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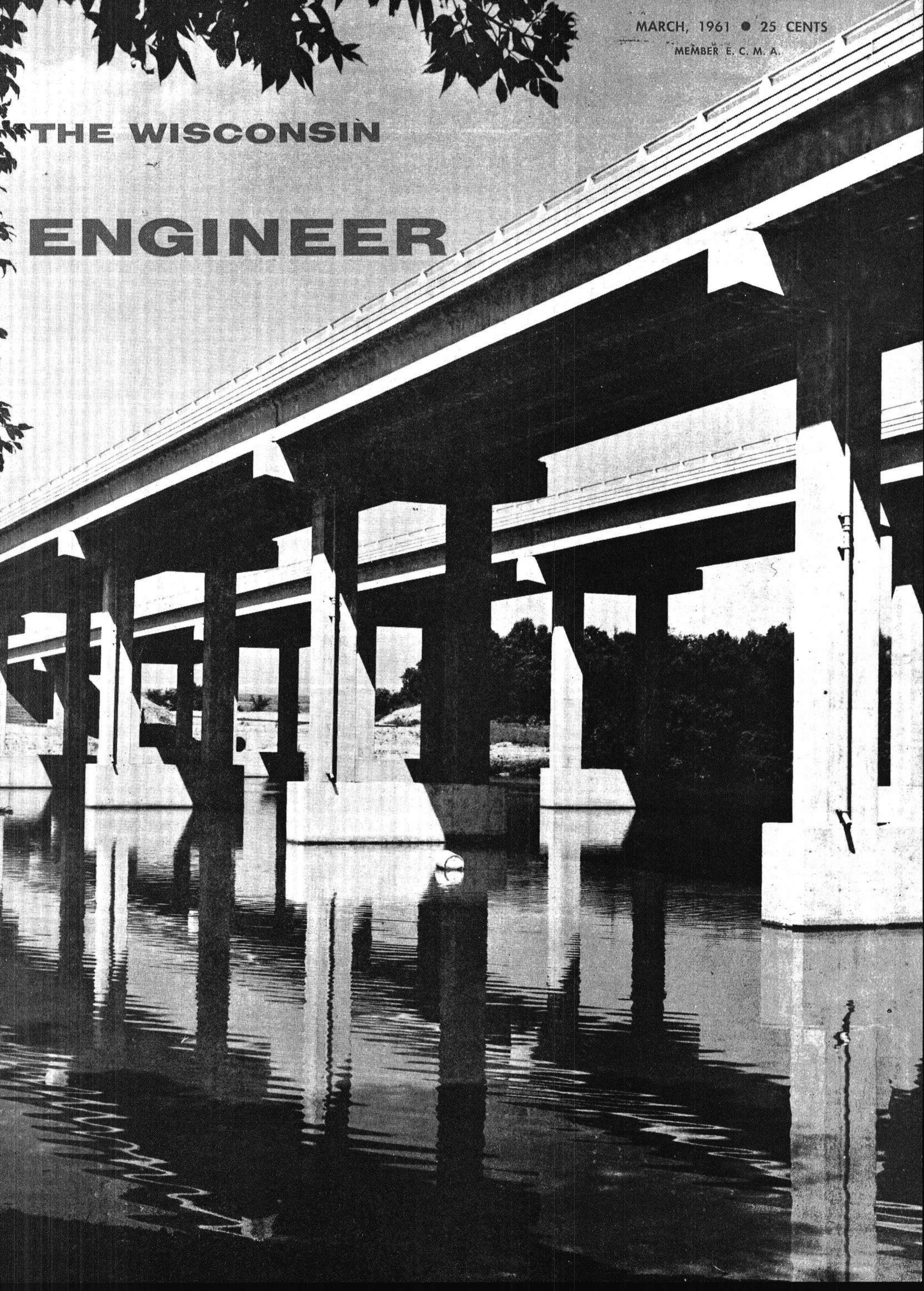
MARCH, 1961 • 25 CENTS
MEMBER E. C. M. A.

# THE WISCONSIN ENGINEER



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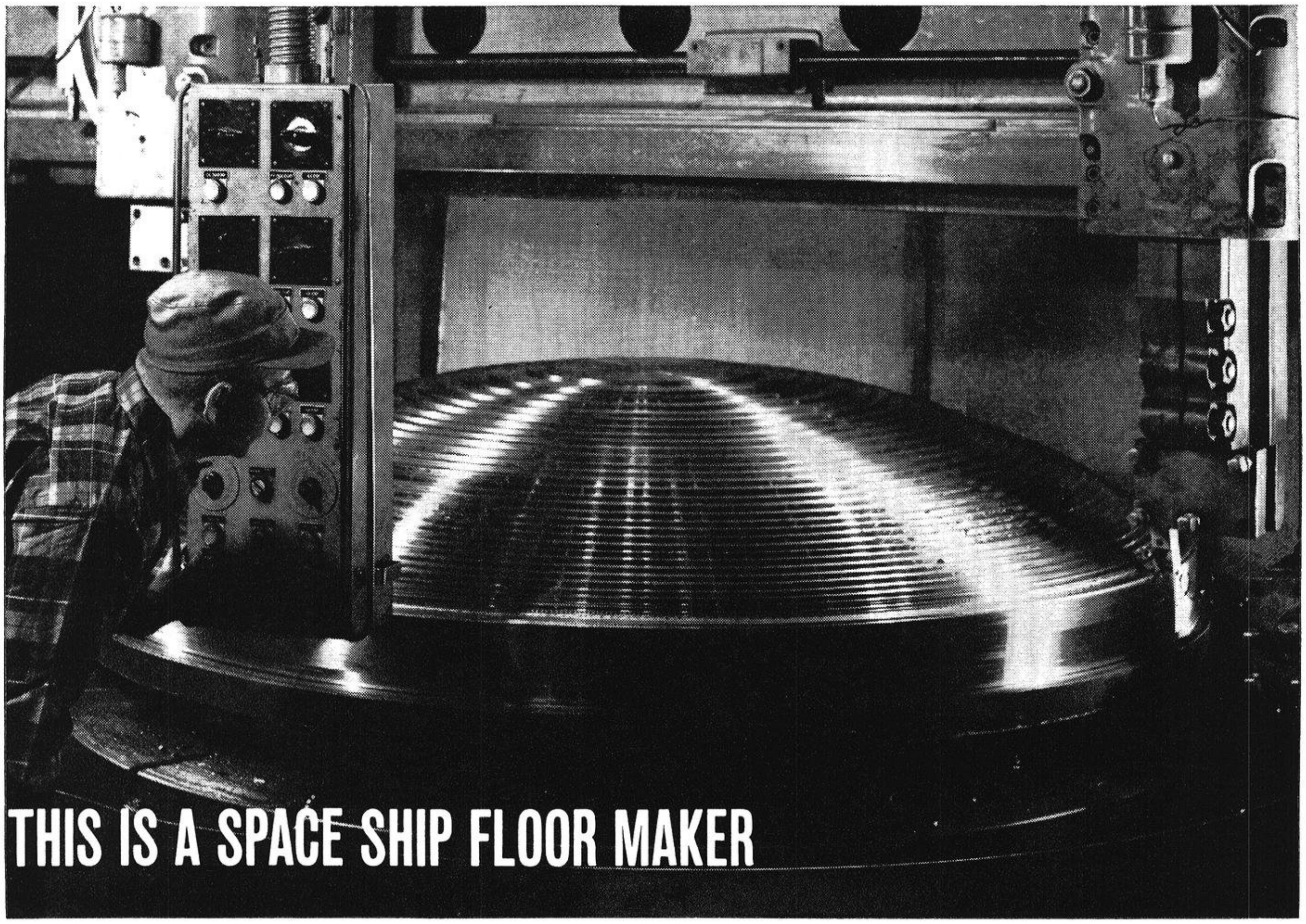


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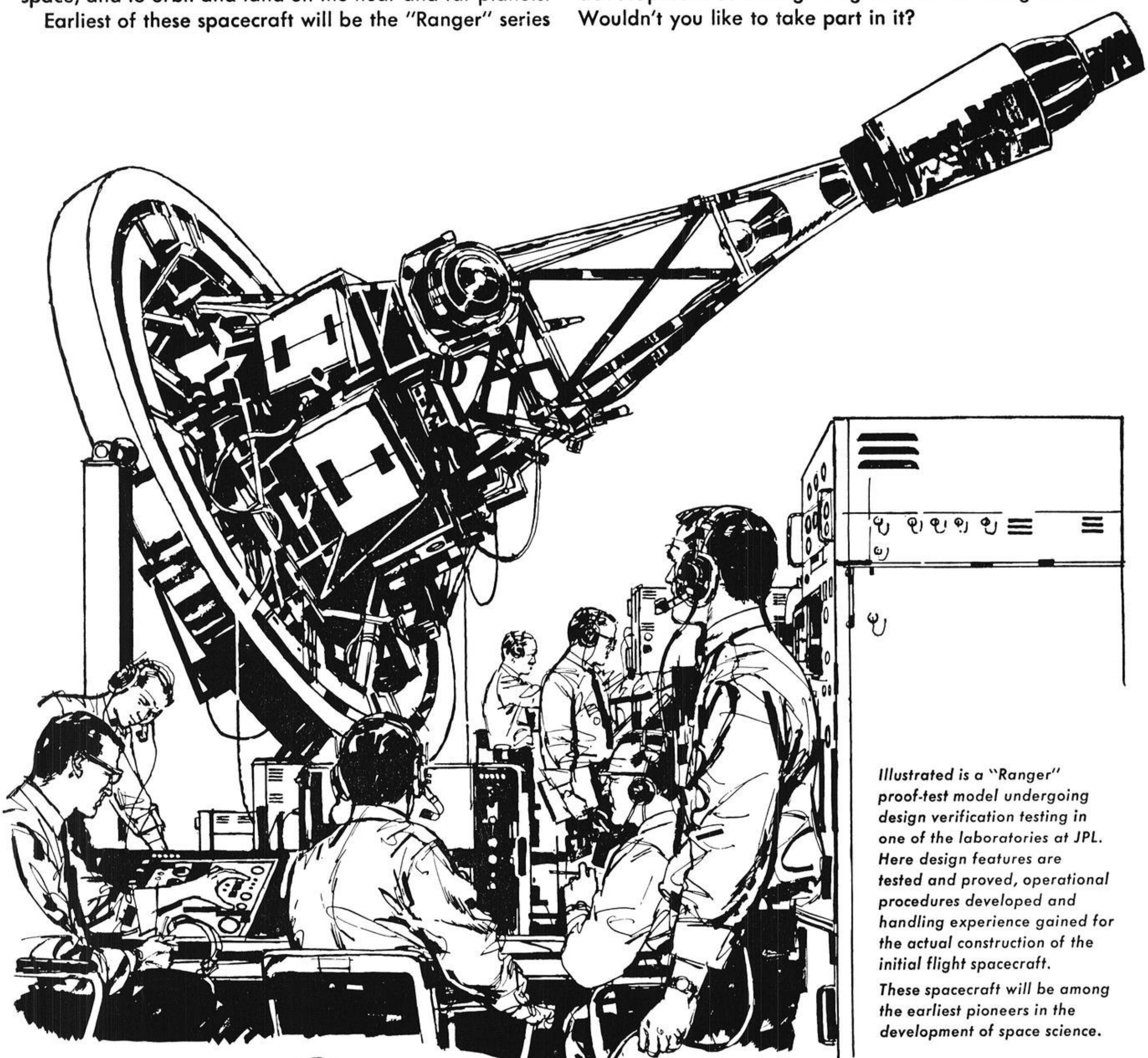

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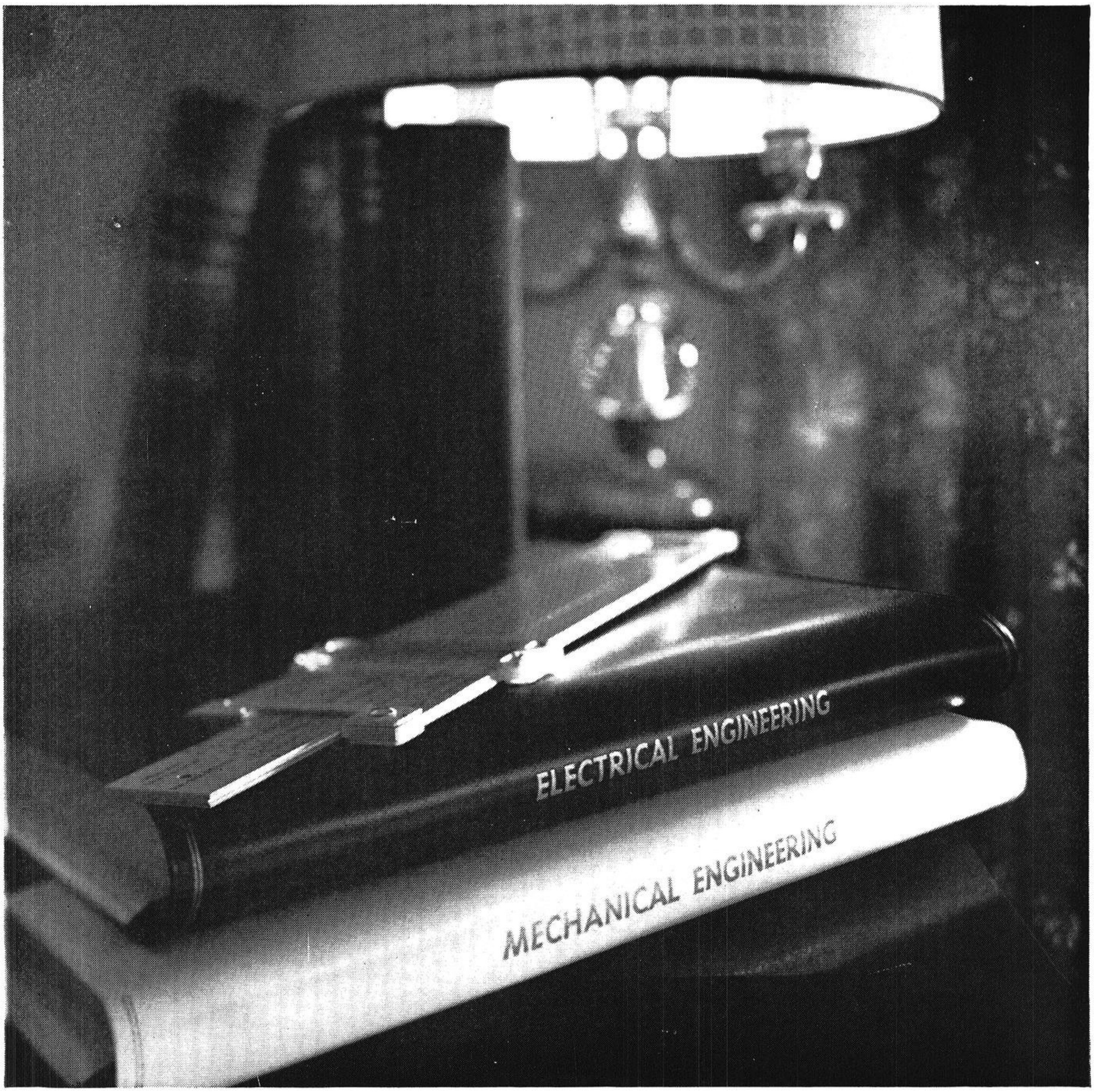
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## ARTICLES



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## DEPARTMENTS



MARCH, 1961

# THE WISCONSIN ENGINEER

*The Student Engineer's Magazine Founded in 1896*

VOLUME 65, NUMBER 6

*THIS MONTH'S COVER: Concrete bridge in the Illinois toll highway system.*

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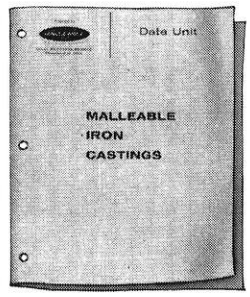


