51 Evans 201 North
	Chem 2a Lab 117 Chem		Chem 2a Lab		Soils 1 Englebert 206 Soils
					Art Educ. 50a Byrd 305 Education

List each subject below in ink, leaving check column blank. Do not enter quiz and laboratory sections below.

SUBJECT (Name of Department	Subj. No.	Cr.
Chemistry	2a	4
Drawing	12	3
English	1a	3
Math.	60	5
Speech	9	3
Phy. Ed.		0
Air. Sci.	1a	0
Fresh. Lect		0
TOTAL CREDITS		18

(OVER)

The University of Wisconsin
Registrar form No. 50

22M 3-27-58

This might be the typical Freshman's schedule of John T. Freshman.

What is Engineering?

by R. L. Boyer

Vice President and Director of Engineering, The Cooper–Bessemer Corporation

In these days, we are hearing through every means of communication of the serious needs for more engineers and scientists. It could well be that our very material existence may depend upon our ability to develop more rapidly along these lines.

Here are some interesting thoughts Mr. Boyer suggests be discussed with young people now setting their sights on a career.

CONTRARY to a general impression, engineering falls short of being a strictly modern profession. It is in fact so old that its beginnings have never been historically traced. Within the confines of history, but still in the ancient history category, great engineering feats were accomplished. Perhaps the best example of this is the great pyramid of Cheops constructed about 6,000 years ago. That pyramid is 481 feet high, its base covers 13 acres, and it is reported to contain six-million tons of stone.

To appreciate the engineering feat, one must realize that this pyramid was built before there was even an understanding of the principle of the wheel. It has been determined that the stone for this project came from a spot 100 miles up the Nile, that it was drawn from the Nile on sleds pulled with ropes, that it was elevated up the pyramid on earth ramps because the principle of the pulley had not yet been discovered. In becoming an engineer, therefore, one probably joins the oldest known profession.

Some years ago, a definition of engineering was presented which fits the profession very adequately. That definition is: *engineering is the art of utilizing the materials of nature and directing the efforts of men for the benefit of mankind.* The definition is so complete and so accurate. Due credit for its origin justly goes to Dean Hitchcock of Ohio State University in the early 1920's.

Let us pause for a moment to take that definition apart and examine its two basic elements. First, consider what are the materials of nature? They are obviously too numerous to list, but we can break down these materials into classifications of groups such as metals and other solids, gases, animal and vegetable products.

In the metals classification some of the more important are iron, copper, aluminum, lead, nickle, and, of course, uranium. The most important liquid is obviously water, but today such liquids as crude oil and mercury stand out with great importance. Every high school student is familiar with gases such as oxygen, nitrogen, hydrogen, helium, and chlorine. Then, we have mixtures of the basic gases such as natural gas and carbon dioxide.

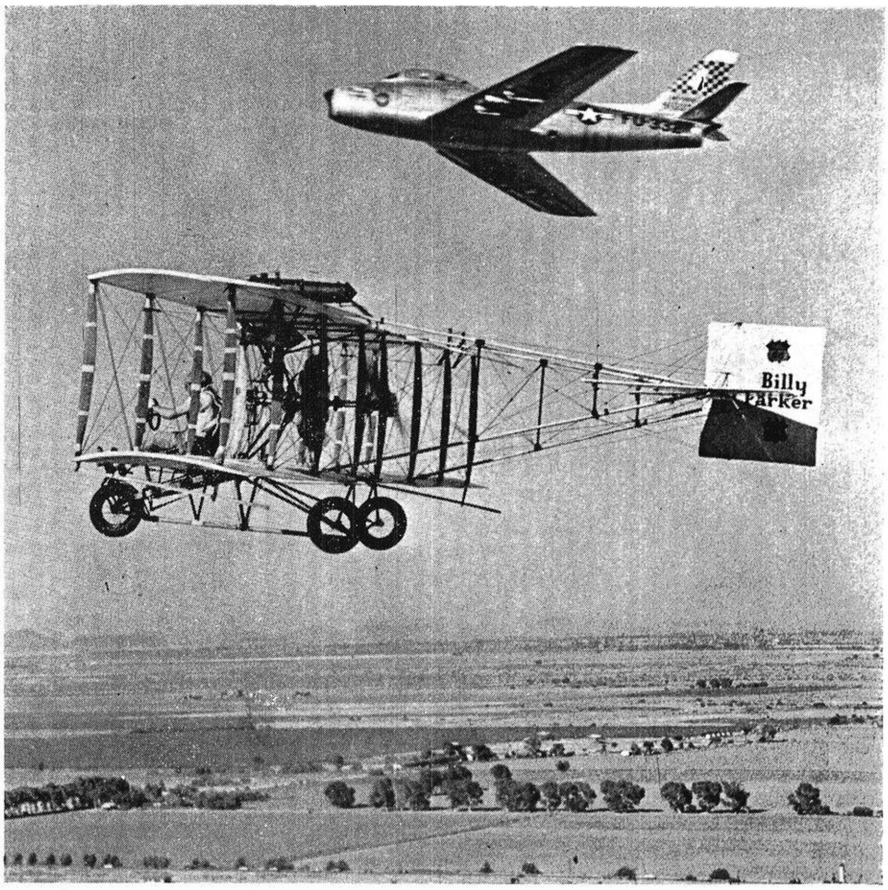
Taking a very prominent place in the materials of nature and animal and vegetable products such as wood, cotton, rubber, wool, and leather. Then, we have literally thousands of man-made mixtures which we think of as basic materials, some of the more important being steel, bronze, gasoline, nylon, and synthetic rubber. All of these materials and hundreds of others are utilized by the engineer to make things.

The Engineer, a Director

But it will be noted that the definition has a second very important aspect. In order to be an engineer, a person must also direct the efforts of man. It will be immediately recognized that most men do not know how to direct themselves. Most men do not know how to utilize the materials of nature, therefore, masses of people need direction in the utilization of materials of nature. It is perhaps in this aspect that the engineer differs most from the scientist. The scientist must know about the materials of nature, and he must know about physical laws to utilize them; but, frequently, he need not, at least on any appreciable scale, direct the efforts of man. In the building of the pyramid, someone did a tremendous job of directing the efforts of man even though his knowledge of the materials of nature was extremely limited and his knowledge of physical laws was equally limited. Thousands of men must have been used in that construction, and it is obvious that relatively few, perhaps only one, had the real vision.

Perhaps a word should be said here about how the engineer usually does this directing. When we see a large bridge being constructed and see an engineer, or engineers, on the job it is apparent that they are directing these activities. On the other hand, when we consider a large industrial plant, perhaps an automobile plant, where thousands of workers are at machines, we do not see the engineer out in the plant telling anyone what to do. Such a plant is organized under foremen and superintendents. It, therefore, probably wouldn't occur that the engineer is actually doing the directing. Each and every one of these workers is being guided in every step by a blueprint of some sort. This blueprint in turn was made by draftsmen who were putting on paper the directions of the engineer. We may conclude, therefore, that even in an industrial plant the efforts of men are being directed by the engineer. It is therefore important that the effective engineer know how to get along with people. The general laws of human behavior must be recognized by him and practiced daily, whether he merely has a natural understanding of those laws or whether he must acquire that understanding. The engineer is a natural administrator if he is truly an engineer. It has been said that many engineers who were not particularly outstanding in mathematics still became world renowned because of their administrative ability.

There are many kinds of engineers, each based on the general knowledge of materials and the general ability to direct men. These various kinds of engineers are highly dependent upon each other in our complex civilization of today. All of these men had the basic training but are merely specialized in different areas.



A dramatic picture of progress in the last 50 years is shown as a Sabre Jet whistles by the 1912 Pusher plane. Progress must continue and engineers are needed to continue it.

Types of Engineers

The civil engineer constructs railroads, builds highways, builds gas and oil pipelines across the country, constructs buildings, bridges, waterways, dams, etc. Without the benefit of his efforts all other divisions of engineering would be helpless.

The mining engineer and the metallurgical engineer are responsible for our fuels and for our metals. Without them, we would not even have coal nor would we have steel for the building of the machinery utilized by other forms of engineering. We would not have copper for the construction of electrical machinery and transmission lines. We would have no aluminum so necessary in this age of air transportation.

The mechanical engineer designs machinery of all types. Some of this is used for the manufacture of products. When we think of all the various items manufactured today in our modern industrial plants that would not be possible without this machinery, we realize how dependent we are on the mechanical engineer. He builds power plants; he builds the equipment that runs on the railroads which were in turn built by the civil engineer; he builds our planes and automobiles.

Today, we are highly dependent upon the electrical engineer. The generating portion of our great power plants, the transmission of electrical energy, the telephones we have in our homes, our radios, our TV's, and in fact all modern electrical conveniences have been products of his thinking.

The chemical engineer plays a highly important role in our present-day civilization. From him, we get fertilizers, drugs, medicines, soaps, explosives, and even the most modern fabrics. We shall make no attempt to describe all phases of engineering but some of these examples should be sufficient to indicate to the high school student what an extremely important role the engineer is playing in our lives of today.

Engineer, a Creator

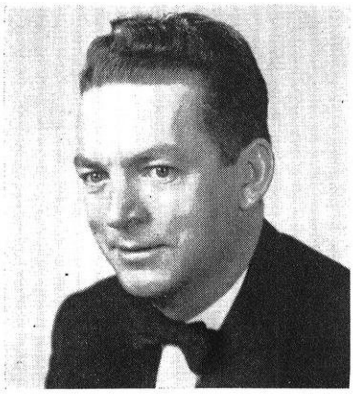
It is apparent that basically the engineer is a creator. Some years ago, I heard an artist say that it was beyond his understanding how we engineers can spend our lives in such drab existence where creation is not possible. Such a pitiful knowledge of what creation really is! The engineer stands out as a creator such as no other profession can approach.

A common comment on the part of young people today is that most of the challenging ideas have already been invented. This comment of course comes out of a com-

(Continued on page 72)

University Extension

by Professor Paul J. Grogan
Chairman, Extension Engineering Department



Professor Grogan has served in the above capacity since 1951. Earlier, he taught in the UW Mechanical Engineering Department and at The University of Notre Dame. His educational background includes a M.S. from UW and a B.S. from Purdue. Power engineering is the professional field in which Professor Grogan has gained the greater amount of his practical experience. This has been reflected in his extensive writings on the subject.

THE University Extension Division is the off-campus arm of The University of Wisconsin for purposes of carrying out undergraduate instruction in engineering at the several Extension Centers in the state. Substantial blocks of credit toward a degree in any of the several fields of engineering so aptly described in this special section may be obtained through the Extension Centers at Kenosha, Racine, Sheboygan, Manitowoc, Marinette, Green Bay, Menasha, and Wausau. The University of Wisconsin–Milwaukee offers considerable opportunity for the study of engineering at both the undergraduate and graduate levels. There are further opportunities for beginning an engineering career at the State Colleges distributed throughout Wisconsin.

The questions quickly come to mind whether or not an individual is able to obtain "full credit" for work taken in an outlying institution, and whether or not an engineering program can be completed in a normal four years if one starts off campus. In some instances, the answer to the above two questions is "Yes." In the majority of instances, however, the answer must be either "No" or "Maybe." There are many qualifying conditions that must be satisfied before specific answers can be given to the above.

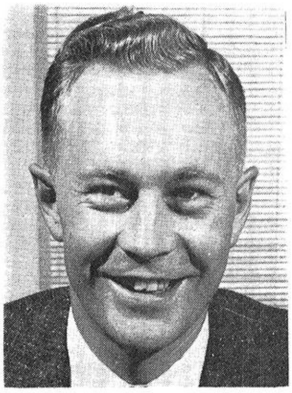
The first point of understanding should be that the engineering programs at Wisconsin vary from 146 to 152 semester credits for graduation. This means that you will have to earn applicable credits in excess of an average 18 hours per semester in order to keep abreast of the schedule. If your freshman and/or sophomore programs contain a sufficient number of courses in the required areas of English, mathematics, chemistry, drawing, physics, economics, history, speech, shop, mechanics, etc., you stand a good chance of maintaining pace with your contemporaries in Madison. But there is little room for elective credit in the typical engineering curriculum. An excess of credits in music, sociology, philosophy, etc., will simply mean that your total credits upon graduation will exceed the numbers spelled out above by virtue of courses taken outside of the rather rigid engineering requirements. There is not space here to spell out the particular requirements of each degree program or some of the allowable course substitutions that may be made. Nevertheless, it is easy for you to visualize a course in geology being useful to a mining or metallurgical engineer, and a third course in physics being useful to an electrical engineer. There are counselors available at every institution who will be happy to work with you and engineering college officials in Madison in selecting the most advantageous sequence of courses before you transfer to the UW campus.

Beginning September, 1959, four years of high school mathematics will be the required preparation for the first course in engineering mathematics. This does not mean that a student without such preparation

(Continued on page 58)

Career Opportunities in Engineering

by James A. Marks
College of Engineering, Placement Director



THE recession in 1958 affected the job situation for engineering graduates just as it did for all other college graduates. But, the effect was much less severe in engineering, and while fewer jobs were available, they were still relatively plentiful. The most noticeable effect was that companies were more selective. Scholastic achievement, extra-curricular activities, personality, character, and all of the factors that employers look for were more critically examined. On the other hand, numerous exhaustive studies by professional, governmental, and business groups all conclude that at least for the next several years, probably for the next decade, the demand for engineers along with other technical and scientific personnel will continue and, very likely, increase.

The expected increase in demand alcng with the intense competition for better students has meant that starting salaries are not only staying as high as they have been in the past but in many cases are increasing. It is not unusual for the graduate engineer to receive a salary of $6,000 during his first year after graduation. There is every reason to expect that starting salaries will continue to rise at least as much, if not more, than general income levels rise. Certainly engineers can expect handsome financial rewards in the years to come.

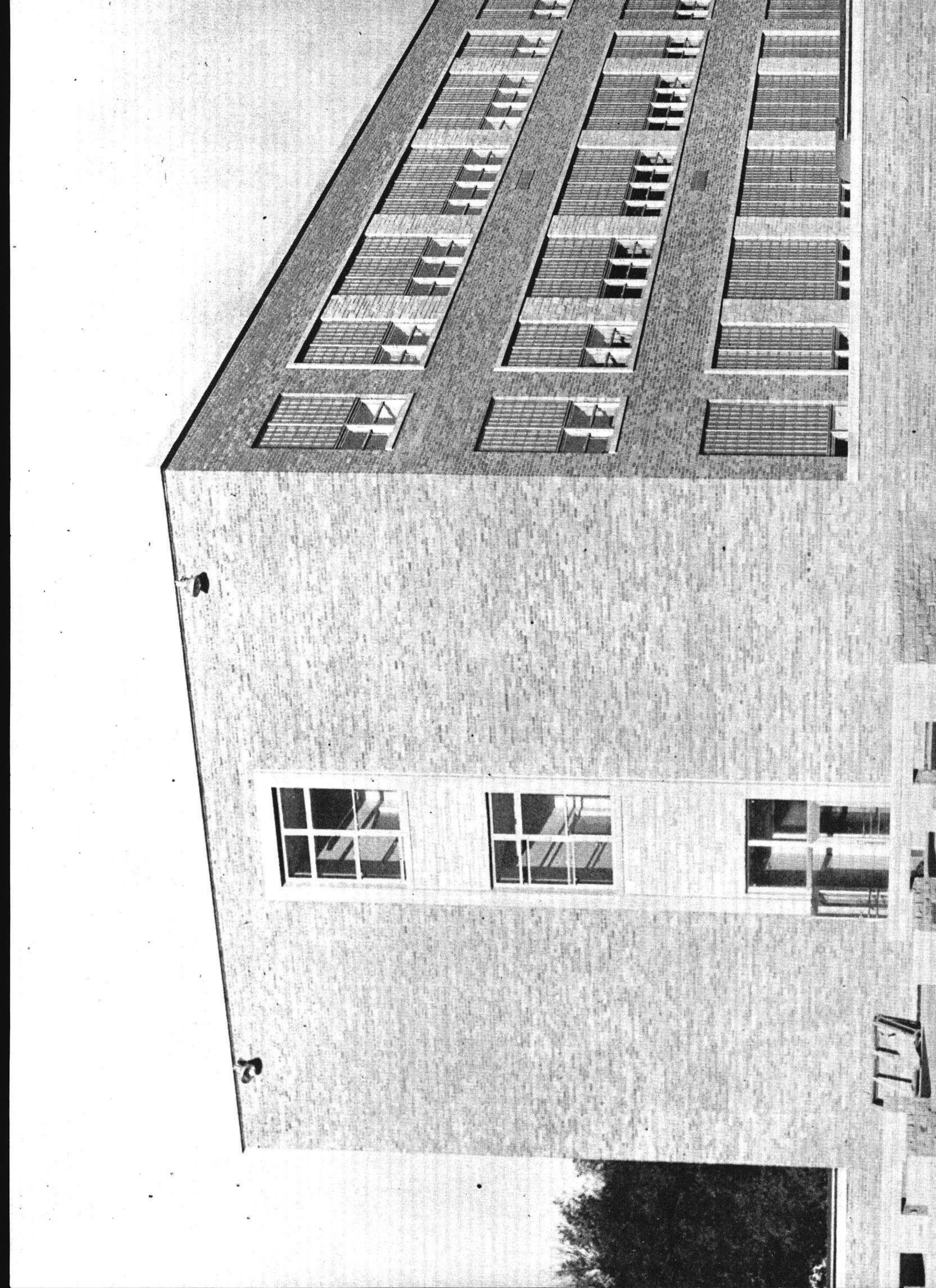
Of course, salary should not be the prime reason for anyone choosing a career in engineering, or in any other field, for that matter. Instead, the individual should consider the kind of work he (or she) will be doing and whether or not he will be happy doing it. While this might imply that only those who have a deep interest in things mechanical, for example, would consider engineering, it should be pointed out that for many jobs normally considered to be non-engineering in actual practice virtually demand an engineering background.

