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THE WISCONSIN ENGINEER

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MAY, 1966
l. 70, No. 8
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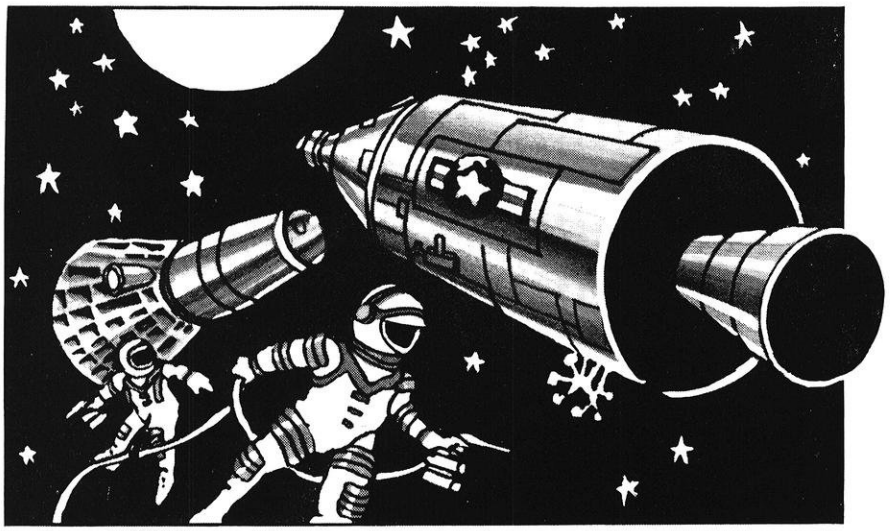
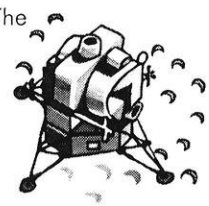
THE GLASS-BARRELED SHOTGUN _____ page 8

Here are 7 knotty problems facing the Air Force: can you help us solve one?



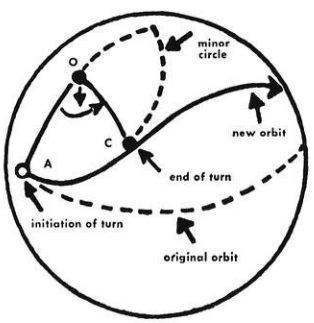
1. Repairs in space. If something goes wrong with a vehicle in orbit, how can it be fixed? Answers must be found, if large-scale space operations are to become a reality. For this and other assignments Air Force scientists and engineers will be called on to answer in the next few years, we need the best brains available.

2. Lunar landing. The exact composition of the lunar surface, as well as structural and propulsion characteristics of the space vehicle, enter into this problem. Important study remains to be done—and, as an Air Force officer, you could be the one to do it!



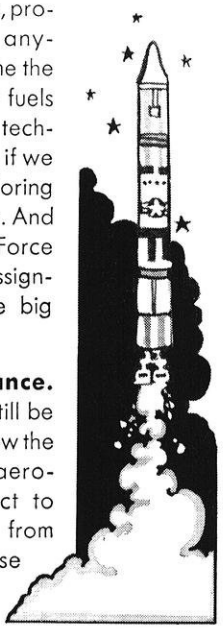
3. Life-support biology. The filling of metabolic needs over very extended periods of time in space is one of the most fascinating subjects that Air Force scientists are investigating. The results promise to have vital ramifications for our life on earth, as well as in outer space.

4. Space orientation. The orbital problems of a spacecraft, including its ability to maneuver over selected points on the earth, are of vital importance to the military utilization of space. There are plenty of assignments for young Air Force physicists in this area.



5. Synergetic plane changing. The ability of a spacecraft to change altitude can also be crucial to space operations. Where but in the Air Force could Sc.B.'s get the chance to work on such fascinating projects right at the start of their careers?

6. Space propulsion. As our space flights cover greater and greater distances, propulsion—more than anything else—will become the limiting factor. New fuels and new propulsion techniques must be found, if we are to keep on exploring the mysteries of space. And it may well be an Air Force scientist on his first assignment who makes the big breakthrough!



7. Pilot performance. Important tests must still be made to determine how the pilots of manned aerospacecraft will react to long periods away from the earth. Of course not every new Air Force officer becomes involved in research and development right away. But where the most exciting advances are taking place, young Air Force scientists, administrators, pilots, and engineers are on the scene.

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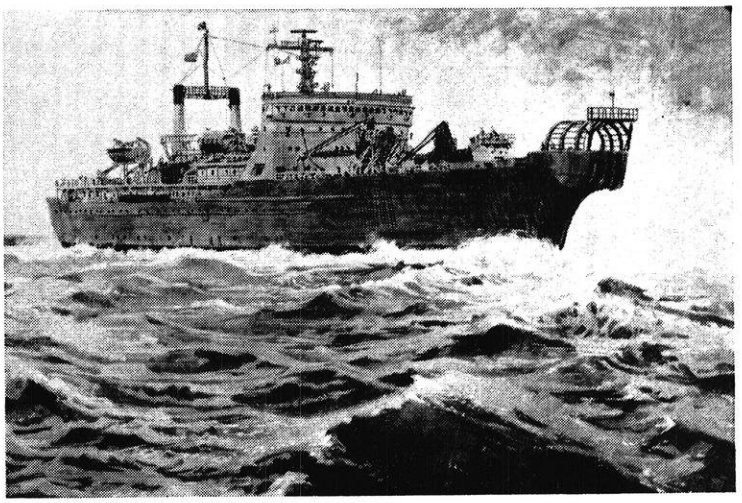

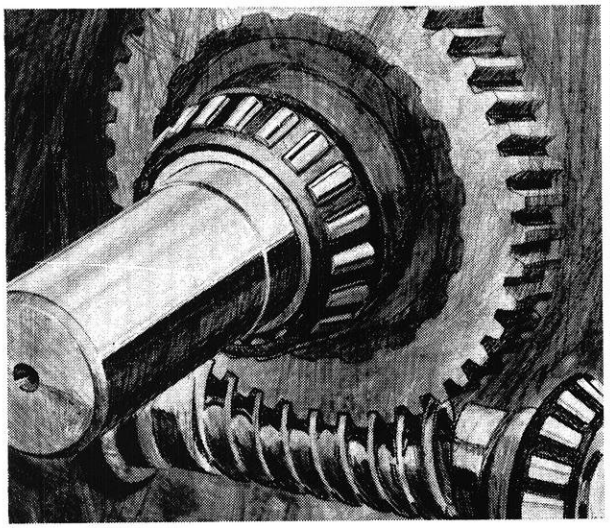

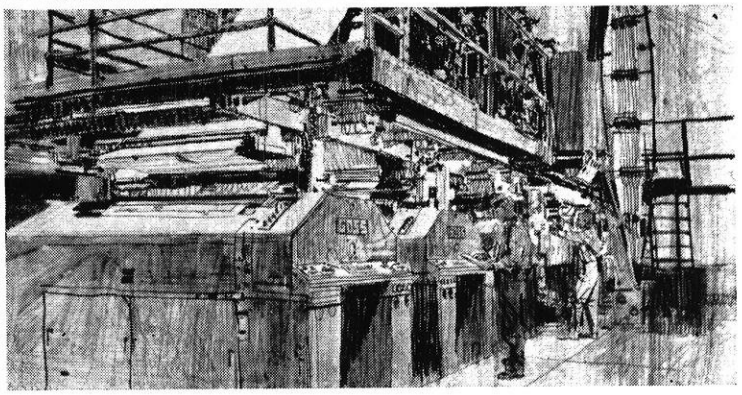

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It's a propitious moment, perhaps, to consider a Boeing career. For further information about career opportunities, write directly to: Mr. T. J. Johnston, The Boeing Company, P.O. Box 3707, Seattle, Washington 98124. Boeing is an equal opportunity employer.