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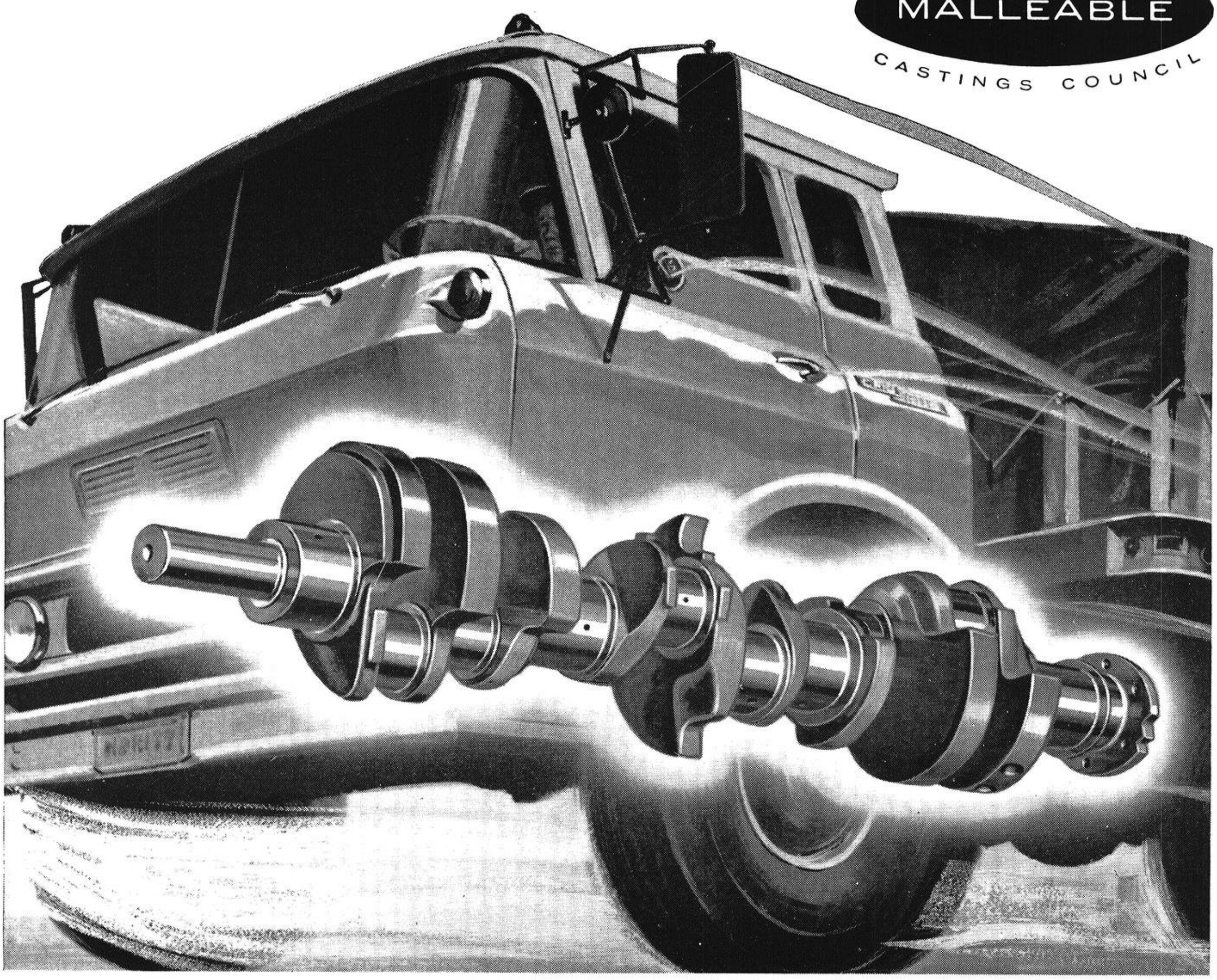

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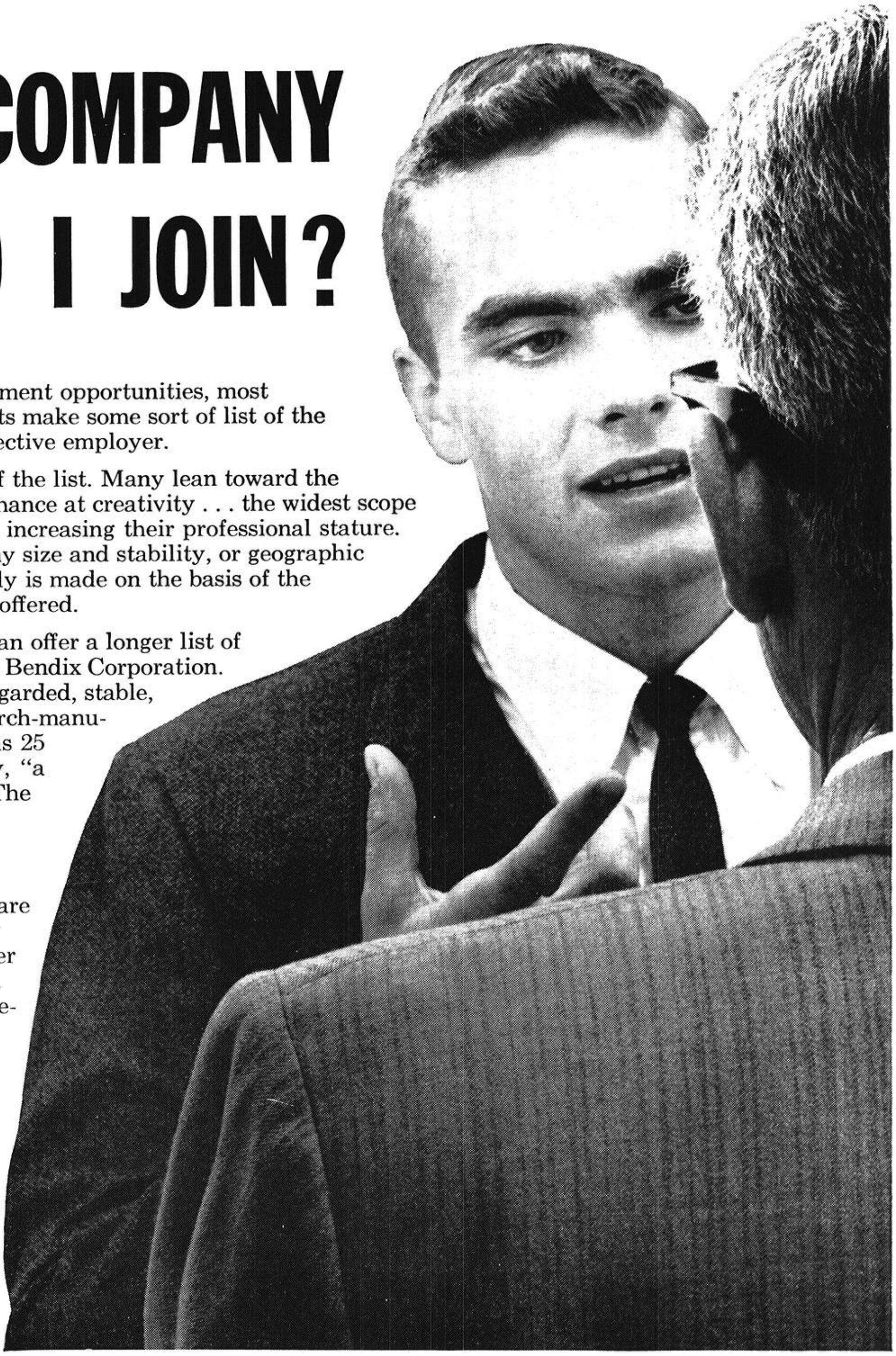

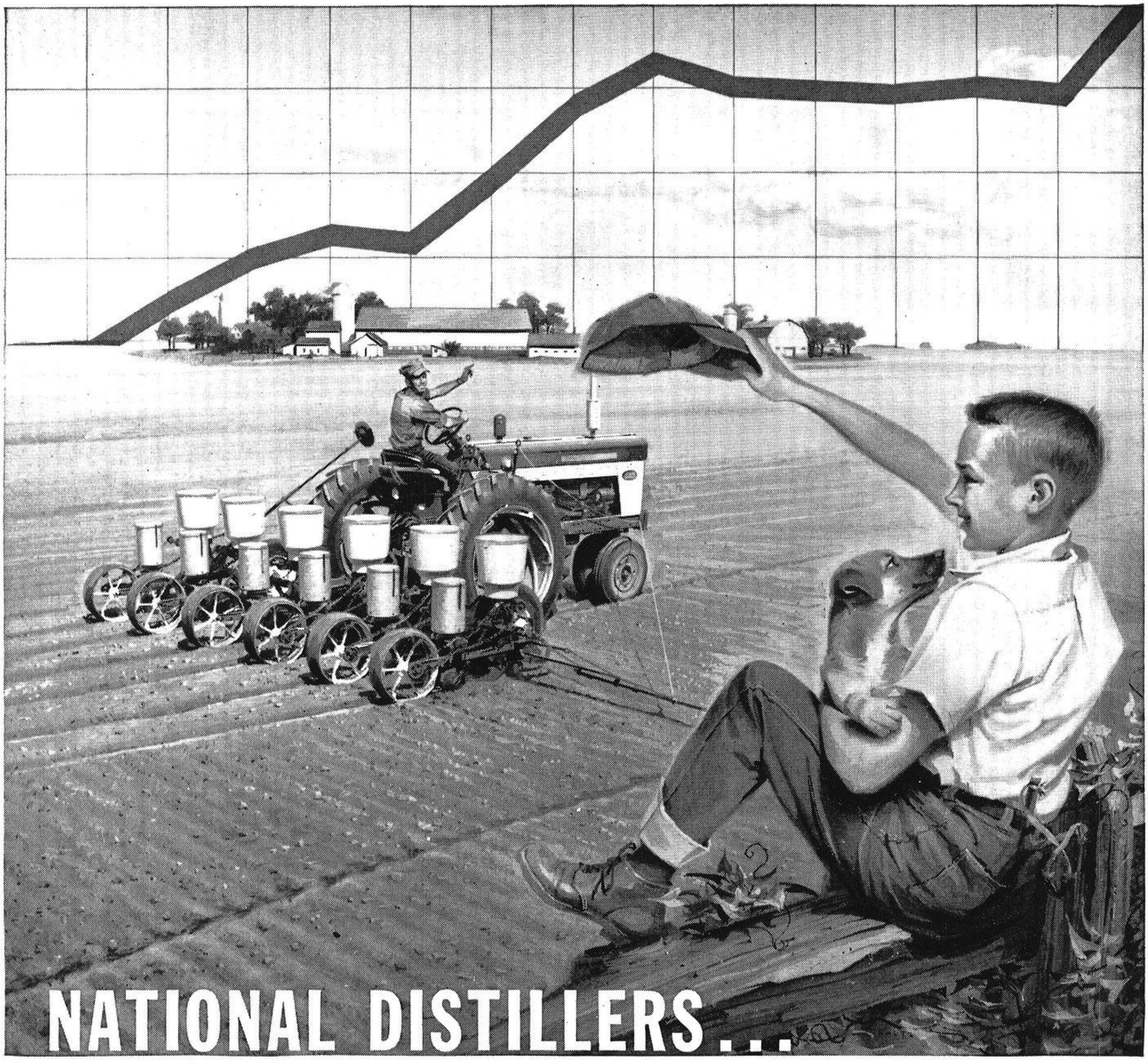


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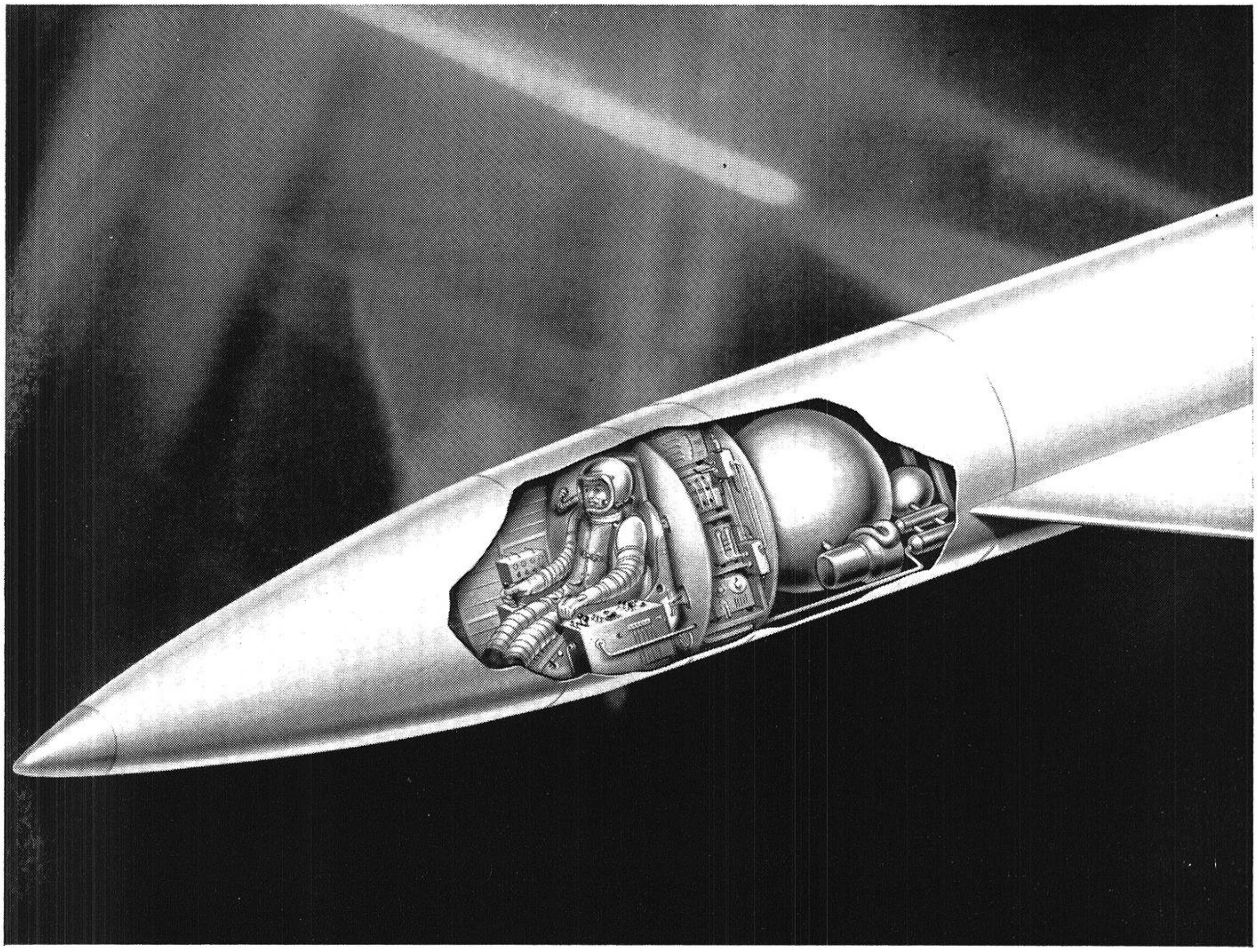

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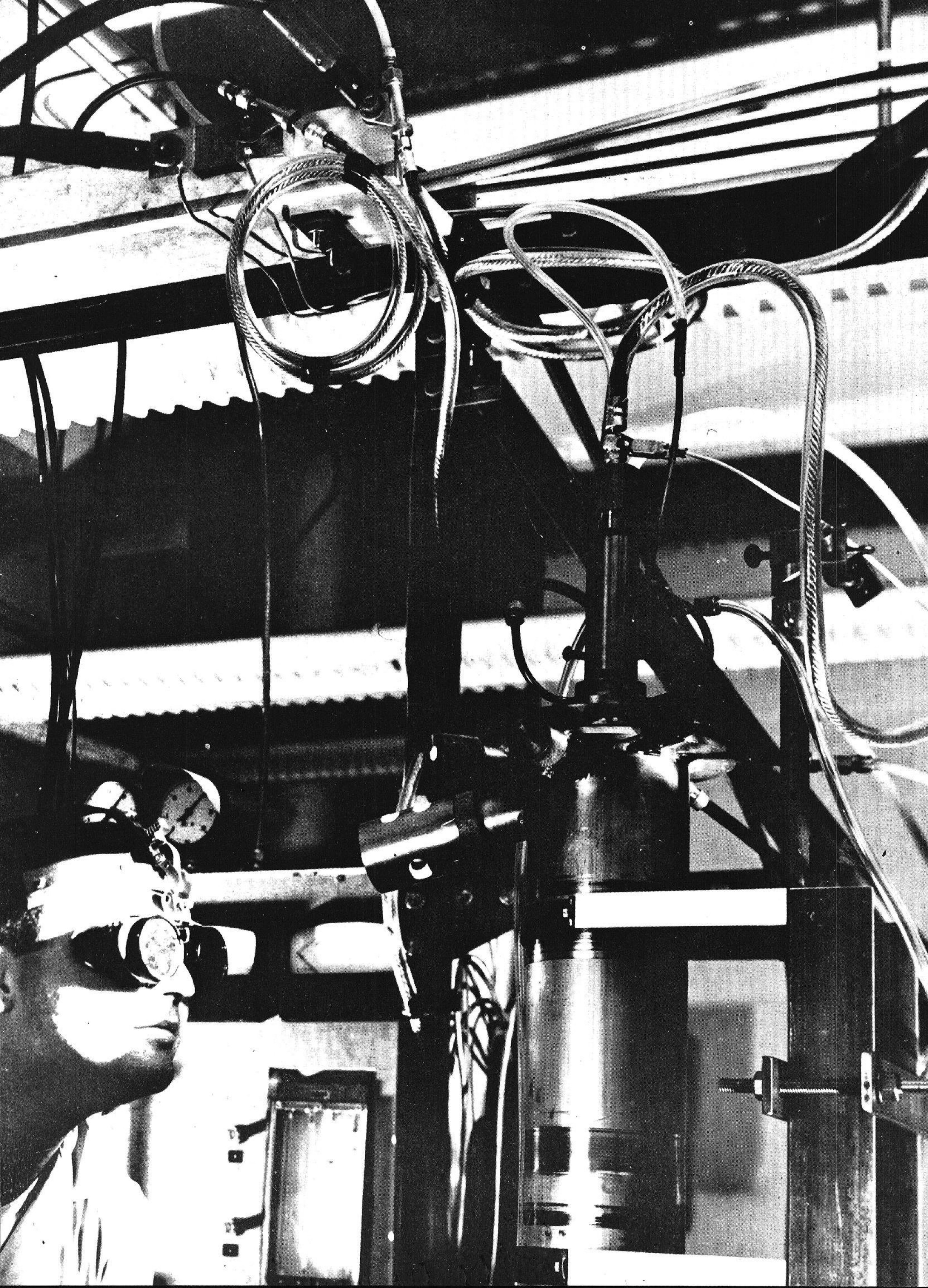


# *Rambling With The Editor*

## Look Out, They're After You

Who you may ask is after you, well the unions that would like to take you into their camp are. There is a big drive on by the unions to get all engineers unionized. They have some arguments why you should join them and some of the arguments they use are true, but look out.