Sales, production supervision, management, and many other jobs have become exceedingly technical in nature and an engineering education is a real asset in almost any field. Under these circumstances, the high school student who has ability will find an engineering education is a real asset in almost any field. Under these circumstances, the high school student who has the ability will find an engineering education to be better basic training than perhaps any other field. Although he is not sure what type of work he would eventually be interested in, an engineering background will always be valuable.

Engineering education, a most vital part of the entire engineering profession, provides excellent opportunities that are often overlooked. The demand for engineers will obviously provide more and more opportunities in the teaching of engineering. The individual who would enjoy a career in education and who has the ability to pursue engineering will find an extremely bright future in engineering education.

The Placement Office of the Col-

(Continued on page 60)



Chemical Engineering

by Professor R. A. Ragatz
Chairman, Chemical Engineering Department

Professor Ragatz is a true native of Wisconsin, born in Prairie du Sac, receiving his BS, MS, and PhD at the university, the latter in 1931. He has done some specialty work in Plastics and is now in the process of writing a book.

THE chemical engineer translates the laboratory discoveries of the research chemist into large-scale manufacturing operations. The research chemist almost always works with small-scale equipment in a laboratory. His equipment is usually made of glass; his product yields are small, usually a few grams at most. The chemical engineer, on the other hand, designs and operates the large-scale apparatus needed to produce the desired material in commerical amounts.

The chemical engineer finds employment with companies engaged in the manufacture of gasoline, fuel oil, lubricating oil, greases, asphalt, rocket fuels, synthetic rubber, rubber products, synthetic textile fibers, synthetic detergents, soaps, insecticides, weed killers, sulfa drugs, and anti-biotics. The chemical engineer produces a host of "petrochemicals" such as toluene, formaldehyde, ethyl alcohol, ethylene glycol, and benzene. The pulp and paper industry and the plastics industry employ many chemical engineers. In all of the foregoing manufacturing activities, research chemists and chemical engineers form a coordinated team.

The manufacturing processes in which the chemical engineer engages are usually quite complex and require a series of well-defined processing steps, some of which are chemical in nature and some of which are essentially physical in character. Typical chemical processes are polymerization, sulfonation, chlorination, nitration, hydrogenation, oxidation, reduction, hydrolysis, and alkylation. Typical physical operations are pumping of fluids, transport of solids, heating or cooling of materials, crushing and grinding, mixing, filtration, drying, absorption of gases by liquids, solvent extraction, crystallization, distillation, and evaporation. Chemical engineers select the various chemical and physical operations needed to make the desired product; they work out the best conditions for each step; they design the equipment needed for each step; they build and operate the complete plant.

In a large company employing many chemical engineers, the type of work carried out by a particular individual may be restricted to one of the following general lines of activity: development, production, maintenance, process control, inspection and testing, design, construction, technical sales and customer service, and administration. If a chemical engineer works for a smaller company, his duties probably will encompass several of the foregoing types of work.

The Department of Chemical Engineering has excellent instructional facilities. The Chemical Engineering Building, which was occupied in the fall of 1952, has well-equipped undergraduate laboratories for instruction in unit operations, chemical manufacture, process measurements and control, applied electrochemistry, plastics, and technical analysis. Facilities for graduate MS and PhD thesis projects are also provided.

The curriculum in chemical engineering has, for many years, been accredited by the American Institute of Chemical Engineers and

(Continued on page 60)

The new Chemical Engineering Building on the University of Wisconsin campus.

Civil Engineering

by ***Professor Arno T. Lenz***
Chairman, Civil Engineering Department

Professor Arno T. Lenz is the new Chairman of the Department of Civil Engineering. He is a Wisconsin native, having been born in Fond du Lac, and has received four degrees from the University. The last was the doctorate in 1940. His professional work has been in Hydraulic Engineering with special emphasis on water resources studies and model tests of dams. In addition to his teaching and research, he has spent several summers on engineering work for the Tennessee Valley Authority, the U. S. Bureau of Reclamation and Wisconsin industries, and as a consultant in law suits concerned with water problems.

CIVIL Engineers are builders. They have been since the early beginning of history when Military Engineers turned to civil pursuits. Building today, however, consists of much more than putting together a few pieces of wood, steel, or aluminum. It now includes conception, design, and construction of the wonders of the modern world. One such wonder close to us is the recently completed Mackinac Straits bridge at the north end of Lake Michigan. Obviously much thought and hard work goes into such a project before it is ready to serve mankind.

Civil engineers must be men of vision to conceive such huge projects and many smaller ones. The planning of cities, expressways, airports, factories, skyscrapers, bridges, dams, power plants, water and sewage treatment plants, and hosts of others is fascinating occupation because a right decision at this time can influence the future of cities and industries and benefit the lives of many.

Once general plans have been made, much data must be collected by means of surveys of many kinds. Civil engineers must collect information on land lines, distances and elevations of specific locations; the flow, width, depth and slopes of rivers and the areas and volumes of lakes; and the foundations which exist for the construction of structures. Often these surveys must be made in the far corners of the earth and Wisconsin Engineers get to all of them. On the other hand, these surveys sometimes are made in the centers of our great cities where property values are astronomically high, or where underground there is an unbelievably complicated maze of pipes and cables.

There then follow many hours of painstaking calculations in design offices. Loads on floors and walls must be computed as well and those on footings which must support structures. Heights of retaining walls to hold back earth or water, and the heights of the greatest flood waters must be selected. The water yields of rivers and lakes during prolonged dry spells must be estimated accurately to insure adequate industrial and domestic supplies. The physical and chemical tests and designs necessary for plants to treat industrial and human wastes must be determined as well as pipe and pump sizes when liquids are moved from one place to another. Civil engineers do these and many other similar tasks. On large projects the young engineer may complete one relatively small task after another as the design progresses. In smaller organizations a few men may do all these things and more on one project of smaller size.

Finally, when designs and specifications are completed, contractors, who are civil engineers and employ many more, bid on these jobs and build them. With concrete and steel and earthmoving equipment they bring physical being to the plans which so many prepared.

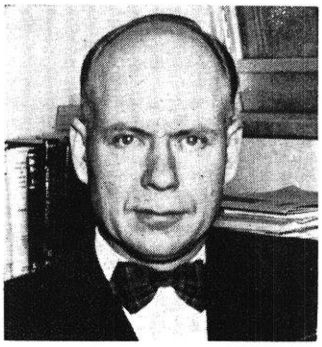
The civil engineer must often lead the way in new developments like the Seabees (Construction Battalions), during the war built air strips on islands and prepared the way for the landing of troops. Now the civil engineers in surveying must know exact locations to which ICBM missiles are fired. Highway and municipal engineers

(Continued on page 60)

Urban portions of Interstate Systems will resemble this Dallas Expressway.

Electrical Engineering

by H. A. Peterson
Chairman, Electrical Engineering Department



Prof. Harold A. Peterson has been Chairman of the Department of Electrical Engineering since 1947. He is from Essex, Iowa, and received his BS and MS (with high distinction) from the University of Iowa. He is a Fellow in AIEE, a Senior Member of IRE, and a member of several other engineering societies. He also holds eight patents in the field of electrical engineering.

ELECTRICAL Engineering is a young profession. Only seventy-five years ago on September 30, 1882, the first water-wheel driven electric generator in this country was put in operation at Appleton, Wisconsin. Since that time, growth and development of the profession have been phenomenal. Today, the American Institute of Electrical Engineers (AIEE) has over 52,000 members, not including student members. In addition, there are over 55,000 members of the Institute of Radio Engineers (IRE). The IRE membership is growing rapidly at a rate of about twelve per cent per year.

A few generations ago, electricity was available in the homes of only a few. Today, it is available in almost every home. Electrical engineers have been largely responsible for bringing this about. Today, heavy tasks around the farm home and other tasks in all homes, can be done quickly, efficiently, and without drudgery. Radio and television have been brought to most homes. These are some of the more obvious consequences of electrical engineering.

Electrical Engineering has expanded tremendously in scope in recent years. Automatic control theory, information theory, the transistor, new analytical techniques, analog computers, digital computers, extra high voltage power transmission, and many other developments have been basically important in this expansion. The control of guided missiles, and the very special instrumentation problems associated with the recording of data and transmitting such data back to earth from satellites are largely the responsibility of the electrical engineer. The problems are fascinating and challenging, requiring much imagination and resourcefulness in obtaining solutions. Advanced training in science and mathematics is required for creative work in these areas.

At the University of Wisconsin, our facilities in the Engineering Building are among the best in the country. Our course of study in electrical engineering is constantly under surveillance so that improvements can be made from time to time to keep in step with the needs of industry. We have recently revised our curriculum in order to make it more suitable to the demands of our rapidly changing technology. This new curriculum applies to all those students entering as freshmen in September, 1959, and thereafter.

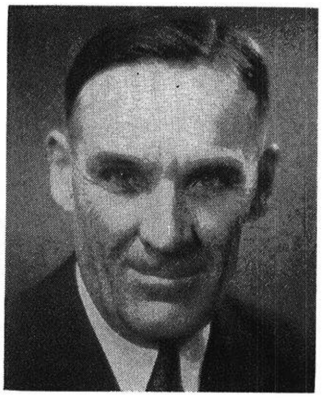
There is a joint student branch of the AIEE–IRE on the campus with a faculty member in charge as branch counselor. This student branch elects its own officers, holds regular meetings, and sponsors activities of interest to student engineers. It affords a means for orienting students with regard to professional activities within the AIEE and IRE following graduation.

The University of Wisconsin offers excellent opportunities for study in electrical engineering. Young men and women with good high school records and a real interest in science and mathematics would do well to consider enrolling in this course of study which leads to a most interesting professional life of basic importance to our economy and security.

Three Engineering students operating the analog computer in the EE Building.
—Photo by Martin Dean

Mechanical Engineering

by Benjamin Elliott
Chairman, Mechanical Engineering Department



Professor Ben G. Elliott has been Chairman of the Department of Mechanical Engineering since 1948. He was born in North Platte, Nebraska and received his B.S. and M.S. from the Rose Polytechnic Institute, and the M.E. degree from the University of Wisconsin. A Fellow of A.S.M.E., he served as vice-president of the society from 1953 to 1957. He was a Director of the National Society of Professional Engineers from 1951 through 1954, and is active in numerous engineering and civic organizations.

MECHANICAL Engineering is one of the oldest branches of the engineering profession dating back to the early 1880's when the American Society of Mechanical Engineers was founded. It is concerned primarily with the design, production and operation of machines, tools, prime movers, and manufactured products of all types.

The Mechanical Engineer designs, develops and produces our vast array of "machine tools" which are the very foundation of our industrial age. He is responsible for the generation of the vast quantities of energy which constitute the life blood of our present day economic and industrial society. One of his current problems in this connection involves the practical application and utilization of nuclear energy and solar energy. He also plays a major part in designing, producing and operating the elements of our vast systems of transportation and communication-automobiles, trucks and buses, locomotives, trains, aircraft, and ships.

In the defense of our country and freedom, the Mechanical Engineer plays a key position. He designs and develops our jet aircraft, rockets, guided missiles and our space ships.

The Mechanical Engineer is also a highly important factor in our great process industries-petroleum, coal, gas, iron, steel, paper, lumber, and forest products. He is an integral part of the great printing industry and the production of our books, newspapers and periodicals.

In the field of consumer goods, the packaging, handling, and moving of the endless list of everyday articles is a particular activity of the Mechanical Engineer.

The Mechanical Engineer has been responsible for our "domestic revolution" which has brought into our homes the products of research and development-heating, cooling, refrigeration, kitchen and laundry equipment, and power tools of all types. He has electrified and mechanized the home as well as the farm.

A prospective Mechanical Engineer should have a pronounced interest and proficiency in mathematics and the physical sciences, should have imagination and inherent curiosity, an interest in exploring new ideas and a desire to "build" and create and a willingness to work.

A career in Mechanical Engineering usually begins by enrollment in an accredited college of engineering. The subject matter studied includes basic courses in mathematics, chemistry, physics, mechanics and materials, drawing and design, thermodynamics and thermal power, electrical engineering, industrial processes, economics and accounting procedures, language, speech, technical writing, and human relations.

Mechanical Engineering is based upon a combination and balance of science and art, the science teaching the fundamental knowledge and the art enabling the engineer to "do." The science back of mechanical engineering may be learned by book study, but the art of mechanical engineering must be learned by practice and experience. In the practice of mechanical engineering, the functional activities may be generally classified under research, design and development, production, operation, service, advertising and sales, public relations and administration.

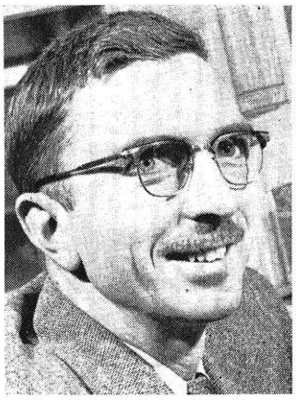
In addition to preparing young men and women for interesting and profitable technical careers, a train-

(Continued on page 58)

The Mechanical Engineering Building of the University of Wisconsin campus.

Mining and Metallurgical Engineering

by Professor P. C. Rosenthal
Chairman, Department of Mining and Metallurgy



This is Professor Rosenthal's fifth year as department head. He received his BS and MS in Metallurgical Engineering from the University of Wisconsin. He has been very active in the AFS and ASM, being chairman of several committees. He was co-author of "Principles of Metal Casting" and has recently completed another book.

IF YOU were to examine a list of the elements and their properties you would find that the majority of them would be classified as metals. Further investigation into the use of these metals would reveal that almost everyone of them has some commercial application in the pure or alloyed form. A more intensive study, such as would be gained in a mining or metallurgical engineering program of courses, would establish that even many of the non-metals such as oxygen, carbon, phosphorus, etc., play an important part in metal processing and alloying. Thus the mining or metallurgical engineer deals with a wide variety of elements and combinations thereof, and must understand the chemical and physical problems associated with their preparation and use.

Utilization of metals begins with the discovery and development of mineral wealth. This is the work of the mining engineer. The curriculum for mining engineering includes, in addition to courses in mine evaluation, development, and ore removal, related courses in geology, mineral concentration and chemical processing. There are also courses in related fields such as hydraulics, suveying, electrical engineering, and heat and power.

One option of the curriculum in this field concentrates on the geological aspects of mining. The graduate from this program is referred to as a geological engineer and would be primarily concerned with finding and exploring new ore bodies or oil fields. He would estimate the economic value of the ore and determine how it might best be extracted from the earth.

The mining engineer designs, constructs, and operates mining properties. He, in effect, begins where the geological engineer leaves off because his principal tasks are associated directly with the mining operation. He plans the method of removing the ore, designs the transportation system and handles related problems of ventilation, power supply, etc.

In the petroleum field, the counterpart to the mining engineer is the petroleum engineer. His job is to plan and operate the oil-drilling and pumping equipment and arrange for the storage of the crude petroleum. He should also be familiar with methods used to locate new petroleum fields.

Once the ore is removed from the earth, it must be processed further before the metal can be extracted. This is called mineral beneficiation, mineral dressing, or mineral concentration. This field represents the link between mining, on the one hand, and metallurgy, on the other. The mineral dressing engineer designs and operates plants for the separation of the valuable minerals from the waste products. This field is becoming increasingly more important as the richer ore deposits become exhausted and lower grade ores must be utilized. In Wisconsin, for instance, the use of the available low grade ores awaits development of economical methods for concentrating these ores to higher iron contents. The mineral dressing engineer uses many methods and devices for concentrating ores such as gravity separation, "heavy media" separations, and flotation. His program of study is much the same as that of the mining engineer but usually contains less mining and more metallurgical engineering subjects. *(Continued on page 60)*

Malleable iron is poured into shell molds on an overhead trolley conveyor.

What's Your Question?

HIGH school students have many questions concerning requirements and activities of college life. Following are questions and the respective answers pertaining to student life at the University of Wisconsin.

What educational program does the University of Wisconsin offer?

Students have the opportunity to study in almost all major areas of endeavor, including the humanities, arts, sciences, and social studies. In addition, preprofessional opportunities and professional opportunities are available in engineering, commerce, teaching, medicine, law, pharmacy, and many allied fields. All told, the University offers over 1,200 courses from which to choose.

What are the admission requirements?

The general method of admission is by presenting a certificate of graduation from an accredited high school with the recommendation of the principal. Sixteen units are the fundamental requirement, which for engineering must include four years of math, including advanced algebra, solid or analytic geometry, and trigonometry.

Does the University have an official grading system?

The University of Wisconsin marks on an alphabetical basis with the grade points per credit as follows:

"A"	(Excellent)	4 grade points per credit
"B"	(Good) ..	3 grade points per credit
"C"	(Fair) ...	2 grade points per credit
"D"	(Poor) ...	1 grade point per credit
"F"	(Failure) .	0 grade point per credit

What the semester fees?

In all colleges and schools except Law and Medicine the fees are $100 per semester for a resident of the state and $275 for a nonresident.

What housing arrangements are available?

Housing accommodations for single students include:

University Residence Halls, Cooperative houses, sororities, fraternities, the University YMCA, International House for graduate men, and rooms in private homes throughout the residential sections of the city. The University Housing Bureau is the clearing center for all student housing information and is located at 434 Sterling Court.

