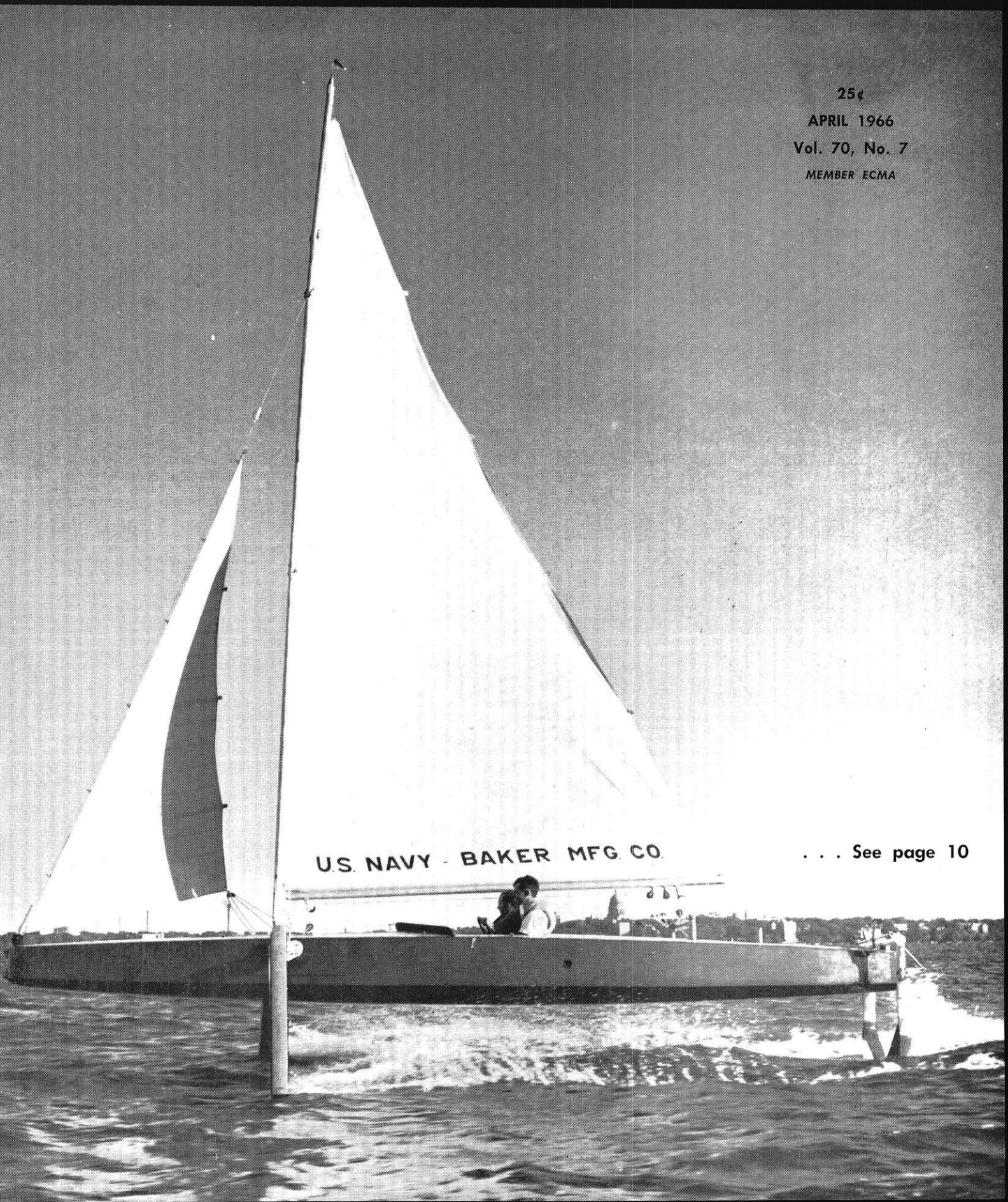
The Wisconsin engineer. Vol. 70, No. 7 April 1966

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

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

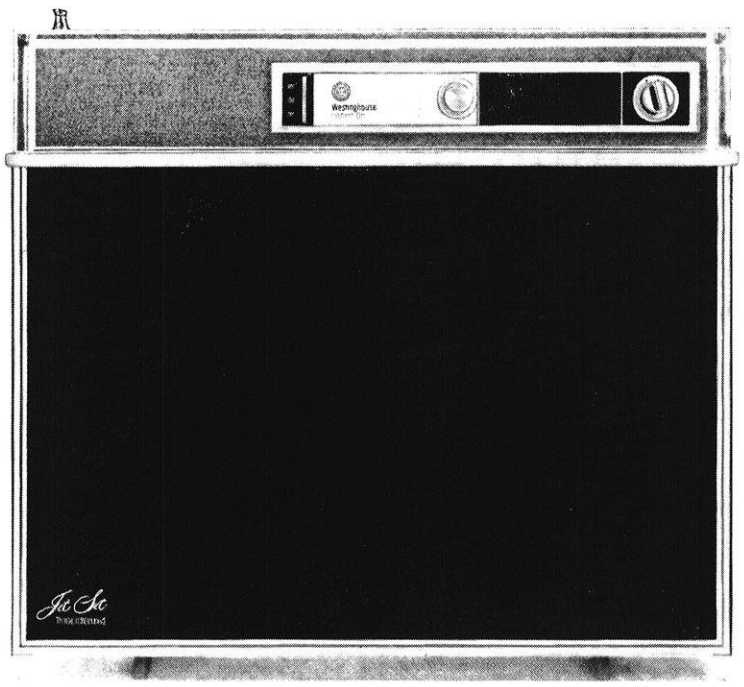
THE WISCONSIN ENGINEER

25¢
APRIL 1966
Vol. 70, No. 7
MEMBER ECMA



. . . See page 10

New Westinghouse Jet Set gives you a beautiful picture...



even when it's off

The picture tube doesn't stare back at you. And there's no wait for warm-up because it's Instant-On™ television.

Turned on, Jet Set delivers a soft, clear, easy-on-the-eyes picture. New Memory Fine Tuning lets you pre-tune each channel for best picture and sound. Set it once—and forget it.

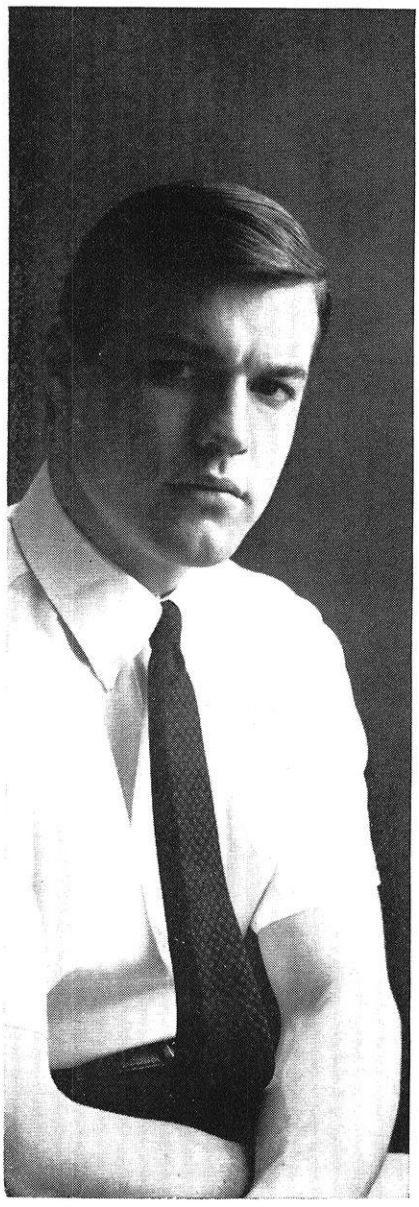
Turned off, Jet Set doesn't even look like a TV set. But off or on, it's beautiful.

Westinghouse makes a product so you'll enjoy it—any way you look at it.

You can be sure if it's Westinghouse

For information on a career at Westinghouse, an equal opportunity employer, write L. H. Noggle, Westinghouse Educational Center, Pittsburgh, Pa. 15221.

Wouldn't you like to join a company that is *really* on the move?



SUNDSTRAND—a company on the move—has many excellent engineering positions open. Here, the challenge of tomorrow is being met by well-trained technical professionals, such as yourself.

A career in engineering at Sundstrand can be rewarding . . . not only from the standpoint of material well-being . . . but also from the intellectual stimulation of exploring the complexities of advancing technologies.

Sundstrand is an engineering-oriented company. The company has built a reputation as a producer of precision products. Key to Sundstrand's product success has been its consistent emphasis on engineering and its willingness to spend heavily on research and development.

In our laboratories, design departments, and test labs, you will find innovators at work in such varied technologies as thermodynamics, undersea propulsion, solid-state electronics, computer programming, fuel cell design, sophisticated secondary power systems for aerospace vehicles, petrochemical handling, and hydrostatics.

Sundstrand has a 60-year record of steady growth. It has operating divisions in Illinois and Colorado . . . and there is expansion going on in all divisions. Annual sales are nearing $100 million, and the order backlog is at an all-time high.

If you are an engineer who would like a challenging position with a medium-sized company on the move . . . you should investigate the opportunities now available at Sundstrand.

Write to:
Manager of Technical and
Professional Placement
SUNDSTRAND CORPORATION
Personnel Center
1401 - 23rd Ave. Rockford, Ill. 61101
an equal opportunity employer

WE HAVE THESE CHALLENGING POSITIONS OPEN:

MECHANICAL ENGINEERS

Openings at all levels in development and project assignments, research and development, product design, sales, application engineering, field service, quality control, reliability, computer programming, manufacturing, and testing.