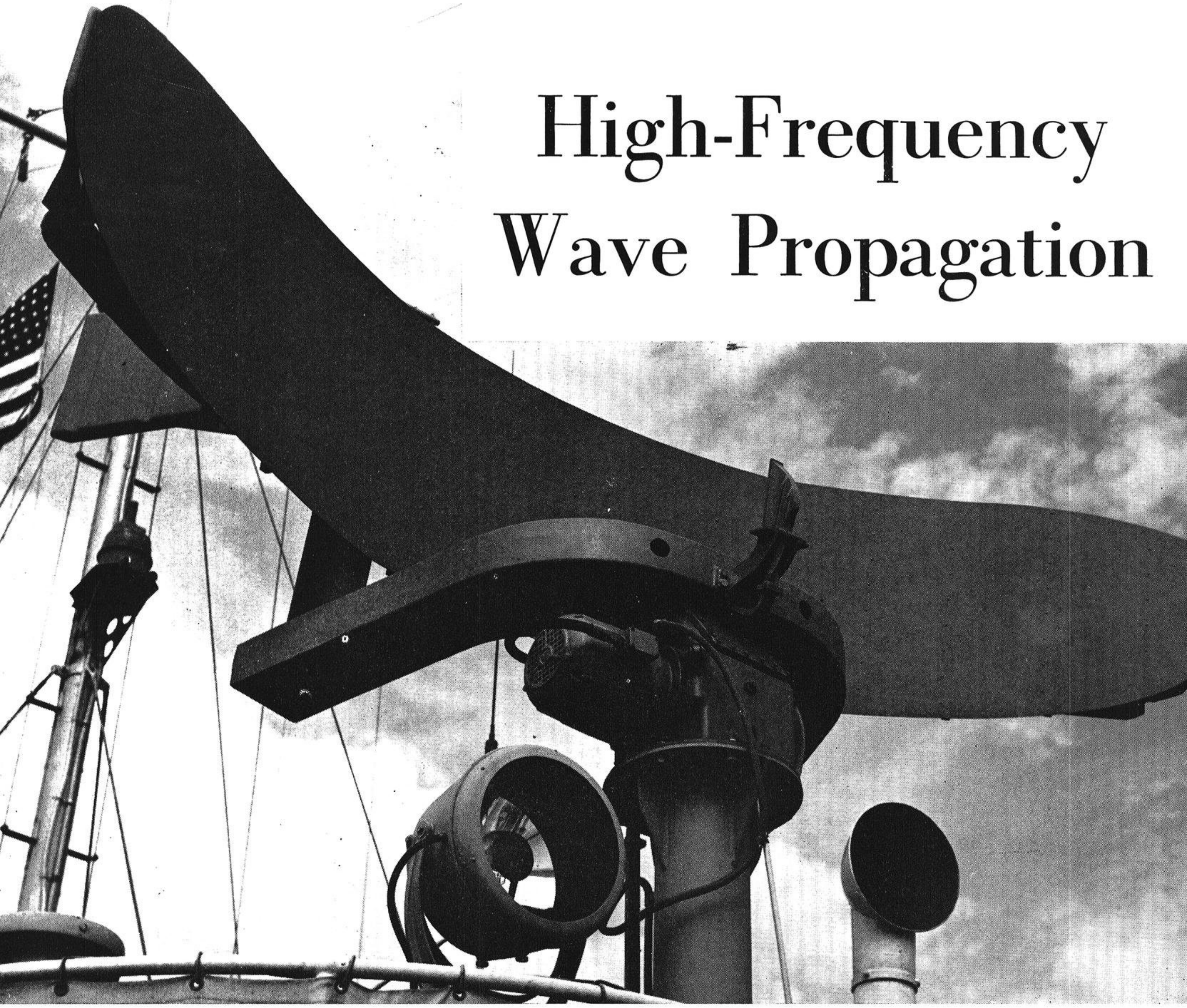
The unions argue that while the starting salary of the engineer is quite high, the increases are too slow and do not keep up with the services rendered. They also argue that many industries do not treat engineers as professional and waste their services. If engineers will join a union, the unions promise to change all this.

It is probably true that they could get the salary increases faster but instead of making engineers more professional, they would destroy all professional recognition that engineers have. If you join a union, you are not a professional, you are only one of the masses. By giving you one thing, they have taken away something more important.

The white-collar workers have been a thorn in the side of all unions for a long time because they have been getting along fine without the union's help and seem to like it that way. The unions would like to have everyone under their control so that they would be all powerful. They do not care if they can help you, they just want you under their control.

Live up to the high standards of your profession and you will always get your awards. If a union man ever tries to talk you into joining a union, LAUGH at him.—W. S. H.

◀ The new large single crystals, just announced by Linde Company, Division of Union Carbide Corporation, are produced by the arc fusion process in individual furnaces like one pictured. Arc fusion is similar in some respects to the Verneuil flame fusion process used in Linde's commercial production of synthetic sapphire, rutile, and other oxide crystals.



# High-Frequency Wave Propagation

*by John Wieber*

OF ALL the accomplishments in communication media, perhaps nothing has been more significant than the discovery of the radio wave and the means of its propagation.

Electromagnetic radio waves are basically of the same nature as light and heat and have therefore similar properties. One would assume correctly that they can be reflected, refracted, and diffracted. All three types of radiation also travel at the same speed (300,000,000 meters per second) in free space. The principal difference between radio waves and the other waves of the spectrum is the difference in the wave length.

The electromagnetic wave is composed of moving fields of electric and magnetic force. The lines of force in the two respective fields are mutually perpendicular to one another and are also orthogonal to the direction of propagation.

The direction of the lines of force in the electric field determines the polarization of a radio wave. The wave is horizontally polarized if the electric lines of force are parallel with the earth. Similarly, if the electric lines of force are perpendicular to the earth, the wave is said to be vertically polarized. When traveling along the ground, waves of longer length generally maintain their polarization but the polarization of shorter waves may be altered from that generated at the antenna.

The speed at which electromagnetic waves travel is dependent upon the medium through which they are propagated. As already stated, the speed of these waves in free space is 300,000,000 meters per second. When the medium is other than free space, the speed is inversely proportional to the dielectric constant of the material. One important fact to be noted is that while a radio wave will travel through a dielectric with relative ease, it cannot penetrate a good conductor to any extent because the electric lines of force become practically short-circuited.

Reflection, refraction, and diffraction are entirely different characteristics. Consider a light ray traveling through air of uniform properties. When it confronts some object having different properties, its path may be shifted if the change in properties is abrupt. Therefore, if a radio wave comes in contact with an object such that the discontinuity is at least comparable to the wave length of the wave, the radio wave will be reflected and the path of propagation will be changed. If a wave meets a discontinuity through which it can penetrate, its path will be deflected rather than reflected.

Remembering that the speed of the wave is inversely proportional to the dielectric constant of the medium through which it is being propagated, the differences in the speed at which the wave travels through the two media will have a definite effect on the direction of travel of this wave. That part of the wave front that enters the new medium first travels at the new speed while the trailing part of the wave front travels at the old speed in the other medium. It is this difference in speed between parts of the wave front that accounts for the wave being swung around or refracted. Long-distance communication at high frequencies is possible by such methods of wave "bending" or refraction. Such bending is accomplished in an ionized region of the earth's upper atmosphere. This region is called the ionosphere.

A radio wave tends to be bent around the edge of an object when the wave grazes such an edge in passing. As a result, there is a diversion of energy of different parts of the wave and so the wave may eventually be received at a distance below the top of an obstruction or perhaps around its edges. Such a phenomena is known as diffraction.

The final point of interest to be noted is that as the distance of the wave propagation increases, the field intensity of the received signal decreases. This results from the fact that the energy in a wave front must be distributed over a greater area as the wave moves away from the transmitter or source of propagation. This effect is known as spreading.

Essentially, radio waves may be classified, according to the altitude of the paths along which they are propagated, as ground waves, tropospheric waves, or ionospheric waves. That part of the total radiation that is directly affected by the presence of the earth and its surface features is the ground wave. It has two components, an earth-guided wave known as the surface wave, and a space wave. The space wave is also the resultant of two components, the direct wave and the ground-reflected wave. That part of the total radiation that undergoes refraction and reflection in the lower atmosphere is known as the tropospheric wave. This wave is refracted and reflected in regions of an abrupt change in dielectric constant such as the boundaries between air masses of differing temperature and moisture content.

Except for distances of a few miles, most communication on frequencies below 30 Mc. is by means of the ionospheric or sky wave. If it were not for the presence of the ionosphere, the radio waves would travel upward from the earth's surface at such an angle that they would continue out into space if their path were not bent sufficiently to bring them back to earth. The ionosphere is the medium that causes such bending to occur. It is a region in the upper atmosphere above an approximate height of 60 miles where electrons and ions exist in sufficient quantity so as to have an appreciable effect on the speed at which radio waves travel. Refraction and reflection occur in layers of varying ionized intensity exactly as was discussed previously. While the wave travels in the ionosphere, it excites random ionized particles into motion thereby giving up some of its energy. Such ionospheric absorption decreases the strength of the signal below that value which would be expected at the receiving point. Ionospheric absorption is critical at the lower frequencies. Because the ionosphere is a region of considerable depth it is convenient to assign it a definite height called the virtual height. From this height a simple reflection gives the same effect as the gradual refraction that actually occurs.

The ionosphere is caused by the ultraviolet radiation from the sun and hence it has sporadic transmission effects which are directly dependent upon the amount of radiation from the sun and the existing intensity of ionization in the respective layers. There are two principal layers of ionization. These are the E and F layers. The only difference between these two layers is the intensity of ionization which exists at different altitudes in the ionosphere. The respective layers are most highly ionized at about local noon and decrease in intensity at night.

The vertical angle which the wave makes with a tangent to the earth is called the angle of radiation or wave angle. The smaller the angle at which a wave leaves the earth, the less will be the bending required in the ionosphere to return the wave back to earth. Greater propagation distances can also be obtained at smaller wave angles.

Normally, there is only one specific distance which can be covered at a particular operating frequency. The area between the end of the useful ground wave and the beginning of ionospheric-wave reception is called the skip zone whereas the distance from the transmitter to the nearest point of ionospheric-wave reception is called the skip distance. There are two basic criteria which must be observed when transmitting radio waves. The first of these is the critical frequency. The critical frequency is that frequency above which vertical reflection in the ionosphere just fails to occur. As such it is a useful index to the second criterion. The highest frequency that can be used to transmit over a specified distance is called the maximum usable frequency. Best results with a minimum expenditure of power are always obtained when the transmitting frequency is as close to the m. u. f. as possible since ionospheric absorption is least at this frequency.

Due to the curvature of the earth, transmission over great distances must be accomplished by

*(Continued on page 34)*

# Route Surveying

*by Peter Akmentins*

## INTRODUCTION

HIGHWAY construction dates back to 300 B.C. when the Romans felt that roads were a necessity to their far-flung military campaigns. They also felt that roads were needed as avenues of trade between Rome and other Countries. The roads constructed at this time were crude, especially since most of them were made out of stone blocks several feet thick. However, these crude roads were the forerunners of the modern highway.

The first surfaced highway in this country was the Lancaster Turnpike stretching from Lancaster to Philadelphia. In 1909 concrete first came into existence and since then concrete has become the leading material for high-type pavements on most highways.

With the development of concrete, highway construction has become more complicated and costly. Because of the great expense involved in constructing a highway, detailed planning has to be done before the actual construction.

## TYPES OF ROUTE SURVEYS

Route surveys are used for several important engineering structures. Among these are: location of highways, and railways; canals and aqueducts; pipe lines for sewage, oil and gas; cable ways, power, telephone, telegraph and transmission lines. In this article we are primarily interested in surveys applicable for highway location.

### Definition of Route Surveying

Route surveying includes all field work and acquiring of data (together with maps, profiles, and other drawings) involved in the planning and construction of any route of transportation. The word transportation not only refers to the transportation of persons but also to the movement of liquids, gases, and the transmission of power and messages. Among the important engineering structures included are: highways and railroads; aqueducts, and canals; pipe lines for water, sewage, oil and gas; cable ways and belt conveyors; power, telephone, and telegraph transmission lines.

Route surveying applies mainly to points a considerable distance apart. Therefore, the setting of a few telephone poles along a highway or reconstruction of a present road a few blocks long would scarcely fit the definition. The principal functions to be accomplished in route surveying are: (1) determining the best general route between the locations to be joined and (2) fixing the alignment, grades, and other details of the selected routes. Sound engineering principles require that the route be selected in such a way that the project may be constructed and operated with the greatest economy and utility.

### Highway Surveying

Highway surveying in itself is divided into two groups: (1) surveys made to establish new highways, and (2) surveys made to improve existing highways.

Surveys made to establish new highways are carried out in about the same manner as railroad surveys, the principal difference being the larger amount of space needed

*Peter Akmentins immigrated to this country from Germany in 1950. Born in Latvia, he and his parents left their homeland before the advancing Russian armies in 1945. From 1950 to 1957 when he moved to Madison, Peter lived in Appleton, Wis. Peter is married and has one daughter.*

**Garden-State Parkway. An excellent example of the problems met by the route surveyor.**

for road way, highway interchanges and overpasses. For this reason, establishment of a highway requires a wider topographic map than for a railway. Perhaps this is the reason why aerial survey methods rarely used by railroads, are replacing field reconnaissance, and even preliminary surveys on important new highway locations.

Topographic maps can be acquired from the United States Geological Survey, which in conjunction with the various states, has prepared such maps of the country. If the proposed road is studied from one of these maps, one survey may be all that is necessary. If the map cannot be obtained, a thorough study of the area should be made on foot or by airplane.

Aside from the use of aerial survey methods, the use of cross-sectioning is employed on new locations. These cross-sections, determined by cross-section leveling, are run along the proposed road at regular intervals. They are determined by cross-section leveling. The cross-sections, plotted to scale, aid in selecting grades and in designing drainage facilities.

The changes in existing highways usually involve widening of pavements, increasing the number of traffic lanes, reducing grades, and flattening curves to increase sight distance and safe speeds. Frequently, most of the old highway can be utilized, but minor relocation of the improved highway is often required. This is especially true when parts of the old highway cannot be improved without incurring excessive land damages to the surrounding property.

Surveys for relocation of old highways involve numerous modifications. The need for reconnaissance is simplified by reference to the original construction plans, tax maps, or aerial photographs. The preliminary survey is not required, with the locational survey run at once. Alignment closely approximating the final location can usually be selected from a study of the reconnaissance information. The important factor in improving on existing roads is to balance the earthwork quantities, dirt taken out from part of the road and used in some other spot to fill, so that the excavated material will be sufficient for all the fills, with no excess or deficiency. When existing highways are improved there is seldom an opportunity to dump waste or borrow material along the way.

### Railroad Surveys

As in highway location, the first step in railway location is a careful study of the best available maps, followed by field reconnaissance of the terrain between the proposed end locations. Aerial surveying methods supplement the other methods of field reconnaissance, and in many cases a route can be established from aerial photographs alone.

In remote regions that are inadequately mapped, and on projects for which aerial-surveying methods are not justified, ground reconnaissance may not definitely reveal the best possible route. In such a case it is wise to run a stadia traverse along each of the possible locations.

Needed measurements are made as rapidly as possible and with the required accuracy. Shots are taken with a transit on stations a considerable distance apart. Single deflection angles need be read no closer than the nearest 10 minutes. A few intermediate shots along the traverse line may be needed to give data for plotting a profile of the traverse.

The resulting maps, plotted by protractor and scale, really serve as high grade reconnaissance. Provided the work is well done, they permit the definite discard of certain routes and go toward fixing closely the best general route to be followed in the more precise preliminary survey.

### Transmission Line Surveys

The survey methods for the location of a transmission line are much the same as those used for highway location. However, the location of a transmission line is controlled less by topography than by the establishment of the most direct route from generating station to substation. Power loss due to voltage drop is proportional to the length of the conductor; consequently, when running high tension transmission lines, we are more concerned with finding the shortest route. Changes in direction are made by using towers and running the lines at an angle. A trunk telephone or telegraph line is usually located within the right-of-way of a highway or of a railroad, and in such case these lines follow the curves of the right-of-way. The precision employed in this survey is generally lower than that used for a roadway.

Although construction is cheapest in level country, lines may be run on fairly heavy grades to avoid changes in direction of the alignment or to avoid the unnecessarily heavy cost of obtaining right-of-way through someone's land. If at all possible the line should be located near a highway or railway; construction cost is reduced in this way, as is the cost of patrolling and maintenance.

### Surveys for Pressure Pipe Lines and Underground Conduits

Surveys for the location of long pressure pipe lines are almost as simple as those for transmision lines. But, since pressure pipe lines are usually located underground, greater attention is paid to foundation conditions, especially to avoid costly rock excavations and frequent stream crossings.

As in the case of transmission lines, right-of-way for a pressure pipe line usually takes the form of easements for its construction and operation. Aerial surveys are particularly useful in the location of long pipe lines. Sometimes, it is possible to determine the exact placement of these pipe lines from aerial photographs alone, thus saving the extra expense of ground surveying.