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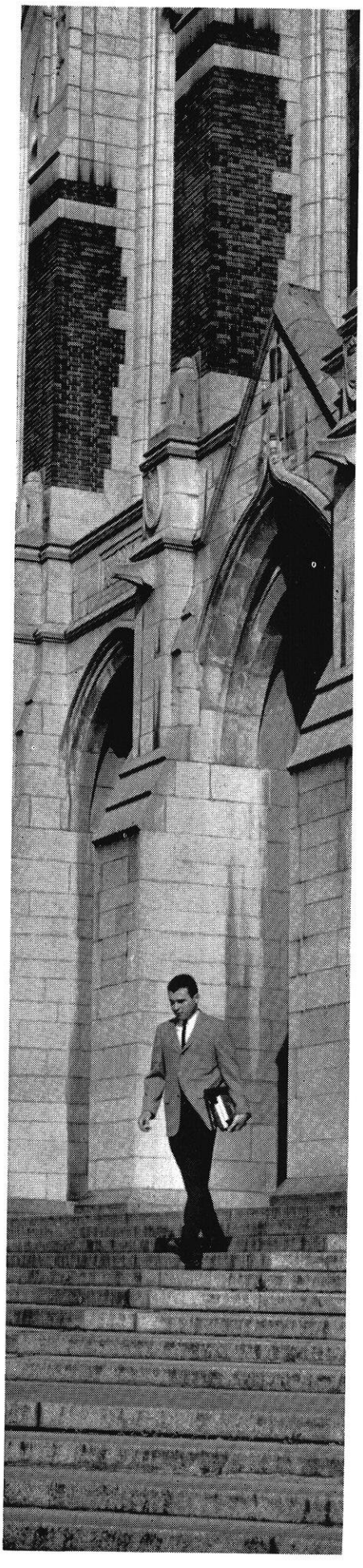
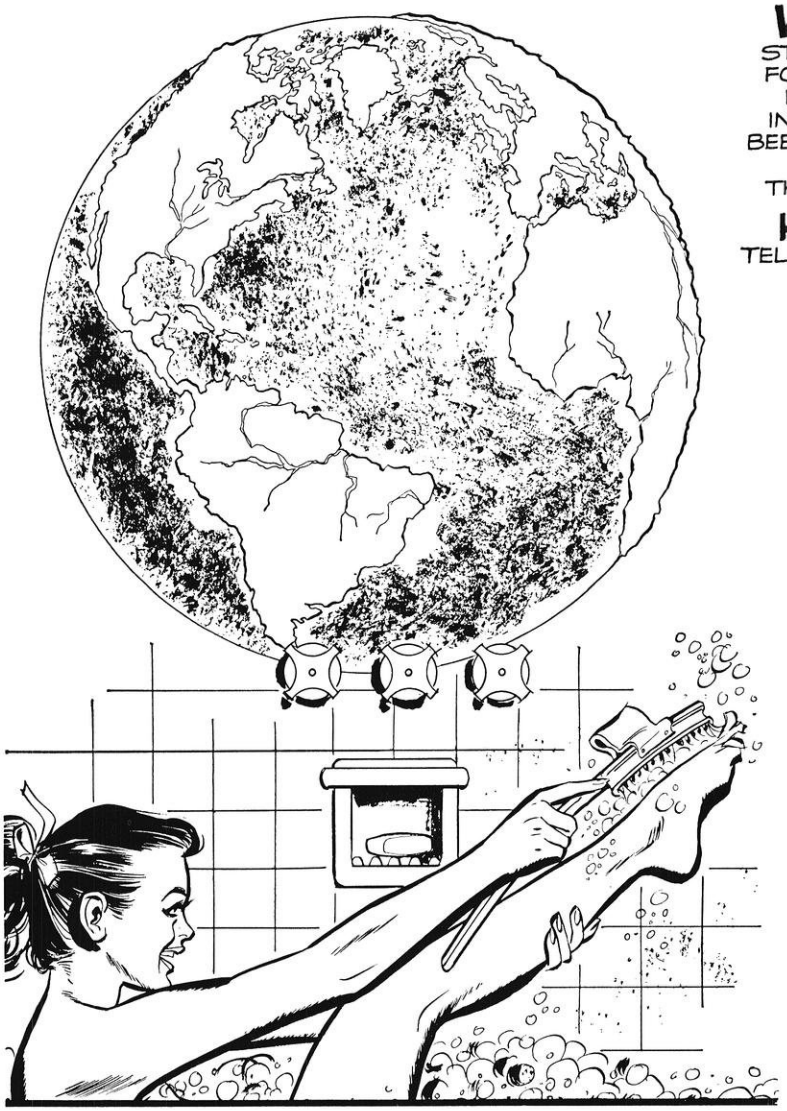


Water never wears out



WATER USED IN ANCIENT GREECE IS STILL IN USE TODAY. WATER DRAWN FOR OUR BATH MAY HAVE BEEN USED PREVIOUSLY BY EARLY AMERICAN INDIANS.....OR IT RECENTLY MAY HAVE BEEN DISCHARGED DOWN OUR NEIGHBOR'S DRAIN. NOT A VERY PLEASANT THOUGHT, BUT TRUE, NONETHELESS.

HOW DO WE KNOW THIS? SCIENCE TELLS US THAT WATER NEVER WEARS OUT. IT JUST BECOMES CONTAMINATED.

A strange paradox. Three-fourths of the earth's surface is covered with water. Yet only a small percentage of this is suitable for human use. And each day, that percentage becomes smaller because of pollution. Who is responsible?

All of us. We all use water. Industry demands are fantastic. 1400 gallons to produce a dollar's worth of steel...nearly 200 gallons for a dollar's worth of paper...500 gallons to manufacture a yard of wool...320 gallons to make a ton of aluminum... 600,000 for a ton of synthetic rubber.

People use water in homes. Tremendous quantities. Estimates of total usage vary. But it's safe to say that when our population reaches 260 million in 1980, our supply of fresh, usable water will be alarmingly short of even our most basic needs.

All of this water...from homes, business and industry...eventually is discharged into a river, lake or stream. A disgracefully large percentage of it is raw sewage...the cause of water pollution. Untreated sewage is not only destroying our supply of fresh water for human use, it also is killing our wildlife and robbing us of badly needed recreational facilities. In short, untreated sewage is rapidly destroying a priceless natural resource.

What can be done about it? First, we must realize that water must be treated so that it can be used ...re-used...and re-used again. The only logical way to do this is to construct modern and adequate sanitary sewers and treatment plants. Much has been done by federal, state and local government agencies. But the task of cleaning up our nation's rivers and lakes is far from finished.

Our water pollution problem will be checked and in time solved only if all of us insist on adequate treatment of waste water through modern sanitary sewerage facilities. This is the responsibility of every citizen.

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The Student Engineer's Magazine Founded in 1896