ELECTRICAL ENGINEERS

Continuing need for graduate E.E.'s to work on equipment related to power generation and numerical control. Includes positions in project engineering, research and development, application engineering, sales, and electronic development engineering.

METALLURGICAL ENGINEERS

Opportunities exist in metallurgical technology with exposure to a wide range of metals, from ferrous castings to alpha titanium alloys. Ample challenges in a variety of work encompassing the material support of the manufacturing departments, research sections, and project groups, with particular emphasis on the investment casting foundry.

INDUSTRIAL ENGINEERS

Responsibilities for a broad range of projects, from determining the manufacturing feasibility of a product to the layout of a completely new automated production facility. Includes creating new tools, processes, and equipment; planning production flow and schedules; working in time-study and methods engineering; coordinating quality control and reliability; and evaluating cost factors.

Plus a variety of specialized positions for graduate engineers with 5 to 10 years' experience in the following areas:

Quality Control Engineering
Machine Tool Design Engineering
Hydraulic Engineering
Electrical Machinery Design Engineering
Circuit Design Engineering
Turbo Machine Engineering
Heat Transfer Engineering
Applications Engineering

SUNDSTRAND

. . . a company on the move!

Ford Motor Company is:

recognition

Eric Mangelsen
B.S., Univ. of Kentucky

What does it take to gain recognition at Ford Motor Company? If you have skills that we can utilize, and if you're ambitious as well as able, you can move ahead fast at Ford! Consider the career of Eric Mangelsen:

Eric came to work at our Ypsilanti Plant in February, 1961. During the initial stage of his training program, he was given the assignment to supervise the development, design and construction of special production calibrating and test equipment for automobile voltage regulators. Later, he was assigned to processing and production of the transistor ignition amplifier system for our 1963 cars. He was responsible for introducing a new cleaning process for voltage regulator contact points, which substantially reduced costs. He was also instrumental in processing the refined transistorized regulator system used in our new 1966 automobiles.

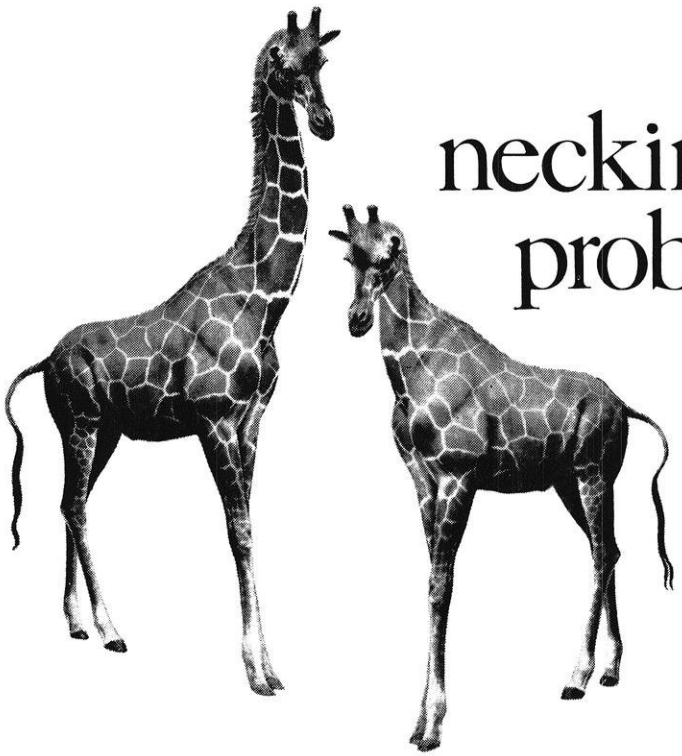
Now a member of management with broad responsibilities in a key Production Department, Eric Mangelsen has moved ahead rapidly with a company that believes in giving young men every opportunity to demonstrate their skill and ingenuity. Why not investigate? Talk to our representative when he visits your campus. *You* can go far with Ford.

Ford

The American Road, Dearborn, Michigan

An equal opportunity employer

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



necking problem

To build a rectangular color TV tube with more of a picture than the earlier round tube type, and then squeeze it into a dimensionally attractive cabinet—you face almost insurmountable challenges.

Just to build a conventional color tube, you must . . .

1.—with absolute precision, lay more than a million red, blue, and green phosphor dots in a perfect triad pattern over the entire surface of the picture screen. Why so tough?—because the light source for the dots is a single ray coming through a pinhole. And it must be bent by a correction lens with precise mathematical calculation (different for each dot) to pass through over a third-of-a-million pinholes and fall exactly at a given spot on the screen.

2.—Once you've figured out the phosphor dots, you must then bend the electron beam broadcast by the TV station so that it too passes through the third-of-a-million pinholes.

These are just some of the feats you must perform. But after going through all this, you wind up with a tube with a neck so long it requires a cabinet nearly a yard deep to hold it. To shorten the neck requires mathematical calculations and engineering techniques so demanding they fall beyond any brief description.

The complexity of the 23-inch rectangular color tube development is considered by some of our consumer products engineers even more of a technological challenge than designing some of the sophisticated command systems required for space flights.

Motorola military engineers tend to disagree.

But now that we've brought it up, Motorola has accomplished both.

TRUST THIS EMSIGNIA  WHEREVER YOU FIND IT

MOTOROLA

WHAT IS A PROJECT ENGINEER?

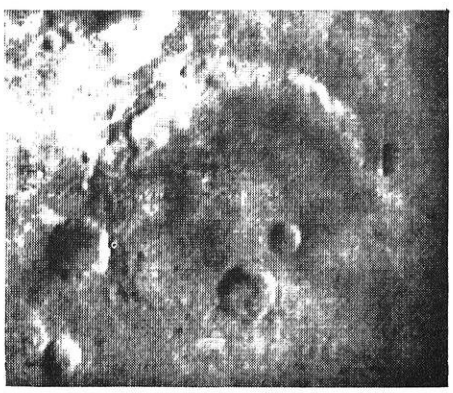
DEAN MORGAN

BS (ELECTRICAL ENGINEERING)
UNIVERSITY OF UTAH

A typical example of a PROJECT ENGINEER is Dean Morgan. He joined UNIVAC upon his graduation in 1960, and was assigned to the Memory Engineering Department. For two years he was engaged in the circuit and logic design of a thin film control memory for the UNIVAC 1107 computer, and a computer developed for the U. S. Navy. During the last assignment, Dean was given the responsibility of Proposal Manager for developing a proposal and cost estimate for a small low power data buffer memory to be used in a deep space experiment to be conducted by Jet Propulsion Laboratories. This was the Mariner IV Program.

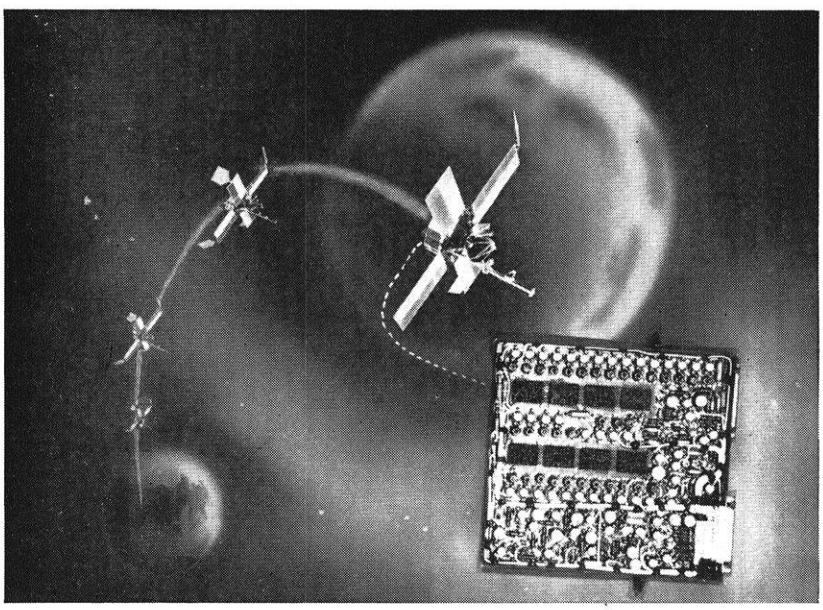
In writing the proposal Dean became the most likely candidate to head up the program should we win. As it turned out, UNIVAC was awarded the contract for the design, development and fabrication of flight models of a data buffer memory system.

FRAME—MARS BY MARINER IV



AT UNIVAC...

...a typical PROJECT ENGINEEER is about 28 years old, has completed two or three design assignments, and this is the first firm he's worked for. He works in an Engineering Department which has about 100 personnel. He is responsible for all facets of a development. He will have direct responsibility over two to five other engineers, and from five to ten technicians, he will be responsible for other functions related to design such as reliability, design drafting, prototype construction, documentation and manuals. On smaller programs he will be indirectly responsible for the fabrication, checkout, environmental testing and delivery of all production units. His administrative tasks will include planning, scheduling, performing merit reviews on the personnel assigned to him. He will have to coordinate with Contracts Personnel the basic contract, changes in scope and all fiscal project reporting. With Marketing he will have to cooperate in selling additional business to the same and other customers. This will require that he generate technical proposals, perform cost estimates and make presentations to management so they can determine if further use can be made of this development.



DATA BUFFER MEMORY...