Surveys for underground conduits containing power lines on private right-of-way are placed in the same manner as pressure pipe lines.

Underground communication circuits are commonly placed in conduits located beneath the highway pavement. Access for maintenance is by means of manholes. Coaxial cables used for telephone, broadcast, and television circuits may be drawn through existing conduits. Sometimes, they are placed directly in a shallow ploughed trench beside the highway. In neither case is any extensive survey work required.

### Surveys for Canals

Surveys for hydraulic construction in which the flow is by gravity require very careful attention to elevations. Since relatively flat grades are used, surveys are identical with those for railroad location, the principal modifications being the use of a narrower strip of topography.

Canal routes are made as short as possible. Sometimes running through areas where access to ground-survey parties is impossible. Under such conditions use is made of aerial photography.

## WHAT DETERMINES A TYPICAL ROUTE

The type of engineering structure that is to be built between given termini will determine the location of the route. For example, the best location for a railroad would not necessarily be the most suitable one for a power-transmission line.

The type of terrain influences the characteristic pattern of a route location. Terrain is generally classified as level, rolling, or mountainous. In comparatively level regions the line may be straight for long distances, with minor deviations introduced to skirt watercourses or other important barriers. In rolling country the location pattern depends on the orientation of ridges and valleys with respect to the general direction of the route. Mountainous terrain presents the greatest problem to the locating engineer. In this type of region we have no simple pattern or basic set of rules to fit the situation.

Once the decision as to the type of route to be constructed has been made, certain steps are followed to build this route:

1. Reconnaissance survey of the entire area between the end points. This also includes the use of aerial photography.
2. Reconnaissance survey of all feasible route bands.
3. Preliminary survey of the best route. The best route is determined from the study of topographic maps, and a soil map.
4. Locational survey includes the placing of the highway on the ground. The highway is located on the ground by means of stakes, with great importance attached to basic factors of alignment and grade.
5. Construction survey is part of the locational survey but at this time the highway slope stakes are also set.

### Reconnaissance

Once we have decided to build a highway our next important decision is the selection of a general route between the termini. This is usually determined by reconnaissance.

Reconnaissance is made by walking, riding or flying. For reference, a contour map is used to guide the surveyor. The reconnaissance must not be of a line but rather of an area. The extent of the area depends on the type of project and the nature of the terrain; the area must be broad enough to cover all practicable routes joining the termini. Of particular importance is the need for guarding against the natural tendency to favor an obviously feasible location. It is possible that country which is covered with tangled undergrowth, or is otherwise rough for foot travel may hide a much better location than is available in more settled or open territory.

The information sought in exploration is: (1) The general features of the country, that is, the general position of rivers, streams, roads, trails, railroads, villages, valleys, summits of hills, gaps, or passes; (2) the geological features, the character and inclination of the strata, and the sources from which materials may be obtained for the construction of the proposed road.

The instruments employed in ground reconnaissance are the pocket compass, the aneroid barometer and hand level for obtaining approximate elevations; distances are estimated by eye or by the use of an engineers' transit with stadia. Sometimes if the character of the country is such that an ordinary reconnaissance will fail to give the desired information, the planetable and alidade are used. When the reconnaissance is made by airplane, aerial photographs of the ground are taken at intervals and, with the aid of some ground surveying to establish a few reference points, these photographs are combined so as to indicate clearly the topographic features of the country.

### Aerial Photography

Aerial photography in highway location is used as a supplement to the usual ground reconnaissance surveys. The advantage of aerial photography is that photographs can be made of the entire area, and from these photographs topographic maps can be made which will greatly aid in selecting the best route.

On a cost per mile basis, comparable maps made by ground survey methods rarely cost less, and usually cost much more than maps made from aerial photographs. Another point to remember is that maps compiled from ground surveys rarely cover as wide a strip of topography as those made by photography.

Aerial maps are made by having adjacent photographs overlap, approximately 30 per cent on the sides and 60 per cent in the direction of flight. This insures that the center in each photograph will appear in the adjacent picture taken in the line of flight. By properly orienting the overlapping photographs (stereopairs) and viewing them through a stereoscope, the process known as "stereoscopic fusion" takes place. In this process there is a vivid mental impression of the terrain in three dimension. In effect, two positions of the camera lens several thousand feet apart are substituted for the observer's eyes. The resulting picture discloses relative heights of hills and structures, depths of canyons, and slopes of terrain.

### Preliminary Survey

A preliminary survey follows the general route recommended in the reconnaissance report. The most important purpose of such a survey is to obtain the date for plotting an accurate topographic map of a strip of territory along one or more promising routes. This map serves as a basis for drawing the final alignment and profile. The data gathered in a preliminary survey permits the estimate of earthwork quantities and gives a close cost analysis.

Preliminary surveys differ greatly in method and precision. However, they consist of at least one traverse which serves as a framework for the topographical details. The instruments used in a preliminary survey are a compass, stadia, transit, and tape. Elevations along the traverse line are taken to existing physical features. Accurate contour lines may be needed, the requirements depending on the type of project.

### Proper Use of Topography

On new locations of highways, grades are particularly important. An accurate contour map is therefore very important. Relocation of an existing highway, on the other hand, may sometimes be made by revising the preliminary survey directly on the ground without the use of a contour map.

The primary purpose of the contour map is to serve as a basis for making a "paper location" of the final route. With the aid of such a map the engineer is able to scan a large area of ground at once and get himself acquainted with the general lay of the land. Furthermore, he is able to study various locations on the map in a small fraction of time. An added advantage of the contour map, provided it is extensive enough, is to supply visible evidence that no better route has been overlooked.

It is possible to put too much reliance upon map topography. Particularly to be avoided is the temptation to control the work from the office with only the contour map as a guide. It is well to remember that no contour map, no matter how accurate it may be, can take the place of actual field inspection. The main purpose of the contour map is to make semi-final location, which is to be further revised in minor detail during the location survey.

### Soil Surveys

Soil surveys reveal bedrock and other obstacles that would increase the expense of the highway. These surveys are also necessary to show the amount of material that is available for borrow, for subbase, or for concrete aggregates in a given location.

Soil investigations are normally carried out by the soil physicist or geologist. These men investigate the past geologic history of the area. From these studies, area soil maps are prepared which show the soil pattern, land forms, types of soil deposits, swamp areas, drainage conditions, and other related information.

The steps used in drawing a soil profile are as follows. Vertical sections of the subgrade are examined at suitable intervals and the depths and characteristics of the various layers of soil are determined and recorded. The distances between

*(Continued on page 34)*

# Fuel Injection For Your Car

*by James L. Wise me'61*

## INTRODUCTION

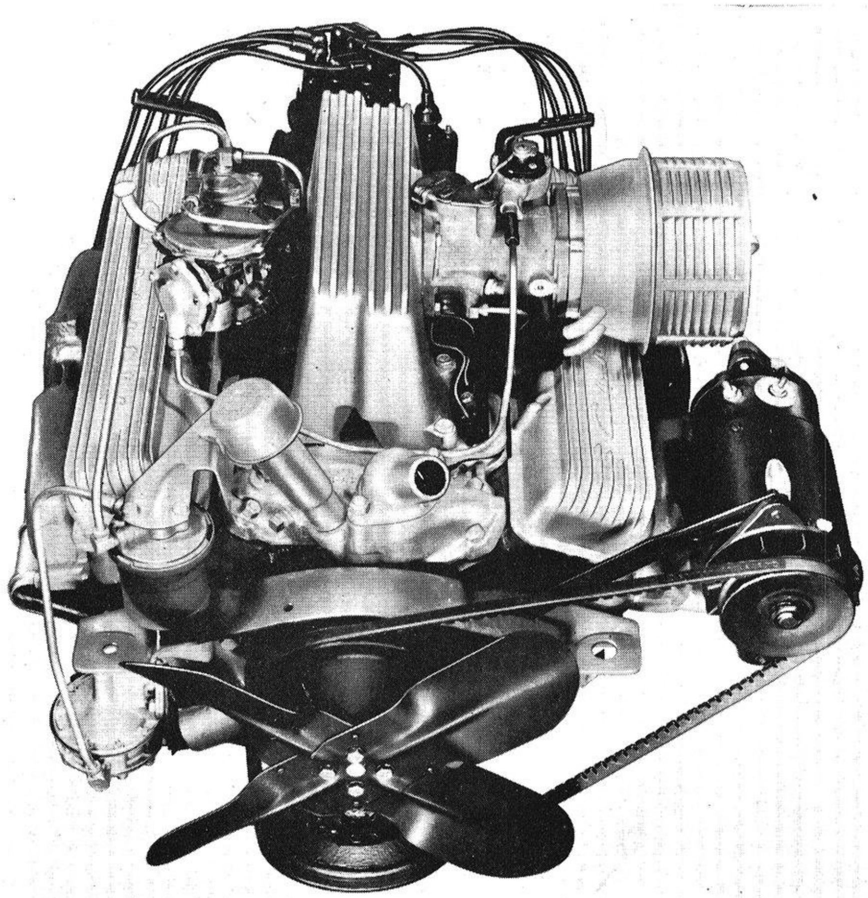
IN 1957, General Motors offered fuel injection as a power option on their passenger car and Corvette V-8's. Mercedes-Benz had been using fuel injection on their 300-SL for several years. These two adaptations of an old Diesel engine principle to gasoline engines set off a wave of interest in fuel injection for passenger cars. At the present time, due to high cost, fuel injection is thought of as a high performance racing car accessory; but, with continued research in the field, it may well be the system of fuel metering used on all the cars of the future.

The basic job of the fuel system on an automobile is changing a liquid fuel into an explosive mixture of fuel vapor and air. Nearly all of our American automobiles accomplish this in a system, where the fuel and air for all cylinders is mixed at one central point, the carburetor. Fuel injection is an alternate system, using the principle used on Diesel engines; that is, the fuel is mixed with air in or very near the individual cylinders.

## PROS AND CONS OF FUEL INJECTION

Fuel injection has many advantages over the conventional carburetor system. These include more power and better economy.

Greater volumetric efficiency is possible in an engine equipped with fuel injection for a number of reasons. The manifold no longer has to be heated because evaporation of the fuel take place in or near the combustion chamber instead of in the manifold. Manifolds are designed with a freer air flow because they carry only air, instead of air and fuel. The restriction due to the carburetor venturi is elimi-



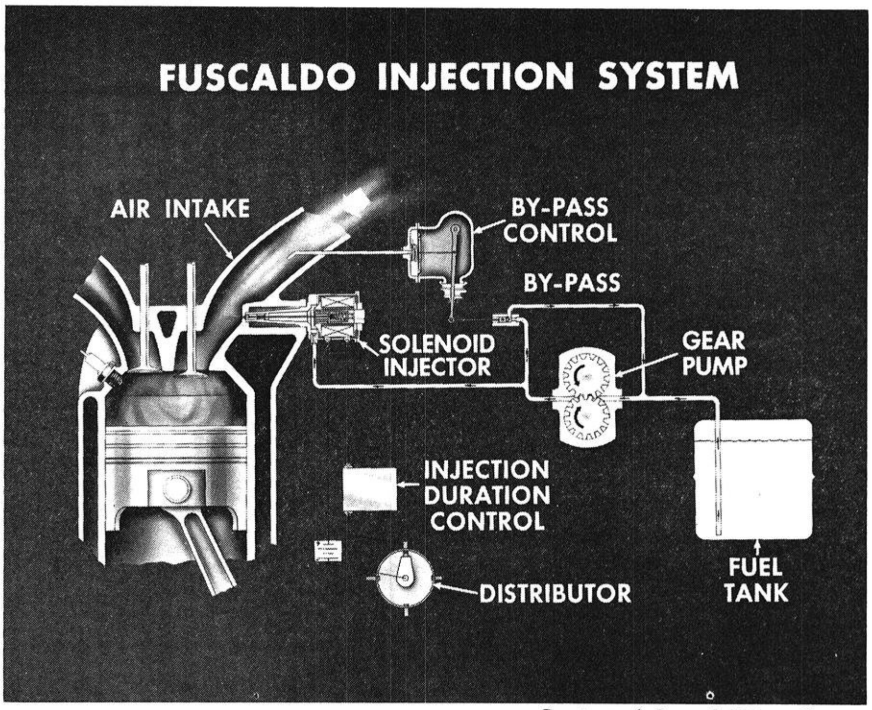
—Courtesy Chevrolet Motor Division

A 1956 Chevrolet V-8 engine with the initial Chevrolet fuel injection system.

nated. This increased volumetric efficiency increases both power and economy. Power is increased because more working substance goes through the system per cycle. The economy increase is due to a greater mechanical efficiency which is in turn due to the increased volumetric efficiency.

Fuel distribution is also superior on a fuel injection equipped engine because all of the problems of delivering the fuel-air mixture from the carburetor to the cylinders are eliminated by mixing the fuel at each cylinder. With the carburetor each cylinder receives a mixture different from that of every other cylinder. The richness of the fuel depends on the distance from the cylinder to the carburetor. The cylinders farthest away receive the leanest mixture. Fuel injection allows a constant distance between each cylinder and its injector.

This improved fuel distribution also tends to give better engine performance. Power is increased by permitting all the cylinders to run at the best air-fuel ratio. Economy is increased by preventing an over-inch ratio in some cylinders. Also, a leaner average fuel-air ratio can be used without rough idling. In addition to these advantages, throttle icing is eliminated because the fuel is introduced behind the throttle. The delays inherent with a carburetor are also avoided by mixing the fuel and air closer to the point of combustion. Complete correction for changing conditions such as climate and altitude is possible; and, many advantageous changes in engine design are possible with fuel injection.



—Courtesy of General Motors Corp.

An early injection system using electronic control.

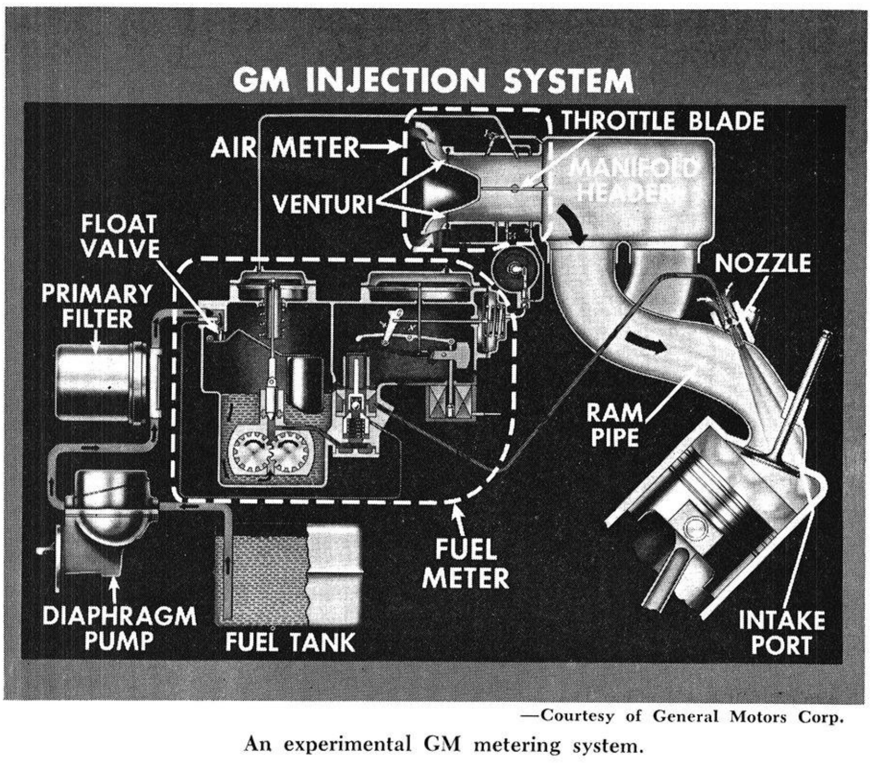
### Disadvantages of Fuel Injection

Along with these numerous advantages go some disadvantages. These are higher cost, greater sensitivity, more difficult and costly servicing, and reduced reliability.

Because of the complexity of fuel injection systems, even the simplest injection system will be more expensive than a simple carburetor. However, when produced in similar quantities, injection would be able to compete in price with some of the carburetor combinations which are used on our cars today. At any rate, injection will give better performance than any carburetor, so that in commercial applications, this gain must be weighed against the increase in first cost. Fuel injection systems, due to their complicated controls and mechanisms, and close tolerance, are very sensitive, particularly to dirt. This sensitivity can be taken care of by protection of the components and filtration of the fuel. The cost of this must, also, be charged against the system.