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A Dedication

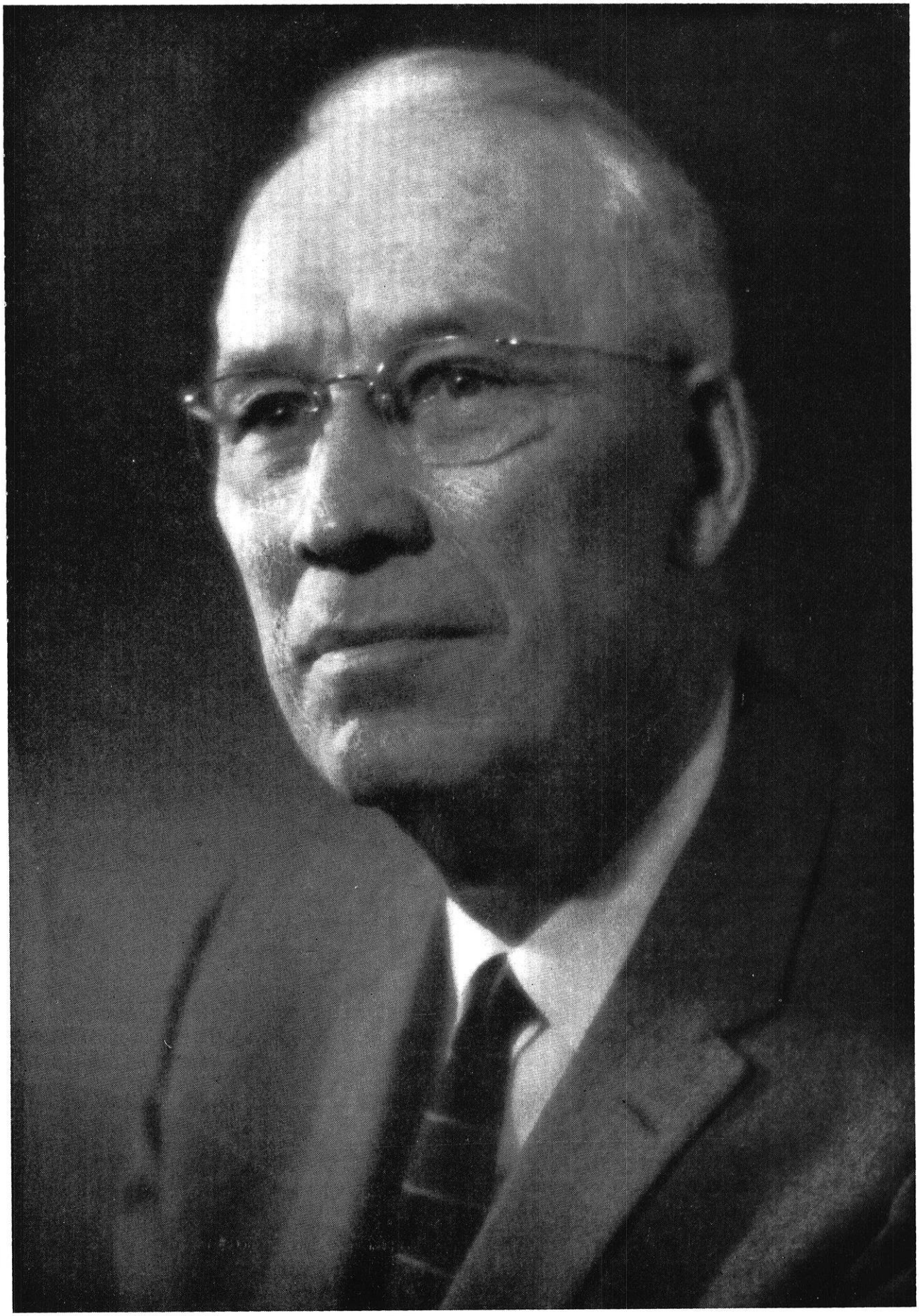
There will be many people leaving campus this year to go their respective ways, but few will be missed as much as Professor Kenneth G. Shiels, Assistant Dean of the College of Engineering, University of Wisconsin.

For forty-six years, Dean Shiels has been with our University. He has carried many responsibilities, both as a teacher and as a dean: instructing engineering drafting classes, chairing the department of engineering graphics, running freshman lectures, and directing the registration, advising, and counseling of freshman engineering students. He is co-author of a volume, "Descriptive Geometry", and author of "Problems in Descriptive Geometry". He was in charge of engineering summer sessions, chairman of the college's Class Schedule Committee and the Fellowship and Scholarship Committee, and is president of the Wisconsin Chapter of Phi Kappa Phi.

We would note though, that a man's jobs and honors are only a partial measure of the man. Dean Shiels will be remembered most of all as a quiet, warm, and friendly person whose work and life are as precise and efficient as his engineering discipline can make them. He always took the time to listen and to think over both sides of any issue before he spoke. And he always, though soft-spoken, let you know that he meant exactly what he said. His honesty and integrity have made him one of the most respected men on campus.

Thank you, Professor Kenneth G. Shiels, for a job well done and for being yourself. We of the "Wisconsin Engineer" dedicate this issue to you.

—Mary E. Ingeman



—Harold Hone Portrait

THE GLASS-BARRELED SHOTGUN

By DONALD P. WILLIAMS

BEGIN with 500 miles of thin glass fibers. Wind the fibers on a 0.020 inch thick steel tube. Add epoxy resin, cure in an oven and grind to finish.

RESULT: A shotgun barrel; rust proof, greater burst strength than steel, stays cool in operation, light weight and won't cause frost bite in cold weather.

Periodically, various materials, processes, and fabrication techniques come upon the scene as new achievements, but in reality they have existed for several years. Filament winding was known and used for 15 years, but until 1960 its full value and potential was not known.

The purpose of this report is to give a brief history of filament winding and its specific application to the production of a shotgun barrel. Also included is a summary of the materials and several winding procedures used in filament-wound structures. In concluding the report, some of the technical advantages, and present and estimated future uses are given.

History of Firearms

The history of man's advancement in the technological arts can be seen in the history of firearms and barrels. This advancement has now resulted in a filament-wound gun-barrel.

In the 14th century firearms became commonly used. However, the art of metallurgy was in its infancy. Thus, firearms had to be made with thick walls because the quality of metals was poor and the burst strength was very low.

During the second half of the 15th century, metallurgy improved and the production of hand guns was started. The barrel of the gun was formed by hammering and heat-welding flat strips of wrought iron. Then in the Machine Age it became possible to make the barrel by drilling or boring solid stock.

About 1840, the Whitney Arms Company was the first to use steel in gun barrels. However, since the quality of the steel was poor, the barrels were still quite massive. Late in the 1890's Winchester started using nickel-alloy steels and the design has not changed much up to the present time.

Thus, over a period of about 300 years, a gradual improvement in materials has allowed firearms to become less massive and easier to handle and carry. Now, through technological advancement, we are able to make gun-barrels out of glass fibers.

Materials Used In Filament Winding

The materials used in filament winding fall basically into two categories: the reinforcing material and the resin system. Within each of these categories there are many materials which can be used. The choice of materials depends on the properties required in the end product.

The choice of glass reinforcement depends on four factors: tensile strength, modulus of elasticity, wet-strength retention, and fatigue properties. It would be desirable to have a material which would combine the best of these properties. Since this is impossible, the material choice is based on the most critical properties of the end product.

The glass fiber is one of the strongest materials now available for mass production. Thus it provides the most efficient filament structure. Rated second are the oriented asbestos or organic fibers. Organic fibers are inferior to glass because they have a low elastic modulus. Asbestos fibers have not been extensively evaluated for filament-wound structures.

The choice of an epoxy-resin system usually depends on the strength considerations. The epoxy system results in the highest strength since it creates the strongest bond between the filaments. There are a great number of epoxy systems; numerous combinations result since each system is composed of an epoxy and a resin.

Resin is defined as a solid or semi-solid material of natural or synthetic origin, and of organic or inorganic nature. It usually is amorphous and has no definite melting point. The binding material (resin) envelops and holds the reinforcement in place.

A minimum amount of resin is applied to develop maximum strength properties. The amount depends on the space between the fibers and the thickness of the separating film which is usually about 0.0001 inch.

Polyesters comprise a large percentage of the total reinforced plastics because they are economical. Other resins in use are silicones, phenolics, melamines, and epoxies. Heavy emphasis has been placed on epoxies for filament-wound structures. About 10 years ago, polyesters accounted for about 85 per cent of all resins used in filament winding. Now, however, 90 per cent of the resin used in filament winding is epoxy. Probably the main reason for this reversal is that polyesters are more brittle and they provide a lower strength bond than do the epoxies.

Winding Procedures

Many fabrication methods are used in filament winding. Four basic methods of winding will be discussed here. The properties given are for glass reinforced structures although any filament material may be used.

The first type of winding is the single circuit circular hoop winding. This type of winding is illustrated in Fig. 1.

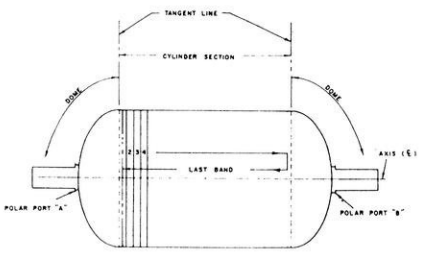


Figure 1.—Single Circuit Circular Winding

Bands 1, 2, 3 and 4 are shown lying adjacent to each other. A complete circuit is two layers of fibers, one layer of windings down the mandrel and one layer back to the starting point. This structure is extremely strong in hoop loading but only as strong as the resin bond in end loading.

The multiple circuit helical windings are shown in Fig. 2. This particular figure shows a 10-circuit pattern. The mandrel is indexed 1/10 the circumference of the mandrel plus 1/10 the band width. The indexing angle of the mandrel depends on the number of circuits used in the pattern. This structure can be designed for the optimum utilization of the strength of the filaments with no circular windings needed for hoop strength.