This tiny memory was approximately 6 inches square, 1 inch thick, weighed 21 ounces, operated on less than ¼ watt of power. It contained 2,640 bits of storage. Its function was to store the video picture each time the lens was opened, and then, at the slower rate required by a tape recorder, the information was transferred to tape for subsequent playback to earth. The picture shown on television and in print here indicates it worked perfectly.

The task of developing this highly reliable device combined with the problems of manufacturing it to extreme environmental specifications were Dean's tasks for over 1½ years. Such cases are typical. Every day brings the possibility of a new request for proposal and the possibility of a new assignment.

Interested candidates are invited to submit resumes to Mr. R. K. Patterson, Employment Manager, UNIVAC Defense Systems Division, UNIVAC Park, St. Paul, Minnesota. Dept. 52.

UNIVAC
DIVISION OF SPERRY RAND CORPORATION

DEFENSE SYSTEMS DIVISION
2750 WEST SEVENTH BLVD.
ST. PAUL, MINN. 55116
AN EQUAL OPPORTUNITY EMPLOYER (M&F)

● *engineering careers*

You meet the nicest people and opportunities at Dunham-Bush

The "right man" will find that he's shifted into high gear swiftly at Dunham-Bush. We're that kind of company.

Without going into the slide-rule aspects . . . our company's past, present and future . . . geographical and familial advantages, etc., etc., we suggest you send for our brochure . . . "careers at Dunham-Bush" . . . then contact us for a personal interview.One day, the "right girl" will be glad you're a D/B man.

Oh, what do we manufacture? The world's most complete line of air conditioning, heating and refrigeration products. As a matter of fact we're internationally known as the "one source—one responsibility" company.

You'll be in good company at Dunham-Bush. Our main office and R&D Center is at West Hartford, Connecticut.

DUNHAM-BUSH

MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman: PROF. J. R. BISSETT, Dept. of Civil Engineering, University of Arkansas, Fayetteville, Arkansas 72701.

Publishers Representatives: LITTELL–MURRAY–BARNHILL, INC., 369 Lexington Avenue, New York, New York 10017.

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

Published monthly from October to May inclusive by the Wisconsin Engineering Journal Association, 333 Mechanical Engineering Building, Madison, Wisconsin 53705. Editorial Office Hours 10:00–1:00 Tuesday and by appointment. Office Phone (608) 262–3494.

VOLUME 70, NUMBER 7

APRIL 1966

ARTICLES

THE WISCONSIN ENGINEER

The Student Engineer's Magazine Founded in 1896

FEATURES

THIS MONTH'S COVER

Baker's "Monitor *in 'Flight'," a photo by Ed Stein, courtesy of Baker Manufacturing Company, is the April cover. For more photos and some details on this Wisconsin-developed craft, turn to page 10.*

SUBSCRIPTION PRICE

$4.00 FOR FOUR YEARS $1.25 FOR ONE YEAR

SINGLE COPY 25¢

If you still think glass is just glass,

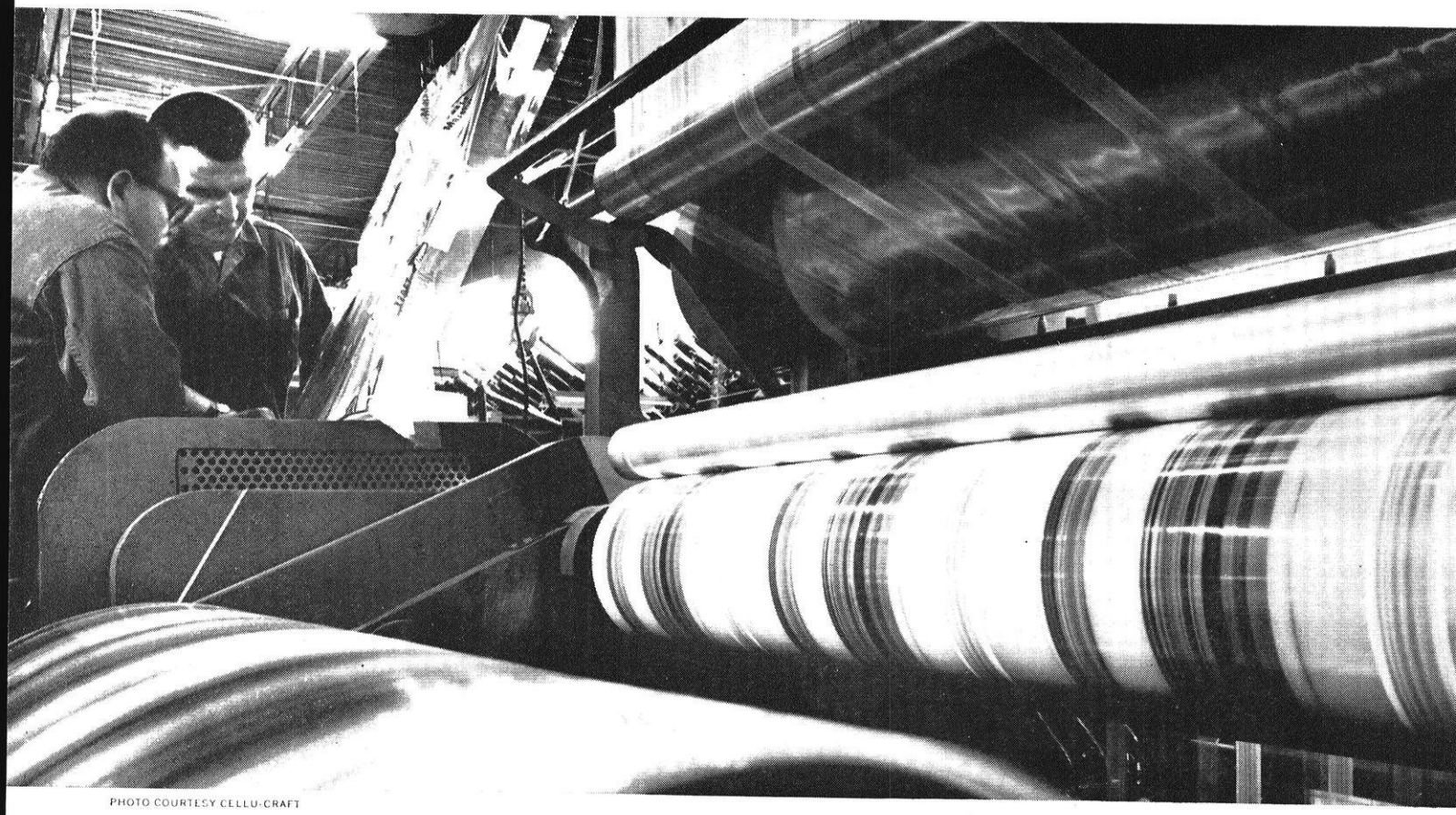


PHOTO COURTESY CELLU-CRAFT

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* glass-master. 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.

CORNING

CORNING GLASS WORKS

AN EQUAL-OPPORTUNITY EMPLOYER

Rambling With The Editor

RETROSPECT . . .

"It has been accomplished," and with mixed emotions we leave this desk, this page, this office. Being on the staff of this publication for the last four years has indeed been an education in itself. There have been shortcomings and disappointments, true, but there has been a great deal of satisfaction also. We are most grateful for the generous assistance and counsel rendered us by our predecessors, our staffs, and particularly our advisors, Professors Sell and Schwebke.

Over the past two years we have attempted to spell out our credo by various means—as the heading implies, we've rambled. And constructively, we hope. You know by now that we're against the lousy instructors, Vietniks, inadequate parking, smog, and apathetic engineering students, among other things. Beyond the realm of an engineering magazine? We think not. Upon us has fallen the responsibility for speaking out on matters that affect *this* campus, *now*. For our finale we dwell upon an issue of grave importance to all humanity.

CONTROL THE EXPLOSION

Looming over the horizon is a crisis the likes of which this world has never seen. Much has been written and more has been said about the population explosion. The time has come for us to get busy and do something positive about it, for as yet we haven't. We are perhaps on the first rung of a mile-high ladder, with problems infinite in number and solutions few and incomplete.

Consider for a moment the substance most basic and vital for the sustenance of all life—water, H_2O, colorless, odorless, chemical weight 18, etc., etc. Shortages of water already exist, but supposedly we will be able to alleviate our problems with atomic power and massive desalination of the oceans. Indeed we may quench the world's thirst with this water, but what will we do with the wastes from the process? Briefly, we will upset a delicate ecological balance which Nature has carefully maintained over the years. So for the present we must strive to conserve and redistribute what fresh water we have.

Do what we may as scientists and engineers, it will not help us one iota if we cannot control that theological bombshell—fertility. Reasonably assuming that we won't be colonizing the solar system for several years, we are approaching a mathematical limit on this sphere named Earth. Nature has always controlled her populations by increasing the mortality rate or decreasing the birth rate. Today the human race is doing the exact opposite—prolonging lives with artificial organs, complex chemicals, and a host of other things, and, at the same time, reproducing the species at fantastic rates. Now obviously we want to decrease the mortality rate through science (and we doubt that any H-Bombs will take up the slack). The only answer is to decrease the birth rate—by regulating fertility, lest we reproduce ourselves to the point of extinction—billions of people, each on their square foot of concrete, choking, dehydrating, and starving to death. Of the two alternatives, there is no question as to which is more moral.

—R. J. Smith

Hydrofoil Sailboats— An Introduction

by Mary Baker, em4

FOR centuries men have been devising new schemes to increase the speed of saling vessels. Everything from planing hulls to double hulls to triple hulls has been tried. This report is based on a scheme which makes the sailboat nearly zero-hulled and which has produced the World's fastest sailboat—the hydrofoil sailboat.