Does the student have any supervision in the planning of his courses and program?

Yes, the University operates on an advisory system whereby each new student is assigned a faculty adviser. The adviser is expected to help the student in the choice of his course and in the selection of a well-balanced program.

Is there additional counseling service available to students?

A trained staff is available to counsel students regarding personal, vocational, or academic problems. The Student Counseling Center is located at 740 Langdon Street.

What provisions do the University provide toward the maintenance of the health of the student body?

The services of the Department of Preventive Medicine and Student Health are available to students who are regularly enrolled in the University of Wisconsin. The Student Clinic and Infirmary are located in the West wing of Wisconsin General Hospital.

Are scholarships available for undergraduate students?

There are many scholarships available to deserving students. Scholarship information and application forms maybe obtained from the Office of Admissions, 166 Bascom Hall. Mr. Field–114 Bascom.

Is there an ROTC program?

Freshmen and sophomores are required to take basic Army, Navy, or Air Force ROTC. Eligible Junior students may apply for advanced training.

Are student loans available?

Loans for educational purposes in amounts up to $250.00 are made for periods of less than a year to students in good standing, who have established a satisfactory academic record of at least one semester at the University of Wisconsin.

What are the possibilities of obtaining part-time work?

The Student Employment Bureau is often able to locate some kind of part-time work for those who desire it. Its address is 435 N. Park Street.

Does the University operate any Extension Divisions?

The University of Wisconsin operates Extension centers in Sheboygan, Milwaukee, Racine, Wausau, Green Bay, Kenosha, Manitowoc, Menasha, and Marinette.

How are the library facilities?

There are more than a dozen libraries, the chief among them being the Memorial Library and the Library of the State Historical Society.

Are there sororities and fraternities on campus?

There are sixteen sororities and thirty-four social fraternities on campus, with all but one maintaining resident houses for their members. In addition, there are many professional fraternities.

Campus News

(Continued from page 27)

NOTES ON THE AIEE–IRE

The first meeting of the second semester for the student branch of AIEE–IRE was held February 11. The speaker for the evening was Prof. K. A. Greiner who gave a very enthusiastic talk on the use of transistors in computers.

The membership drive held at the start of this semester was very successful. The fine work of Don Martell and all the fellows who worked with him showed over 40 new members.

Kurt Riesen discussed the feasibility of having this years' banquet on May 13 at the ESBMA Hall which was the scene of last years' banquet. The date and place were approved so now Kurt can start working on the finer details.

The AIEE Display Committee, headed by Don Hardin, is working on devices which show the good and bad effects of hystersis. Illustrating the useful side, Don wants to show how hystersis effects can be used to heat water or fry an egg and drive certain types of motors. He also expects to have some apparatus to show why hystersis effects is a problem in other types of electrical apparatus.

The American Power Conference this year will be held in Chicago on March 31, April 1 and 2. Leroy Kwarcinski was in charge of the committee to select six EE's to be sponsored by local power companies. The six EE's chosen are: David Cavil, William Dachelet, Robert Lang, Don Martell, Lanny Smith, and Dan Donohoo.

This year, the UW is host to the AIEE district paper contest on April 24 and 25. Don Olsen is in charge. There will be a banquet on the Friday night and a luncheon Saturday noon. The guests will be housed in the short course dorms. This is really going to be a big event and if you EE's want to find out how to give a technical speech, come around these days.

The March 11 meeting of the AIEE–IRE will be held jointly with the Madison section of the AIEE. Dr. Lewis of the Physics Department, who is an outstanding speaker will talk on "Thermonuclear Fusion."

NUCLEAR ENERGY INSTITUTES FOR ENGINEERING INSTRUCTORS

Six Summer Institutes on Nuclear Energy for engineering educators will be held throughout the nation this summer under the sponsorship of the Atomic Energy Commission and the American Society for Engineering Education.

The purpose of the institutes is to provide special training in the fields of nuclear energy and the nature of nuclear reactor problems. The teachers then can incorporate the material in their teaching programs or teach new courses in the rapidly expanding nuclear programs of the country's colleges of engineering.

Five of the 1959 institutes are for teachers in colleges of engineering having curricula approved by the Engineer's Council for Professional Development. No special background in nuclear energy is required for the basic course. The highly successful basic course for teachers in technical institutes offered for the first time last year, will be repeated; it does not require special training or experience.

This program of summer institutes reflects the continued need for such courses, first offered in the summer of 1956. The six 1959 institutes will provide instructional capacity for about 150 teachers who participate in nuclear education programs for engineering students.

The AEC is again making a substantial investment in this program, including the cost of operation of the six institutes. Attendees will be selected by sub-committees of the ASEE Nuclear Committee on the basis of the candidate's experience and the instructional use to be made of the training.

For an applicant to be considered, his educational institution will be required to grant him an amount at least equal to one month's salary in addition to the salary for the academic year. The AEC will match this grant, through the institution, to a maximum of $750, plus a travel allowance for each participant.

Each of the two basic institutes for engineering teachers will be a combination of a program at a university and at a national laboratory, with a quota of 25 to 30 participants at each location. The dates are June 22 to August 14, and they will be held at North Carolina State College at Raleigh, with Oak Ridge National Laboratory, and Cornell University, Ithaca, New York, with Brookhaven National Laboratory.

The advanced institutes, with

(Continued on page 68)

Sandy Sandstrom, admires the beard of Tom Underbrink, Finalist in "Most Distinguished Beard Contest."

Meet the Presidents


Thorvald E. Thoreson.


Perry Wilder.

Thorvald E. Thoreson, president of the Northwest chapter WSPE, was born on October 15, 1913, at Woodville, Wisconsin. He attended Wisconsin State College at River Falls, and received the BS in Agricultural Education in 1935. He later attended the University of Wisconsin where he received the BS in Electrical Engineering in 1943. In 1955, he received the MS in Agricultural Engineering from the University of Minnesota. While at the University of Wisconsin, he was a member of KHK.

Mr. Thoreson was employed as Vocational Agriculture Instructor at Spring Valley, Wis., from 1935 to 1938, and at Wisconsin State College at River Falls from 1938 to 1939. He then became an assistant in the department of agricultural engineering at the University of Wisconsin from 1939 to 1943. From 1943 to 1946, Mr. Thoreson worked for General Electric Company. He now is the head of the department of agricultural engineering and industrial arts at River Falls State College.

In June, 1940, Mr. Thoreson married the former Wilma Martin, and they now have three fine children. His primary hobbies are travel, skiing, boating and canoeing. He also likes to fish.

Mr. Thoreson has also been active in civic affairs, being a church deacon, officer of Lions, chairman of various Scout committees while also being a member of Masonic Lodge No. 109.

Perry Wilder was born January 14, 1925, in Waukesha and has been happy to return there from his two sojourns away, once to earn his BS degree in Civil Engineering (1950) from the University of Wisconsin and the other time while a member of Uncle Sam's "team."

At the present time, he is Plant Manager for the Waukesha Cement Tile Company, but as Vice President of the Waukesha Culvert Company, he also sells corrugated pipe.

On June 14, 1947, he married Elli A. Zuler, the girl who sat behind him in High School, and now has a fine family: Mark Allen, 8; Brent Perry, 5; Barbara Lee, 3; and Scott Louis, 1.

Wisconsin Society of Professional Engineers

by Darell Meyer ee'61

THE AD HOC COMMITTEE ON STUDENT CHAPTERS WSPE

Place: Marquette University Office of the Dean: Date: January 24, 1959.

Present: A. B. Drought, E. C. Wagner, Karl O. Werwath. Absent: W. S. Cottingham.

It was determined after a thorough discussion that it would be desirable to institute a program of activity of student chapters within the framework established by the NSPE and within policies yet to be enacted by the WSPE.

The Committee recommended that the WSPE Committee reviewing the current revision of articles and by-laws include provisions for the establishment and operation of student chapters within schools of engineering. Two types of student chapters were suggested, namely:

1. "Student chapters" in those schools which qualify to participate in the NSPE program, and
2. "Associate student chapters" in other schools which would not so qualify but which offer a four-year course leading to a baccalaureate degree in an area of engineering.

It was recommended that the student groups which successfully petition for NSPE chapter status be known as Student Chapters, and those affiliated with only the state societies be known as Associate Student Centers. Student groups at schools with 2-year pre-engineering curricula would be known as Affiliate Student Chapters.

ENGINEERS' CREED

As a professional engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare.

I PLEDGE

To give the utmost of performance, to participate in none but honest enterprise, to live and work according to the laws of and the highest standards of professional conduct. To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations. In humility and with need for Divine Guidance, I make this pledge.

It was further suggested that a regulation stating the number of members required to establish a chapter be enacted in accordance with the NSPE pattern, which reads:

"The requirements established by the Board require that a student chapter: 2. Shall have during the past school year members in good standing in accordance with the following schedule:

College of Engineering Enrollment	No. of Student Members
Under 200	10
200 to 400	20
400 to 600	30
600 to 800	40
Over 800	50."

The matter of dues was discussed, and it was suggested that the dues be kept to a minimum, with each student chapter having the authority to set its own dues to cover local expenses, WSPE dues, and, where applicable, NSPE dues.

It was recommended that it would be desirable to have the national magazine, American Engineer," and a state magazine made available to the students, perhaps on a bulk basis, where other provisions do not apply.

Such student chapters, it was suggested, are to have both a faculty adviser and a professional-engineer-adviser from the participating section of the WSPE in which the student chapter is located, the latter to be responsible to the Board of the State Society, or a designated committee, for the operation of the chapter and to be appointed upon nomination from the school by the president of the Society.

Karl O. Werwath was directed to draft a student manual for the consideration of the Committee as an outline for future steps.

No action was taken on the question of the establishment of a student council of such student chapters and associate student chapters on a statewide basis.

(Continued on page 70)

Space Materials

(Continued from page 13)

crease must be carefully considered before cost can be fairly analyzed.

Because of the potential of beryllium as a metal, the Air Force has initiated a beryllium-sheet rolling program. Although the program is still young, it has been found that rolling temperatures in the vicinity of 1400° F. gives sheets with good strength and ductility in the plane of the sheet.

NON-METALS

Many of the exact requirements of materials are not clearly defined because environmental conditions under which they must operate are not yet known. At any rate, high strength-to-density ratio and a good long- and short-time elevated temperature properties are at the top of the list of requirements. If these requirements cannot be met by metals we must consider other materials. Some non-metals of interest are graphite, ceramics, and cermets.

Graphite is of interest in the astronautic age because it has potentially useful properties at 2700° F. and above. Graphite retains its mechanical properties up to 5800° F. and its strength is superior to the refractory metals, tantalum, and molybdenum, at 2700° F. If tungsten is compared on a density basis, it would need almost 50,000 psi tensile strength at 4500° F. to compare with graphite.

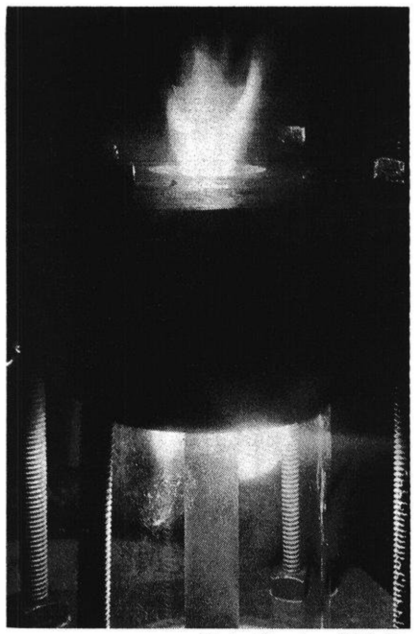
Materials engineers working in problem areas agree that graphite is the most singularly attractive material proposed for high-temperature service. It is not unreasonable to expect it to find use for certain applications at 5000° F. It is of present interest for structures, rocket nozzles, and components such as jet vanes, leading edges of air foils, nose cones, and other high-temperature applications.

Graphite is susceptible to oxidation and erosion in high-temperature air and combustion environments. But, for certain short-time applications the degree of degradation of unprotected graphite may not interfere with its performance. Structural use for relatively long times at high-temperatures under oxidizing conditions will require a coating.

Ceramics and Cermets

A few years ago, cermets looked promising for use in turbojet engines. Then a point was reached where super-alloys approached the best of the titanium carbide-base cermets. As a result, the problem of design with a brittle material was unnecessary.

Problems exist in the use of these materials as high-temperature structural components. For example, many ceramics which have fair resistance to thermal shock tend to oxidize at elevated temperatures. Those that do not oxidize have poor thermal shock resistance.



—Photo Courtesy Wright

Air-stabilized plasma arc is used for exposing materials test samples to 20,000 degrees Fahrenheit.

Present research has demonstrated that some ceramic-type materials are not inherently brittle. Magnesium oxide, sodium chloride, and lithium fluoride can be very ductile. Freshly fractured specimens, taken from single crystals, show high ductility. Prolonged exposure of the fresh fracture to the atmosphere, however, destroys this ductility.

ALTERNATIVES

It is a reasonably safe assumption that no one material would even come close to possessing all the properties needed for space operation. Different approaches must be taken to solve this problem. Alloying of metals has in the past solved many problems and there is no reason to believe it will not be considered in the future. Still other possibilities are composite materials, sandwich structures, coating, and surface treatment.

Super-alloys will be called upon to furnish the bulk of heat-resistance materials for the space age. Data so far indicates that all but certain "hot spots" may be within their capabilities. The possibility exists that these "hot spots" will be protected either by cooled super-alloys or by coated refractory metals. At the present time, several new alloys are appearing which indicate potential usable properties at high stresses up to 1800° F.

There is little doubt that super-alloys are reaching the limit of increase in temperature. It seems that the most that can be expected is an increase of service temperature of some 100 to 200° F.

It is reasonable to believe that cooling will be employed so that super-alloys can be used at temperatures in excess of those normally allowable. At least two methods of cooling are available. One is air bleed off for supersonic flight, the other is liquid coolants for flight through the heat barrier into outer space and return into earths atmosphere.

Two methods are available with the use of liquid coolants. The first is to circulate liquid fuel to absorb heat. This adds no weight to the structure. With solid propellants however, it will be necessary to carry an expendable liquid such as water that will escape as steam.

New and different composite materials are needed for future air and space vehicles. There is virtually no limit to the possible combinations. Many multilayer configurations will be used. A light weight composite inner layer can carry the load, while an insulated cooled or otherwise resistant layer can be placed on the outside. If the load carrying layer is sufficiently resistant, it can be on the outside and the insulated or cooled layer can be located on the inside to protect internal mechanisms, fuel, and personnel.

Other approaches may be modeled after reinforced plastics in which reinforcements with good tensile strength are supported in compression by matrix materials having poor tensile properties. For example, a material similar to reinforced plastics is wire reinforced ceramic. Simply a sheet metal strip wound around a suitable form and bonded with a structural adhesive.

There are many possibilities in the composite area. Reinforced plastics could be faced with metals to give increased rigidity. Metals coated with reinforced plastics could dampen vibrations, improve fatigue resistance, and perhaps provide some resistance to thermal penetration.

REQUIREMENTS FOR MATERIALS OR IMPROVED QUALITIES REMAINS URGENT

It can be concluded that astronautics will not lessen the pressing requirements for materials. Perhaps the emphasis on flights of long duration within the atmosphere where aerodynamic heating is severe will be decreased somewhat. The requirements for materials of improved heat resistance and strength, however, remain as urgent as ever. There is no indication that the earth's atmosphere will disappear, and it must be penetrated at least twice in every trip to and from outer space.

The present aeronautical requirements for materials with higher strength-to-weight ratios will be even more urgent for astronautics. After considering the various environmental problems, the conclusion is reached that they will certainly complicate the future requirements for materials. Each component and structural part used must be made of the material best suited for the job and there will be many special jobs to be done. Old reliable materials such as aluminum, magnesium, steels, and conventional high temperature alloys will probably be called upon for many jobs. They will always be good materials and have the advantage of a background of manufacturing knowledge and wide experience in diverse uses. They are very adaptable and will constitute a large fraction of the structural weight of astronautical vehicles.

Special purpose materials are apt to cause most of the headaches but could solve a good many problems. Substances which will withstand the extremely high temperature of propulsion systems and re-entry vehicles are already receiving much attention in the research and development programs.

Weight reduction will require the ultimate in strength of materials and may also dictate the development and use of multi-functional materials. For example, a satellite skin, which in addition to providing the structural envelop, protects against meteoric particles, regulates internal temperature, and also converts solar radiation into electrical energy.

Since the ideal material does not exist, materials already developed will have to be relied upon to solve current problems. Their metallurgical properties and fabricating characteristics must be improved as rapidly as possible, because design with them will continue until new materials can be discovered and developed.

THE END

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—Courtesy Chrysler Corporation

The U. S. Army's Jupiter Ballistic Missile leaving the launch pad.

Flight to Moon

(Continued from page 15)

minutes until the spaceship accelerates to a speed of 24,900 miles per hour. Then the spaceship starts coasting and losing speed, being slowed down by the earth's gravitational field until it reaches this point. For the last thousands of miles, before it reaches this point, it would be moving very slowly. Then the moon's field would cause the spaceship to gain speed. From the time the speed of 24,900 miles per hour is reached until the ship reaches the moon, approximately five days would pass. When it reached the moon, unless the speed would have been checked, the ship would have attained a velocity of 5,200 miles per hour.