Obviously, a more complex mechanism is more costly to service. But, diesel equipment of a similar nature indicates that gasoline injection will give very little occasion for servicing, provided dirt is kept out of the system. Fuel injection is less reliable in the sense that failure of a component is likely to make the system, and thereby the engine, inoperable,

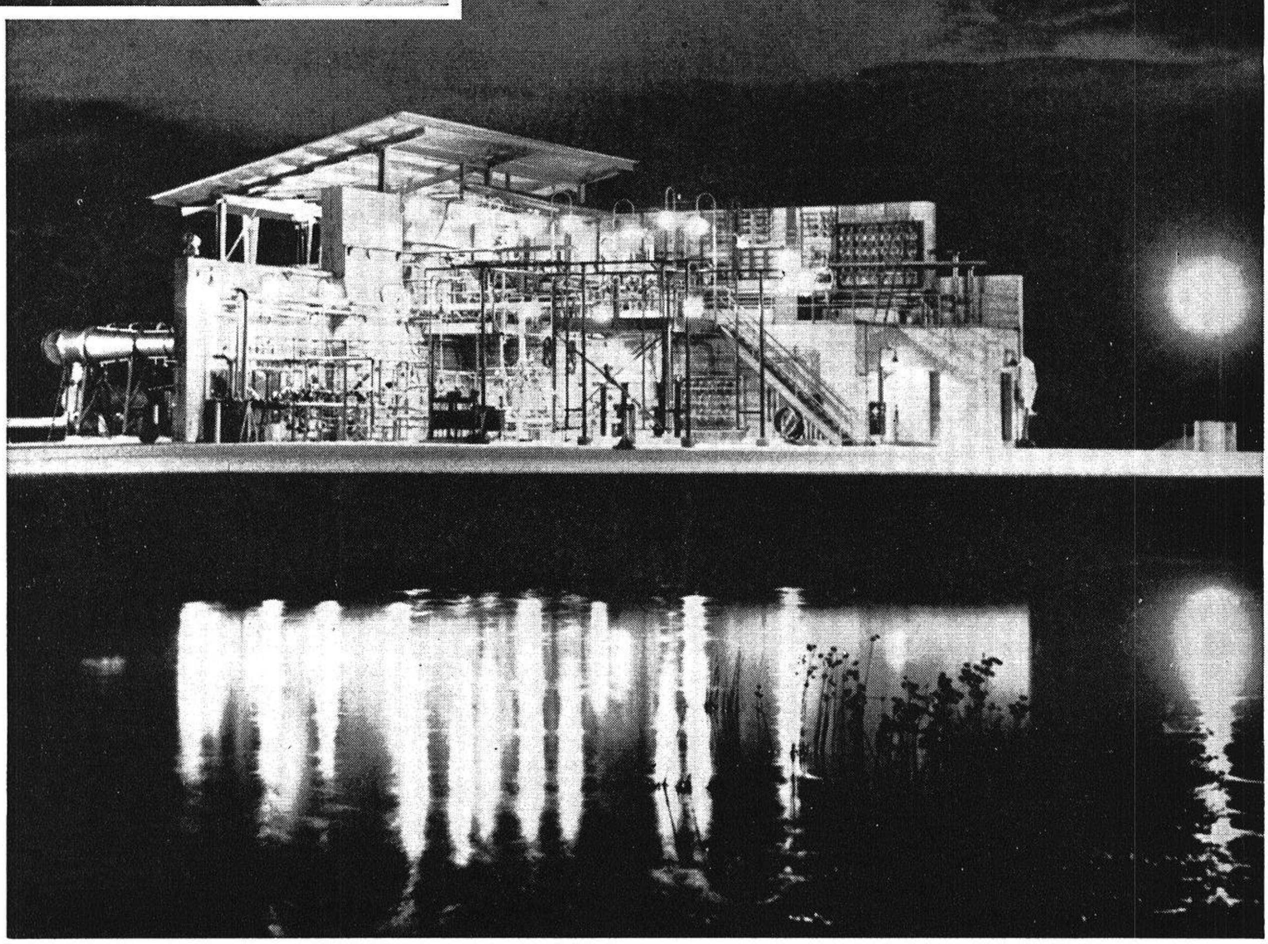
(Continued on page 22)



—Courtesy of General Motors Corp.

An experimental GM metering system.

# What would *YOU* do as an engineer a



Development testing of liquid hydrogen-fueled rockets is carried out in specially built test stands like this at Pratt & Whitney Aircraft's Florida Research and Development Center. Every phase of an experimental engine test may be controlled by engineers from a remote blockhouse (inset), with closed-circuit television providing a means for visual observation.

# Pratt & Whitney Aircraft?

Regardless of your specialty, you would work in a favorable engineering atmosphere.

Back in 1925, when Pratt & Whitney Aircraft was designing and developing the first of its family of history-making powerplants, an attitude was born—a recognition that *engineering excellence* was the key to success.

That attitude, that recognition of the prime importance of technical superiority is still predominant at P&WA today.

The field, of course, is broader now, the challenge greater. No longer are the company's requirements confined to graduates with degrees in mechanical and aeronautical engineering. Pratt & Whitney Aircraft today is concerned with the development of all forms of flight propulsion systems for the aerospace medium—air breathing, rocket, nuclear and other advanced types. Some are entirely new in concept. To carry out analytical, design, experimental or materials engineering assignments, men with degrees in mechanical, aeronautical, electrical, chemical and nuclear engineering are needed, along with those holding degrees in physics, chemistry and metallurgy.

Specifically, what would *you* do?—*your own engineering talent* provides the best answer. And Pratt & Whitney Aircraft provides the atmosphere in which that talent can flourish.

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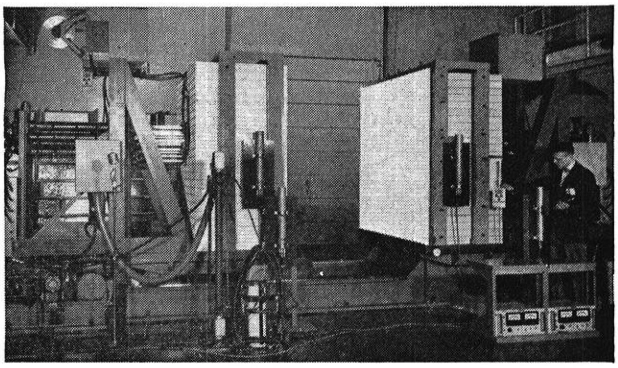
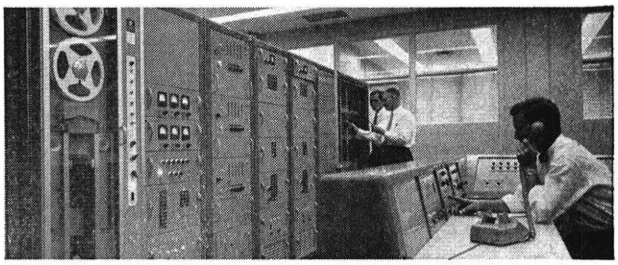
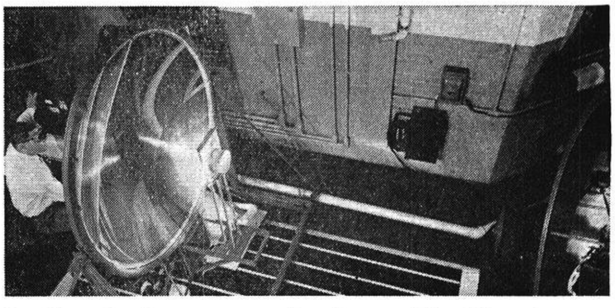
For further information regarding an engineering career at Pratt & Whitney Aircraft, consult your college placement officer or write to Mr. R. P. Azinger, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.



At P&WA's Connecticut Aircraft Nuclear Engine Laboratory (CANEL) many technical talents are focused on the development of nuclear propulsion systems for future air and space vehicles. With this live mock-up of a reactor, nuclear scientists and engineers can determine critical mass, material reactivity coefficients, control effectiveness and other reactor parameters.



Representative of electronic aids functioning for P&WA engineers is this on-site data recording center which can provide automatically recorded and computed data simultaneously with the testing of an engine. This equipment is capable of recording 1,200 different values per second.



Studies of solar energy collection and liquid and vapor power cycles typify P&WA's research in advanced space auxiliary power systems. Analytical and Experimental Engineers work together in such programs to establish and test basic concepts.

**PRATT & WHITNEY AIRCRAFT**

Division of United Aircraft Corporation

**CONNECTICUT OPERATIONS — East Hartford**

**FLORIDA RESEARCH AND DEVELOPMENT CENTER — Palm Beach County, Florida**

rather than merely producing less than optimum performance.

The advantages obviously outweigh all the disadvantages, except cost. All the other disadvantages can be eliminated or greatly reduced by good design. The costs of fuel injection, and thus its acceptance, will depend upon the number built and the advancements made in the field.

A good fuel system accomplishes the following things: it provides the basic fuel-air mixture; enriches the mixture for starting; maintains the enriched mixture until the engine is warmed up; provides the correct mixture for hot starting; provides for changing conditions; and cuts off the fuel supply during coasting. The basic fuel-air mixture, used during normal running, should not vary with changes in engine loading. However, since at low temperatures only the lighter components of the fuel are vaporized, a cold engine requires a richer mixture to compensate for this poor evaporation. This enriched mixture should be maintained until the engine is warm. With fuel injection warm-up time is much shorter than with carburetion, because the points at which the fuel is injected, being much closer to the source of heat than a carburetor would be, heat up to the required temperature much more quickly.

### Altitude and Temperature Compensation

For the majority of drivers altitude change is rarely a problem, but a change in atmospheric pressure is with us constantly. Because lower atmospheric pressures will reduce the amount of air entering the engine during an intake stroke, the fuel rate must be adjusted to prevent over-richness. Likewise, the amount of air entering an engine varies with the temperature of the air. This must also be accounted for in the fuel rate. Finally, while the engine is coasting the fuel supply must be shut off to prevent waste and allow the engine to a braking effect.

## FUEL INJECTION SYSTEMS

All fuel injection systems fall into two general categories—continuous flow and timed flow. Continuous flow injection supplies fuel to the air flow at all times.

The fuel supply to the air stream at each cylinder is varied only to maintain the basic fuel-air mixture, and provide the special requirements of the engine. The fuel and air for the intake stroke is being supplied during the compression, power and exhaust strokes that precede it as well as during the intake stroke. (See Fig. 1) This presents a problem in that fuel being supplied to one cylinder while the intake valve is closed is often robbed by an adjacent cylinder whose intake stroke is taking place. The problem is solved in practice by using long pipes to supply air to the cylinders, preventing fuel and air from transferring from one cylinder to another. These pipes can be used to further advantage when they are ram tuned for better volumetric efficiency.

Timed flow injection, on the other hand, supplies fuel to each cylinder only on the intake stroke. (See Fig. 2) With timed flow injection, there is no problem of fuel transfer between adjacent cylinders. Of course, long pipes can be used for ram tuning this system also.

## MIXTURE CONTROL

In every fuel system, engine speed is controlled by regulating the amount of air that is allowed to enter the engine. This is accomplished by the throttle valve in the intake manifold, which is controlled by a footfeed. The basic problem is then to mix the fuel and air in the right proportions.

There are two mixture control systems in use with fuel injection at the present time, the mass airflow system and the engine speed-air density system. The mass airflow control system, used on the continuous flow injection system, utilizes a venturi in the air stream to meter the fuel. The venturi measures the volume of air that enters the engine. By adjusting this valve for pressure and temperature, the weight of air entering the engine is obtained. Fuel supplied is a function of the weight of air entering, thus providing the proper basic air-fuel ratio.

In the engine speed-air density control system, the fuel supplied to the cylinders is a function of the engine speed and the density of the air entering the engine. The fuel pump speed varies with engine speed while fuel output per stroke is a function of air density, of manifold pressure and of temperature. With either system the requirements mentioned previously are met by further adjusting the basic fuel-air mixture according to operating conditions.

## COMMERCIAL SYSTEMS AVAILABLE

With some of the principles of operation established, a look at several commercial systems presently on the market is in order. The only components mentioned will be those which must be understood to understand the system.

General Motors Ramjet fuel injection, offered on Chevrolet Corvette V-8 engines, is unique in that it is the only continuous flow injection system in use on automobiles today. General Motors claims that it accurately controls the fuel-air ratio to each cylinder, with rapid accelerator response and smooth running. In this system, the accelerator controls the volume of air which enters the engine. A venturi measures the weight of air, by measuring the volume and correcting this for pressure and temperature. Then the correct amount of fuel to provide the proper fuel-air mixture for the existing conditions is injected into the air stream at each cylinder, immediately before the air enters the intake port.

The system can be better understood by tracing the fuel and air routes. The fuel is pumped from the gas tank by an engine-driven, constant output-per-stroke pump to a fuel reservoir. The level of the fuel in this reservoir is maintained by a float. Submerged in the reservoir, is a small, high pressure, engine driven pump that pumps the fuel to a metering chamber, from which it can go to the injection nozzles or back to the reservoir, depending on the needs of the engine. The air goes through an air filter into the metering chamber which contains the fuel controlling venturi. Volume measurements from the venturi are converted to weight measurements. It is this quantity that determines how much fuel is pumped from the metering chamber to the nozzles and how much is returned to the fuel reservoir. From the controlling venturi, the air goes through the intake manifold to the combustion chamber. The intake manifold has long, ram tuned pipes leading to the combustion chambers to prevent fuel transfer between adjacent cylinders.

The American Bosch fuel injection system is a timed flow, engine speed-air density controlled fuel injection system. It uses port injection from a multiple unit pump. The major components of the system are: a multiple unit injection pump and control, a constant output supply pump, and a mixture control. The injector pump, driven off the distributor shaft, supplies fuel to all the cylinders and therefore runs at half engine speed. Thus the engine speed part of the control system is taken care of. The pump itself is a plunger, driven by an eight-lobe face-cam. A metering sleeve is attached to the plunger. The plunger pumps the same amount of fuel on each stroke, but the metering sleeve allows some of the fuel to return to the pump before the plunger starts pumping to the injectors. Thus, the start of fuel flow to the cylinders is varied according to the setting of the metering sleeve, which is in turn controlled by the injector pump control. The same plunger and metering sleeve feed each cylinder by rotating within the pump housing.

The injection pump control, which positions the metering sleeve, is mounted on the injection pump. It consists of a piston in a cylinder, the piston biased against control pressure by a spring. At high control pressure, which corresponds to low manifold vacuum (full throttle), the spring is compressed, and the piston positions the metering sleeve at full fuel position. As the engine speed increases, manifold vacuum increases, and the spring exerts enough force to decrease the fuel supply. A second spring counter-balances the first spring at very high manifold vacuum to prevent complete shutoff. Control pressure is provided to the injection pump control by the mixture control. This is nothing more than a device to modify the manifold pressure during cold starting and warm-up. Other than that, manifold pressure is used as control pressure without modification. Fuel is supplied to the injection pump by an electrically driven gear pump. A check valve prevents fuel pressure decay when the engine is stopped.

The Bendix Electrojector system, as indicated by its name, is an electronically controlled and electrically actuated fuel injection system. It has timed intake port injection from a common rail fuel system, and it employs controls responsive to intake manifold pressure, engine speed, air pressure, and temperature. The fuel flow through this system is relatively simple. An electric non-metering pump supplies fuel from the fuel tank to the injector valves—one at each cylinder.

The control unit is the heart of this system. Control begins with a sandwich type unit that is added to the distributor, between the base of the distributor and the standard cap. This unit consists of a triggering selector unit and rotor. In the selector unit, there is a set of breaker points and a commutator, with a section of the commutator for each injector valve. The breaker points are operated by the standard distributor cam. Thus, for every two engine revolutions, as many impulses as there are cylinders have been sent out.

The impulses go to an electronic modulator control, where through a transistorized circuit, the impulses are changed to pulses of standard width. Simultaneously, signals indicating engine conditions are being received by the electronic modulator control from sensing units located in various parts of the engine. By integrating these external sensing signals into the standard pulse-width circuit of the electronic control system, the standard pulse-width is modified to reflect engine conditions. These pulses are then sent to the cylinders which are ready to receive fuel.

The injector valve is opened by a solenoid, which is in turn actuated by the pulse from the electronic control modulator. Thus, the length of the pulse which has been modified to reflect engine conditions—starting, accelerating and coasting, determines how long the fuel should be admitted to the intake port. In this system, like the previous two, the fuel is sprayed at the intake port.

### Robert Bosch Fuel Injection

The Robert Bosch Fuel Injection system is a timed flow, engine speed-air density controlled fuel injection system. The feature that makes this injection system unique is injection directly into the combustion chamber, instead of into the intake port. A multiple unit pump, having a pumping element for each cylinder, is used to pump the fuel. Each element consists of a plunger of constant stroke in a close fitting barrel. The plungers are driven by an eccentric shaft which is controlled by a diaphram that senses manifold conditions. Thus, engine speed and air density control the unit. The diphram turns the plungers, and rotation controls the length of time the plunger pumps fuel to the injectors during its stroke. This injection system is used on the Mercedes-Benz 300 SL with considerable success.

## CONCLUSION

Of the four systems presented here, the cheapest is the General Motors fuel injection, and the most expensive is the Robert Bosch system. This is because cost rises with complexity. The General Motors system uses a simple metering system and port injection, while the Robert Bosch injection system uses both a more expensive timed metering system and very costly direct cylinder injection.

The other two systems run about the same price, with the Bendix system slightly higher because of the electronic equipment which it uses.