In order to interest engineering students in working on hydrofoils for sailboats, this article first describes the advantages and demonstrates the increase in speed that hydrofoils make possible. Next, it presents some typical problems involved that are apt to be of interest to an engineering student. Finally, it describes some successful experimental hydrofoil sailboats.

Throughout the following discussion it is assumed that the reader is familiar with the fluid dynamics of air foils and basic sailing terms and theory. It is also assumed that the designs discussed are intended for a small and simple boat that would be practical for the sportsman.

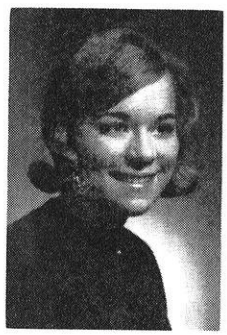
DEFINITION

A hydrofoil sailboat sails with its hull completely clear of the water surface once the boat has reached a certain speed. A boat of this type has a system of lifting surfaces, called hydrofoils, attached beneath its hull. As these surfaces are moved through the water, they experience lift just as airfoils (i.e. airplane wings) experience lift when they are moved through the air. When the lifting force is large enough, the hull of the boat will "take off" from the water surface and climb onto its foils.

ADVANTAGES OF HYDROFOIL SAILBOATS

This ability to clear the water surface has several important advantages: The boat sails smoothly over rough water; the hull avoids the pounding force of the waves; the hydrofoils slice through the waves without allowing the boat to be tossed about or drenched with spray; the resistance to forward motion of the boat is greatly reduced resulting in the most important advantage of all—the increase in speed.

This last advantage is especially pronounced for sailing vessels. The reason for this is that the propulsive thrust of a sail increases with speed. (The maximum obtainable thrust from a given engine decreases as the propeller moves more rapidly through the water). The behavior of an iceboat provides a demonstration of this fact. In a given wind it may be necessary to push an iceboat to get it started, but once it is under way, it may travel at four times the wind speed. A quantitative verification of this phenomenon is given by the following statement from *Research Reviews:*



Mary Baker is no stranger to the *Wisconsin Engineer,* for her name formerly occupied the space opposite Circulation Manager on our staff listing. Mary, who is from Evansville, Wisconsin, plans to graduate in August after which she will pursue graduate work in applied mechanics at Cal Tech. As you may have already noticed she has been associated with hydrofoil boat development for some time—it's a family project perhaps. But Mary is interested in sailing too—she belongs to the UW Sailing Club, in addition to YAF, Y-GOP, and the Union Mid-Day Programs Committee. A very busy girl! And, we might add, a pleasant addition to our engineering campus.

In a beam wind of a given velocity, an increase in sail speed by a factor of four increases the maximum obtainable thrust by a factor of 1.5. By contrast, an increase in speed of a motorboat by a factor of four with the same engine means a reduction in the maximum obtainable thrust to about one-quarter.

This demonstrates the large potential of sailboats for speed increase that can be utilized by reducing resistance to forward motion.

A dramatic demonstration of the speed advantage of hydrofoil sailboats was given when the Baker Manufacturing Company's sixteen-foot hydrofoil sailboat sailed a circle around a catamaran of comparable length. The efficiency of a hydrofoil sailboat is shown also by its ability to sail at twice the wind speed, while a conventional sailboat seldom achieves a speed as high as wind speed. Table 1 gives a more quantitative comparison of speed of a hydrofoil sailboat with that of several other of the fastest known boats.

The high speed and smooth sailing of hydrofoil sailboats provide much fun and excitement for the sailing enthusiast. The experience of climbing free of the water surface and traveling at twice the wind speed is indeed unique. The sailor can quietly pass many motor-driven boats with nature supplying all his power. At the present time there are no hydrofoil sailboats available to the general public. Those mentioned in this report are experimental.

Table 1.—Speed Comparisons

Type of Boat	Name	Knots	Date	Source of Information
American Cup Boat	Yankee	13.5	1931	Communication from Yachting Publishing Corp., N. Y., N. Y., Sept. 19, 1955.
Clipper Ship	Sovereign of the Seas	17.7	About 1854	"Clipper Ship Days," by John Jennings, published by Random House, N. Y., N. Y., 1952.
Catamaran	——	25.0	1952	"World's Fastest," Life Magazine, Aug. 25, 1952, Vol. 33, Pg. 55.
16-foot Flying Sailboat	——	20.0	Before 1952	Comparison with a motorboat with a known speed-tachometer relationship.
Flying Sailboat	Monitor	26.1	Sept. 1955	Comparison with two different motorboats with known speed-tachometer relationships.
		30.4	1956	Comparison with Univ. of Wisconsin motor lifeboat, which has a known speed-tachometer relationship.

DESIGN PROBLEMS

The design of a hydrofoil sailboat presents many interesting problems and choices to the engineer. He must choose which type of foils to use and then design a configuration of these foils that resists the rolling and pitching moments of the sail force and the rolling moment of the centrifugal force that is developed in turning. He must solve also problems such as ventilation drop, which may cause loss of lift on the foils and allow the boat to fall suddenly to the water's surface. In solving these problems he must always keep in mind the convenience and practicality of the over-all boat.

First, a choice must be made between the two main types of hydrofoils—surface-piercing and fully-submerged. (See Fig. 2) For the surface-piercing type, the boat level is area-stabilized. That is, as the boat sinks lower in the water, more foil area is submerged and more lift is developed which then raises the level of the boat. The fully-submerged type of foil has more efficient lifting surfaces than the area-stabilized type has, but must be angle-stabilized. This means the angle of attack must be adjusted in order to create more or less lift and thereby raise or lower the level of the boat. The latter method of level-stabilization requires a complicated control mechanism for adjusting the angle of attack. Since the hydrofoils discussed here are for a small boat—for the sportsman—simplicity is important, and the best choice is surface-piercing foils.

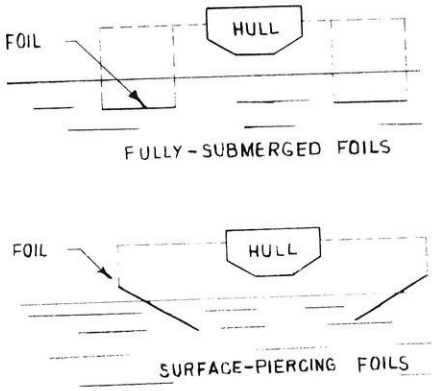


Figure 2.—Comparison of Surface-Piercing and Fully-Submerged Foils

Again there is a choice: Which type of surface-piercing foils? Symmetrical and asymmetrical foils are shown in Fig. 3. Also shown here are the hydrodynamic foil reactions that are developed when the boat is traveling directly forward with no lateral force applied. The label "force intersection level" in figure 3 refers to the level at which the resultant of the hydrodynamic forces on the foils acts and will be used to refer to this in the following discussion.

Resistance To Rolling Moment

Now the way in which these two types of foils resist the sail side force and the centrifugal force developed in turning will be considered.

A boat with symmetrical foils must roll in order to sustain these lateral loads. When the wind or centrifugal force pushes the boat sideward, the boat starts to slide in that direction. The resulting increments in hydrodynamic forces are shown in Fig. 4. The resultant forces are also shown.

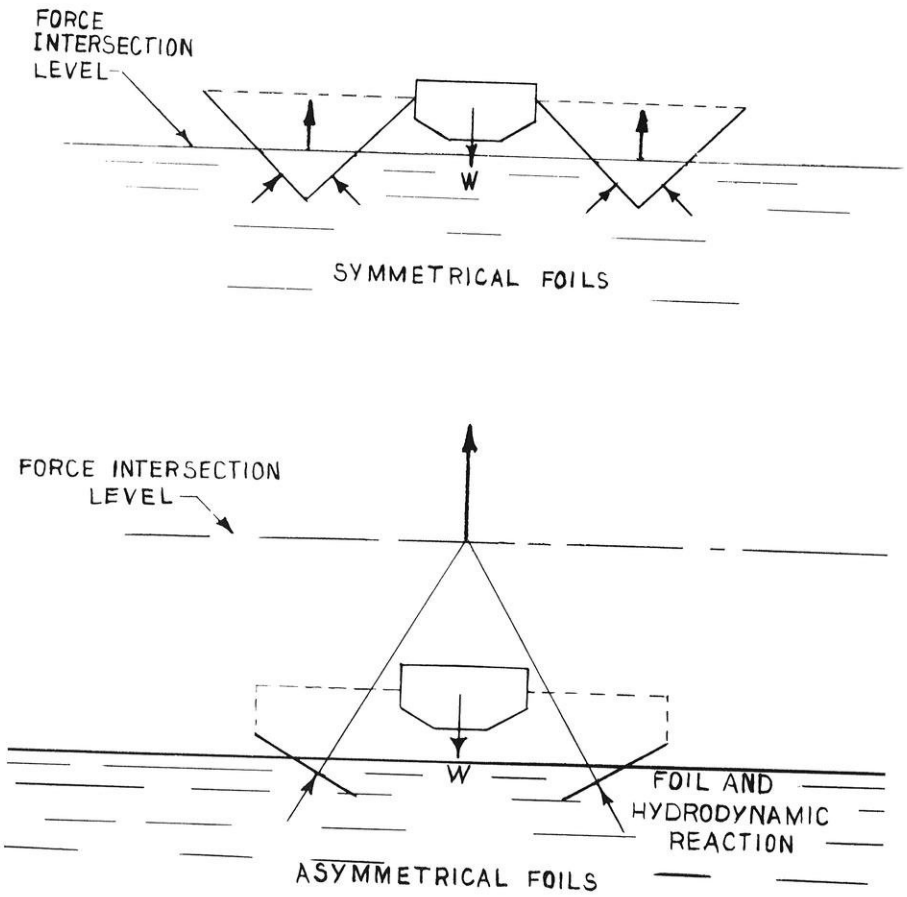


Figure 3.—Comparison of Symmetrical and Asymmetrical Foils

These increments sustain the lateral force, but since the force intersection level is far below the applied forces, there is a moment that is not resisted. The boat must roll because of this moment until the increased area submerged on the lee foil develops enough force to balance it.