At the cutoff speed of 24,900 miles per hour, everything becomes weightless. There is no up or down sensation. Moving around in the spaceship becomes difficult because everything seems to float.

Any time the ship deviates from its course, little flywheels will orientate the rocket engine, which will be cradled, to correct the error. The engine would automatically start and stop, imparting just enough velocity to correct the error.

Turning the ship end over end in space would have no effect on it because there is no air resistance. To land on the moon the spaceship would have to be reorientated in a sort of take-off-in-reverse position. Flywheels which start turning one way would create a torque in the opposite direction, turning the ship around.

A radar altimeter would show the distance to the moon and the rate of descent. With the cut-in of the rocket engine, the speed can be controlled until the rate of descent and distance reach zero simultaneously. This will be done automatically. The ship's pilot can use manual controls to make slight adjustments in order to avoid craters and crevices.

Just before landing, a long hydraulically operated spike would extend from the center of the spaceship. Upon landing the spike would bury itself in the ground balancing the ship momentarily, while the landing gear is being released. This gear would consist of four spider-legs hydraulically controlled with several disks on the ends. Each leg would be controlled separately to provide an optimum length so the spaceship would always be level.

The trip back to earth will be the same as the trip to the moon, only in reverse. The spaceship will accelerate up to 5,200 miles per hour and then coast the rest of the way home.

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THE END

MEET JOAN

SUBJECT:

Joan Herreid

ORIGIN:

Madison

DESCRIPTION:

Class—Sophomore

College—Music

Age—19

Dimensions—Naturally

PROCEDURE:

CE 3–3862

or call

Alpha Chi Omega

OBJECTIVES:

1. Ice Skating
2. Men
3. TV Modeling

Dean Wendt

(Continued from page 32)

from the earth; the field naturally divides itself into mining geology, mining engineering, and mineral dressing.

The metallurgical engineer extracts metals from their ores and subsequently refines and combines metals to produce alloys possessing special properites.

In the following pages, you will find detailed statements about each of these fields of engineering. Many combinations of engineering and agriculture, commerce, city planning, light building industry, or law are also possible and provide unusual opportunities for qualified students. Anyone interested should write for a pamphlet giving further information about "combined programs in engineering."

Regardless of field, many areas of work and a large variety of duties are common to all engineers. For this reason you will find many courses common to all engineering curricula. As in any profession, success in engineering demands integrity, industry, perseverance, courtesy, and good personality. In addition, interest in and strong aptitude for mathematics, the sciences, and written and oral expression are of primary importance. If you possess these qualities and aptitudes, find the duties of engineers attractive, and are willing to work hard, you should and can become a successful engineer. The rewards, materially and in personal satisfaction, are substantial.

Be Prepared

(Continued from page 33)

make good grades. Learn to direct yourself and develop good study habits. When you come to college, you will face keener competition. Material will be presented in greater quantity and at a more rapid rate than in high school. Your instructors will be more demanding. You will encounter many more distractions. Your school work will no longer be so closely supervised. You will have to depend upon your own effective study habits, which should be developed long before you come to college. Learn the techniques which contribute to effective study, such as how to budget your time, where to study most effectively, the importance of recitation in learning, and how to review to best advantage. Consult your school librarian, guidance counselor, or remedial reading teacher for books or information on these points.

If you think you would like to become an engineer, remember to:

Be prepared to choose your career on the basis of information and self-knowledge,

Be prepared to enter college with the best academic background possible, and

Be prepared to use effective study habits when you get to college.

Be prepared! It's your future!

Prof. Grogan

(Continued from page 38)

may never become an engineer. It does mean, however, that no students can earn credit toward an engineering degree by taking mathematics below the level of Course 60, ... The course or courses you may be required to take in bridging this gap might be offered for "credit" in the institution of your choice. Such credit will always show on your final transcript, but it simply may not be applied against the 146 or more credits required for graduation in engineering.

The above has been offered not as an apology of the Extension Center system or the State Colleges. Rather, it has been offered as evidence that beginning your course work off the main campus is no different so long as you understand there are no magic shortcuts to an engineering degree. Of necessity, many students at Madison will have to take non-credit mathematics. Others will carry a reduced program of 14 to 16 credits. These students will be confronted with essentially the same deficiencies of credit as any other and will require probable extensions of their programs by a summer session, a semester, or a full year the same as the student beginning work off campus under similar handicaps. Records here show that fully one-half of the graduates in engineering require more time for completion than the normal eight semester into which the credits have been cataloged. Each student has to decide for himself whether or not the sacrifice in time and effort will be compensated later by the satisfaction of making a valued contribution to our economy or our defense while, at the same time, receiving some of the financial rewards currently associated with a beginning engineering career.

The suitability of the Extension Center system as a means of entry to the College of Engineering is evidenced by the fact that there are at the present moment 272 Sophomores, Juniors, and Seniors studying engineering on campus who began their careers in one or another of the eight Centers. This represents some 12 to 15 percent of all students in the three upper classes of the college. Another substantial number of Center students transfer to other engineering schools in Wisconsin and surrounding states.

A study of your personal situation may strongly suggest to you that you begin work in one of the Extension Centers of the State Colleges. If you do, there is every reason to believe that time will bear out the overall wisdom of your selection.

Prof. Elliott

(Continued from page 47)

ing in mechanical engineering is extremely valuable in many other fields of activity. Graduates go into business, commerce, agriculture, law, and public service. The number of engineers in responsible executive and administrative positions in industry, business and government is increasing.

The future for properly trained engineering graduates is excellent. Opportunities are numerous, starting salaries are relatively high and advancement depends upon ability and capacity, and the willingness to work hard.

Prof. Rosenthal

(Continued from page 49)

After the mineral dressing engineer has completed his work of concentrating the ore, the metallurgical engineer steps in to reduce the ore to the metallic state. In this work he may utilize heat, electricity, chemicals or a combination of these factors. Since this treatment usually involves chemical reactions, this metallurgical engineering field is called chemical or extractive metallurgy. An example of an extractive metallurgical operation is the reduction of iron ore in the blast furnace to produce pig iron, the pig iron being subsequently refined to steel. The large metal refineries scattered through the country all depend upon metallurgists for their design and operation. New processes, increasing use of low grade ores, new metal requirements, etc., have all added to the scope and importance of the work done by the extractive metallurgists. When the extractive metallurgist has completed his job of reducing the ore to the metallic state, the physical metallurgist takes over to improve the product.

The alchemists of old were constantly striving to change base metals to noble metals. Had their efforts succeeded they probably would be no less spectacular than the efforts of the present day physical metallurgists who have succeeded in greatly improving the mechanical and physical properties of metals by alloying and special treatments. The physical metallurgist finds opportunities in a wide variety of industries. He may be employed by a metal producer and concerned with the improvement of the properties of the products sold. On the other hand, he may be associated with a metal-consuming industry like the automotive industry, the appliance industry, or the aircraft industry, where his primary job in specification, inspection, and control of the various metals and alloys that are used. There are many additional opportunities in the foundry field, welding, and other metal-processing operations. Besides being engaged in production work the metallurgist may specialize in research, teaching, development work, or engineering sales.

New requirements for metals and alloys and other materials that have arisen as a by-product of atomic energy, guided missiles, gas turbines, and other high temperature applications have greatly expanded the demand for metallurgical engineers. To prepare for these demands, the curriculum includes a good background in physics, chemistry, and mathematics, and a number of courses in alloying, heat treating, metal working, etc.

Prof. Ragatz

(Continued from page 41)

also by the Engineers' Council for Professional Development. The curriculum is constantly under scrutiny, and periodic changes are made as called for by new scientific discoveries and changed industrial conditions. After an extensive study extending over a period of a year and a half, a revised curriculum was recently adopted and placed in operation.

The tremendous growth of the chemical industry since World War II has created many employment opportunities for graduates from the chemical engineering course. Prospective students should bear in mind, however, that Wisconsin has relatively few chemical industries, with the result that most of our graduates secure employment outside of the state. A notable exception is Wisconsin's large pulp and paper industry, in which many of our graduates have secured employment.

Prof. Lenz

(Continued from page 43)

are busy on the interstate system and preparing runways for jet aircraft. Structural engineers are working on prestressed concrete to cut the costs of bridges and buildings. Sanitary engineers are working on new methods to reduce the pollution of air and water so we may enjoy a better place in which to live. Hydraulic engineers are looking for ways in which to develop our water resources to their greatest potentiality. All these problems some within the province of the civil engineer.

Prof. Marks

(Continued from page 39)

lege of Engineering has expanded along with the increased enrollment of engineering students and the need for engineering graduates. The primary purpose of the Placement Office is to provide facilities and information for seniors when they begin looking for a job and give counsel and advice to those who want help.

Each year, several hundred representatives from companies throughout Wisconsin and all over the country visit the campus to interview seniors. These companies provide literature and other information about the opportunities available. The seniors examine this material and interview companies that are interesting to them and which have expressed a need for people with their particular qualifications. If, after the campus interview, there is mutual interest between the company and the student, he will very likely receive an invitation to visit the company to further discuss employment possibilities. In some cases, seniors must enter military service after graduation, but some companies will hire these individuals and grant military leave when they are called to active duty. If the graduate prefers, he can use the Placement Office after returning from service. At any time after graduation, College of Engineering alumni can use the Placement Office if they wish to relocate.

New opportunities are also developing in terms of summer employment for engineering students while still in college. Even after the freshman year it is sometimes possible to find summer work in some phase of engineering. Besides just providing the chance to earn money, the student can gain worthwhile experience in summer work and see how engineering theories are applied in industry. And he may discover special interests in a particular phase of engineering and tailor his selection of courses accordingly. As a result, he will be better prepared to continue his career after graduation.

THE END

Satellite Tracking

(*Continued from page 18*)

the proper functioning of the satellite's transmitter. Also, the batteries which power the transmitter do not last indefinitely, and, under perfect conditions, the transmitter will operate for only about a month.

Therefore, there is a great need for other methods of tracking. Two visual methods are being used with success. The first of these, professional tracking using cameras, is quite accurate. The second, operation Moonwatch, while not as accurate, can be carried on by amateurs.

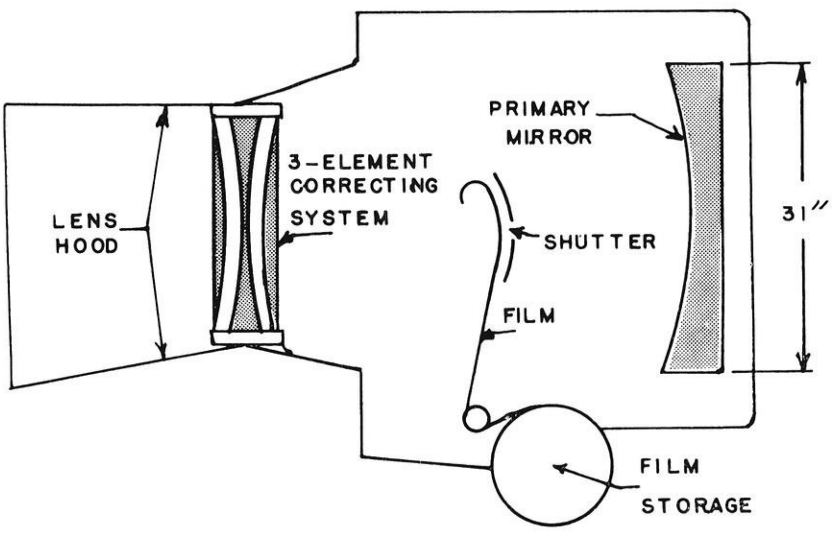


Fig. 4.—A drawing showing the essential features of the Baker–Nunn camera.

Professional Optical Tracking. The professionals are under the direction of Dr. J. Allen Hynek of Harvard College. Dr. Hynek's group developed a special camera for the job. This unit, called the Baker–Nunn camera, is very large. The camera is about ten feet high, nine feet wide, and six feet deep, and weighs three tons. The optics are very good—the unit can photograph a twenty-inch satellite at a distance of 1500 miles and a twenty-foot sphere at the distance of the moon. Also, it can locate the sphere, in distance, within thirty feet. This great power limits the field of view, however, so that the satellite must be located quite accurately by some other method before the camera can be used.

The film of the Baker–Nunn camera is advanced by synchronous motors which are controlled by a clock accurate to within 1/1000th of a second. This clock is synchronized to the National Bureau of Standards' official clock.

The camera takes two pictures simultaneously. The first exposure is fixed on the satellite and follows it. The time to within one-one thousandth of a second is recorded on the negative. The second exposure is set on the background stars and follows them. This provides a point of reference for following the satellite, in the same manner that the Minitrack stations are calibrated.

Because the satellite is visible only at dawn and dusk, the use of the cameras is quite limited.

Before the Russians had released information on the size of Sputnik II, two of the cameras were used to approximate its length. Using the two cameras at the same time, through triangulation, the distance to the satellite was determined. From this distance and by measuring the image size on the negative, the satellite's length was determined. A surprising degree of accuracy was obtained when the length thus estabilshed was compared with the figures later released by the Russians.

Operation Moonwatch. Operation Moonwatch is a very important project. During the initial path stages of a launching the satellite's position has not been determined. Thus the large cameras can not go into operation. Of course Minitrack can be used, but if the transmitter should fail to work, the entire task is in the hands of the amateur Moonwatch teams. Considering the tremendous amount of money which goes into a launching, it is of great importance to find the satellite quickly. We have not perfected the launching yet and cannot guarantee that a satellite will stay in orbit very long.

Also, during the final stages of orbit, Moonwatch will be very valuable. The transmitter will be dead by this time. Because the artificial moon is entering the atmosphere, it will be slowing down too fast for the cameras to track it. While the satellite is entering the atmosphere, much information can be gained about the density of the air and only Moonwatch will be able to track the sphere.

Operation Moonwatch is under the direction of Dr. Armand Spitz, the famous producer of planetarium equipment. The success of the operation depends upon simple equipment and teamwork. Many teams are organized, not only in the United States, but throughout the world. In most cases, local corporations sponsor the groups and pay for the equipment needed.

Each team monitors a fan-shaped "interception zone." This zone lies through a north-south line which includes a station marker. Five members of the ten-man teams sit on each side of this marker—a mast about forty feet high—and look through special telescopes. The mast cuts across their field of view as a sort of hairline. The closer an observer is to the mast, the more vertical his field of view is. All together, the observers cover an arc of forty-five degrees. With this setup, one of the observers is apt to spot the satellite. Each station is equipped with a radio receiver to pick up the time signal from WWV. WWV is the call signal of the radio station operated by the National Bureau of Standards. The station broadcasts a continuous time signal which is the standard for the United States and most of the world.

There are two hazards connected with this setup. If an airplane

(*Continued on Next Page*)

should pass through the area at approximately the time when a satellite is expected, the light from the plane may be mistaken for the artificial moon. Secondly, after a period of operation, the observers will become familiar with the expected orbit and, thinking that the satellite will not pass through their field of view, may be tempted to look in other areas. With proper guidance, this should not happen.

To test the organization, a simulated satellite will be flown. An airplane flying at a high enough altitude so that its motors cannot be heard, will carry a light simulating the expected brightness of the satellite.

The easiest way to describe the operation of a station is to reprint a set of instructions which the observers use. This excerpt is taken from the Smithsonian Bulletin Number Four.

I. During transit of the satellite.
   A. Give warning so the time can be recorded when:
      1. The satellite is first observed.
      2. The satellite passes behind the mast.
      3. The satellite leaves the field of view.
   B. Mentally record, as accurately as possible, the path of the satellite with respect to the stars.
   C. Note the position of the mast with respect to the stars.
   D. Estimate the satellite's brightness relative to one of the stars.

II. Immediately after the satellite has left the field of view:
   A. Sketch the path of the satellite on the sky chart, also the position of the mast.
   B. Mark the points on the path when the times were observed.
   C. Determine the brightness relative to stellar magnitudes as obtained from the star chart.

III. Measure, with a protractor, the position angle of the satellite on the chart and calculate the angular velocity using the times and positions.

IV. Report the observations in the prearranged form.

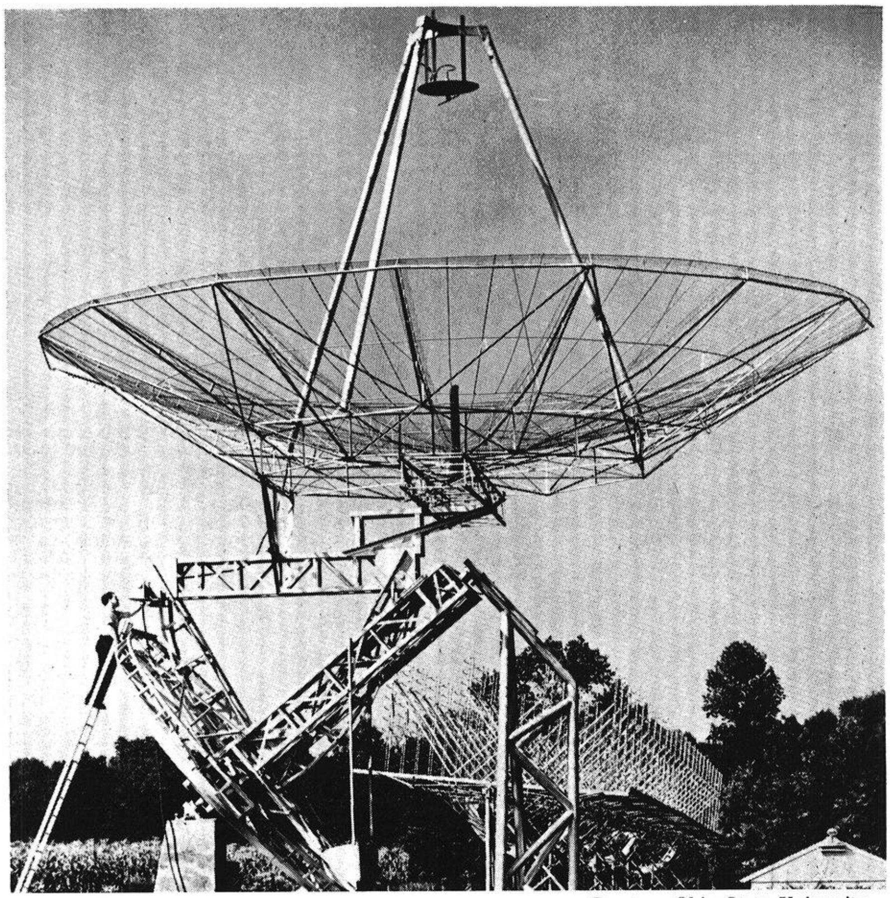
ADMINISTRATION

Dr. Fred L. Whipple of the Smithsonian Astrophysical Observatory is in command of the entire program. Dr. Hynek and Dr. Spitz serve under him.