All of these systems are relatively new, and have "bugs" that must be worked out. The problems of reliability and sensitivity to dirt must be solved before fuel injection will be mass produced. Then, and only then, will it reach a price level where every car can be equipped. If these problems can be solved some day fuel injection will be universally used.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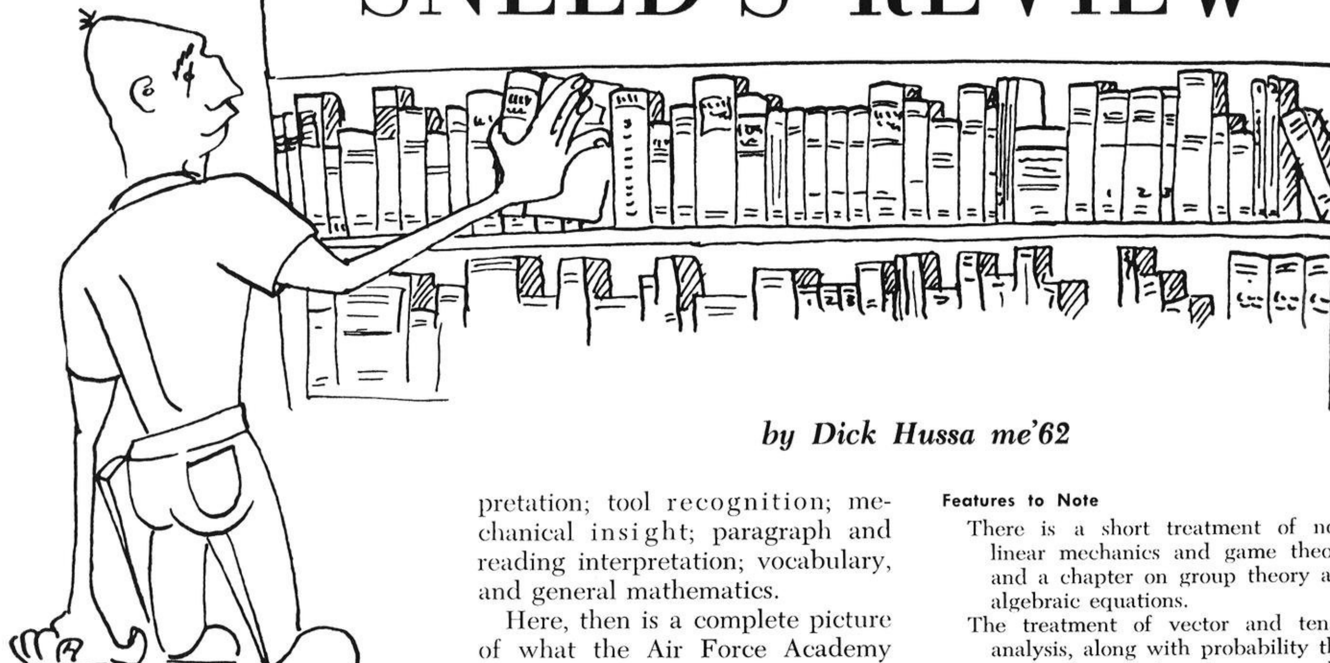
# SNEED'S REVIEW



*by Dick Hussa me'62*

### HOW TO QUALIFY FOR THE UNITED STATES AIR FORCE ACADEMY

**212 pages. $3.00**

For the military-minded young man the new book—"How to Qualify For United States Air Force Academy"—is an absolute necessity if he chooses to cast his lot with the air power of the future. Here, under one cover, is the necessary study material for hopefuls to the nation's newest military college.

All entrance requirements and sample questions from the entrance exam are fully explained. This includes the procedures for making application and physical qualifications. The written examination is outlined as to subject matter and methods of questioning.

Study material for the written examination is presented in chapter form, each chapter covering the subjects which the candidate will encounter on the entrance test. Included here is preparation for general science quizzes and general background tests; aviation mathematics; spatial orientation and relations tests; the College Entrance Examination Board test (which is an integral part of the Air Force Academy test); lessons in judgment; graph, chart and table interpretation; tool recognition; mechanical insight; paragraph and reading interpretation; vocabulary, and general mathematics.

Here, then is a complete picture of what the Air Force Academy expects of its applicants, with instruction material patterned on the examination as announced by the Air Force Department.

### ELEMENTS OF PURE AND APPLIED MATHEMATICS

**Harry Lass**

**491 pages. $7.50**

Of great interest is the book "Elements of Pure and Applied Mathematics" by Harry Lass, Professor in the Electrical Engineering Department at the University of Southern California and Research Specialist in the Jet Propulsion Laboratory of the California Institute of Technology.

Containing a more rigorous treatment of individual topics than is found in the majority of applied mathematics texts, this work is a valuable reference book for all readers and an excellent text for upper-division undergraduate courses for physical science, engineering, and math majors.

The book provides a thorough treatment of the various subjects in classical mathematics which are most useful to the engineer and physicist. It covers and illuminates most of the subjects that an undergraduate math major will encounter in his course work, and gives him an exceptionally good preparation for the use of applied mathematics.

**Features to Note**

There is a short treatment of non-linear mechanics and game theory, and a chapter on group theory and algebraic equations.

The treatment of vector and tensor analysis, along with probability theory and statistics, is unusually complete.

The handling of orthogonal polynomials is unique in such a book.

The material has been so written that each chapter is independent of the others although many cross references tend to unify the subjects at hand.

A considerable number of examples are worked out in detail, and problems follow each section.

Extensive bibliographies follow each chapter.

*From the Author's Preface:* "This book is not meant to be a compendium of formulas. The discriminating reader should enjoy the rigor of analysis which is missing from most applied-mathematics texts. On the other hand, the reader who is chiefly interested in obtaining a cursory knowledge of the material will find that the text contains most of the elementary topics found in existing applied-mathematics texts."

### THE JAGUAR GUIDE

**John Bently**

**127 pages. $2.75**

John Bentley's outstanding new book, "The Jaguar Guide", is a must for every owner and would-be owner of one of the world's finest sports cars. This extraordinary manual is a true guide in every sense of the word for "Jag" owners, but it also is excellent reading for

*(Continued on page 34)*


# "IT'S HERE—IF YOU WANT TO WORK FOR IT"

Even before Ron Spetrino received his engineering degree from Case he had good job offers from six companies.

He joined The Ohio Bell Telephone Company—his reason: "I was convinced an engineer could go further here—if he was willing to work for it."

As soon as Ron got his feet on the ground in telephone engineering, he was tapped for a tough assignment. The job—to engineer switching equipment modifications needed to prepare Cleveland for nationwide customer dialing of long distance calls.

Ron wrapped it up in five months, and found he had earned a shot at another tough assignment. In this job Ron helped engineer a completely new long distance switching center for Cleveland. This switching center connected Cleveland with the nationwide customer dialing network. It was about a year later that Ron put the finishing touches on the specs for this $1,600,000 project.

Today, as a Supervising Engineer, Ron heads a staff of five engineers and is responsible for telephone switching in much of the greater Cleveland area.

He supervises the design and purchase of $3 million worth of equipment a year. And even more important, he is charged with developing the technical and managerial skills of his staff.

Ron knows what he's talking about when he says, "In this business you have to do more than a good job. We expect a man to be a self-developer. We expect him to take responsibility from his first day on the job and think for himself. You don't get ahead around here by just doing time."

*If you want a job in which you're given every chance to prove yourself, and real responsibility right from the start—you'll want to see your Placement Office for further information.*

*"Our number one aim is to have in all management jobs the most vital, intelligent, positive and imaginative men we can possibly find."*

FREDERICK R. KAPPEL, *President*
American Telephone & Telegraph Co.

BELL TELEPHONE COMPANIES

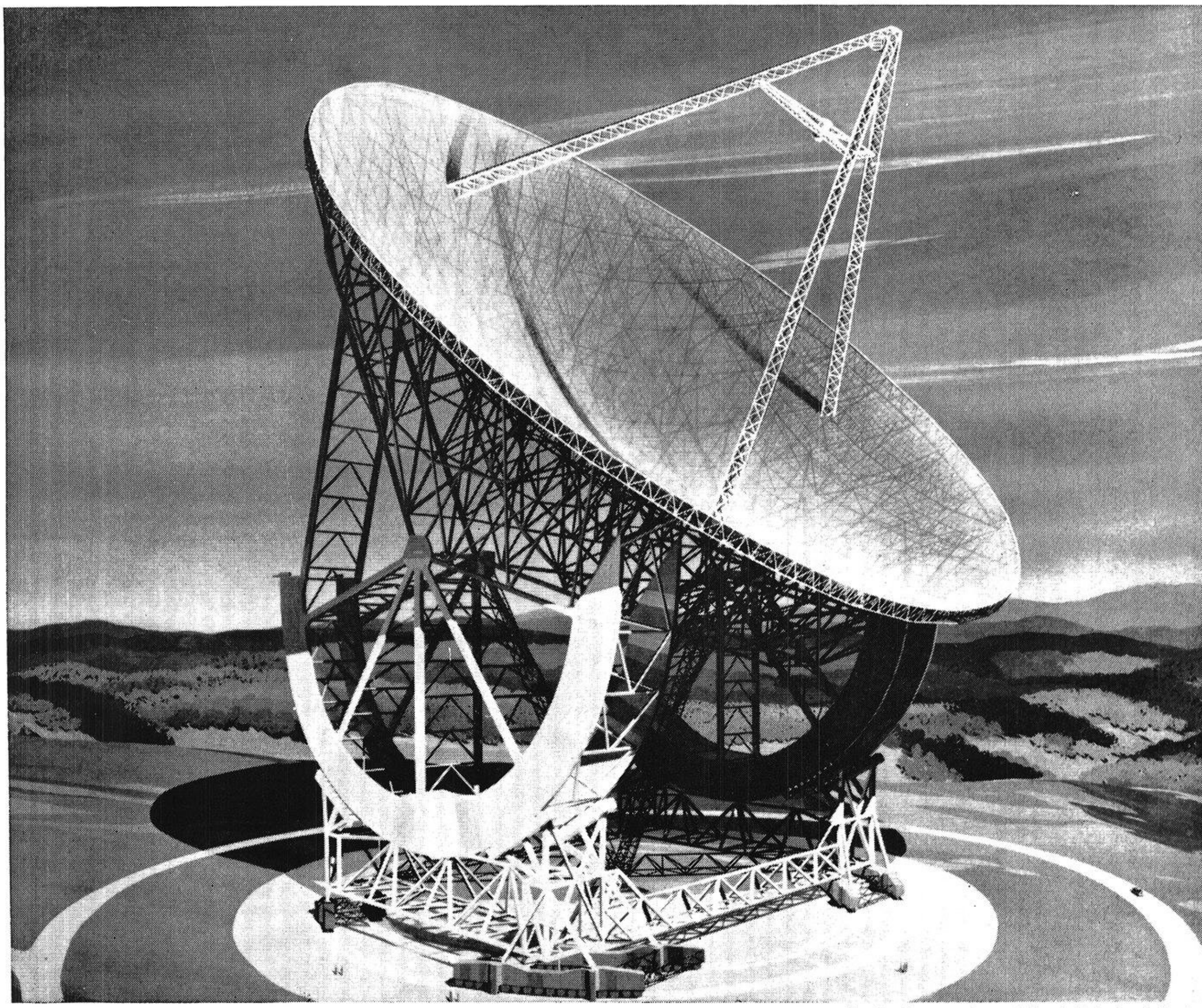


*Illustration courtesy of Grad, Urbahn & Seelye.*

# Girl of the Month

## JULIET STARK

These pictures were taken while an Lp "Bongos and Brass" was playing, for Julie's stereo is playing almost continually. Besides liking music she enjoys swimming, walking, and talking.

Often work on her masters degree in English is briefly put aside for a cup of coffee. Julie claims a cup of coffee is the best way to start and end a day. We wonder if she would like some company.

One sure bet—when she starts to teach English the photographer will be attending classes.

# SCIENCE HIGHLIGHTS

*by Dave Cress me'63*

### IMPROVED CIRCUIT BOARDS

Capacity is measured 10 times more accurately than before with new capacitor test and storage circuit boards developed by Corning Electronic Components.

The boards are used in the reliability research and development program for the Minuteman missile guidance and control systems. The program is conducted by Autonetics, a division of North American Aviation, Inc.

Difference between the old and new boards lies in a sophisticated wiring design and use of a unique material.

A fiberglass-epoxy board with a two-terminal wiring design was used originally. Meaningful measurements were prevented by stray capacitance and variable insulation resistance that often masked capacitor IR.

Then Corning engineers worked out a three-terminal shielded circuit design and utilized the company's Fotoceram glass-ceramic.

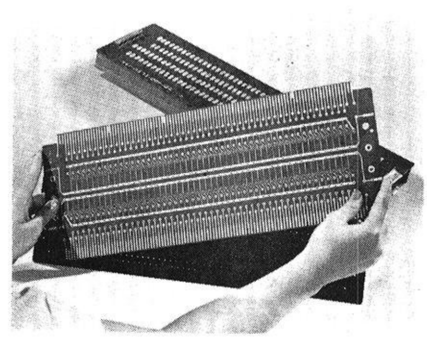
Besides the 10-to-1 improvement in capacity measuring accuracy, the combination allowed meaningful measurements down nearly to the level of capacitor IR and .05 per cent of dissipation factor.

An unmetallized Fotoceram upper board in each circuit board assembly carries 200 Corning fusion-sealed capacitors for Minuteman. Leads extend through it to a Fotoceram lower board, which carries the circuit pattern. The assembly allows rapid and repetitive measurements, convenient identification of capacitors, which are inventoried individually throughout their life, and efficient handling and shipping.

After testing, Autonetics removes the lower boards and returns them to Corning for re-use. The capacitors are stored on the top boards until installed in the missile systems.

Hole patterns in Fotoceram, which is derived from photosensitive glass, are obtained by chemical machining. Metallized areas can be subjected to soldering more than 50 times without damage. An additional advantage of the material in this use is that it is less glossy than fiberglass-epoxy.

Size of the bottom board is $6\frac{1}{2}$-x-$17\frac{1}{2}$-x-.070-inch. The top board is an inch narrower. Manufactured in the thousands, the boards are the largest Fotoceram articles made by Corning.



**Improved circuit boards used in Minuteman missiles.**

### WESTINGHOUSE PROPOSES ROLLER ROADS AS NEW HIGH-SPEED HIGHWAY CONCEPT

Under a new concept for mass transportation put forward by Westinghouse Electric Corporation, a high-speed electrically driven system of "Roller Roads" would transport groups of automobiles and their occupants at speeds up to 150 miles per hour or commuters at speeds up to 75 miles per hour. In this conception advanced by Westinghouse engineers Charles Kerr, Jr. and Clarence Lynn, the roadway would consist of a series of rubber rollers spaced approximately 20 feet apart to resemble inverted roller skates. Powered by individual motors, these rollers would both support and propel the flat-bottomed carriers in which automobiles and passengers would travel.

Commenting on the proposal, Westinghouse vice president, said the Roller Road has potential for solving problems of highway traffic congestion and metropolitan rapid transit service in the near future. A further comment was that the new concept would provide more reliability and safety than any proposal Westinghouse has seen for solving the country's very complex transportation problems.

In an address on January 10 before the 40th annual meeting of the highway research board of the National Academy of Sciences in Washington, D.C., General Motors' vice president and director of research, mentioned the Roller Road as one of several promising approaches for solving interurban transportation problems.

Mr. Kerr and Mr. Lynn said the need for a new concept was suggested by their belief that conventional methods of intercity turnpike travel will be inadequate when our present 61,000,000 automobiles exceeds the 100,000,000 mark expected in the 1970's. In examining ways in which new highway systems might be constructed, Mr. Kerr reported that airborne conveyances, monorails, electrified trains, self-propelled trains and other concepts were considered, but that only one seems to offer the best chance of providing the extreme reliability needed without sacrifice in other essential requirements.

In essentials, the new concept was described by Mr. Kerr as follows:

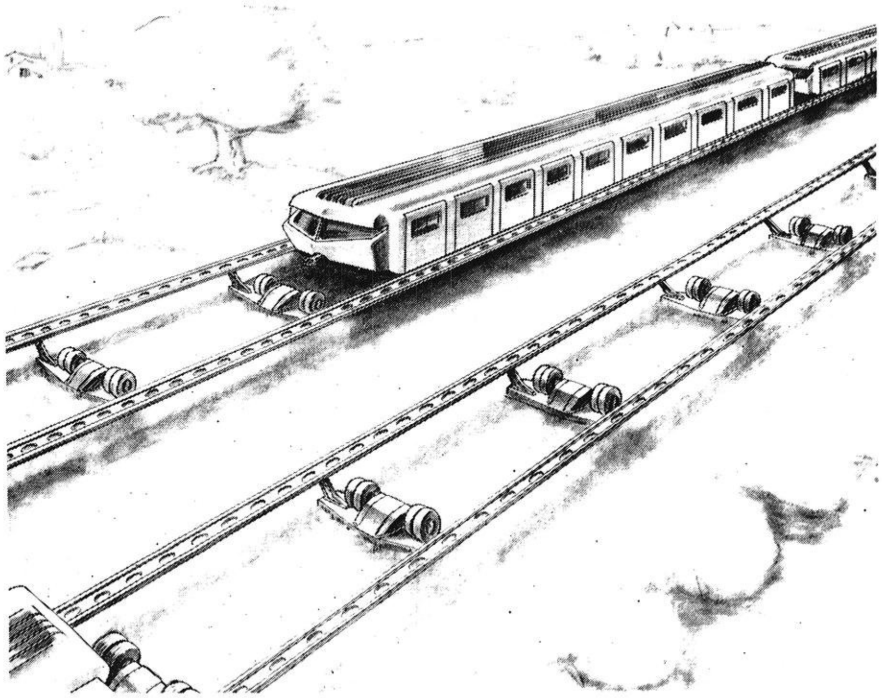
1. The conveyances which carry automobiles will be devoid of all apparatus whose failure might cause a highway shutdown or delay.