A boat with asymmetrical foils does not need to roll to resist a lateral force. These foils can be designed so that the force intersection level is the same as the level of the load; then, once the applied force is sustained, no moment remains. This can be seen by considering the two foils to be arcs of a circle which will be called "foil circle" in the following discussion. (See Fig. 5). The resultant forces will then act as the center of the foil circle. The foil can be placed so that the center of the foil circle is at the level at which the lateral force will act—say the center of pressure of the sail. In this way a system of asymmetrical foils can be designed for zero roll.

Now what happens when another lateral force at a different level is applied, such as the centrifugal force of turning which acts through the center of gravity of the boat? A small moment is created and the boat starts to roll. If the force intersection level is designed to be above the center of gravity as is true in Fig. 5, the rolling will be positive banking in the turn which is desirable. However, since all forces on the foils act through the center of the foil circle, no counter moment is developed as the boat rolls, and there is nothing but scrambling of the crew to keep the boat from capsizing. Actually the preceding sketches are oversimplified in that no struts, which are needed to hold the foils in place, are shown. These struts provide some roll resistance by sustaining reactions, as the boat begins to roll, which do not pass through the center of the foil circle. As long as these reactions on the struts are not so large that they dominate the reactions on the foils, the boat will sail forward with zero roll and bank positively in turns.

From the above discussion, it appears, from the standpoint of rolling stability, that asymmetrical foils are better than symmetrical foils, but there are other things to consider. Of the two types, the symmetrical foil is more efficient for carrying a vertical load because all the surfaces are contributing to lift; there are no parts that provide for roll resistance alone. Also, the asymmetrical foil has discontinuities which contribute to drag. The choice is not obvious; it will depend on what factors are most important in a particular design.

Resistance To Pitching Moment

The next problem—the resistance of pitching moment created by the forward sail force—involves the fore-and-aft placement of the hydrofoils rather than the lateral arrangement just considered. A steady pitching moment can be maintained by having most of the lift in the forward foils, and any gradual change can be offset by a manual foil angle adjustment to vary the lift of the foils. A sudden wind change can create a change

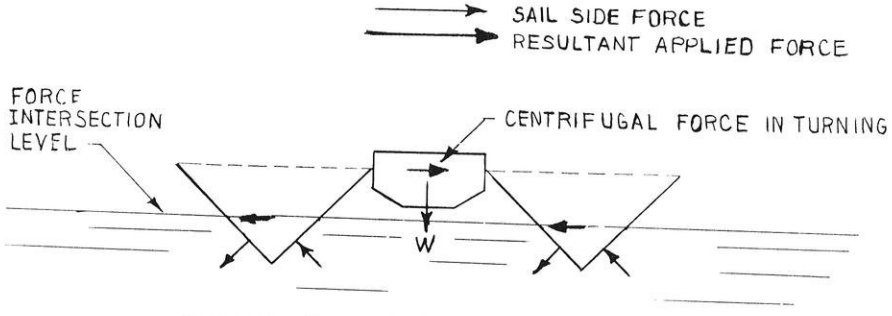


Figure 4.—Symmetrical Foils With Lateral Loads

in moment which causes the boat to dive suddenly or to climb, either of which is a rotation about a lateral axis. As the boat rotates, the increased submerged area on the foil at one end and the reduced submerged area on the foil at the opposite end cause a counter moment that resists the pitching moment. However, if the boat is allowed to rotate through too great an angle, the boat will dive into the water or climb so high that lift on the foils is lost, and the boat again plunges into the water.

The magnitude of a sudden change of moment that can be tolerated increases with the square of the distance between the fore and aft hydrofoils. To understand why this is true, refer to Fig. 6. The boat will continue to rotate until the countermoment, RL, equals the applied moment, Ph. Setting these moments equal, and realizing that R is proportional to d, the following is obtained:

$$Ph = RL = (k\tfrac{1}{2}L\Theta_{max})L = KL^2\Theta_{max}$$

(k, K are constants)

Therefore, for a given Θ_{max}, the corresponding pitching moment is proportional to the square of the length between the fore and aft hydrofoils. Unfortunately, a boat long enough to sustain a large pitching moment is apt to be too long to be practical.

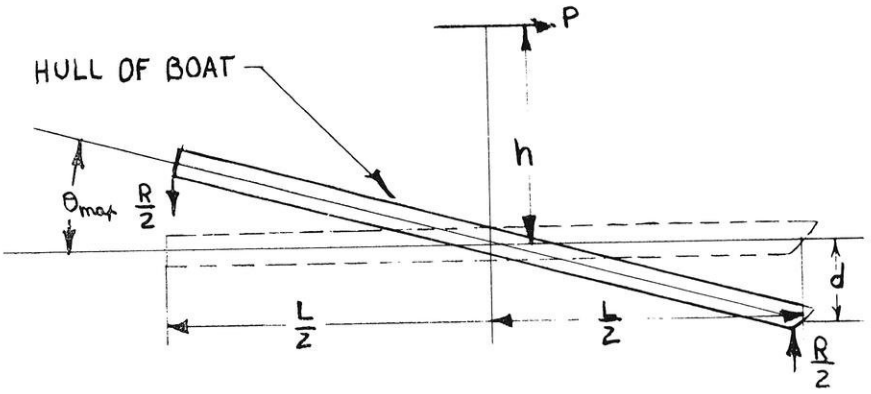


Figure 6.—Force Diagram of Boat Subjected to Pitching Moment

Ventilation Drop

Another design problem became evident when hydrofoils were first being tested. At that time hydrofoil boats were becoming well known for drenching their passengers by suddenly dropping to the water's surface with a large splash. This drop was due to a phenomenon known as "ventilation drop" which is the sudden loss of lift due to the air's reaching the upper surface of the foil. (This air is thought to come from the water's surface along the surface-piercing foil.) The vacuum just above the foil surface, and therefore the lift that this vacuum creates, is reduced by the air, thus causing the boat to start falling. The greater the vacuum above the foil, the greater the possibility of ventilation; therefore, since the vacuum increases with the angle of attack, so does the possibility of ventilation. Tests have shown that there exists a certain angle called "ventilation angle", above which ventilation is apt to occur. It would appear that the solution to the problem is to keep the angle of attack below this ventilation angle, but this is not always possible. In waves, the angle of attack is always changing and may go above the ventilation angle. It may seem as though there should be no objection to letting the angle of attack go slightly over the ventilation angle, for the foil will soon regain lift as it starts to climb the next wave. However, the system is self-aggravating. As the foil starts to fall, the relative velocity of the water past it is the vector sum of the wave velocity plus the negative of the foil velocity which includes the velocity of the fall of the foil. This means that the relative flow is at an even greater angle than before; therefore, ventilation increases and the boat falls to the water surface.

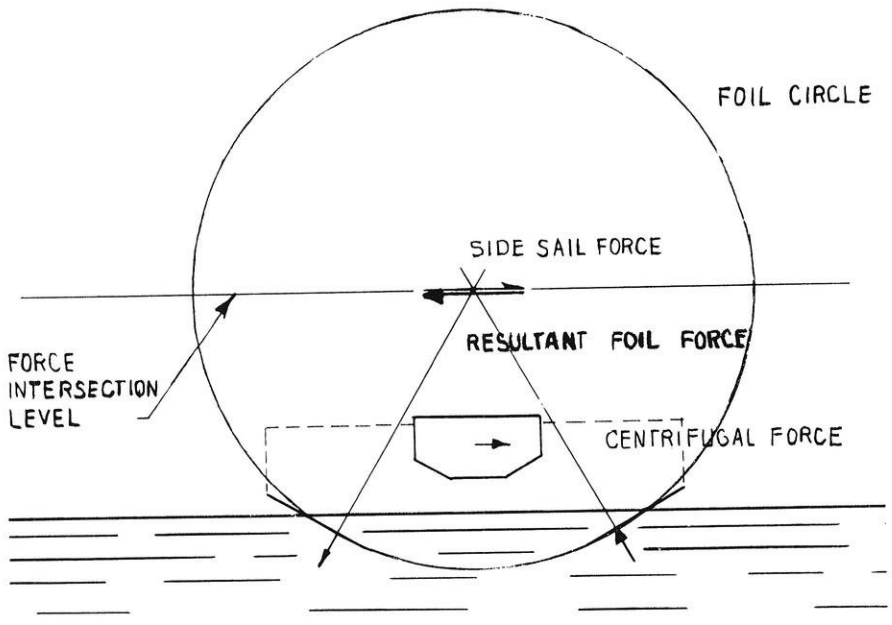


Figure 5.—Asymmetrical Foils With Lateral Loads

The approach used to avoid dropping from ventilation is the use of redundant surfaces. This means having four foils when only three are needed for support, or having two foils, one on top of the other, in place of each single foil that is needed. If more surfaces than are necessary to carry the load are present, when one surface ventilates, the other can momentarily carry the load. The disadvantage of redundant surfaces is the drag that they add.