From the many tracking stations of all types, the information is sent to the Vanguard Computing Control Center in Washington. This center is operated by the United States Navy and the information is fed into IBM-704 electronic computers.

Already stored in the machine are the correction factors for each Minitrack station and factors to correct for systematic errors, such as the bending of the radio waves as they pass through the ionosphere. The computer applies all these figures to the incoming information and, after "smoothing" the resultant to compensate for random errors, gives the resulting orbit data.

The computer can then derive a minute-by-minute orbit for the satellite at a rate 150 times as fast as the satellite actually progresses.



—Courtesy Ohio State University

Fig. 5.—A photograph of the Ohio State University 40-foot steerable dish antenna.

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THE END

"Torch"

(Continued from page 51)

through an intense arc that is struck inside the torch. It is at this point that the temperatures above 15,000 degrees are reached.

Because of the enormously high heat of the arc, the material passing through is converted into a fluid or plastic state. It is then carried out of the torch by inert gases flowing at high velocity and is finally deposited on the part being made or plated with such force that a firm bond results.

The choice of wire or powder; and there is a separate torch for each; is largely one of convenience or economics. Stainless steel, for instance, is readily available in wire form and would most often be used with the wire-fed Plasma Arc Torch.

Tungsten and the carbide materials, on the other hand, are more usually found in powder form and are regularly used with the powder-fed Arc Torch.

A nozzle liner for a rocket engine is made of tough tungsten with the Plasma Arc Torch. The Torch, which harnesses the highest temperatures ever used in industry; between 15,000° and 30,000° F; fabricates shapes like this by applying successive coatings on a spinning mandrel until desired thickness is reached.

Research Uses Available

Although the Plasma Torch is a new development in the fabrication field, it has been used for some time in advanced research. Set up as a wind tunnel tool for either large or small units, the plasma arc can simulate speeds up to Mach 20 and reproduce the conditions which a missile would encounter when it re-enters the earth's atmosphere at terrific speeds.

In a different field, the Torch can be significant in determining the physical changes that take place when solids, liquids, or certain types of gases are passed through the heat of the arc.

Studies bearing on the use of high-temperature torches for promoting unusual chemical reactions are under way.

It is also believed that this invention will contribute to improvements in the knowledge of high-temperature furnaces.

Torch Background Summarized

Although a primitive plasma device was first built in Europe 35 years ago, the modern plasma arc did not come until 1955 when Linde introduced the Heliarc plasma jet for cutting aluminum. This was the first commercial process ever to use the power of plasma.

The present Plasma Arc Torch is the latest step, and engineering work is continuing with bigger and bigger arcs and higher concentrations of power.

An experimental High Current DC Arc Torch is now in operation to explore problems involved in using electric power above 10,000 amperes.

This will result in concentrations of power equivalent to 3 megawatts per square inch; equal to putting the total output of the largest electrical generator into an area six inches square.

The problems of arc constriction are also under constant study along with improvements in methods for producing stable arc plasmas.

POTENTIAL OF WATER RESOURCES COMING UNDER CLOSER SCRUTINY

Local, state, and federal authorities are taking a longer look into the potential of water resources.

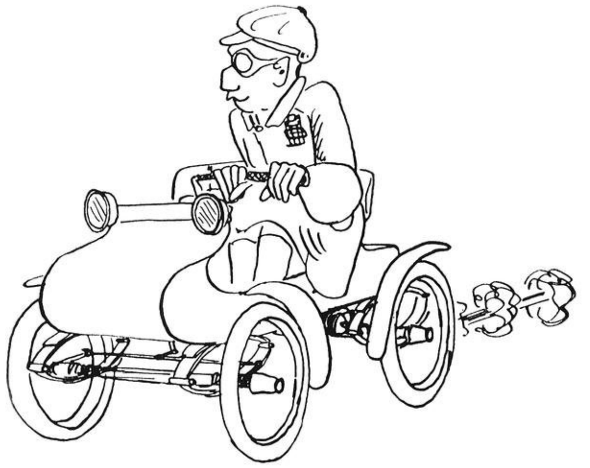
One of the most significant advances in over-all river planning in 1958 occurred at the federal level when a rivers-and-harbors bill included a broadened water-supply concept. For the first time, the Army Corps of Engineers and the Bureau of Reclamation are allowed to provide water storage capacity for future needs in their new reservoirs.

Out of Texas (drought-plagued in recent years, but flood-washed in 1958) came a real contribution to partnership-type, over-all river planning. The state-created Trinity River Authority came up with what is believed to be the first comprehensive basin-wide river program in the U. S. to be developed at local level.

Long-Range Development

The plan involves cooperation of local, state, and federal authorities. It covers long-range development of the entire 18,000 square mile Trinity watershed, with due con-

(Continued on page 66)



THE ENGINEER OF YESTERYEAR

by John Nichols ee'60

MOTOR DRIVEN PASSENGER COACH

November, 1930

A MEANS of transferring existing passenger coaches into motor-driven units for branch service has been devised by the Chicago and Northwestern Railroad. Two 70- horsepower gasoline motors were installed on the under frame of a test car recently equipped and are so arranged that both motors may be operated from either end of the car. On a trial run the car developed a speed of 45 miles per hour without undue vibration and also proved its ability to switch two loaded box cars. One of the chief advantages of such a type of motor car over light specially constructed cars is its safety at high speeds. Another argument greatly in favor of this type of installation on lines of light traffic is its low initial cost.

REMARKABLE RAILWAYS OF THE WORLD

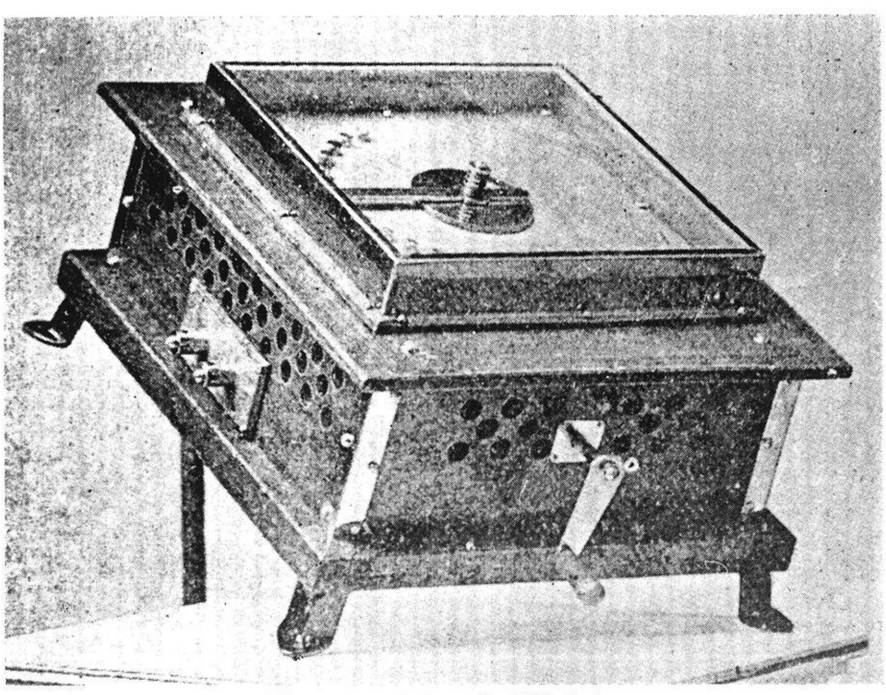
February, 1924

Perhaps one of the most curious railways in the world is a comparatively short monorail line in Ireland between Killarney and Bally Bunion. The track is carried on "A" frames about 3½ to 4 feet high and the coaches are hung on each side of these. Road crossings are carried over the track by means of lift bridges and farm entrances are easily made by hinging a portion of the track and "A" frames so that in effect it becomes a gate.

Another type of construction is in use on the Sao Paulo Railway of Brazil, where a raise of 2600 feet is accomplished in 6.2 miles by means of cable inclines. This railway was constructed in 1867 at the unusual cost of $497,000 a mile. In 1901, it was relocated and double tracked. Notwithstanding, the high cost of construction and the fact that its maintenance expenses were $39,820 a mile in 1913, the net earnings in this same year were $46,400 a mile, which made it the most profitable railroad in the world. There are five of the double-track cable inclines on 8 percent grades, and all operate simultaneously with one train each way on each incline. The largest train consists of six loaded cars of 145 tons and in 10 hours 5,000 tons can be hauled in each direction.

When the Ax-les-Thermes-Ripoll Railway between France and Spain was built, rock walls were encountered that were so steep that engineers had to be lowered by cables in order to take topography. A spiral tunnel 5,579 feet long had to be resorted to in gaining an elevation of 207 feet.

Another remarkable physical feature is on the railway line from Port Augusta to Kalgoorlie, connecting eastern and western Australia, a tangent 330 miles long, the longest piece of straight railroad track in the world. There was nothing to prevent its construction as there were no hills, valleys, rivers, trees, nor was there any water for 500 miles of line. However, these very features made the work of construction extremely difficult; there were no inhabitants for four-fifths of the route and water and all the materials of construction had to be carried in some cases for more than 300 miles. The line opened in November, 1917, after five years of construction work.



Rheostat used in early E.E. Labs.

Water Resources

(Continued from page 63)

sideration for water supply, siltation control, flood control, navigation, pollution abatement, and soil conservation.

That there is a need for a longer look into the future potential of water resources can best be illustrated by federal work in the Columbia River area.

A little more than ten years ago, there had been a feeling that Bonneville and Grand Coulee Dams generated more power than the area could absorb for many years. However, when rising power demand proved the assumption false, McNary Dam was begun. Soon afterward came Chief Joseph and The Dalles, both now virtually completed. And last year, construction was started on what is believed to be the last federal project on the Columbia River's main stem, John Day Dam.

Awareness of Problem

A growing awareness of sewage treatment and pollution problems is indicated by activity at state and local level; in Pennsylvania, Texas, Kentucky, Vermont, Washington, Tennessee, and California, to name a few states.

But everything is not bright in the pollution picture. Public Health Service statistics show that although sewage treatment plants are going up at a faster clip, the need for them is growing even faster.

Industrial activity in water pollution is promising. One company announced the defeat of a nylon-wastes problem in Pensacola, Florida, after two-and-a-half years of research and development work on this problem. And at Bound Brook, New Jersey, another treatment plant was opened to handle "waste that couldn't be treated."

A simple treatment plan has been considered by the Ohio River Valley Water Sanitation Commission for the control of the concentration of untreatable chloride wastes in the Ohio. The scheme is simply storage of the wastes at the point of origin for later release in amounts and at times picked to avoid overloading the river.

This method could also help control other pollutants. The commission is also considering it for control of taste and odor-producing substances.

BY TRAIN TO TRAIN

A small sub-critical nuclear reactor for use in training future nuclear scientists is on its way from Georgia to the University of Texas.

The training reactor will be used in the University's new nuclear engineering curriculum, being developed with the aid of the Atomic Energy Commission. Students will be trained in the use of radiation equipment and in the characteristics of reactors.

Compared to the big research reactor at the Georgia Nuclear Laboratories at Dawsonville (built to conduct experiments leading to development of an atomic-powered aircraft), the Texas training reactor is like an "erector set."

The school's reactor has a core ten inches in diameter and 14 inches long. It uses two types of reflectors, polyethylene and graphite, with thicknesses varying from three to ten inches.

In the experiments students will place an uranium core inside the reflector and then add a neutron source. Neutrons will be multiplied by the core, but they will be retained by the reflector so there will be no danger to student observers. When the source is taken away, the multiplied neutrons will die out. However, it will be dangerous for anyone to come in close contact with the neutron source.

HIGH RANGE TRACKING SYSTEM

A space range for testing the mile-a-second X–15 research airplane which will fly at 100 miles altitude, is being readied in the Nevada wastelands by the National Aeronautic and Space Administration.

The new high range will provide 600,000 answers per second to electronic questions on the safety of the pilot and the condition of the airplane when the North American Aviation rocket-powered research airplane drops from a B–52 bomber and roars into space.

Extending across 400 miles of California and Nevada dry lakes, the master control station in the chain radar instrumentation system is located at the NASA High Speed Flight Station at Edwards AFB, California. Two "up-range" stations are located at Beatty and Ely, Nevada.

A continuous flow of electronic information is provided by the range so that flight engineers and scientists may observe everything from the heart beat of the pilot to the skin temperature of the airplane. Ground observers at any station may instantly observe conditions of the pilot and the airplane as it soars through space, as though they were looking over the pilot's shoulder and taking his pulse.

Simultaneously, radar and plotting boards pinpoint and trace the course of the research vehicle as it slips swiftly through space at more than 3600 miles per hour and higher than 100 miles altitude.

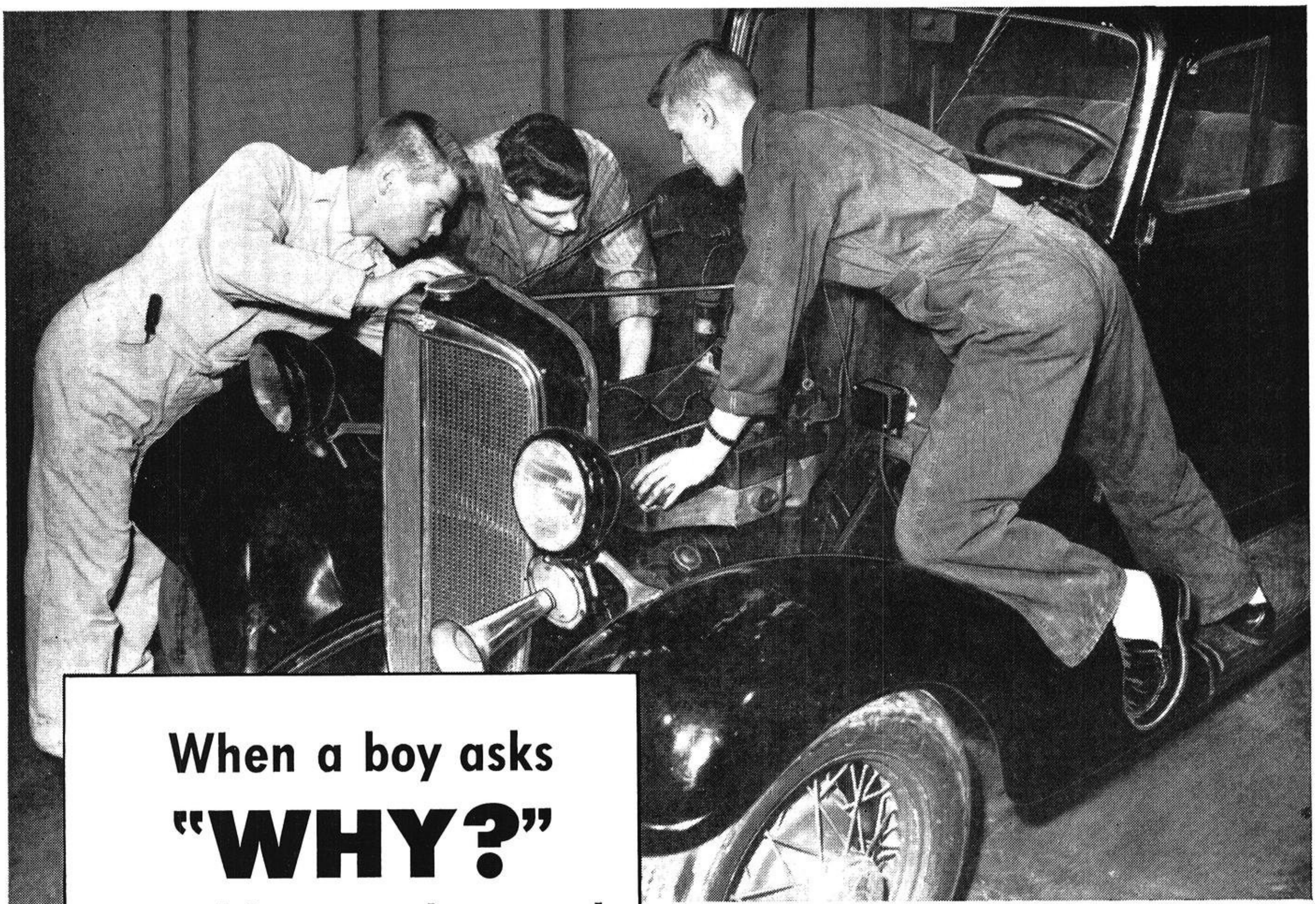
A constant contact communications system enables the pilot and all three of the ground stations to be in touch at all times. If for any reason the pilot cannot contact one ground station, the other stations can receive his voice and relay it via telephone line to the other stations in less time than it takes to tell about it. All of the UHF radio transmitters and receivers at all stations are on the air simultaneously and at the same time are interconnected via long distance telephone line. This system required nearly 3000 miles of long distance line to assure constant communications.