2. Each lane of the highway will be a continuous, computer-controlled system of individually powered rollers, receiving electric energy from neighboring interconnected electric utility systems. This roller system will not only be the highway surface, but will accelerate the conveyances, keep them moving once accelerated, and provide braking power at proper locations.

3. The conveyances will be stopped at fixed stations where the automobiles will be loaded and unloaded automatically to achieve uniform loading in minimum time.

Each carrier would be approximately 110 feet long. Provision would be made for 10 automobiles plus a lounge with rest room facilities.

The carriers would be operated in strings of 3 to 10 units under normal conditions. The only factor limiting the number of carriers would be the length of the loading platforms.



—Courtesy of Westinghouse

**A new concept in mass transportation is this high-speed electric highway system called Roller Road.**

Guide wheels operating against the rails at either side of the Roller Road would steer the carriers along the rollers. As the only rotating devices on the carriers, these wheels could also be used to power generators to supply light and heat inside the carriers.

Mr. Lynn said the drive package for each roller would consist of a three-phase induction motor, a torque converter, a brake, and a reduction gear. The time required for a 1100-foot string of 10 carriers to pass over a given roller at 150 mph is about 5 seconds, Mr. Lynn said. Consequently these motors would work for five seconds and then would idle until the next conveyance came along. The motors thus could be heavily overloaded for short peak intervals, greatly reducing their size. The mechanical brake would be included on each roller, to provide for emergency stops anywhere along the highway.

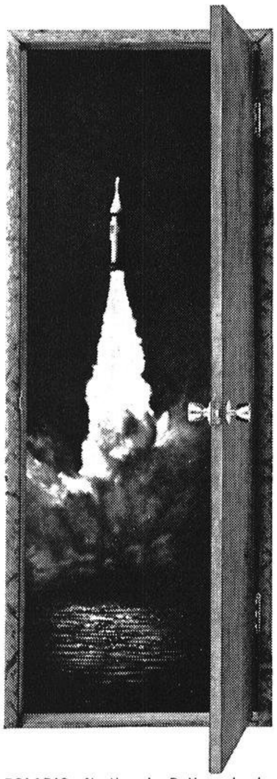
Mr. Lynn said a loading and unloading time of one minute was set as a goal in order to maintain an average speed of 120 miles per hour over the highways. Drivers intending to board a carrier would place their cars on dollies at platforms adjacent to the highway. This would be the last action required of the driver until he and his car were automatically unloaded at his destination.

Computer-controlled lights would indicate to a driver which spaces were empty on the approaching carrier. When the carriers stop, automatic devices attached to the station platform raise the proper doors on each side of the carriers. With the doors raised, a mechanical device would push the dolly and the car onto the carrier. The corresponding dolly on the carrier, whether or not it carries an automobile, is pushed off the carrier on to the other side of the platform.

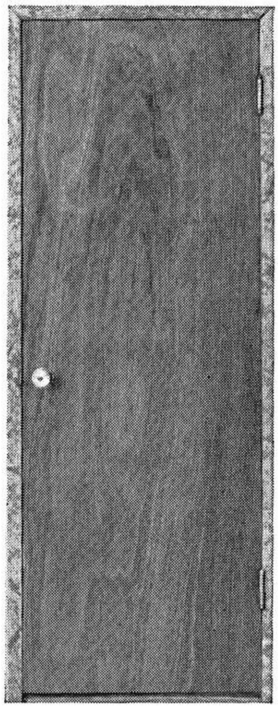
Consideration was given to the possibility of people driving automobiles on and off the carriers, Mr. Kerr said, but was discarded because of the uncertainties of human behavior The computer control for the system could dispatch strings of carriers at proper intervals; provide protection against rear-end collisions should any string of carriers be stopped; control the automatic loading and unloading at stations.

Mr. Kerr pointed out that "the

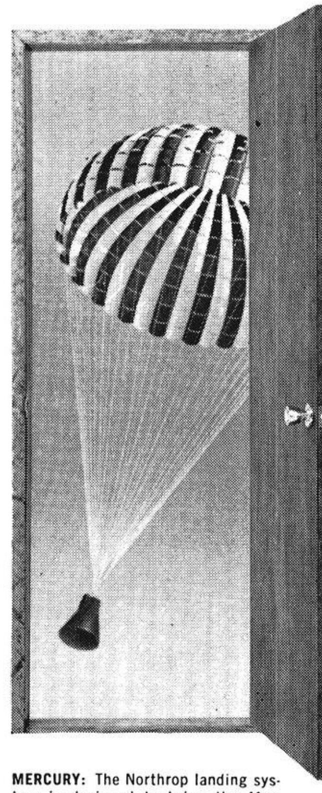
(*Continued on page 36*)



**POLARIS:** Northrop's Datico checks out Polaris at all levels of maintenance and operation.



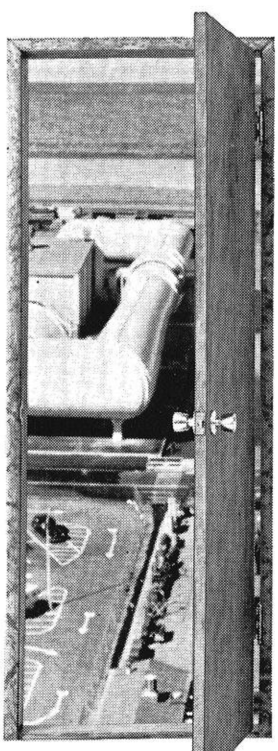
**SKYBOLT:** Guidance and navigation systems are being developed by Northrop for this new and highly secret air-launched ballistic missile.



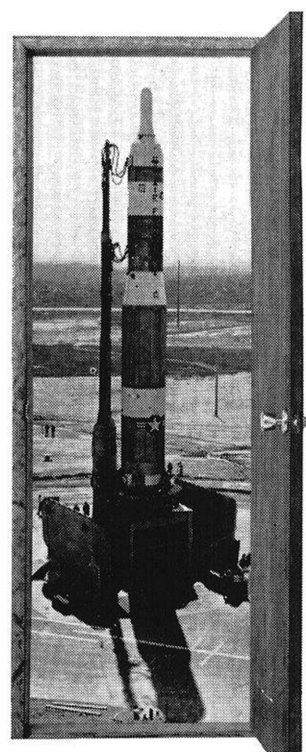
**MERCURY:** The Northrop landing system is designed to bring the Mercury astronaut down safely.

# Northrop is now active in more

**X-15:** Northrop produces Q-Ball, the flight angle sensor for safe re-entry of X-15 and other aerospace vehicles.

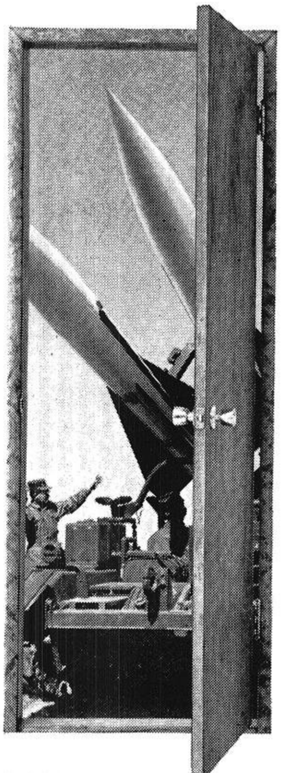


**AERODYNAMICS:** Northrop's Laminar Flow Control technique is designed to greatly increase aircraft range, flexibility, cargo and passenger capacity.

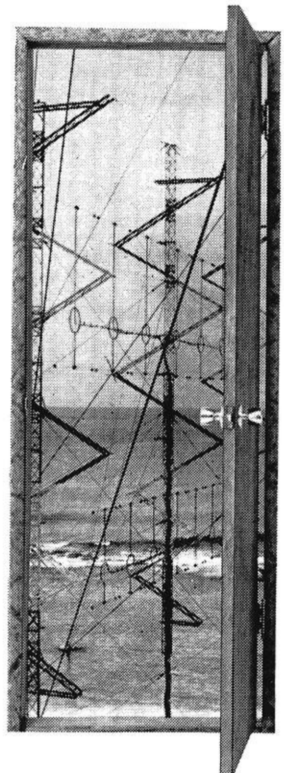


**TITAN:** Northrop supplies complete technical and industrial management to activate the T-2 Titan missile base.

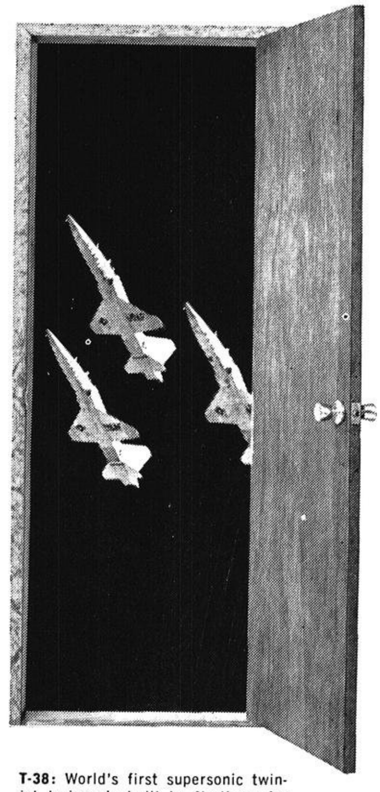
**For work on these advanced programs, we seek exceptional engineers, scientists and mathematicians.**



**HAWK:** Northrop produces airframe components, ground handling and launching equipment for this air defense missile.

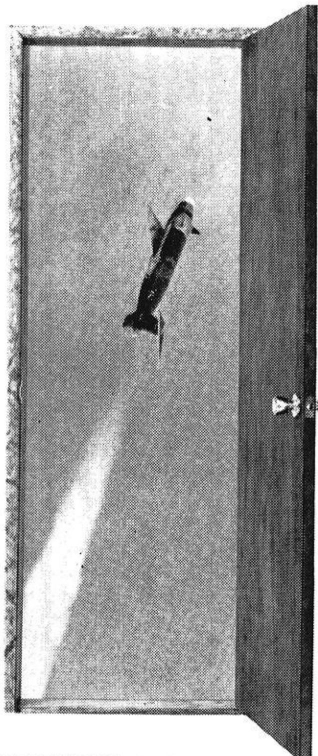


**COMMUNICATIONS:** Northrop designs the trans-Pacific Scatter Communications Network and other worldwide communication systems for U.S. and free world governments.

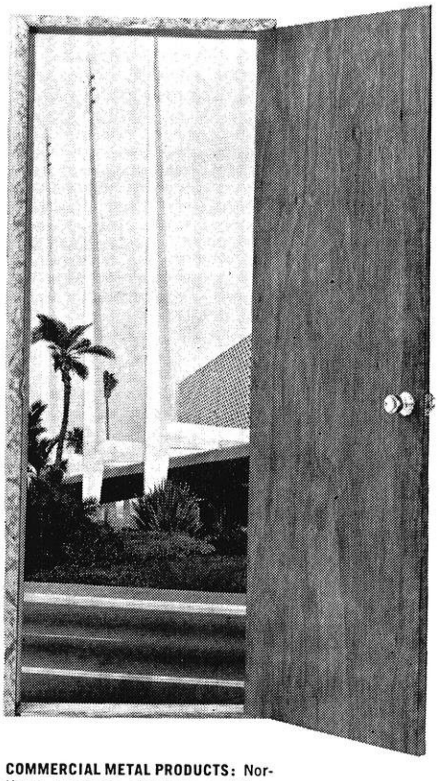


**T-38:** World's first supersonic twin-jet trainer is built by Northrop for the United States Air Force.

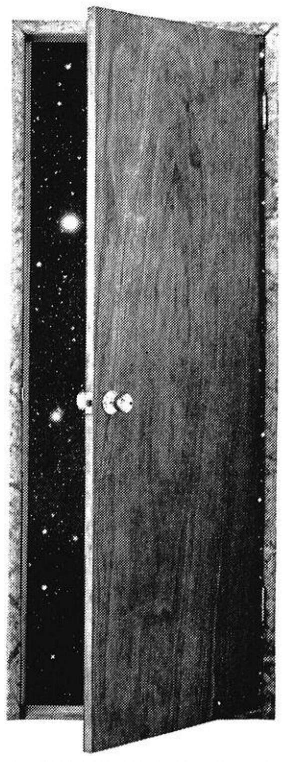
# than 70 important programs



**TARGET MISSILES:** Northrop has produced more than 50,000 electronically-controlled aerial targets, and surveillance drones.



**COMMERCIAL METAL PRODUCTS:** Northrop produces aluminum architectural shapes for many important industrial and commercial buildings.



**SPACE RESEARCH:** Northrop's accelerated space research programs reach into such advanced areas as maneuverability, rendezvous, space vehicle maintenance, space probes, and the survival of men in space.

**Write Northrop Corporation, Box 1525, Beverly Hills, California. Divisions: Norair, Nortronics, Radioplane.**

## Sneed's Review

(Continued from page 24)

anyone who has ever turned to look at the sleek lines and listen to the deep-throated roar of the engine of this fine automobile.

Keyed to today's thirst for speed, power and performance in automotion, the author has given a detailed account of the birth of the Jaguar, especially the Model XK-120, the forerunner of all sports models. Included in the contents is a chapter on maintenance and stopping, a chapter devoted to cylinder heads, and 13 tables of Specifications and Performance Data on all models from the XK-120 to the new 3.4 litre sedan, including the newest sportster, the XK-SS. Special attention has been given to competition driving with a list of the successes of the Jaguar in Major International Racing Events and a history of the C-Type at Le Mans and a detailed account of the "D-Jag" competition car.

Mr. Bentley has not overlooked the singularly important item in the history of the Jaguar, the people who conceived and developed the reputation that the company now enjoys. According to Sir William Lyons, founder and President of Jaguar Cars, Ltd., it is a spirit of teamwork that has succeeded in making Jaguar what it is today. The author quotes Sir William on the reason behind the growth of Jaguar's reputation in the luxury car field, "because we give the buyer everything he wants at a price which offers best value for the money. Success is due to making a first-class car by high-efficiency methods; a luxury car produced in greater number than any other car of its type."

John Bentley, a recognized authority on competition sports cars, has combined his journalistic talents with his personal experience behind the wheel in some of the world's greatest races to produce this book. No other writer is better qualified today to tell the fascinating story of the Jaguar Car.

## Wave Propagation

(Continued from page 13)

multihop propagation of radio waves. On returning to the earth the wave can be reflected upward and travel again to the ionosphere where it once more can be refracted and sent back to earth. However, as the number of such hops increases the strength of the received signal decreases. This is caused by the increased ionospheric absorption.

When two or more parts of a wave follow slightly different paths from the transmitter to the receiver, the difference in path lengths will cause a phase difference to exist between the wave components at the receiving antenna. Since these wave components may be such as to either aid or oppose one another at any time, a variation in signal strength called fading will occur. Conditions in the ionosphere will determine whether the fading will be rapid or slow. It is also possible to receive signals from within the skip zone. This phenomena, called scatter, is the result of random reflections from distances beyond the skip zone. These reflections occur when the transmitted energy strikes the earth at a distance and some of it is reflected back into the skip zone to the receiver.

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## Route Surveying

(Continued from page 1)

sections are then plotted to a convenient horizontal scale, and the limits of the various layers of each section are plotted to a convenient vertical scale; the points marking the boundaries of similar layers are connected. Each distinctive layer is identified by a number.

The details of constructing the soil profile are illustrated in Figure 1. As shown in view (a), alternate numbers are used for the successive soil layers at Section No. 1, so as to allow insertion of other layers that may be encountered at later sections. In the assumed case, the same three layers, marked 1, 3 and 5 respectively, occur also at Section No. 2 and at Section No. 3. However, at Section No. 4 there is a new soil type between layers 1 and 3, and the layer of this soil is marked 2. In order to locate the end of layer 2, it is necessary to examine one or more other sections between No. 3 and No. 4.

A proposed route traversing the region covered by an area soil map is then the subject of a preliminary soil report which shows the relationship of the soils to the engineering consideration of alignment, grade, drainage and compaction process.

#### Locational Survey

The purpose of the location survey is to transfer the paper location, complete with curves, to the ground. It is too much to expect that this line on the ground will conform to the paper location in every detail. There will usually be some deviations, resulting from errors in the preliminary traverse or in the plotting of the topography.

#### Basic Factors of Alignment and Grades

In route location, the existing topography and physical features rarely permit a straight location of a line between the termini. Because of these circumstances the introduction of vertical and horizontal changes in direction are needed. This is accomplished by grades, vertical curves, and horizontal curves. Through the use of curves the engineer can fit the road to the natural swing of topography in such a way as to be pleasing and economical. Poorly designed curves introduce serious operating hazards and may add greatly to the cost of construction and maintenance.

(Continued on page 36)

Steep grades are also a menace to safety. It is therefore desirable to eliminate as many bad grades as possible. In many instances a reduction in grade may considerably increase the cost of construction, but this has to be done in order that the public will enjoy the benefit of a smooth curve.

It is common practice to increase the distance between two fixed points in order to reduce the grade. It is the aim of the locating engineer to attain a proper balance between curvature and grade. To produce this harmonious balance and to do it economically requires that the engineer possess broad experience, mature judgment and a thorough knowledge of the objectives of the project.