Ventilation Yaw

This same phenomenon of ventilation causes another problem called "ventilation yaw". When the foils are turned, the angle of attack is increased on the side of a foil or strut. This is apt to cause the foil to suddenly slide sideward due to ventilation. When one foil slides, so does one end of the boat, causing a sudden turn or "yaw". Redundant surfaces are not as effective a solution to this problem as they are to ventilation drop.

SOME SOLUTIONS

The two successful experimental hydrofoil sailboats of the Baker Manufacturing Company represent possible solutions to most of these problems.

Their sixteen-foot boat has V-foils which are spaced widely enough so that rolling moment can be resisted without difficulty.

The *Monitor*, their twenty-six foot boat, has asymmetrical ladder-like foils. The rungs of the ladder are arcs of concentric circles. Each rung acts as an asymmetrical foil. The sides of the ladder resist roll by sustaining reactions which do not pass through the force intersection level of the rungs of the ladder. If just one rung of the ladder were present, the hydrodynamic characteristics of the sides of the ladder would dominate the behavior of the foil system. Several rungs in the ladder dominate the behavior and the characteristics of this hydrofoil system are like those described under asymmetrical foil with the added advantage of resistance to roll.

Figure 7.—Baker's 16-Foot Hydrofoil Sailboat on Lake Mendota

The sixteen-foot Baker boat will often dive or climb when under a pitching moment, but for the *Monitor* the problem of resistance to pitching moment is solved by an automatic pitch regulation. This is accomplished by continually determining the pitching moment of the sail on the hull with a mechanical computer and using a motion proportional to the pitching moment to vary the angle setting of the rear foil. This varies the lift of this foil and thereby produces an opposite pitching moment on the hull. All the power required to operate this device is derived from the sail.

The sixteen-foot boat has small extra foils attached beneath its V-foils. These help to prevent ventilation drop and ventilation yaw without adding excessive drag. The rungs of the *Monitor's* ladder foils provide the redundant surfaces necessary to prevent ventilation drop. Both of these boats still experience some ventilation yaw.

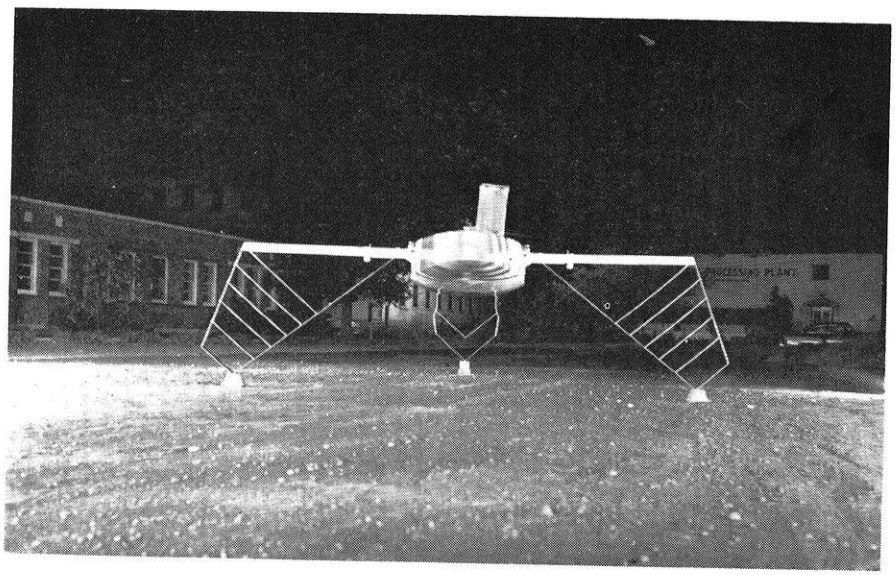


Figure 8.—Hydrofoil System of the *Monitor*

CONCLUSION

The *Monitor* is now the world's fastest sailboat; its speed has been measured at over 35 mph. It has provided much fun and excitement for those who have sailed it and caused much interest and amazement from those motorboat occupants by whom it has passed. (The

(Continued on page 30)

Picture yourself as a Western Electric engineer. What might you be doing?

As a MANUFACTURING ENGINEER you'd work closely with Bell Telephone Laboratory engineers on the latest concepts in communications systems. It would be your job to work out production techniques for these systems, which might mean developing special tools, machines, or test equipment. You would have the opportunity of guiding products from their final development to the point where they roll off the production line.

As an INDUSTRIAL ENGINEER your work would be more closely related to the search for new ideas to reduce the cost of currently manufactured products, to improve their quality or make the job easier. Many of the Industrial Engineer's problems relate to human engineering as well as to operations research and the establishment of wage incentive rates.

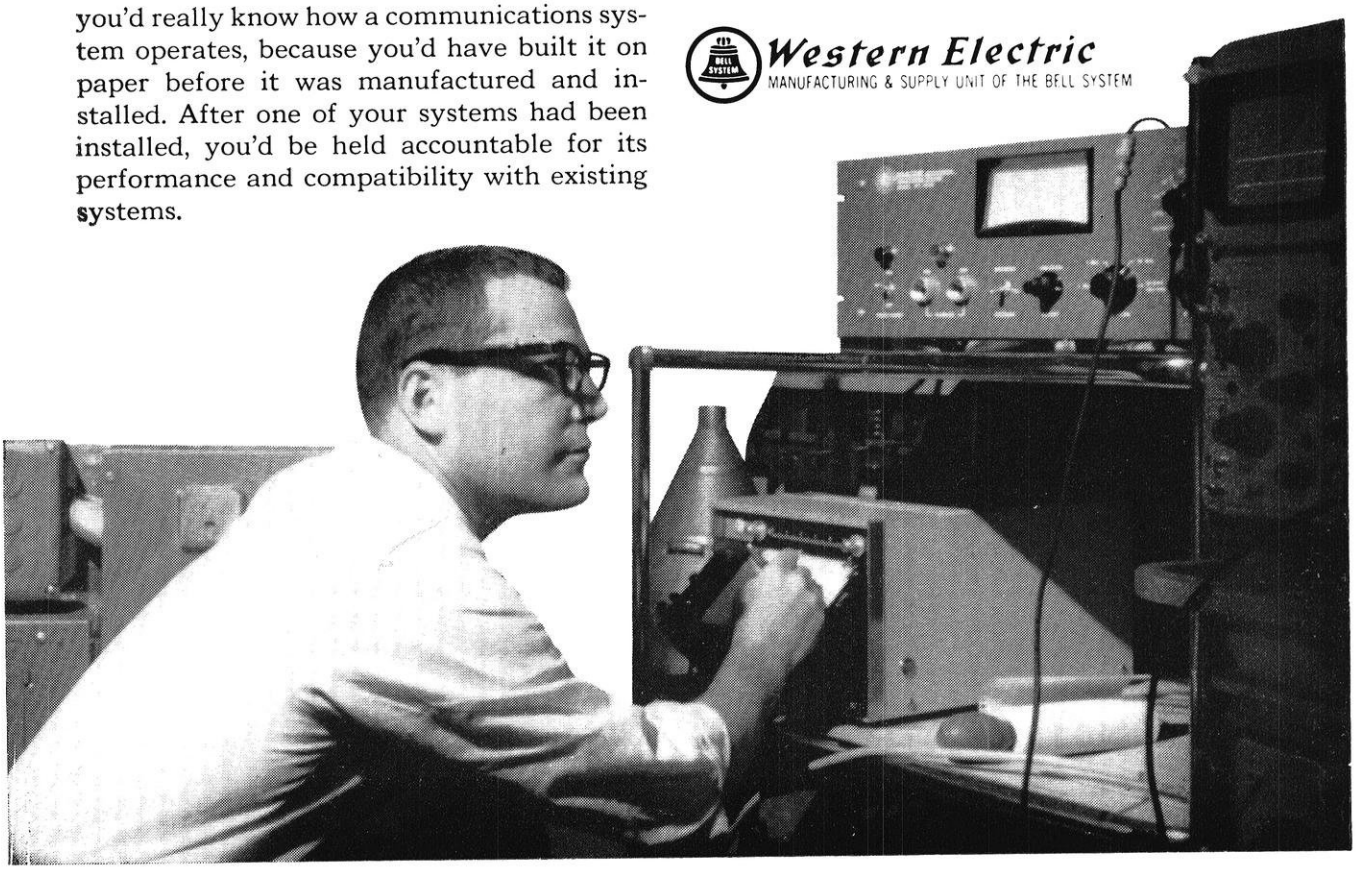
As a SYSTEMS EQUIPMENT ENGINEER you'd really know how a communications system operates, because you'd have built it on paper before it was manufactured and installed. After one of your systems had been installed, you'd be held accountable for its performance and compatibility with existing systems.

As a MILITARY SERVICE ENGINEER you'd be concerned with research, design, development, testing, production, delivery, and assistance to the military in the operation and maintenance of complex military systems. Systems applications range from the ocean depths to outer space. You could expect a wide variety of engineering assignments in many diverse fields.

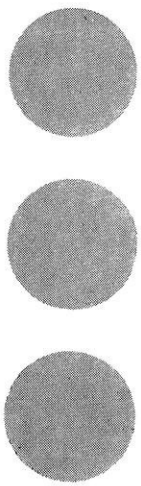
The challenges are big at Western Electric — and so are the opportunities. Now is the time to investigate them. Be sure to talk to the Western Electric people on the Bell System recruiting team when they visit your campus.