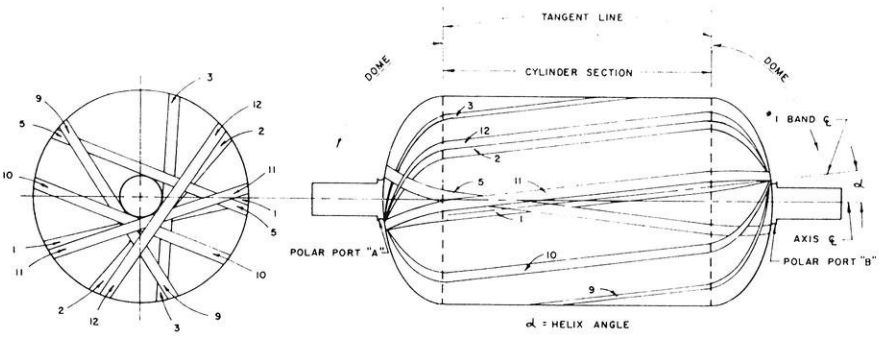


Figure 2.—Multiple Circuit Helical Windings

Dual helical winding is used when the part diameters of each end are different (Fig. 3). This system has different helix angles for each end so that a stable winding pattern can be kept at each end. The main problem with this winding is that the programming of the machine can be quite complex—therefore it is not economical to use unless many units are to be produced.

For winding odd shapes such as parabolas or cones, variable helical winding is used. Fig. 4 shows two units back to back being wound at the same time. The helix angle at the largest diameter will be smaller than the helix angle at the smaller diameter in order to have a stable band during the winding operation. Because of the low helix angle at the maximum diameter, the hoop strength will be low at this point. To strengthen the structure it is necessary to use helical windings of high angles, similar to circular windings.

or standards exist at this time so the physical properties depend much on the techniques and methods used in manufacture.

Table 1 summarizes the physical properties of filament-wound structures. The composition in these structures ranges from 65 per cent glass, 35 per cent resin to 70 per cent glass, 30 per cent resin.

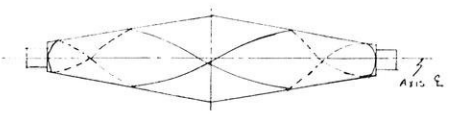


Figure 4.—Variable Helical Winding

Two of the most significant properties are the tensile strength and weight. For a comparable structure dimensionally, the filament-wound structure will have one-fourth the weight of steel and three-fourths the weight of aluminum. The tensile strength is about three times that of steel and one and one-half that for aluminum.

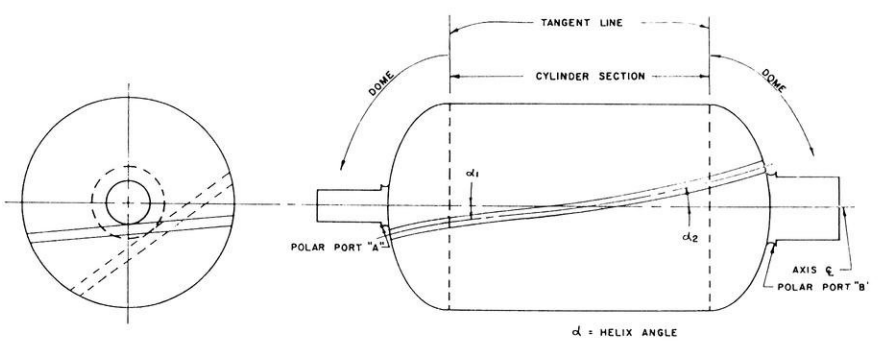


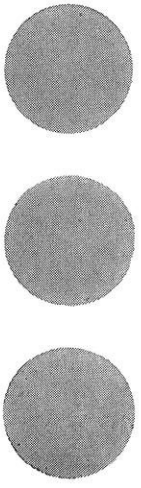
Figure 3.—Dual Helical Winding

Physical Properties of Filament-Wound Structures

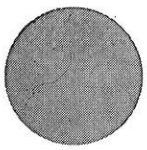
In examining the physical properties of filament-wound glass-fiber structures, some interesting engineering criteria is seen. No codes

For aircraft and missle applications the strength-to-weight ratio is important. As can be seen in Table 1, the filament-wound structures are much better than any other type of structure. *(To page 12)*

LATE NEWS for 1966 ENGINEERING GRADUATES



Expanding military and commercial business has created even more openings.



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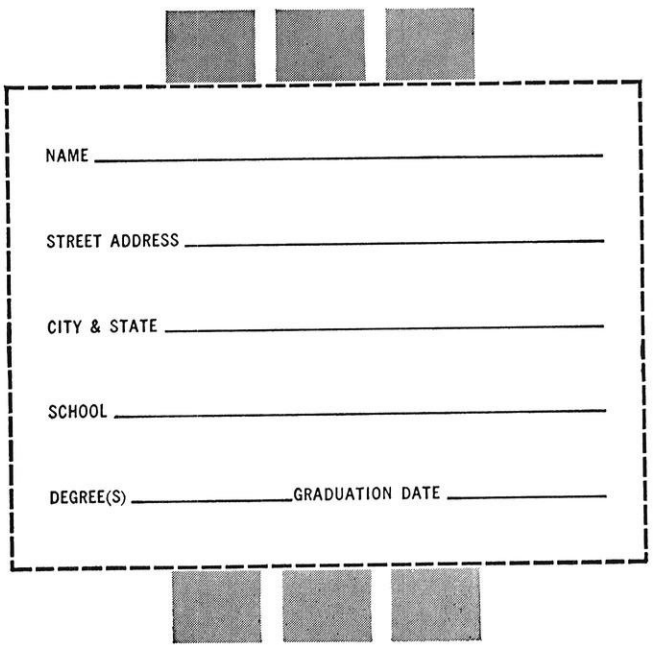

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Table 1.—Physical Properties of Filament-Wound Structures

Properties	Filament-Wound Structures	Plain Carbon Steel	Heat-Treated Alloy Steel	Aluminum
Density—lb./in.	0.072	0.283	0.283	0.097
Tensile strength, psi (ultimate)	130,000	40,000	240,000	80,000
Strength-to-weight ratio	1,808,000	138,000	828,000	825,000
Thermal coef. of expansion, in/in/F	$5\text{–}6 \times 10^{-6}$	6×10^{-6}	6×10^{-6}	13×10^{-6}
Thermal conductivity	2.3	314	314	1,416

Steel fixtures may be attached to the filament-wound structure since the coefficient of thermal expansion for steel is comparable to that of the glass-wound tructure.

The low thermal conductivity of filament-wound structures provides insulation which is not found in other high-strength structural materials.

From this analysis of the physical properties it can be concluded that filament-wound structures have many definite advantages over steel. To see where some of these advantages are useful, we will examine a glass filament-wound shotgun barrel.

Manufacture of Filament-Wound Gun-Barrel

The "Win–Lite" filament-wound glass fiber is part of the Winchester Model 59 semi-automatic shotgun. It is produced by the Winchester–Western Division of Olin Matheison Chemical Corporation.

The "Win–Lite" barrel is comprised of a thin metal liner and a surrounding resin-glass-wound structure. The liner is made from a seamless drawn-steel tubing 0.020 inch thick. A high bore polish is attained through conventional microhoning operations.

The liner is now placed in a lathe-type machine. It is wound with glass filaments which are pulled from a creel through an epoxy-resin bath and wound by rotation of the barrel. The completed wound assembly is now oven cured.

At this point the burst strength of the barrel is very high but there is a tendency for the barrel to have some longitudinal whip. Therefore, unidirectional glass cloth tape is applied to the barrel to correct the whip effect.

The barrel is oven-cured after being wrapped and then impregnated with a modified epoxy-resin system. The barrel then goes through its final oven cure and is then ground to a finished contour. It is given a spray finish of a prime coat and a finish coat of baking type materials formulated from epoxy resins.

Comparison With Steel Barrels

The "Win–Lite" barrel has several advantages over conventional steel barrels. First, the glass filament-wound barrel is very durable. The finish of the barrel has the appearance and flexibility of the best steel barrels. Yet the filament-wound barrel will not rust or rot and it is not affected by the weather. Also, it will not fade or discolor and it is not affected by gun oil, bore cleaner or any other preparation.