Incorporated within the high range system is a specially designed radar data recording system which automatically converts radar information into a form which is utilized by the Air Force Flight Test Center automatic data processing system.

Data from a single flight can be fed from the high range equipment and processed through the datum system in about 30 hours using two operators. Formerly such a procedure, using photo panel methods and manual data reduction, required more than 30 days and nearly a dozen or more data interpreters. Aeronautical design engineers sometimes had to wait for more than a month before being able to make a design decision based on flight test information.

THE END

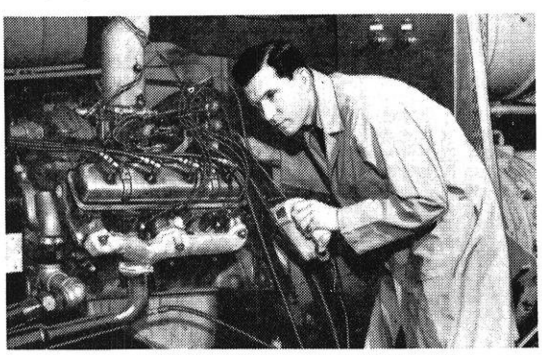
The story of Standard Oil's contributions to oil progress through research is told to the public in advertisements like this during the year.



When a boy asks "WHY?" ...anything can happen!

This scene can be duplicated thousands of times throughout the country. And as long as it goes on, America can be sure of continued progress. Here Bob Hansen (left) and two friends explore the mechanical wonders of an engine (1933 model). The two other boys are Tony Riccardi (center) and Bill Hess. They are all students at Niles Township High School, Skokie, Illinois.

Ever since Bob Hansen was old enough to hold a wrench, he has been tinkering with machines. Next year his repair shop on his driveway at home will disappear because Bob, an honor student, is going to college to study engineering.



The efficiency of gasoline and lubricants is improved constantly in Standard Oil's huge automotive laboratory in Whiting, Indiana. Here fuels are designed, too, for automobiles that will not be on the street until five years from now. Robert W. Boydston, above, is working on a "fuels of the future" experiment.

Bob is one of thousands of American boys with a restless curiosity about things mechanical. What makes a clock tick? What makes a bicycle brake hold? What makes a car run? From such curiosity comes the mechanical progress that has helped to make America great.

In Standard Oil's big automotive laboratory in the research center at Whiting, Indiana, engineers are going through a similar process every day—asking questions and finding answers. How do fuel additives affect combustion? How do they affect engine deposits? How do burning rates differ?

And the questions continue outdoors, too. In all kinds of weather—hot, cold, wet, dry, low barometer, high barometer—different blends of gasoline are tried to see what happens under what conditions. Fuels are designed in the laboratories for experimental engines that won't appear in an automobile for five years. Standard Oil products are under constant improvement to give the finest performance possible. You get years-ahead quality with Standard Oil products—and at a reasonable cost.

Where does progress start? Does it start on the private driveway of a boy's home or in a huge research laboratory? Progress starts whenever someone asks "Why?" and sets out to find an answer.

What makes a company a good citizen?

Perhaps even more than an individual, a company must have a healthy respect for the future. Many companies, like Standard Oil, have large families—tens of thousands of people who depend on Standard for their livelihood. Progress through research is one way of protecting the future of both employees and investors and of helping to assure economic stability for the communities in which they live and work.

STANDARD

STANDARD OIL COMPANY

THE SIGN OF PROGRESS... THROUGH RESEARCH

Engine Ears

(Continued from page 28)

quotas of from 20 to 25 participants will be:

"Reactor Operation and Design," University of Michigan at Ann Arbor, Michigan, June 22 to August 14

"Specialized Nuclear Studies," Argonne National Laboratory, Lemont, Ill. (near Chicago), June 22 to August 14

"Chemical Processing," Hanford Laboratories, Richland, Washington, June 22 to August 14.

The course for teachers in technical institutes, with a quota of from 25–30 participants, will be held at The Pennsylvania State University, University Park, Pennsylvania, from June 29 to August 7 and at Argonne National Laboratory from August 10 to August 21.

PROFESSOR GEORGE BARKER ANNOUNCES RETIREMENT

One of the Wisconsin's pioneers in the promotion of greater cooperation between American industry and engineering education and research recently brought to a close his long career in mining and metallurgy studies and teaching at the University of Wisconsin.

He is Professor George J. Barker who has completed 37 years of service in the UW College of Engineering's department of mining and metallurgy.

Practicing that which he preaches concerning industry-education cooperation in engineering, Barker has served on educational and research committees and boards of directors of half a dozen national industrial organizations and foundations.

He has been called the "Patron Saint of FEF." FEF is the national Foundry Educational Foundation, which annually provides scholarships to help outstanding engineering students gain their education. He was one of the founders of FEF.

Barker himself never realized how much of his time above and beyond his UW teaching-research duties he was devoting to his pet cause of industry-education cooperation until one time, back in 1948, he discovered that he was serving as education's representative on six different committees of the American Foundrymen's Society (AFS).

He was chairman of the society's Textbook committee; chairman of its committee on Recruiting of Engineers for the Foundry Industry; vice-chairman of its Graduate Industrial Training committee; and also a member of its Executive committee, its Foundry Courses committee, and of the Program and Papers committee for its annual convention.

In 1953, Barker was presented with an honorary life membership in AFS in recognition of his "outstanding contributions to the society and the castings industry in the education of young engineers." Prof. Barker is rightly proud of the tribute.

Barker is a Wisconsin product. Born in Sparta in 1888, he lived his early life and received his secondary education there. After graduation from high school, he taught country school at Hankinson, North Dakota, for one year. After a summer's work in an engineering survey camp near Sparta, he decided to make engineering his life work.

He entered the UW College of Engineering in 1909 to study mining engineering. Needing money to complete his education, he went into mining work at Galena, Ill., and then served as superintendent of the National Zinc Separating Co., at Cuba City, Wis., from 1913 to 1917. He returned to his UW studies in 1917, and then left school for another year in 1918 to install a power plant for the Armour Phosphates Co. in Columbia, Tenn.

He came back to the University in 1919, and left once more to work for the Anaconda Copper Co. at Great Falls, Mont., in 1920. He returned to Wisconsin to complete his work for his B.S. degree in engineering in 1921. He began his long career on the UW staff as an instructor in mining engineering while he continued his advanced studies.

In 1923, Barker received his professional Engineer of Mines degree from the University and became assistant professor of mining engineering. In 1941, he was promoted to associate professor, and in 1945, became a full professor in the College of Engineering. He served as chairman of the UW Mining and metallurgy department for seven years from 1943 to 1950.

Besides his contacts with hundreds of students in mining and metallurgy, Prof. Barker has conducted a vast amount of research in cooperation with industry in Wisconsin and other states.

He did a research study and experimentation on an electrolytic process for Wisconsin zinc ores during his early years on the UW staff; completed a study of Wisconsin magnesium lime mortars in 1933; and in cooperation with the Wisconsin Clay Products Association, made a study of brick and tile plants in Wisconsin to help them with technical information regarding their product and its manufacture.

It was out of this lengthy study that Barker and one of his colleagues on the UW faculty, Prof. Emil Truog of the College of Agriculture's soils department, came up with the Barker–Truog Clay Improvement Process—more familiarly known as the B–T process—used by brick and tile manufacturers. The process, which involves the controlled addition of soda ash to clay, cuts both production costs and manufacturing headaches for the brick and tile industry, and has led to sounder clap products for less money.

The new process bearing their names was patented by Barker and Truog in 1941 and the patent was assigned to the Wisconsin Alumni Research Foundation (WARF) which receives funds through its patent rights to aid research studies on the UW campus.

Barker received another honor from American industry for his successful research in the nation's clay industry; he was chosen an honorary fellow of the American Ceramic Society.

Prof. Barker has had many other honors and positions of trust. He served as chairman of the educational division of the American Foundry Society in 1950; he was elected to the board of directors of the Milwaukee chapter of the American Society of Metals in 1953; he served on the board of directors of the Chicago chapter of the American Institute of Metallurgical Engineers from 1938 to 1953; and he was elected to the council of the American Society for Engineering Education in 1948.

Prof. Barker was married in 1913 to Cleo Desmond of Galena, Ill. They have a son, George, Jr., who followed his father's footsteps in mining and metallurgy, is a graduate of the UW College of Engineering, and now works for the Electromet Co. in Alloy, W. Va.

Prof. Barker is going to take it easy in his retirement. He's going to indulge in his hobbies, the sports of curling and fishing, and do some traveling, mainly south or west to warmer climes in the winter. Otherwise, he's going to stay right in Madison, near his beloved UW College of Engineering campus.

RESEARCH ACTIVITIES INCREASE AT UW ENGINEERING EXPERIMENT STATION

Research activities of the University of Wisconsin's Engineering Experiment Station reached an all-time high during the past year, it is revealed in the annual report of the station made public recently.

The station's annual report shows that the number of staff members engaged in research, funds available for research, number of active research projects, and research publications of the staff members have all increased to new high levels.

Dean Kurt F. Wendt, who is also director of the Engineering Experiment Station, said, "The 267 active projects described in this year's report represent an increase of nearly 15 per cent over last year. More of our staff were engaged in research, more funds were available for research, and more publications by the staff have appeared during the year than ever before.

"These accomplishments demonstrate not only increased staff interest and activity but also increased interest and confidence on the part of industry and foundations in supporting this important phase of the University's functions."

The report shows research projects during 1957–58 increased from 235 in the previous year to 267 or nearly 15 per cent; the number of faculty-staff-graduate students engaged in the enlarged research program increased from 232 to 263, also a near 15 per cent increase; total funds allotted to engineering research increased $166,294 from $442,801 to $609,095 or 38 per cent; and research publications by the UW engineering staff increased from 26 to 40 or nearly 54 per cent.

The report shows that the total of $609,095 to pay for the research came during the past year from industrial grants and fellowships; $116,383; from state funds, $158,450; from different foundations, $90,155; from the Wisconsin Alumni Research Foundation, $133,135; and from the federal government, $104,492.

The 267 engineering research projects were carried on as follows: in the departments of chemical engineering, 34; civil, 44; electrical, 91; mechanical, 46; mechanics, 27; and mining and metallurgy, 25.

The report discusses these 267 departmental research projects as well as seven cooperative research and public service projects conducted by the Engineering Experiment Station itself. These include the high school research program to find and encourage gifted high school students, cooperative research with the UW dairy and food department on milk spray drying, solar energy research, cooperation on the Wisconsin space satellite, a program for nuclear engineering, the Network Calculator Laboratory, and the Electrical Standards and Instrumentation Laboratory.

The report also shows that UW engineering faculty members published a total of 40 papers on their research during the year, bringing the total publications of Wisconsin engineering staff members to 345; that one additional Experiment Station research report was published; that 77 students were granted their master's degrees and 24 their doctor's degrees in engineering; and that 29 students were granted graduate fellowships ranging in value from $1,500 to $3,000.

Dean Wendt pointed out that "it is difficult to single out particular projects for special mention from the many excellent studies underway" in engineering as shown by the report.

"I cannot refrain, however, from calling attention to the gratifying progress in our high school research program to find and encourage our gifted high school students, the timely work on the Wisconsin space satellite in cooperation with the meteorology department, the cooperative research with the dairy and food department on the spray drying of milk, and the nuclear engineering program.

"These all represent the fine teamwork between departments and colleges so essential in advancing research on a broad front," the UW engineering dean said. "With the increasing emphasis on scientific progress, we look forward with confidence and enthusiasm to the challenge of new problems and greater productivity in the years ahead."

WISCONSIN ENGINEERS RECEIVE GRANT OF $57,600

Under a grant of $57,600 from the National Science Foundation, three University of Wisconsin engineers are about to launch a continued study of the process by which liquid fuels mix with air and become combustible in the combustion chambers of motors and engines.

The three engineers who will make the study are Profs. Phillip S. Myers, Otto A. Uyehara, and M. M. El-Wakil, all of the UW College of Engineering's department of mechanical engineering.

In the study, liquid fuels under investigation will be sprayed, and their behavior under conditions simulating various types of combustion chambers will be photographed and the vaporization analyzed.

The photographic technique for studying fuel sprays, which will be used in the new study, was developed by the UW engineers under an earlier grant of $22,000 from the National Science Foundation.

Under the technique, fluorescent dyes mixed with the fuel droplets make them primary light sources under high intensity light. Photographs taken under these condi-

(Continued on page 71)

W.S.P.E.

(Continued from page 53)

THE PROFESSIONAL PILGRIMS PROGRESS

THE first of the "professional engineers," men who received the recognition their works deserved, was the master builder of ancient Egypt. A trusted advisor of the king, he had a full staff, thousands of willing (more or less) workers, and an opportunity to build in a really big fashion. He did not know very much, from our technological standpoint, but the pyramids at Giza, the Sphinx, and the long gone palaces he turned out certainly qualified him as an effective practitioner.

Engineers' professional reputations did not fare too well after the Egyptian master builder faded into the past, though. Generally the "engineering" field remained pretty narrow for centuries. Little knowledge was added to the engineers' stock in trade through the eras of the Greek *architectron* (though the Greek natural philosophers made significant progress toward understanding the scientific principles) and the Roman road- and aqueduct-builders. The field of engineering started and ended with construction; the ancient F.P.M. was the only "professional."

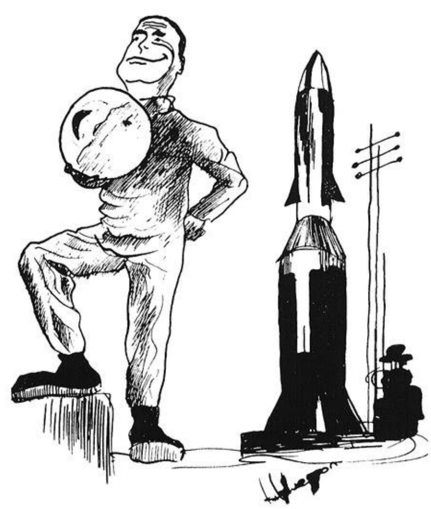
Matters did not improve for the growth of engineering until some several centuries after the fall of the Roman Empire. Through the Middle Ages and well into the 17th century, the "ingeniator" (a name picked up in the 11th century), was pretty much a builder, and largely a military one, at that. What other

phases of engineering were developing (surveying and metallurgy, in very basic form) were also fostered by military demands. The surveyors were mighty handy for figuring range and elevation for the new-fangled cannons, and metallurgists were hard at work improving the materials for making the big guns. The "engineers" of the day guarded their knowledge jealously . . . Leonardo's fabulous notebooks, for example, were strictly private records, unshared with any other technologist of his day.

Science—"pure" science—meanwhile, was moving ahead slowly but measurably. During the Renaissance, a wealth of basic information was developed and discovered. The engineers of the 17th and 18th centuries made their great strides in the application of this knowledge, and the age of technology was about to begin.

The first professional recognition of engineers in relatively modern times came, strangely enough, to the last of the "Ancient Engineers," the French builders of the 17th century. They were organized into a special army corps, and the first engineering school, the Ecôle des Ponts et Chausees (still training engineers for the French Army), was founded in 1716. Bridges, roads, cathedrals, and palaces, however, were still the main considerations of the engineers, and it remained for a remarkable "wedding" to begin the course of engineering as we know it today.

That wedding took place during the 18th century in England, when, for the first time on any scale, engineers began to apply science to the solution of industrial problems. The combination of engineering and industry was a revolutionary one. It spawned the Industrial Revolution, vast social and economic



changes (it's estimated that the average British worker's purchasing power multiplied nearly threefold during the 19th century), and the entire concept of modern engineering. The Age of Iron and Steam had begun, and British industry, under the guidance of the first modern engineers, was 'way out in front. All through the Victorian era, up to the turn of the 20th century, the accomplishments of the engineer kept Britain in the forefront of world progress.

This era of tremendous growth brought with it the kinds of engineering we know today. Around 1750, one John Smeaton announced that he was a "civil" (not necessarily courteous—just non-military) engineer, and by the early part of the next century, a group of ex-civils had decided that they were mechanical engineers.

Professional recognition was understandably slow in arriving. Most of the engineers who revitalized industry were millwrights who switched from making equipment to designing it; the early American engineers were largely just canal- and railroad-builders. As the contributions of the engineer to industrial success became more marked, his recognition as an important participant grew. But this didn't mean professional stature just yet, for the evolution from millwright to professional engineer depended on a

wide range of factors and accomplishments. It's difficult to say when the "professional" spirit entered the engineering scene. Nearly 1900 years ago, the Roman equivalent of Commissioner of Water Supply set down some rules . . . attention to detail, insistence on first-hand information, and honesty and incorruptibility as distinguishing marks of the professional.

The earliest period of professional growth was during the 19th century, which saw the establishment of the first professional societies, the Institution of Civil Engineers of Great Britain in 1818, and America's first, the American Society of Civil Engineers, in 1852. After technical associations covering most of the special engineering disciplines had been established, the National Society of Professional Engineers and Engineers Joint Council came into being in 1934 and 1941 respectively, to unite the profession laterally.