For advance information, get a copy of our career opportunities booklet from your placement officer. Or write: College Relations Staff Manager, Western Electric Co., Room 2510A, 222 Broadway, New York, N.Y. 10038. An Equal Opportunity Employer.

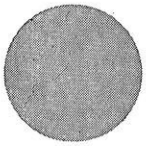
Western Electric
MANUFACTURING & SUPPLY UNIT OF THE BELL SYSTEM



LATE NEWS for 1966 ENGINEERING GRADUATES



Expanding military and commercial business has created even more openings.

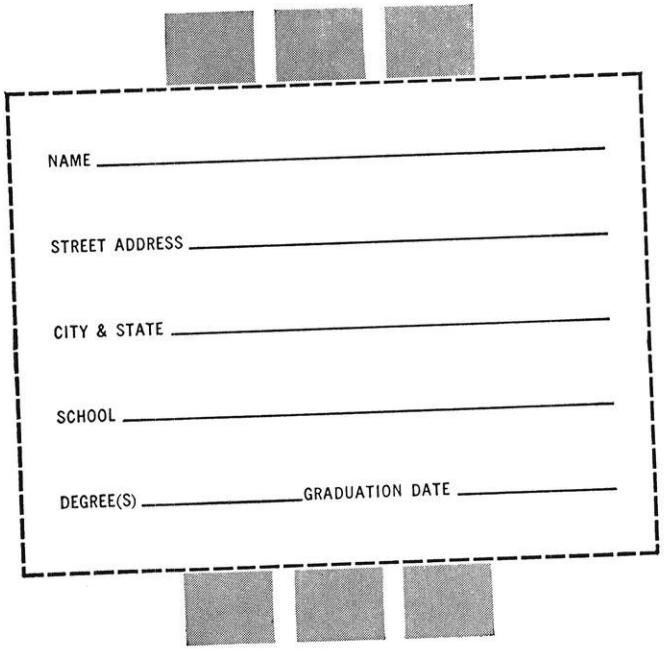


As you contemplate one of the most important decisions you have yet had to make, we suggest you consider joining us at Pratt & Whitney Aircraft. Like most everyone else, we offer all of the usual "fringe" benefits, including our Corporation-financed Graduate Education Program. But, far more important to you and your future, is the wide-open opportunity for professional growth with a company that enjoys an enviable record of stability. You will be working on challenging new problems of propulsion.

And make no mistake about it... you'll get a solid feeling of satisfaction from your contribution to our nation's economic growth and to its national defense as well.

Your degree can be a BS, MS or PhD in: **MECHANICAL • AERONAUTICAL • ELECTRICAL • CHEMICAL ENGINEERING • PHYSICS • CHEMISTRY • METALLURGY • CERAMICS • MATHEMATICS • ENGINEERING SCIENCE OR APPLIED MECHANICS.**

For more specific information (and immediate action) concerning a career with Pratt & Whitney Aircraft, write today (or use coupon) to Mr. William L. Stoner, Engineering Building 1-A, Pratt & Whitney Aircraft, East Hartford, Connecticut 06108.



NAME _____

STREET ADDRESS _____

CITY & STATE _____

SCHOOL _____

DEGREE(S) _____ GRADUATION DATE _____

SPECIALISTS IN POWER . . . POWER FOR PROPULSION—POWER FOR AUXILIARY SYSTEMS. CURRENT UTILIZATIONS INCLUDE MILITARY AND COMMERCIAL AIRCRAFT, MISSILES, SPACE VEHICLES, MARINE AND INDUSTRIAL APPLICATIONS.

Pratt & Whitney Aircraft

DIVISION OF UNITED AIRCRAFT CORP.

CONNECTICUT OPERATIONS EAST HARTFORD, CONNECTICUT
FLORIDA OPERATIONS WEST PALM BEACH, FLORIDA

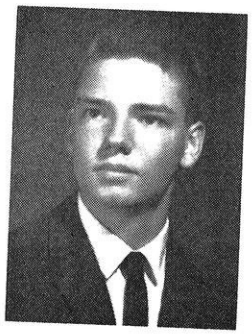
An Equal Opportunity Employer, M & F

Highway Right-of-Way Acquisition Analyses

by James L. Hanson, cie3

THE equitable and timely purchase of highway right-of-way is an important task for the builders of today's highways. As rights-of-way grow wider, and space becomes more valuable, the problems associated with public land acquisition become more complex. The Interstate System alone will need a million and a half acres of land, costing approximately 6.5 billion dollars. It is the aim of highway officials charged with spending such large sums of money to assure its wise use. A recent study conducted by the United States Bureau of Public Roads shows that, contrary to public belief, most property owners benefit from their encounters with state highway departments, that the partial taking of property for right-of-way has, in most cases, been beneficial to the remaining property.

In determining a fair price for the purchase of right-of-way as much background information as possible is needed. To obtain this information, most State highway departments are conducting, analyzing and publishing the results of severance damage studies. It is the purpose of this report to describe the procedures used in such studies, and to explain their major findings.



Jim Hanson is a Junior in Civil Engineering and lives in Madison. His summer and part-time employment has been with the State Highway Commission and the City of Madison Parks Department (Planning Unit). Jim, who is interested in a career in Engineering Administration is a member of the UW Men's Glee Club.

SEVERANCE DAMAGE STUDY EFFORTS

Severance damage studies are case study analyses of the experiences of properties partially taken for highway right-of-way. Closely related to land economic studies, severance damage studies provide necessary information in determining proper compensation for property taken. Economic impact studies, useful in furnishing guides to broad trends of values in particular sets of circumstances, have a more general scope than the severance damage study. Economic impact studies and severance studies are alike in that they both identify and measure the effects, on land value, of various types of highway improvements. (5)

Study Applications and Importance

Because of the complexity of problems associated with public land acquisition, severance damage studies have been receiving attention and use. Severance studies usually deal with specific parcels of land and specific types of highway situations, such as various types of

access control (5). By recording and analyzing past experiences, it is possible to determine with greater certainty, the present and future effects of taking portions of properties for right-of-way. A recent report on some twelve hundred severance damage studies compiled by the United States Bureau of Public Roads predicts, "as more is learned about what happens to properties taken in part for right-of-way, and especially about those factors or characteristics that affect value, considerable savings in right-of-way costs can be realized." (2) It should be pointed out that these studies are not only intended to reduce right-of-way costs. Inadequate payments are just as important to the highway administrator as excessive payments. Severance studies offer a way of correcting certain overpayments as well as the relatively few underpayments for right-of-way. There appears, however, to be general agreement that ". . . the production and use of economic evidence of value must increase both in quantity and in sophistication of technique." (5)

UW MAN REPORTS

Orrin L. Helstad, Associate Professor of Law at the University of Wisconsin places further emphasis on the importance of severance damage studies in a report, written for the United States Bureau of Public Roads entitled "Recent Trends in Highway Condemnation Law." In his article, Professor Helstad states in reference to the determination of correct compensation by the fair market value rule and the before and after, or value of the part taken plus damages rule, ". . . it is difficult to discern any general trends in this area. It appears to be an area that merits further study." Furthermore, ". . . State legislatures have made few attempts in recent years to clarify or codify rules of valuation." (4)

Systematic study of the effect of highway improvements upon nearby land has also led to the development of files, or banks of reported cases from which comparable market data may be obtained for valuation purposes.[5] Severance damage studies are now underway, or have been completed, in forty-six states. In 1961, the United States Bureau of Public Roads established a central file of severance damage studies and asked the individual states to submit case studies. By January, 1964 the states had supplied over 1,200 cases. These studies were reported to the Bureau either on IBM punch cards or standardized Bureau forms. In addition to those studies submitted to the Bureau of Public Roads, the individual states have published over 1,500 reports, either narrative or on State forms. By 1964 twenty-nine states were submitting punch cards or standardized Bureau forms, four states were publishing narrative reports, 13 had studies underway and four states, Puerto Rico and Washington D. C. had done no research in this area (see Figure 1).[2]

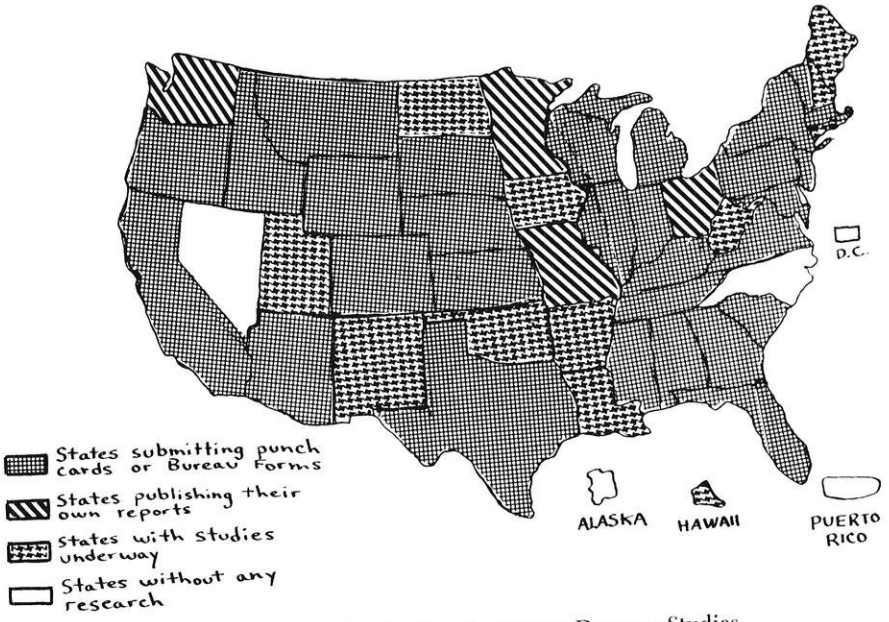


Figure 1.—States Conducting Severance Damage Studies

Individual Case Studies

Individual severance damage studies provide important experience in similar situations useful to the appraiser in determining correct compensation. Study results best suited for this application are usually completed within the boundaries of the state. In some special or unusual cases the central file of the United States Bureau of Public Roads is searched for comparable situations. Individual studies can be useful in negotiations, public relations, and increasingly more so in the court room.[2]