The "Win–Lite" barrel has an added safety factor in that the burst strength is much greater than in a steel barrel. To indicate the strength of a filament-wound barrel, a 20-guage shotgun shell was put in the barrel in front of a 12-guage shell and the gun was fired. Even with this added charge, the barrel was unaffected and could easily stand the pressure. It was found in testing the barrels that bore obstructions large enough to burst steel barrels only caused a slight ring in the filament-wound barrel.

Another advantage of the "Win–Lite" barrel is cooler shooting. Because of the low thermal conductivity much of the heat is absorbed by the barrel. This eliminates hot barrels and heat wave distortion.

Finally, the light weight of the barrel allows for faster pointing. This also makes the gun lighter and easier to carry.

The glass filament-wound barrel cannot be used as a crow bar as can some all-steel barrels. On the other hand, if the barrel is bent it can be straightened without cracking or chipping.

Technical Advantages of Filament-Wound Products

There are several quite varied reasons why filament-wound parts are replacing homogeneous metal parts.

In general, there is no limitation on the size of parts which can be made. The limitation is more on the handling equipment than in the fabrication of the part itself. Machines are available which can fabricate parts up to 15 feet in diameter and 65 feet long (See Fig. 5).

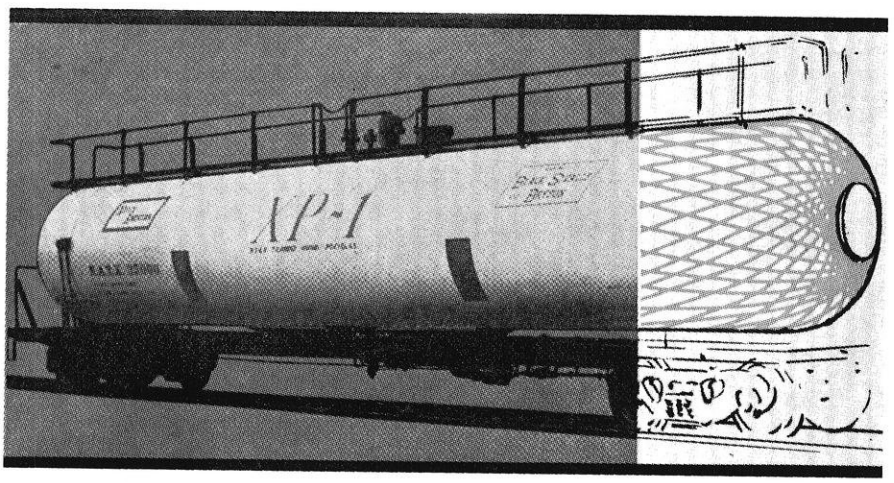


Figure 5.—A 22,500-Gallon Filament-Wound Railroad Tank Car

The thermal conductivity of reinforced plastic materials is very low compared to metallic structures. This also results in a saving of weight because of the reduction or elimination of insulation.

Like other reinforced plastic structures, filament-wound structures are very corrosive resistant. In many cases the resins used in filament winding are applied to metal to improve its corrosive resistance. Thus a savings in cost results because of a longer life and less maintenance on a filament-wound structure.

The impact resistance of filament-wound structures are quite good. A metallic structure might dent from a blow whereas a glass filament-wound structure would spring back and keep its shape.

Also a filament-wound structure is shatterproof. When a metal vessel breaks, it fragments and sends flying many small pieces of metal. On the other hand, a filament-wound vessel will break without fragmenting.

Use of Filament-Wound Structures

Glass-filament wound structures are being used more every year. The volume of filament-wound glass fiber plastic in non-defense applications will increase from 2.9 million pounds in 1963 to more than an estimated 16 million pounds in 1970.

In 1963, sporting goods manufacturers used more than 65,000 pounds of filament-wound laminates in shotgun barrels, archery bows, and other equipment. It is estimated that by 1970, 100,000 pounds will be used for this purpose.

REFERENCES

Chazottes, M. L., "Filament Winding is Coming of Age", *Canadian Chemical Processing*, v 48, April 1964.

Gorcey, Richard, *Filament-Wound Pressure Vessels*, ASME Publication, Paper No. 61–MD–17, 1961.

Don Williams will get his BSME in June and then go to work for Sundstrand Corporation's Aviation Division in Rockford, Illinois. Don is from Barneveld, Wisconsin and previously attended Loras College in Dubuque. He is a member of ASME.

STRENGTH

One of the outstanding properties of Malleable Iron Castings

One of the first considerations in designing a metal part is its strength to perform a given function.

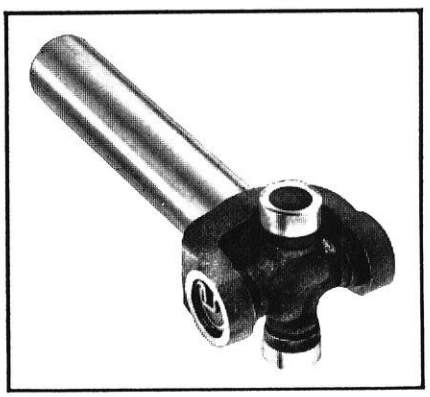
In most instances, the second question is always how to provide the necessary strength . . . at the lowest possible finished cost. On both counts, Malleable iron castings offer exceptional advantages. Here is why:

Malleable castings are available in two general types (ferritic and pearlitic) and in 9 ASTM grades that range in tensile strength from 50,000 to 100,000 PSI. Tensile strength figures represent the load at which materials fail. Yield strength and fatigue strength are among the more important engineering yardsticks.

Yield strength represents the point at which materials exceed the elastic limit. Fatigue strength is the greatest stress which can be sustained when the load is applied repeatedly. As indicated by the table below, Malleable has an advantage over steel in fatigue strength and yield strength when grades of identical tensile strength are compared.

	TENSILE	YIELD	FATIGUE
1020 Steel	75,000 PSI	48,000 PSI	34,000 PSI
50007 Pearlitic Malleable Iron	75,000 PSI	50,000 PSI	37,000 PSI

Strength and Cost — Malleable iron has been described as providing more strengh per dollar than any other metal. There are many factors which contribute to this reputation. Malleable can be cast close to finish shape, thereby reducing or eliminating machining operations. What machining must be done can be accomplished quickly because Malleable iron is the most easily machined of all ferrous metals of comparable hardness.



This is a pearlitic Malleable iron universal joint yoke for an automobile. Subjected to repeated torque as the car reverses, speeds up and slows down, these high strength parts have an enviable record for reliability and service. One automaker reports no warranty claims on this part for the past seven years!

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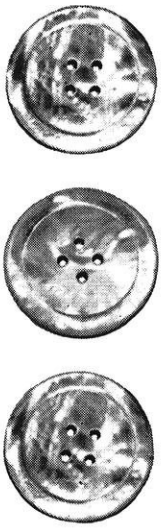
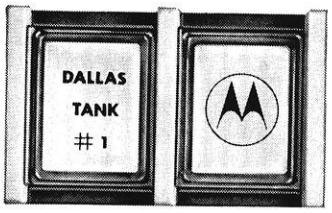
CONSUMER PRODUCTS ★ COMMUNICATIONS ★ SEMICONDUCTOR PRODUCTS ★ MILITARY ELECTRONICS ★ AUTOMOTIVE PRODUCTS ★ CONTROL SYSTEMS



button button...



Want to know how much oil is in your Dallas tanks while you're sitting in Tulsa? Push a button.

Making salad dressing? Not at home by the spoonful—but industrially by enormous vats-full. No more hand pouring or mechanical dumping. Hit the vinegar button and it's measured precisely. The oil—to the drop. Lace the concoction with zesty oregano? Just push a button.

Load a gas truck with gasoline, check the gallons left in the storage tanks, make out the statement, give the driver a receipt, and then record the whole transaction. Tough? Just have the driver push a button (or a lever). You don't even have to be there.

So goes the lively art of solid state electronics. Remote Control, Data Acquisition Systems, and Process Control Systems. All available *right now* for modern industries—control devices for—you name it.

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And who's got the button? Why Motorola of course . . . they've been button-controlling for years!

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MOTOROLA

If you still think glass is just glass,

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ask your printer.

Now glass can do what metals can't. Add sharpness and distinction to printing by flexography and simplify the whole process as well. Ask your printer.

Flexography is the art of printing with rubber plates on flexible materials, such as the paper, film and foil used for packaging. Conventionally the rubber plate is prepared from a metal engraving. Trouble is, rubber tends to exaggerate the tiny irregularities found in etched metal.