The biggest single step in terms of public recognition of the engineer and his role was the growth of the registration movement. Initiated in Wyoming in 1907, registration laws defining and governing the practice of engineering are in effect in every state, territory, and possession . . . more than half the members of the profession hold state licenses; the words "Registered Engineer" are a part of the country's professional life.

There's no doubt each of these steps contributed to professional recognition, but recognition isn't professionalism. That comes from the man himself—from the attitude and efforts of the engineer as a person—standing beside a rocket, donning a hard hat at a construction site, safe behind safety glasses in the plant, or leaning over a drafting board. If he's a real engineer, he's a professional . . . and if he's not professional, he's no engineer.

APPLICATIONS FOR MEMBER AND AFFILIATE MEMBER—FEBRUARY 14, 1959

Name and Position	Address	Reg. No.	Sponsor
MILWAUKEE			
John F. Murphy, P.E. Sales Engineer Allis-Chalmers Mfg. Co.	2713 E. Oklahoma Ave. Milwaukee 7, Wis.	E-6565	John Gammell, P.E.
George E. Sonntag, P.E. Design Engineer Vapor Blast Mfg. Co.	10555 W. Spenser Pl. Milwaukee 8, Wis.	E-5736	Reinstatement
David W. Stone, P.E. Design Engineer Harnischfeger Corp.	4400 W. National Ave. Milwaukee 46, Wis.	E-6739	W. J. Cherones, P.E.
Joseph M. Clemens Liaison Engineer Milwaukee Bridge Co.	5567 N. 103rd St. Milwaukee 18, Wis.	ET-1986	E. L. Liebert, P.E. J. R. Meyer, P.E.
NORTHWEST			
F. Joseph Palzkill Project Engineer Dist. 6, Wis. Hwy. Comm.	1731 Goff Ave. Eau Claire, Wis.	ET-2112	Louis Schmidt, P.E.
SOUTHWEST			
John O. Dahl, P.E. Owner John O. Dahl—Gen. Contractor	5408 Healy Lane Madison 4, Wis.	E-6454	Charles Ryan, P.E.
Total—Members 4 Affiliates 2			

Engine Ears

(*Continued from page 69*)

tions are sharp, and devoid of the defects of photographs obtained by other techniques.

The engineers point out that present-day designs of combustion chambers for liquid fuel engines such as ramjets and reciprocating engines have to a great extent been based on trial-and-error techniques.

Ever-increasing requirements for speed and power in propulsion have created a greater need for the development of a scientific basis for the design of these combustion chambers, in order that optimum efficiency in use of the fuel can be achieved. It is believed that basic studies of the injection, atomization, and vaporization of liquid fuels in air, such as the UW engineers will now be making, will eventually be of considerable value in combustion-chamber design.

After taking data at atmospheric conditions the necessary optical equipment will be constructed in order to adapt the photographic technique to other than atmospheric sprays. In this way it is hoped that a number of different fuels, including some of the new high energy fuels, can be studied under varying conditions.

Ultimate goal of the study, according to Prof. Myers, is formulation of an overall theory of the atomization and vaporization of liquid fuels in continuous flow heterogeneous combustion systems such as rockets, ramjets, and turbojets.

ULTRASONIC SEAM WELDER

An ultrasonic seam welder that can weld sheets of dissimilar metals continuously has recently been developed. This welder brings to seam welding the advantages of ultrasonic welding: making dissimilar metals weldable and eliminating the need for surface preparation prior to welding.

The new apparatus will weld dissimilar metals which are not now weldable by fusion processes.

THE END

What's Engineering?

(Continued from page 37)

plete lack of understanding of the situation. While it is true today that we depend more on group action and group thinking than was true a century ago, it is certainly no exaggeration when we say that the opportunities for creation and the opportunities for new developments are far greater today than just a few years ago. The more we discover the more we find yet to be discovered. The engineer of today is extremely fortunate in that he is able to build on such wide foundations. His duty is to learn what has gone before and start from there.

Mention should be made of compensating the engineering profession. While it would be disastrous for the young person to enter the engineering profession purely on the basis of the money it might afford, nevertheless, we must be practical and realize that everyone is interested in his rate of compensation. It may be positively stated that engineering today is a well paid profession. Just as should be the case, the salaries of engineers today are extremely variable, depending on their accomplishments and depending on their worth. As an average, the rate is good. For those who readily adapt themselves to this profession, the rate is excellent.

Any discussion of this type wouldn't be complete without mentioning the posibilities of women in engineering. While most engineers are men, there is no basic reason why a girl interested in mathematics, science, and creating things cannot become a successful professional engineer if she chooses. I have known of several women who are very successful professional engineers today.

Who is Engineering Material?

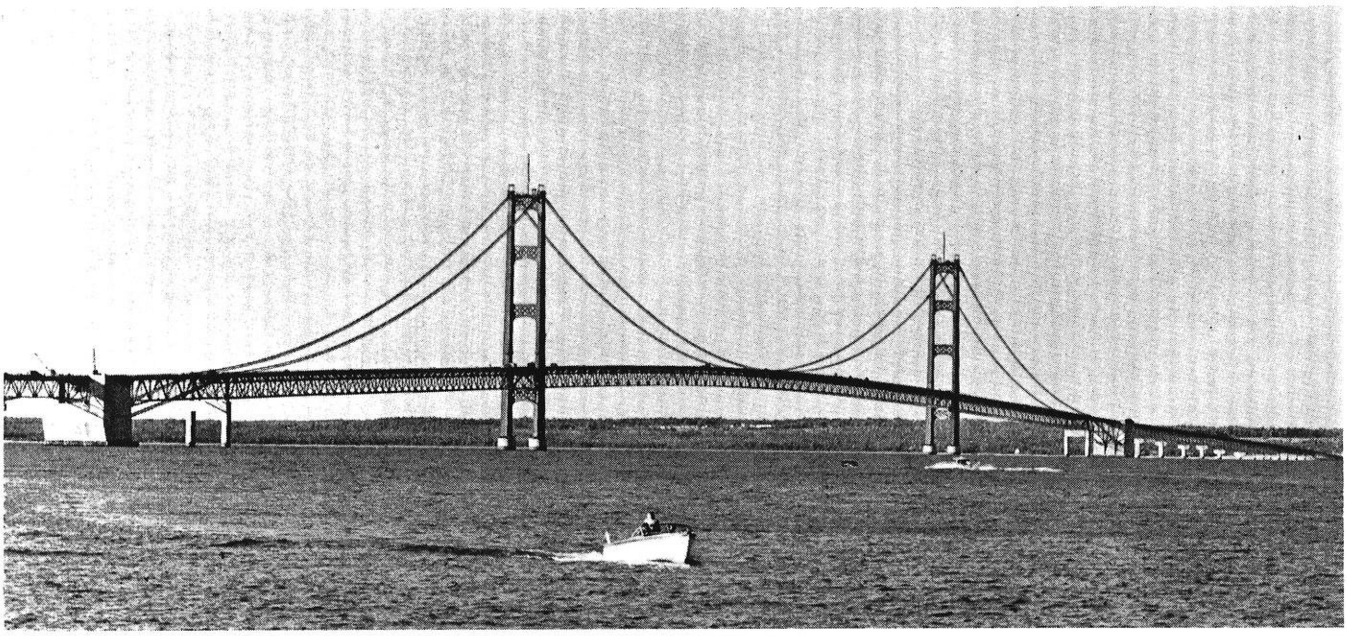
A question goes through the minds of each young man and woman who gives any consideration to engineering as to whether or not he is engineering material. The qualifications of an engineer are probably basically imagination, ingenuity, curiosity, and a general interest in the workings of natural laws. The first indication of engineering leanings is probably a liking of mathematics and science.

At this point the student might be asked: Do you have inquisitiveness? Do you care what happens when the automatic washer goes through its cycle? Are you interested in what happens when you dial the telephone? Do you care what happens when you step on the accelerator of a car? Are you at all interested in how a huge suspension bridge is designed? Does it interest you to know how sand is converted into glass? Do you care how iron is transformed into the high-temperature steels necessary in today's jet engines? Are you interested in what happens when black crude-oil is converted into high-octane gasoline? Are you at all concerned about how natural gas, or even coal, is transformed into nylon fabrics? Are you curious show the wings of a plane lift a hundred tons or more six miles up? Are you interested in how man can guide a missile thousands of miles and strike a target? If you do not care what happens in any of these cases, you are definitely not engineering material.

Civilization of this old world is traveling at a tremendous rate of speed. While we must not lose sight of the fact that the future of the world is probably most dependent upon our spiritual laws, our brotherly understanding of other people, it can certainly be said that next to that our future depends upon engineering and scientific developments. Does the engineering hopeful want to be a part of this? Would it thrill him to help create something that fits into this picture? Does he want to help utilize the materials of nature and does he want to help direct the efforts of man, or would he rather be directed?

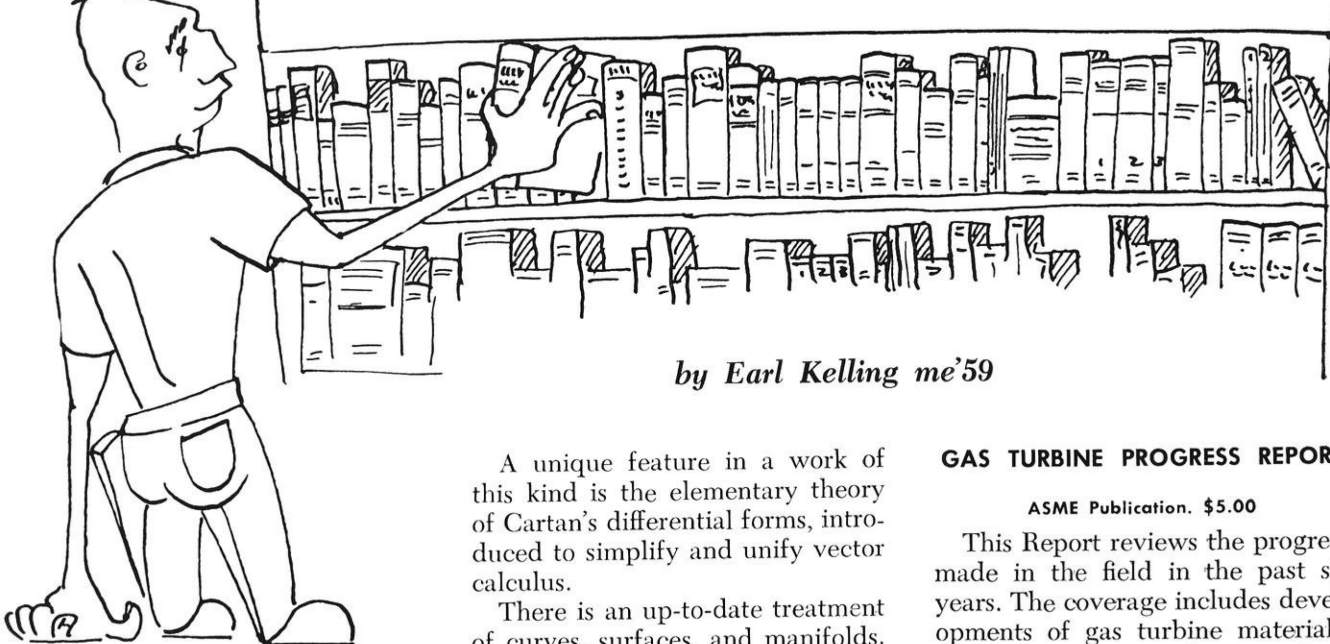
Only a serious analysis of some of these points should be of aid to the young man and woman of today to decide if he or she should become an engineer.

THE END



The Mackinac Bridge is one of the latest feats of engineering.

SNEED'S REVIEW



by Earl Kelling me'59

ADVANCED CALCULUS

By R. Creighton Buck
423 pages $8.50

The purpose of this text is to review elementary calculus with rigor, but without retracing already familiar ground; to give a systematic and modern approach to the differential and integral calculus of functions and transformations; to develop analytical techniques for attacking some of the typical problems which arise in applications of mathematics; and to introduce the student to modern points of view in mathematics.

Functions of one variable and of several variables are discussed simultaneously, and are unified by regarding both as functions of a point. This gives the student greater understanding of the scope and meaning of basic concepts and processes, and shows him the importance of the essence of a theory, rather than the particular form it may assume.

To emphasize the distinction between integration and anti-differentiation, the author discusses the double integral in detail before taking up the fundamental theorem of calculus.

An effective balance is maintained between theory and applications.

A unique feature in a work of this kind is the elementary theory of Cartan's differential forms, introduced to simplify and unify vector calculus.

There is an up-to-date treatment of curves, surfaces, and manifolds.

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"Reynolds Aluminum for Heat Exchangers" summarizes, in 16 page of charts and pictures, technical information needed by the heating engineer, fabricator, and industrial purchaser.

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ASME Publication. $5.00

This Report reviews the progress made in the field in the past six years. The coverage includes developments of gas turbine materials, the advances in turbine cooling, fuels and the technical problems associated with them, cycle components and the trend toward simplicity in their arrangement, the compound piston-and-turbine engines, aviation gas turbine developments, rocket turbines, gas turbine in the automotive field, gas turbine locomotive advances, the gas turbine and the free-piston gas turbine in the marine field, industrial and central station applications of the gas turbine, and the nuclear gas turbine plant and areas of development.

DIAPHRAGM CHARACTERISTICS, DESIGN AND TERMINOLOGY

ASME Publication. $3.75

This Manual gives a clear understanding of diaphragm characteristics and limitations. Specifically it defines a diaphragm and its performance characteristics, describes methods of measuring and representing them, shows how they are related and used, describes and illustrates the effects of design details and manufacturing methods on the characteristics. Appendixes define the terms and notations used, describe the equipment and methods of testing, classify the applications of the diaphragms, and give the various equations.

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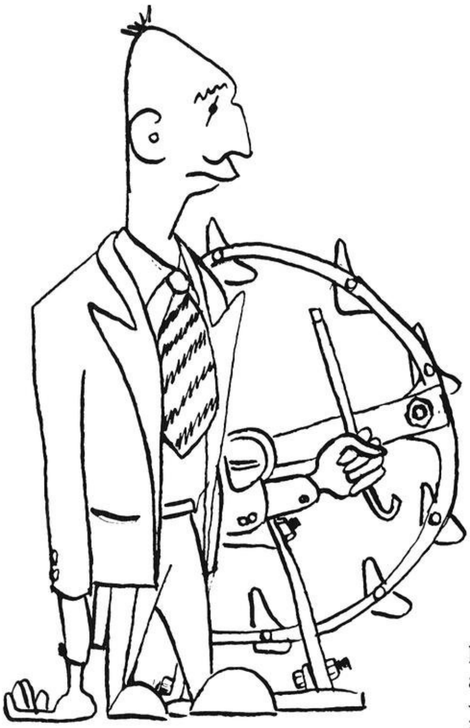


THE FERROUS WHEEL

by Bill Timmler

A first grade teacher fresh from college was taking over a class for the first time. Upon entering the classroom she noticed a nasty word on the black board followed by the signature: "The Phantom." So she said, "Now children, let's fold our little hands, put them on our little desks, and put our heads down onto the desks. Then the person who wrote this word on the blackboard can come up and erase it."

So they all folded their hands, put them on the little desks and put their little heads down on the desks. All was quiet for a while, then there was a thump, thump, thump of little feet, a pause, and the thump, thump, thump of little feet scurrying back to a desk.

After everything was quiet again, the teacher said, "Now let's see if the bad word is thoroughly erased." So they looked up at the blackboard to see a new, nastier word, followed by: "The Phantom Strikes Again!"

* * *

Jones was sitting down to breakfast one morning when he was astounded to see an announcement of his death in the newspaper.

He rushed to the phone at once to call up his boss.

"Hello!" he shouted. "Did you see the announcement of my death in the newspaper?"

"Yes," said the boss, "where are you calling from?"

"Darling, your eyes are like deep pools of sparkling water; your lips are like two little red rosebuds; your teeth are like the finest pearls; but you have the damnedest looking nose I have ever seen on anything but an African Anteater."

* * *

Doctor: "I've examined you thoroughly, but I can't seem to find the cause of your trouble. However, it's probably due to drinking."

Engine Student: "Oh, that's okay Doc. I'll come back sometime when you're sober."

* * *

The world is so full of a number of things that it's hard to keep up payments on them.

* * *

A lady bought a parrot from a pet store only to learn that it cursed everytime it said anything. She put up with it as long as she could, but finally one day she lost patience. "If I ever hear you curse again," she declared, "I'll wring your neck."

A few minutes later she remarked rather casually that it was a nice day. Whereupon the parrot promptly said, "It's a hell of a fine day."

The lady immediately seized the parrot by his head and spun him around in the air until he was almost dead.

"Now then," she said, "It's a fine day today isn't it."

"Fine day!" exclaimed the parrot. "Where in hell were you when the cyclone struck?"

"Everybody all set back there?" called the bus driver.

"Wait just a minute," a girl's voice said, "until I get my clothes off."

Every head in the bus snapped around—to see a girl step off the bus carrying two packages of laundry.

* * *

A burly fellow left a note pinned to his expensive hat in a restaurant while he made a telephone call: "This hat belongs to a champion fighter, and I'm coming back."

When he returned the hat had gone. In its place was another note: "The hat was taken by a champion runner—and I'm not coming back."

* * *

"Jackson and Williams had a terrible row at the tavern last night," said Wilson.

His companion looked surprised. "That's strange," he said. "I thought those two were inseparable."

"They were," said Wilson. "It took six of us to drag them apart."