### Construction Surveys

Field layout and staking are more complex in highway work than they are in any other engineering construction. This is primarily due to the multiplicity of lanes and the many ramps and intersections. Staking practices vary with the type of highway, the nature of the terrain, the depth of the cuts and fills and the type of practice employed by individual states.

The convenient method is to establish the base line from which all measurements are taken. Next, stations are established at 50 foot and 100 foot intervals along the construction base lines. On either side of this base line, tacked line stakes, marked with station numbers are set. The offset stations are no more than 50 feet apart on the construction. Their elevations are determined and recorded for future use in setting grade stakes. After the right-of-way has been cleared, a double line of slope stakes is set at 50 foot intervals. These slope stakes determine the embankment that the road will have. Finished stakes are necessary for the final operations of sideslope trimming, subgrade preparation, and setting of forms for paving.

### CONCLUSION

Though new methods such as photogrammetry are being developed to shorten the time for locating a highway, the engineer will still be called upon to carry out the four distinct steps: reconnaissance survey, preliminary survey, locational survey, and construction survey. These new methods will greatly aid and simplify the locating of a route for a highway. Photographic reconnaissance has come into wider use recently, but even with this and other new developments the engineer must still go out on the job and select the best route.

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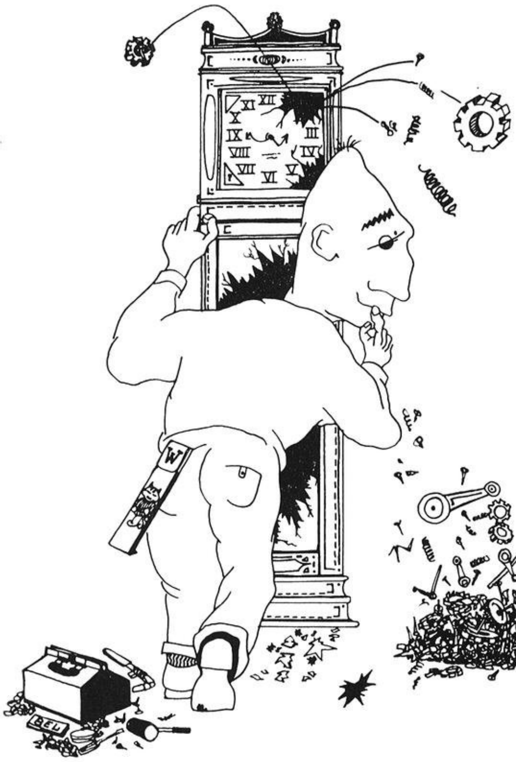
## Science Highlights

*(Continued from page 31)*

major problem in an automatic system designed to handle the tremendous traffic of modern turnpikes is that of reliability in the propulsion system. While the Roller Road concept naturally introduces many problems it encompasses the only propulsion plan which we have seen that seems to offer the reliability needed to make a high-speed system of this kind workable."

There's a Chem E. on campus who had completed work on a process to utilize excess doughnut holes to stuff macaroni.

"Well," remarked the undertaker as the coffin rolled off the truck, "we'll have to rehearse that again."



# STRIPPED GEARS

*edited by William S. Huebner*

**Radio soap opera announcer: "Will the governor's pardon reach Ronald in time? Will Geraldine, speeding through the night rain, see the washed-out bridge? These are things you'll never know . . . the sponsor has canceled the rest of the series."**

Girl: Do you love me?
Boy: Yes, I love you.
Girl: How much?
Boy: Plenty.
Girl: Would you be sad if I died?
Boy: Very sad.
Girl: Show me how sad.
Boy: Die first.

**A motorist was picked up unconscious after a smash and was being carried to a nearby filling station. Opening his eyes en route, he began to kick and struggle desperately to get away. Afterward he explained that the first thing he saw was a "Shell" sign, and "some fool was standing in front of the 'S'."**

Progress is so great these days that the liberal artist who says it can't be done is generally interrupted by an engineer doing it.

**"The traps on this course are very annoying," observed a member of the golfing foursome.**

**The one who was putting raised his head. "They certainly are," he commented. "Would you mind shutting yours?"**

Ah, pity the Miscalculations,
The man with the scissors and paste,
Oh, think of the man who must read all the jokes
And think of the time that he wastes.
He sits at his desk until midnight
How worried and pallid he looks,
As he scans through the college comics
And reads all the comical books.
This joke he can't clip—it's too dirty.
This story's no good—it's too clean.
This woman won't do—she's too shapely.
This chorus girl's out—it's obscene.
The jokes are the same; full of Coeds
And the guys who get drunk on their dates,
Bathtubs and sewers and freshmen,
And stories of unlawful mates.
Jokes about profs and their readers,
Jokes about overdue bills,
Jokes about girls in their boudoirs,
And each one as old as the hills.
Sprinkled with "damn", "louse" and "hell,"
The blurbs must be pure but yet filthy
Or pity the man with the clipper,
He's only a pawn and a tool.
In trying to keep his jokes dirty and clean
He's usually kicked out of school.

**One moonlit night, after a dance, a fellow begged to drive a beautiful young girl home. She accepted and got into his roadster. As they were driving along, he sighed deeply.**

**"You're beautiful!" he murmured audibly. "That gold hair!"**

**"Thank you," she answered.**

**"And your big blue eyes! They are beautiful too!"**

**"Thank you."**

**"And your lips—and pearly teeth."**

**She thanked him again. As they rode along he continued to shower her with compliments, but she remained silent. Suddenly she spoke.**

**"Can you drive with one hand?" she asked softly.**

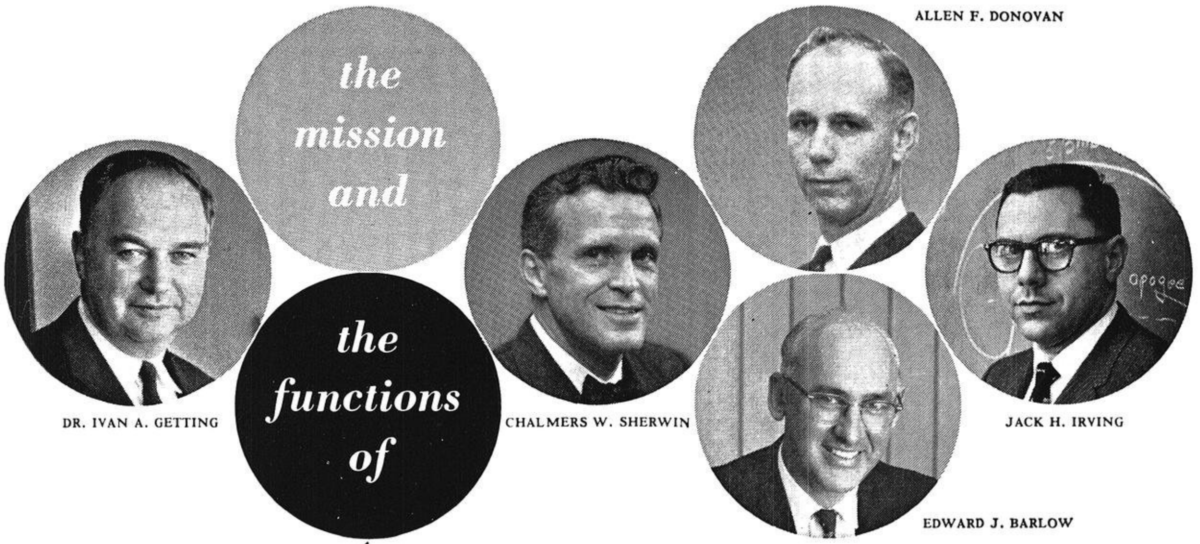
**"Sure," he quickly replied, hopefully.**

**"Well," she suggested, "wipe your nose—it's running!"**

Critic: It strikes me as being a rather impressive statue, yet, isn't it a rather odd posture for a general to assume?"

Sculptor: "It isn't my fault, I had the job half done when the committee decided they couldn't afford a horse for the general."

**Woman to garage mechanic: "My husband tells me there's a screw loose in the driver—whatever that is."**

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# So You Think You're SMART!

*by Sneedly, Law'66*

I'M SORRY but they just could not find room for me last month. This is ridiculous considering that it is a well known fact that this column, the jokes, and the girl of the month are the only things that anyone looks at in the magazine. Oh well, if the editors want to kill what little circulation they have now, that is their business.

The winner of last January's $10 prize was Stephen Peterson, Ch.E II. His correct answers were:

1) The slack in the rope around the earth would be noticeable, for it would extend approximately six inches above the surface. 2) If 5 were $\frac{1}{2}$ of 3, then 10 would be 3. If 10 is 3, then $\frac{1}{3}$ of 10 is 1. 3) The shortest distance for the spider would be 40 feet.

Here are this month's puzzles:

A man had a stick forty inches long. By cutting it into four lengths he was able to measure any length from one to forty inches—no fractions of course. What lengths did he cut the four pieces?

The area of an inclined face of a pyramid is equal to a square described upon its altitude. What value does this condition give for the angle which the plane of a face makes with the base.

One morning a certain chemical reaction was started at exactly a quarter of the hour. The chemical reaction finished precisely at the first meeting of the minute and hour hands. If the reaction took more than an hour, what was the exact time it started and how long did it take?

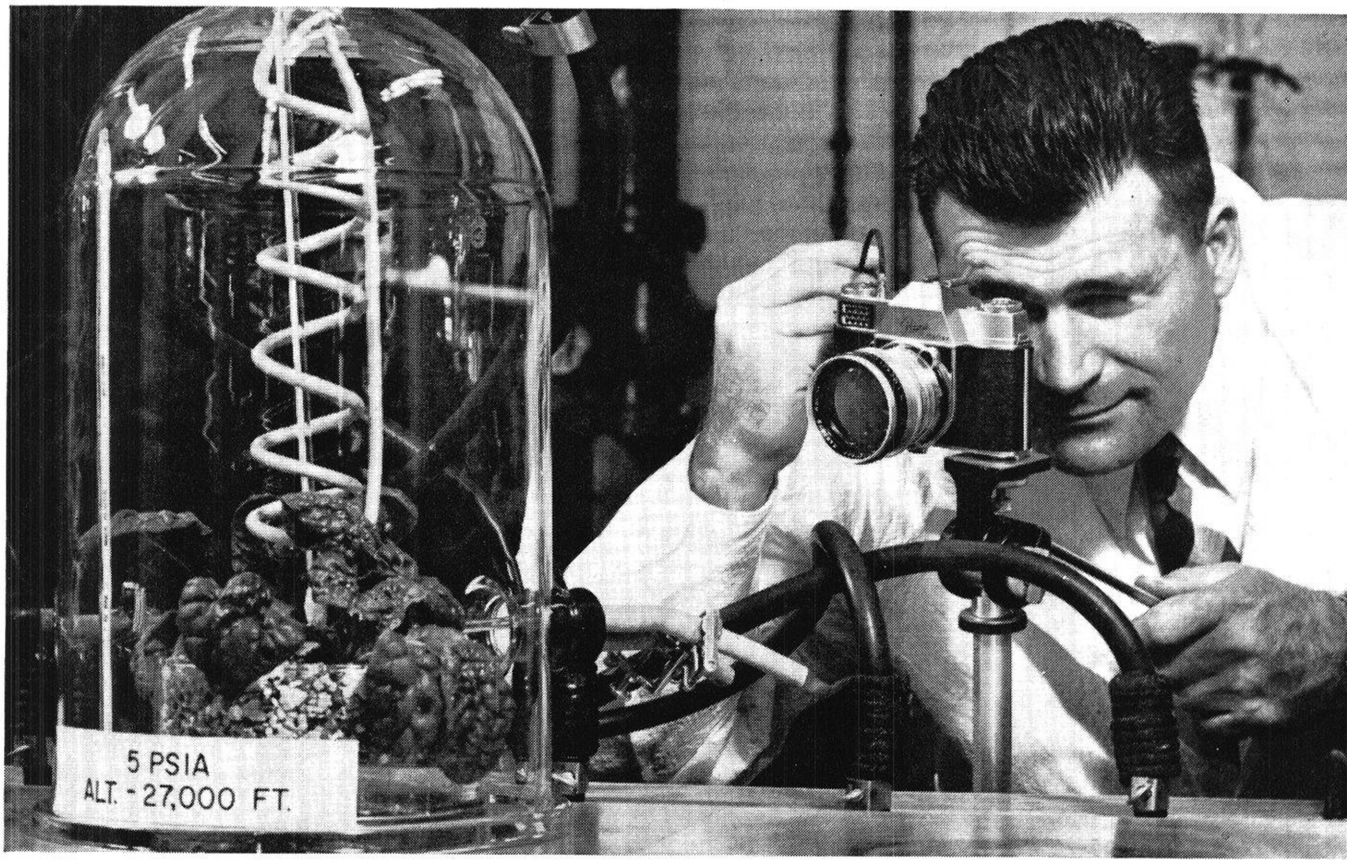
Send your answers with your own name and address to:

SNEEDLY
% The Wisconsin Engineer
333 Mechanical Engineering Building
Madison 6, Wisconsin

All answers must be sent in the mail and only letters with the correct answers having the earliest postmark will be considered the winner(s). THE END

If your sights are set  on space survival–







Scientist photographs the development of experimental "lunar" plant at the Republic Aviation Corporation's "Lunar Garden."

# –you'll find **Photography at Work** with you

Solving the problems of a human being living in outer space has become the task of scores of engineers, chemists and botanists. And serving them as a valuable working tool is photography. It records the growth of experimental plants and fungi that can well become the space voyager's food supply. Through autoradiography it can show the absorption of cosmic radioactive material, trace its circulation within the organism.

There's hardly a field on which you can set your sights where photography does not play a part in advancing work and simplifying routine. It saves time and expense in research, on the production line, in the engineering and sales departments, and in the office.

So in whatever you plan to do, take full advantage of all the ways photography can help.

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One of a series

*Interview with*
*General Electric's Byron A. Case*
*Manager—Employee Compensation Service*

# Your Salary at General Electric

Several surveys indicate that salary is not the primary contributor to job satisfaction. Nevertheless, salary considerations will certainly play a big part in your evaluation of career opportunities. Perhaps an insight into the salary policies of a large employer of engineers like General Electric will help you focus your personal salary objectives.

Salary—a most individual and personal aspect of your job—is difficult to discuss in general terms. While recognizing this, Mr. Case has tried answering as directly as possible some of your questions concerning salary:

**Q Mr. Case, what starting salary does your company pay graduate engineers?**

**A** Well, you know as well as I that graduates' starting salaries are greatly influenced by the current demand for engineering talent. This demand establishes a range of "going rates" for engineering graduates which is no doubt widely known on your campus. Because General Electric seeks outstanding men, G-E starting salaries for these candidates lie in the upper part of the range of "going rates." And within General Electric's range of starting salaries, each candidate's ability and potential are carefully evaluated to determine his individual starting salary.

**Q How do you go about evaluating my ability and potential value to your company?**

**A** We evaluate each individual in the light of information available to us: type of degree; demonstrated scholarship; extra-curricular contributions; work experience; and personal qualities as appraised by interviewers and faculty members. These considerations determine where within G.E.'s current salary range the engineer's starting salary will be established.

**Q When could I expect my first salary increase from General Electric and how much would it be?**

**A** Whether a man is recruited for a specific job or for one of the principal training programs for engineers—the Engineering and Science Program, the Manufacturing Training Program, or the Technical Marketing Program—his individual performance and salary are reviewed at least once a year.

For engineers one year out of college, our recent experience indicates a first-year salary increase between 6 and 15 percent. This percentage spread reflects the individual's job performance and his demonstrated capacity to do more difficult work. So you see, salary adjustments reflect individual performance even at the earliest stages of professional development. And this emphasis on performance increases as experience and general competence increase.

**Q How much can I expect to be making after five years with General Electric?**

**A** As I just mentioned, ability has a sharply increasing influence on your salary, so you have a great deal of personal control over the answer to your question.

It may be helpful to look at the current salaries of all General Electric technical-college graduates who received their bachelor's degrees in 1954 (and now have over 5 years experience). Their current median salary, reflecting both merit and economic changes, is about 70 percent above the 1954 median starting rate. Current salaries for outstanding engineers from this class are more than double the 1954 median starting rates and, in some cases, are three or four times as great.

**Q What kinds of benefit programs does your company offer, Mr. Case?**

**A** Since I must be brief, I shall merely outline the many General Electric employee benefit programs. These include a liberal pension plan, insurance plans, an emergency aid plan, employee discounts, and educational assistance programs.

The General Electric Insurance Plan has been widely hailed as a "pace setter" in American industry. In addition to helping employees and their families meet ordinary medical expenses, the Plan also affords protection against the expenses of "catastrophic" accidents and illnesses which can wipe out personal savings and put a family deeply in debt. Additional coverages include life insurance, accidental death insurance, and maternity benefits.

Our newest plan is the Savings and Security Program which permits employees to invest up to six percent of their earnings in U.S. Savings Bonds or in combinations of Bonds and General Electric stock. These savings are supplemented by a Company Proportionate Payment equal to *50 percent* of the employee's investment, subject to a prescribed holding period.

***If you would like a reprint of an informative article entitled, "How to Evaluate Job Offers" by Dr. L. E. Saline, write to Section 959-14, General Electric Co., Schenectady 5, New York.***

*Progress Is Our Most Important Product*

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