Then Corning came along with a remarkable method for engraving on glass, every particle of which is photosensitive. The image to be etched is developed all the way through the glass.

So the etch is deep. Clean. Diamond-sharp. The reproduction sparkles. Type glitters. The blurred look of rubber plate printing is gone.

Photosensitive glass was developed by Corning. It opens up a world of unprecedented applications, like the discovery of a major new basic material. Yet it is only part of the enormous promise in glass.

Today, glass can be made six times stronger than steel. Or as soft as silk. It can bend or not bend. Break or not break. Melt or not melt. It can be molded, cast, machined, drawn and pressed. In short, it possesses more useful capabilities than any other known material.

For solutions to their materials problems, industry and government are coming to Corning. Because Corning is *the* glassmaster. It's a broad, international company, with one of the most daring, expert and imaginative research and engineering staffs in the world. Plus a marketing principle that commits them to developing products only in areas where a need exists and no product does.

Young engineers seeking challenge, opportunity and advancement are invited to write to Career Development Manager, Corning Glass Works, Corning, New York.

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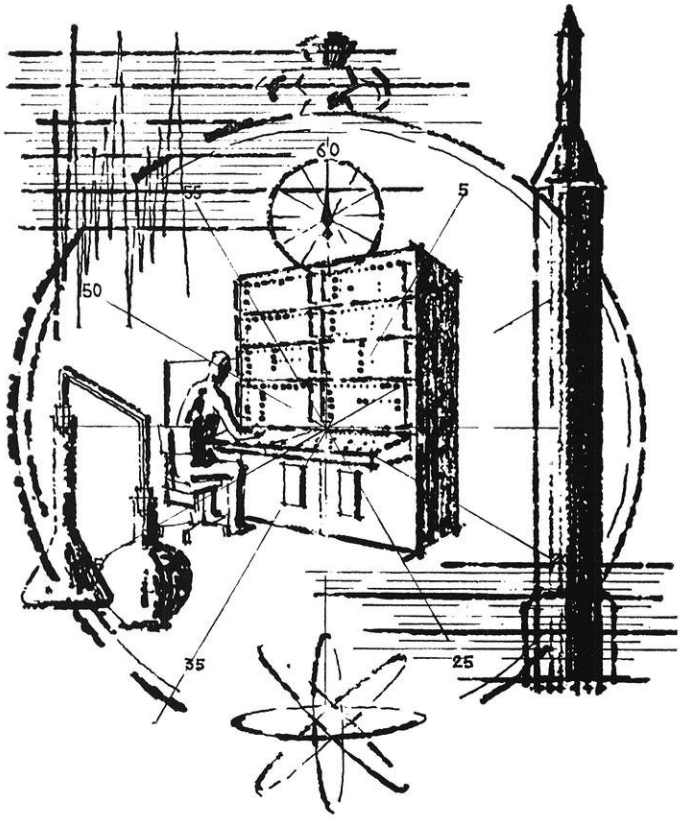
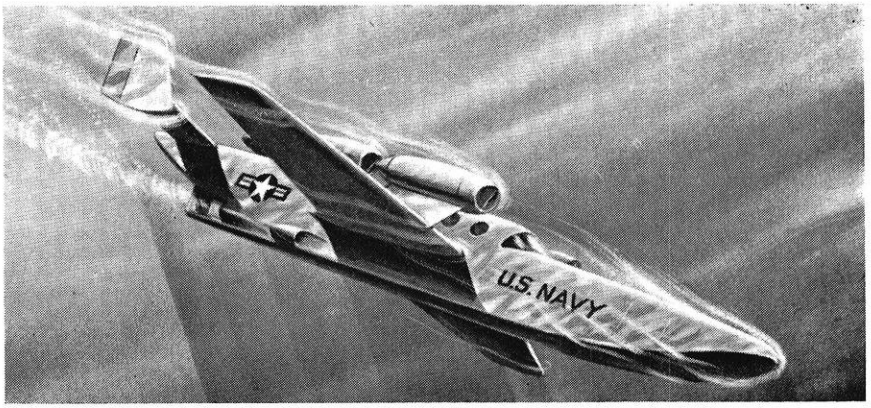


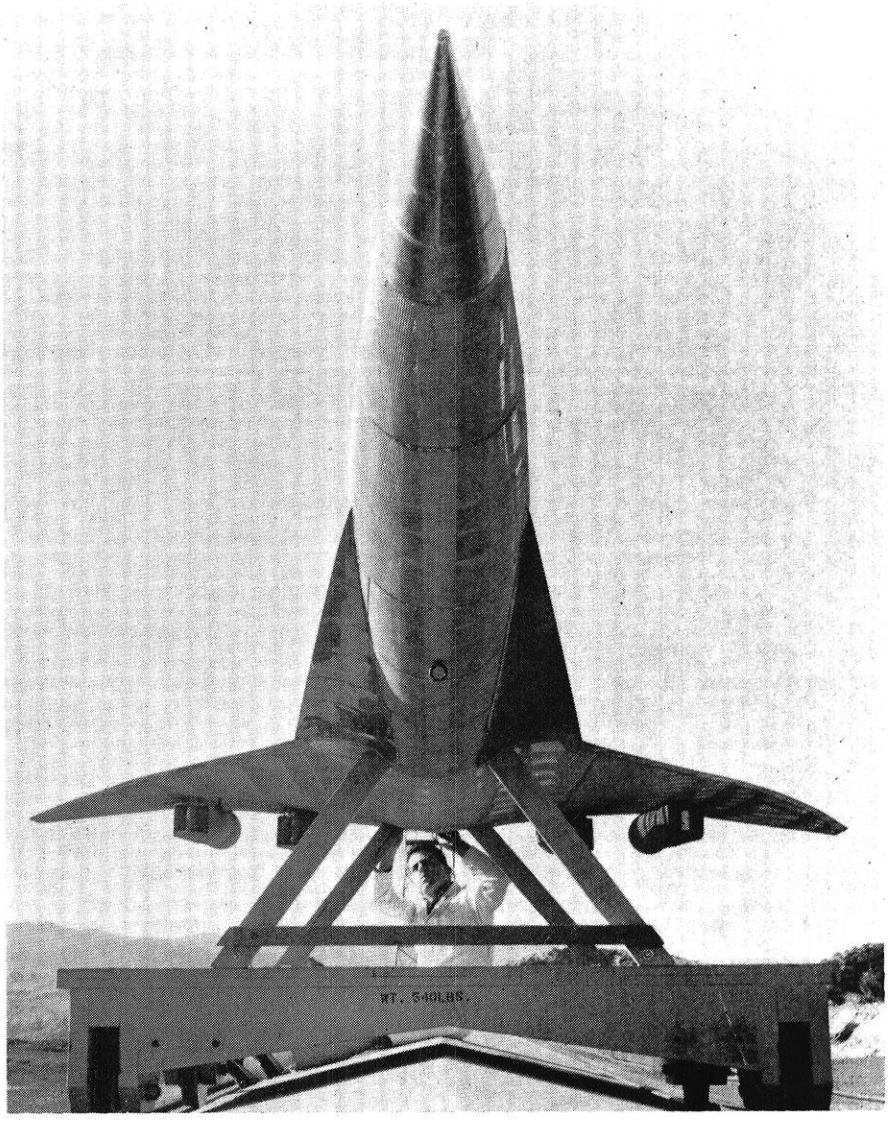
SCIENCE HIGHLIGHTS

A brief resume of new developments in government and industry, compiled by the *Wisconsin Engineer* staff

Truss walls, sheathed in stainless steel, form a lattice on four sides of the new IBM Building, Gateway Center, Pittsburgh, and support all wind and floor loads. To accentuate the truss action, architects Curtis and Davis extended trusses above the roof and below the lobby ceiling.