* * *

"Well, Jenkins, glad to see you. How's life been treating you?"

"Hah! It hasn't treated me at all. I'm working for a living."

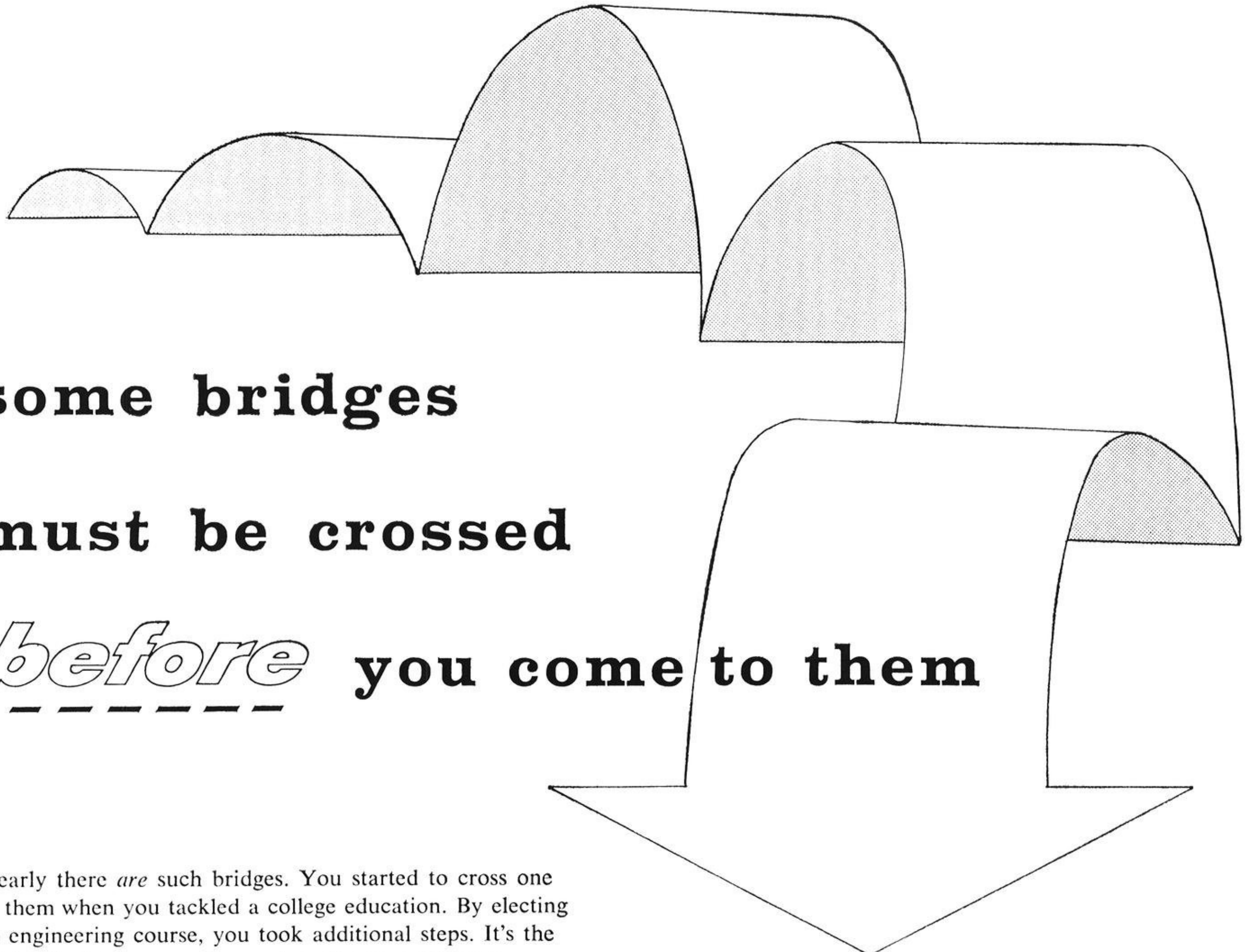
* * *

To find fault is easy; to do better may be difficult.—Plutarch.

* * *

An aged woman had been given a birthday party each year at which she received knick-knacks for her house. When she reached 90, a friend asked her what she wanted.

"Just give me a kiss, so I won't have to dust it off," she replied.



some bridges must be crossed *before* you come to them

Clearly there *are* such bridges. You started to cross one of them when you tackled a college education. By electing an engineering course, you took additional steps. It's the bridge that takes you from education to profession.

Perhaps several companies on the "profession side" will beckon to you. Naturally, you'll try to choose the firmest and highest ground accessible to a beginner—ground that leads to more challenge, more responsibility and greater reward. Companies situated on the firmest and highest ground will be those whose products or services enjoy a lively and continuing demand.

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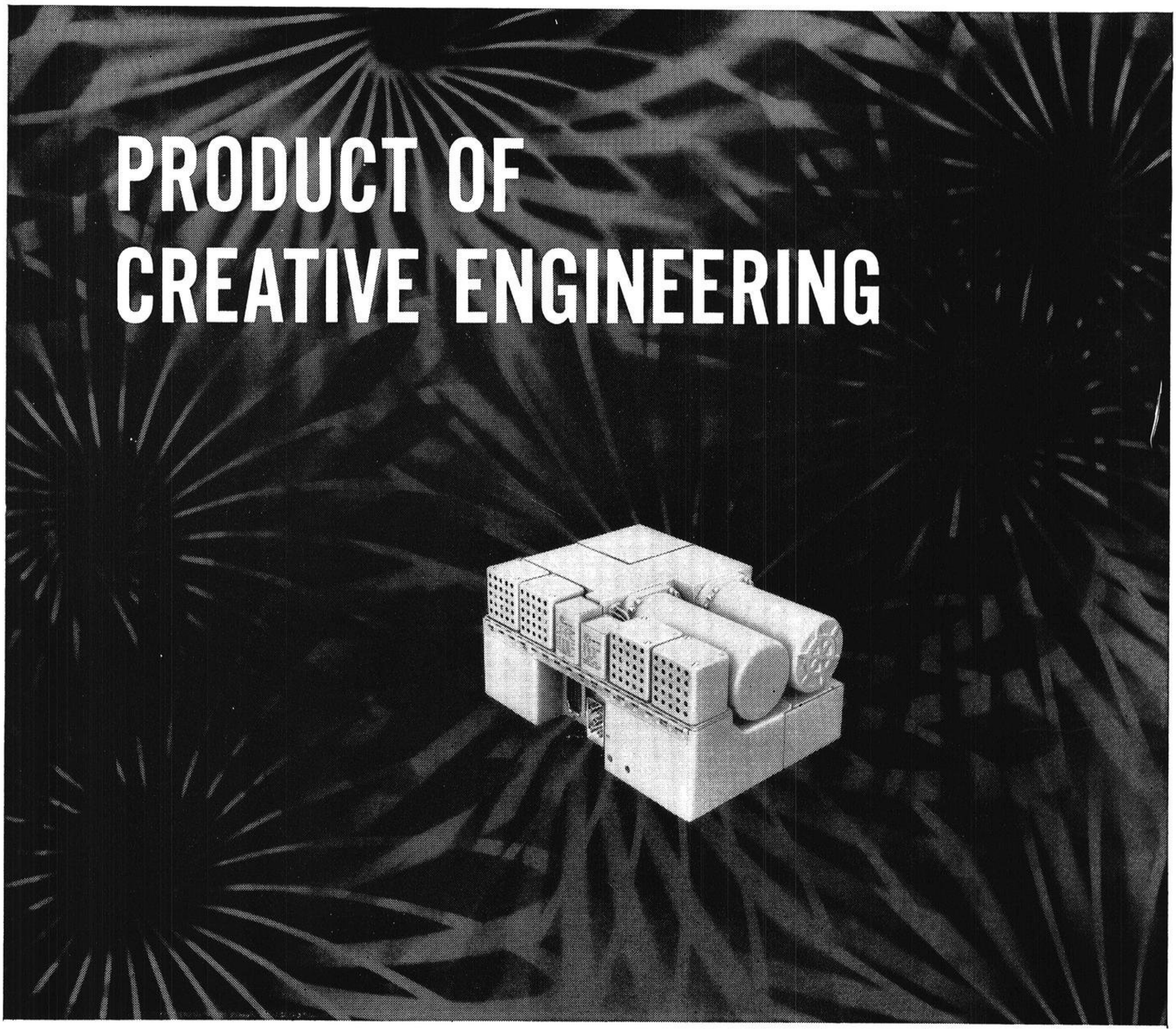

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So You Think You're SMART!

by Sneedly bs'60

NOW that the Engineering Exposition has so gloriously passed Sneedly (speaking from experience) is sure that the thoughts of a true Engineer are turning to spring and all that comes with it.

It looks as if it is finally going to warm up and Sneedly has noticed many an engineer sailing on Lake Mendota with the tiller in one hand and the calculus in the other. So, for those of you who would like to go sailing, but who cannot quite afford it here is a tip: be the first one to send in this month's correct solution and win $10. For that, you could sail from now until school lets out and really enjoy life. Those who don't like to sail are also invited to try the problems.

However, before I let you tackle this month's problems, I would like to congratulate Bob Stephens, ChE 1, for winning in February.

Here are this month's teasers:

1. A suit of thirteen cards, the ace, king, queen, jack, 10 . . . 2 of spades, is arranged in a certain order. The first card is taken off the pack, the second is put at the bottom, the third is taken off, the fourth is put at the bottom, and so on.

What was the original order if the order in which the cards were taken off was ace, king, queen, jack, 10 . . . 2?

* * *

2. Hanging over a pulley, there is a rope with a weight on one end; at the other end, hangs a monkey of equal weight. The rope weighs four ounces per foot. The combined ages of the monkey and its mother are four years and the monkey's weight is as many pounds as its mother is years old. The mother is twice the age the monkey was when the mother was half as old as the monkey will be when the monkey is three times as old as the monkey was.

The weight of the rope is one half as much again as the difference between the weight of the weight plus the weight of the monkey. How long is the rope?

* * *

3. A paramecium divides once a day so that on four successive days from the start there are 1, 2, 4, 8 paramecia. If it takes thirty days for a single paramecium to cover a culture dish in this manner, how long would it take for three paramecia to cover the dish?

The answers to last month's problems are:

1. The blind date was 73 years old.

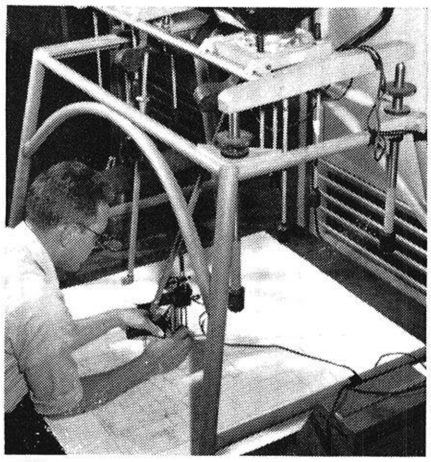
2. 9567
   1085
   ———
   10652 was the amount of money he had asked for.

3. The camper reached a point 3 2/3 miles upstream from his camp. He first met the bottle 2 miles away, the distance he could travel in 48 minutes at the net rate of 2 1/2 mph. The bottle then floated 2 miles at the rate of the stream taking 80 minutes to reach the camp. In this time, the canoer with respect to the water went upstream some distance and then returned to his starting point. The distances and times must be equal. The total time being 80 minutes, the upstream time occupied 40 minutes. With respect to the banks of the stream the canoer still proceded at the net rate of 2 1/2 mph and therefore traveled an additional 1 2/3 miles away from camp.

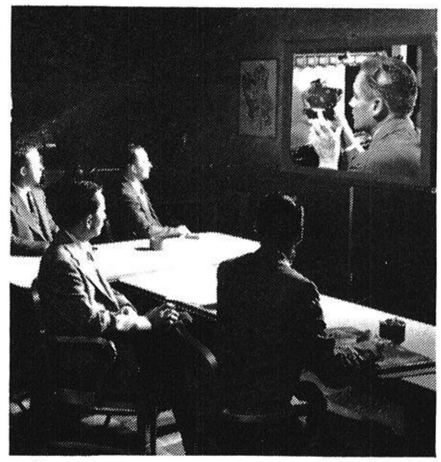
* * *

Send your solutions to:
SNEEDLY
c/o The Wisconsin Engineer
Mechanical Engineering Bldg.
Madison, Wisconsin

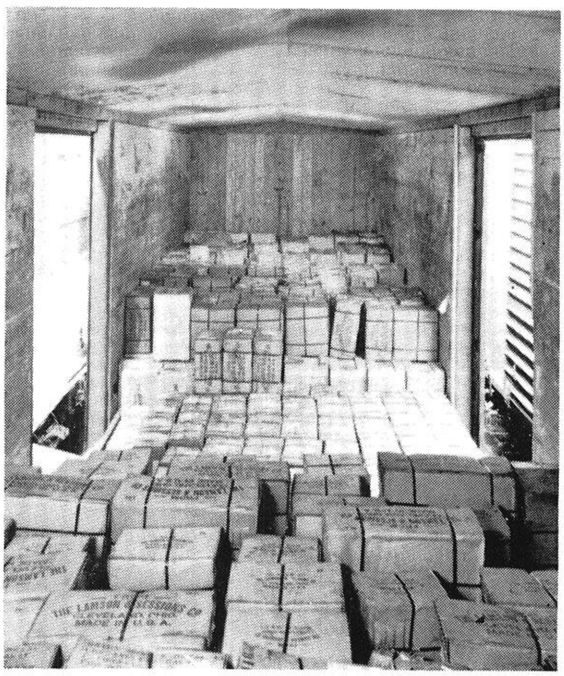
1 By setting templates of standard components on photo-sensitive paper and exposing it, hours of hand drafting are saved.



2 With this plotter, stereo aerial photos become contour maps, show highway routes, mineral-bearing formations, volume of coal piles.



3 Slides give the sales staff quick understanding of the engineering superiority of their product—equip them with facts for their customers.



4 Photographs of freight cars as loaded and as received provide information for engineers to develop better loading practices (as well as data for damage claims).

From drawing board to shipping platform...

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One of a series

Interview with General Electric's Hubert W. Gouldthorpe Manager—Engineering Personnel

Your Salary

Although many surveys show that salary is not the prime factor contributing to job satisfaction, it is of great importance to students weighing career opportunities. Here, Mr. Gouldthorpe answers some questions frequently asked by college engineering students.

Q. Mr. Gouldthorpe, how do you determine the starting salaries you offer graduating engineers?

A. Well, we try to evaluate the man's potential worth to General Electric. This depends on his qualifications and our need for those qualifications.

Q. How do you evaluate this potential?

A. We do it on the basis of demonstrated scholarship and extra-curricular performance, work experience, and personal qualities as appraised by interviewers, faculty, and other references.

Of course, we're not the only company looking for highly qualified men. We're alert to competition and pay competitive salaries to get the promising engineers we need.

Q. When could I expect my first raise at General Electric?

A. Our primary training programs for engineers, the Engineering Program, Manufacturing Program, and Technical Marketing Program, generally grant raises after you've been with the Company about a year.

Q. Is it an automatic raise?

A. It's automatic only in the sense that your salary is reviewed at that time. Its amount, however, is not the same for everyone. This depends first and foremost on how well you have performed your assignments, but pay changes do reflect trends in over-all salary structure brought on by changes in the cost of living or other factors.

Q. How much is your benefit program worth, as an addition to salary?

A. A great deal. Company benefits can be a surprisingly large part of employee compensation. We figure our total benefit program can be worth as much as 1/6 of your salary, depending on the extent to which you participate in the many programs available at G.E.

Q. Participation in the programs, then, is voluntary?

A. Oh, yes. The medical and life insurance plan, pension plan, and savings and stock bonus plan are all operated on a mutual contribution basis, and you're not obligated to join any of them. But they are such good values that most of our people do participate. They're an excellent way to save and provide personal and family protection.

Q. After you've been with a company like G.E. for a few years, who decides when a raise is given and how much it will be? How high up does this decision have to go?

A. We review professional salaries at least once a year. Under our philosophy of delegating such responsibilities, the decision regarding your raise will be made by one man—the man you report to; subject to the approval of only one other man—his manager.

Q. At present, what salaries do engineers with ten years' experience make?

A. According to a 1956 Survey of the Engineers Joint Council*, engineers with 10 years in the electrical machinery manufacturing industry were earning a median salary of $8100, with salaries ranging up to and beyond $15,000. At General Electric more than two thirds of our 10-year, technical college graduates are earning above this industry median. This is because we provide opportunity for the competent man to develop rapidly toward the bigger job that fits his interests and makes full use of his capabilities. As a natural consequence, more men have reached the higher salaried positions faster, and they are there because of the high value of their contribution.

I hope this answers the question you asked, but I want to emphasize again that the salary *you* will be earning depends on the value of *your* contribution. The effect of such considerations as years of service, industry median salaries, etc., will be insignificant by comparison. It is most important for you to pick a job that will *let* you make the most of your capabilities.

Q. Do you have one salary plan for professional people in engineering and a different one for those in managerial work?

A. No, we don't make such a distinction between these two important kinds of work. We have an integrated salary structure which covers both kinds of jobs, all the way up to the President's. It assures pay in accordance with actual individual contribution, whichever avenue a man may choose to follow.

*** We have a limited number of copies of the Engineers Joint Council report entitled "Professional Income of Engineers—1956." If you would like a copy, write to Engineering Personnel, Bldg. 36, 5th Floor, General Electric Company, Schenectady 5, N. Y.** 959-7

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