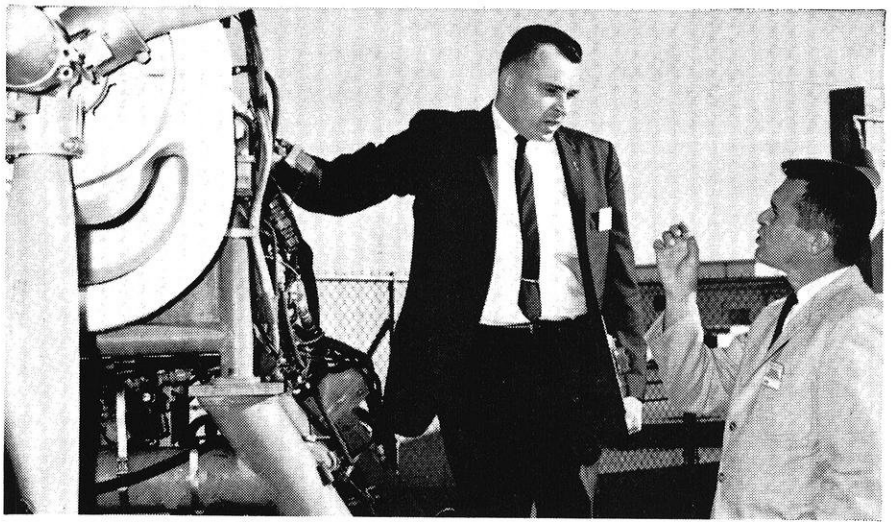


SUB-PLANE—This is an artist's conception of a submersible seaplane based on feasibility study results obtained by General Dynamics/Convair, San Diego, Calif. Sub-Plane is a vehicle that would be at home in the air and underwater. After a six-month study program on Sub-Plane, sponsored by the U. S. Navy Bureau of Naval Weapons, Convair division engineers have concluded that development of such a vehicle is feasible and practical. On an underwater mission, as depicted in the artist's conception, the vehicle would be powered by electric motors and batteries. The three flight engines, two mounted on struts above the wing and a third located aft of the wing on top of the hull, would be sealed for the underwater mission.



DELTA WING SUPERSONIC TRANSPORT of the 1970s will have as many as 28 antennas for communication, navigation and complete "blind" landing to provide the most reliable communications ever put into commercial aircraft. Tenth-scale model of the Lockheed 2000 SST is seen being fitted with antennas designed and developed at the Lockheed–California Company's Rye Canyon Research Laboratory. Communications from 70,000 feet-plus with ground stations thousands of miles away may be relayed through proposed stationary satellites positioned 24,000 miles out in space, according to Lockheed electronics experts. Waffled appearance of the SST model is caused by a surface covering of special hardware cloth to simulate the titanium skin of the proposed Mach 2.7 airliner. The entire SST model serves as a conductor for high frequency energy paths between the aircraft and parabolic antennas in the company's electromagnetics laboratory, the most advanced facility of its kind in the free world.

What kind of engineer will you be... preliminary design, design, development? At AiResearch Phoenix, you work as all three before you decide.



Your future as an engineer is strongly influenced by your first assignment. What that assignment will be, should be, is an important decision.

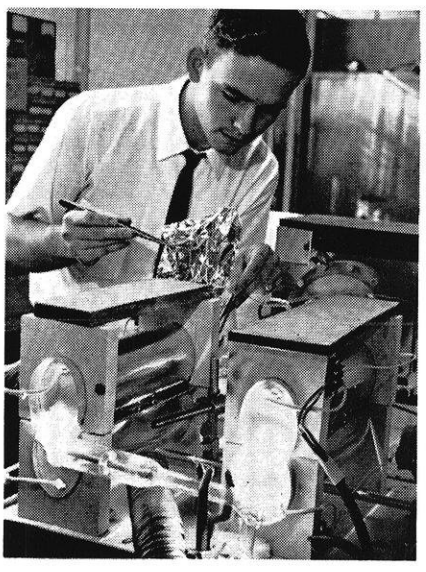
At Garrett you control that decision. During an eight-month orientation program, you work with experienced engineers on a variety of assignments in different areas. Your permanent assignment depends on your own aptitude and interest.

In preliminary design you may work on gas turbine engines, jet engine starters, or advanced power systems for space vehicles. Analysis is the key – and the emphasis is on thermodynamics, fluids, vibration, heat transfer, and math to solve today's problems.

As a *design engineer*, you see your solution to a product design problem take shape on the drawing board and in fabrication. You may work on controls systems for turbine drives, engine fuel systems, or a laboratory test system. Mechanics is the theme – statics and dynamics, materials and processes, and graphics are your tools.

In *development*, you'll test designs before they go into production. Manufacturing processes are examined and production techniques are explored. Everything from nuts and bolts to complete power systems are tested, and your lab work and practical judgement will pay off in this area.

Your career at AiResearch Phoenix can be stimulating and rewarding. You can work in all three important areas of engineering on diverse aerospace products. You can use your total education, learn more on top of it, and take part in a wide variety of advanced engineering.



At AiResearch Phoenix, the product lines include gas turbines for auxiliary power, turboprop engines for business and military aircraft, secondary power equipment for aircraft, advanced space vehicle nuclear power systems, pneumatic and hydraulic control systems, as well as a variety of related equipment for aerospace, ground, and undersea applications.

Find out the whole story in our new booklet, Your Future at Garrett. Get it from your campus placement office, or write AiResearch Manufacturing Division, 402 South 36th Street, Phoenix, Arizona 85034.

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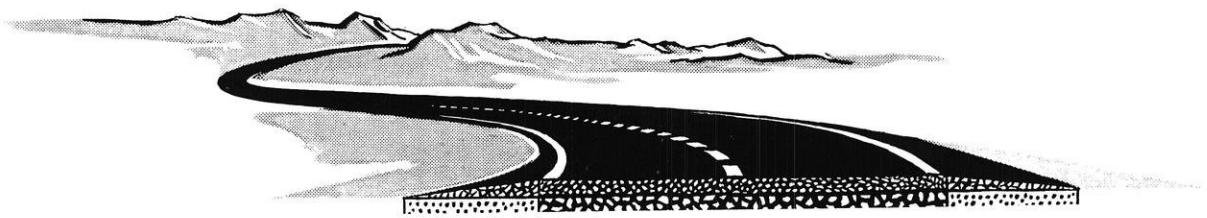
RESEARCH OPPORTUNITIES IN HIGHWAY ENGINEERING

The Asphalt Institute Suggests Projects in 5 Vital Areas



Phenomenal advances in roadbuilding techniques during the past decade have made it clear that continued highway research is a must.

Here are five important areas of highway design and construction that America's roadbuilders need to know more about.

If you or your department are planning research studies, you can make important contributions to highway technology through projects in one or more of these areas:

1 Rational Thickness Design and Materials Evaluation.

Much remains to be done in the refinement of thickness design concepts for asphalt pavement structures. Research is required in areas of asphalt rheology, behavior mechanisms of individual and combined layers of the pavement structure, stage construction and pavement strengthening by Asphalt overlays.

Traffic evaluation, essential for thickness design, requires the development of improved procedures for utilizing loadometer and other traffic data. These new procedures will more adequately permit conversion of mixed traffic loads into terms of 18,000-lb. single-axle loads as required by design guides of the American Association of State Highway Officials, The Asphalt Institute and others. Also needed are better methods for predicting future traffic volumes and characteristics.

2 Materials Specifications and Construction Quality-Control.

Needed are more scientific methods of writing specifications, particularly for determining rejection and acceptance criteria. Also urgently needed are speedier methods for quality control tests at construction sites, such as improved air- or water-permeability procedures for controlling pavement density.

3 Drainage of Pavement Structures.

Better and more positive methods are needed in this area. Suggested are experiments with two-layer systems and investigations of differing roadbed cross sections.

4 Compaction of Pavements, Traditional Lifts and Thicker Lifts.

Rolling procedures, compaction equipment and compaction testing-methods for traditional thin lifts of asphalt pavements need further study. The recent use of much thicker lifts in asphalt pavement construction suggests the need for new studies to develop and refine techniques of compaction to obtain the densities desired.

5 Conservation and Beneficiation of Aggregates.

In light of greatly increased road and street construction, in which high-grade materials are being used in abundance, the conservation of aggregates has become a pressing requirement. A study of the use of Asphalt in membrane form to envelop low-quality base courses and soils would be helpful. Other procedures utilizing Asphalt also could be studied.

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"Field Notes"

M.E.: "Do you know how many students they have at UW?"
E.E.: "Oh, about one out of ten."

° ° °

No one knows what a short skirt will be up to next.

° ° °

What do you get when you cross an elephant with a grape?|Elephant|grape| sin θ
In case you wondered, θ is the angle between the stem and the trunk.

° ° °

At last I've found my soul mate,
One could not ask for more . . .
She's deaf, and dumb, and over-sexed,
And owns a liquor store.

° ° °

"I wanna come in."
"You can't come in."
"Why not?"
"Because Mama says little boys shouldn't see little girls in their nightgowns. . . ." (short silence) "You may come in now. I took it off."

° ° °

I have a new boyfriend now who is an engineer.
What's he like?
Oh—whiskey—gin—anything.

° ° °

Two men got off a bus. One had come to town for good. The other was a Marine on a furlough.

° ° °

Definition of Robot—A girl an engineer can make.

° ° °

We've just heard about the girl who was picked up so often that she began to grow handles.

Mary had a bathing suit;
It was very airy.
Five percent was bathing suit,
And all the rest was Mary.

° ° °

The two couples were enjoying their vacation together at a resort hotel. They were in the middle of a card game in the lobby when a thunderstorm cut off the hotel's electricity, leaving little to do but retire to their rooms. Will, was a rather devout chap, so before getting into bed with his companion, he said his prayers. As he got under the covers, the lights suddenly went on and he discovered he was in the wrong room. He instantly jumped up and started to dash for the hallway. "It's too late," called the girl from the bed, "my guy doesn't pray?"

° ° °

"Jack, are you sure it is I you are in love with and not my clothes?"
"Test me, darling."

° ° °

It was three a.m. when he staggered home after a glorious evening. In a few minutes a series of unearthly squawks howled out of the radio. His wife looked into the room and discovered him twisting the dial back and forth frantically.
"For heaven's sakes," she exclaimed, "what in the world are you doing?"
"Go away, go away! Don't bother me," he yelled. "Shom poor devil's locked in the safe and I forgot the combination!"

A professor is a person whose job is to tell students how to solve the problems of life which he himself has avoided by becoming a college professor.

° ° °

Engineer: "She's a nicely reared girl, isn't she?"
Physicist: "Not bad from the front, either."

° ° °

A college football coach was surprised to see a busty coed wearing a varsity sweater. Stopping the girl, he growled:
"What are you doing with a letter sweater? Don't you know you're not supposed to wear one unless you've made the team?
The coed smiled, then cooed, "WELL?"

° ° °

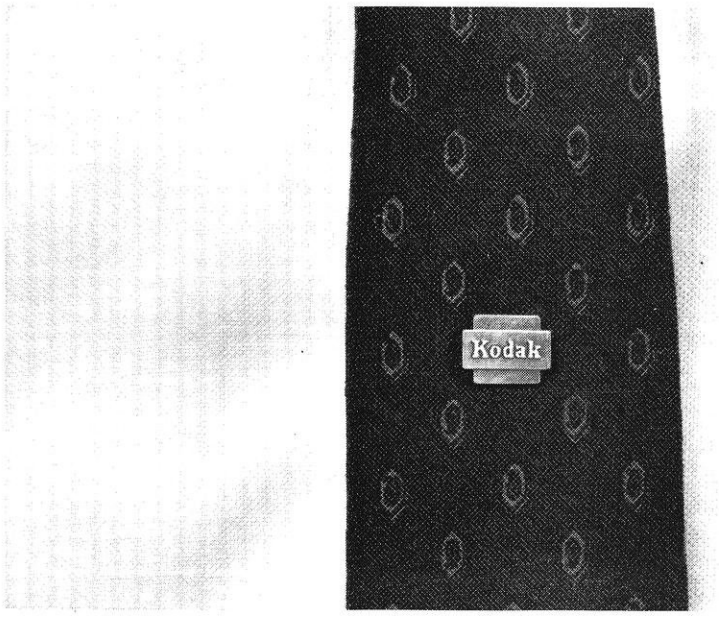
The southern father was introducing his family of boys to a visiting governor.
"Seventeen boys," exclaimed the father, "and all Democrats—except John, the little rascal. He got to reading."

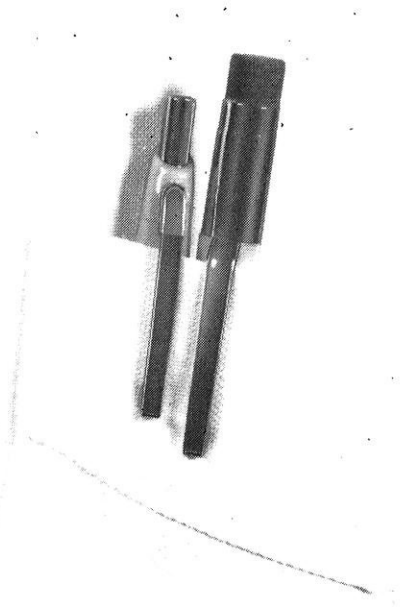
° ° °

CE: What would you say if I stole a kiss?"
She: "What would you say to a guy who had a chance to steal an automobile but only took the windshield wiper?"

° ° °

The deans who think our jokes are rough
Would quickly change their views
If they'd compare the ones we print
With the ones we're scared to use.





Should man aspire to a nobler role?

The business press reports that many outstanding members of the Class of '66 have balked at entering industry.

Are we then to lie down and die for lack of smart new talent? No, thank you. We shall succeed in attracting high-ranking people from the Class of 1967 as we did from its predecessors on the country's campuses. We have no fear.

High-rankers are those who have demonstrated good grasp of the subject matter that scholars have gathered for them. The gathering must continue. Professors have an obligation to hang on to good gatherers. They are discharging it well. We too have an obligation. Ours is to lure high-rankers with their well grasped subject matter out into the world to put it to use. "Use" means tying it to the needs and desires of all kinds of people, everywhere. Which is what, at this particular stage in history in this particular land, business is all about.

Enough members of the Class of '67 will grasp that principle along with all the other principles they have grasped.

They will therefore seize the opportunity to take over the mighty machinery built by charter-writers with 19th century minds and convert it to late-20th century needs. **Who else is there to put in charge?**

Those who feel motivation in that direction and want to taste the realities without, before, or during pursuit of advanced degrees will find Kodak a sound choice among the blue chips.

We do indeed fill genuine needs—teaching, recording facts, improving the effectiveness and efficiency of health services, putting better clothes on more backs and better food on more tables, and all the rest of the long, long chain of technological consequences from our well known original and still flourishing involvement with Sunday afternoon snapshooting.

Let's get together and talk over the more personal details.

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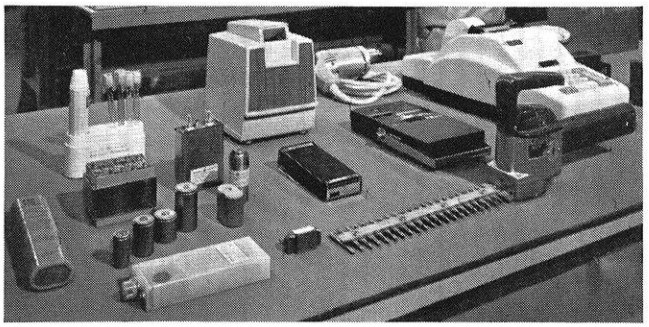
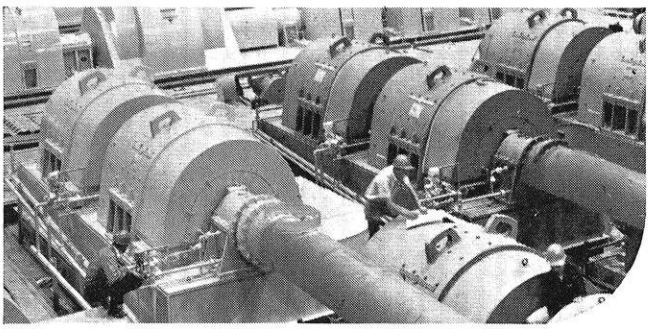
DEFENSE—G-E engineers designed and produced six J93 engines to push USAF XB-70 to Mach 3.

ELECTRIC UTILITY—Built by G.E., the Dresden Station produces commercial electric power from the atom.



CONSUMER—Nickel-cadmium batteries for cordless products were created by G.E. for new business demands.



INDUSTRIAL—G-E knowledge and skills contributed to automation of new Bethlehem Steel mill.

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