Collections of Cases

By analyzing many individual case studies, it is possible to see certain trends emerging. It should be pointed out that because of the relatively small number of cases available for examination and a lack of concern as to a typical cross section of cases for study, nothing more than a few general guide lines can be set up at present. It is hoped that in the future, relationships between certain variables will be found and formulas developed for determining fair compensations.[1]

GENERAL SEVERANCE STUDY RESULTS

Collections of cases have made it possible for the State Highway Departments and the United States Bureau of Public Roads to analyze the relationships between variables common to all or most of the cases. It has been fairly common to find that the results of partial takings for right-of-way were much less adverse than originally feared. Often it has been found that the remaining parcels received a significant benefit. Because of their size, individual state analyses have, for

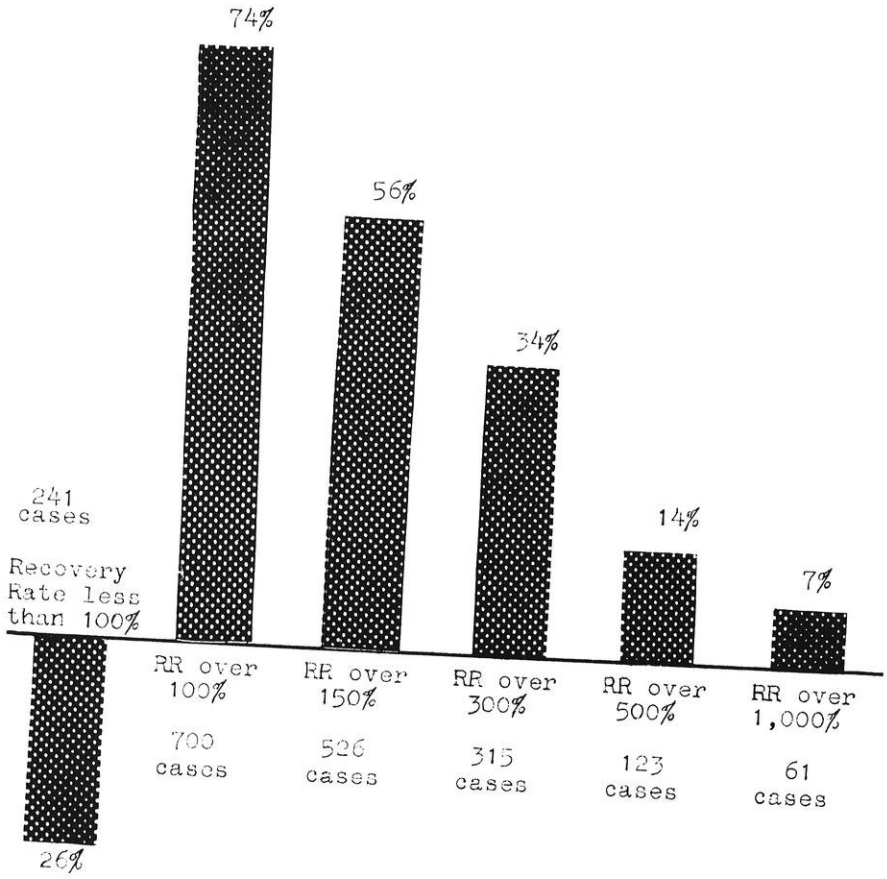


Figure 2.—Land Value Recovery Rates

the most part, failed to turn up any concrete or even tentative results. In ". . . an attempt to ascertain the economic effects of controlled-access facilities in North Carolina on surrounding property values and development,"[3] researchers found:

> "Results of the analysis indicate that the average unit price of property increased significantly within all sites. However, patterns of significance for the independent variables are most erratic and, as a result, these increases cannot necessarily be attributed to the construction of the test facilities. The predominant type of land use within the study areas is farm land, whereas the most active category in terms of sales is vacant property. The statistical analysis indicates that the investigated highways have had no measurable effect on development within the study areas."[3]

An analysis made by the United States Bureau of Public Roads of cases submitted to their central file has brought forth some tentative findings. Because of the increased number of individual cases available for study, this analysis is probably the most significant to date. The results it points up are only tentative, however, and may change as more information is compiled. The Economic Research Division of the Bureau of Public Roads has made the following observations:[1]

> "1. The recovery rate for cases in the Public Roads' bank tends to be more than 100 percent, the median is 138 percent.
>
> 2. Certain characteristics tend to be associated with a higher-than-average recovery rate. These include: nearness to an interchange, a sale after some period of time (e.g., more than a year) after the taking, a vacant rather than a residential land use before the acquisition, and full visibility of the highway from the remainder.
>
> 3. When the simultaneous effect of several factors acting in combination was analyzed by multiple regression, the most influential factors were: a change in land use, time elapsing from acquisition to sale, travel distance to the new highway, type of remainder, and nearness to an interchange.
>
> 4. The owner is being made whole in four out of five cases.
>
> 5. Property owners who lost generally had lost very little. Gains ranged from small amounts to fantastically large gains.
>
> 6. Owners of residential properties are more likely to experience losses than owners of land in other uses. Gains are often associated with vacant remainders.
>
> 7. Damage payments made to owners of vacant parcels often are unrealistically high. Experience suggests that high damage payments for vacant properties partially taken should receive close scrutiny in the future."

These results are only tentative, but it is a start. They should help to assure the proper spending of tax money for right-of-way purposes in the future.

METHODS OF ANALYSIS

Even though there is agreement as to the purpose of severance damage studies—to learn how to provide equitable payments for right-of-way at present, and in the future, from past experiences—there are three variations in evaluating the study results.

The Recovery Rate (1)

The recovery rate is simply the per acre selling price of the remainder, divided by the per acre value at the time of the taking. A remainder parcel experiencing no change in value has a recovery rate of 100 percent. If the recovery rate is over 100 percent the remainder has increased in value, similarly if the recovery rate is less than 100 percent the remainder has decreased in value. In order to determine the recovery rate, only a part of the remainder must have been sold.

The recovery rate has drawbacks. A recovery of less than 100 percent gives no indication of whether just compensation has been paid. It leaves out any consideration of damage payments made to the owner by accounting only for property value. Arithmetic averages can not be used to accurately summarize the cases which have been studied. Because of the extremely high recovery rates of a few parcels, median values are

used to summarize the overall recovery rate.

Of those cases in the central file of the United States Bureau of Public Roads by January of 1964, approximately three out of four showed a recovery rate of more than 100 percent. The median recovery rate for all cases was 138 percent. As shown in Figure 2, seven percent of the cases showed a recovery rate of more than 1,000 percent and another 26 percent showed a recovery of less than 100 percent.

In addition to analyzing recovery rates for all the cases in the central file, groups of cases have been categorized and rates compared according to time of sale, land use before the taking, type of highway involved, visibility of highway from remainder parcel and location of the parcel in relation to an interchange.

Time of Sale. Time of sale had a very noticeable effect on the recovery rates. Remainders which were sold more than a year after the severance tended to have higher recovery rates. Those parcels which were sold within a year had a lower recovery rate. a third of these had a recovery of less than 100 percent. The median rate for property sold within a year was 119 percent; for property sold between the first and second year, 135 percent; for property sold between the third and fourth year. 157 percent; and for properties sold more than three years after they had partially been taken for right-of-way, 238 percent. Even after these median recovery rates are adjusted for the general increase in property values, the recovery rates of those parcels which were sold a year or more after the severance remain substantially high (115 percent, 121 percent, 129 percent, and 155 percent, respectively).

Land Use. Land use at the time of the right-of-way taking also seems to have an effect on the recovery rate. Residential property suffered the lowest median recovery rate, 126 percent. Vacant land had a median of 143 percent; a combination of services, trade, manufacturing and government, 145 percent; and agriculture, 149 percent.

Type of Highway System. Comparison by type of highway system shows that some differences may be the result of the type of road along which a parcel is located. The median recovery rate for those parcels located along the Interstate System was approximately 140 percent, slightly above the median for all types of highway systems of 138 percent. The recovery rates for properties along Federal-aid primary and Federal-aid secondary highways were slightly less, 132 percent and 135 percent respectively.

Visibility from the Remainder. Surprisingly, property from which the highway can be seen, sells at higher prices than that property from which the highway cannot be

seen. The median recovery rate for property from which the highway is fully visible was 145 percent, compared to recoveries of 133 percent for properties from which the highway is partially visible and 117 percent for those from which the highway cannot be seen.

Interchange Effects. The recovery rates of properties located within half a mile from an interchange were generally higher than those located outside this limit. The median recovery rate for property within a half mile was 164 percent, while that of properties farther away was 131 percent

Multiple Regression Analysis (1)

Multiple regression analysis is a statistical method by which the simultaneous effect of several factors acting in combination can be determined, and the relative strength of each factor measured. When the effects of several factors acting simultaneously on the recovery rate were analyzed, the most influential factors were change in land use, time elapsing from acquisition to sale, travel distance to the new highway, type of remainder (land locked, isolated, or separated) and nearness to an interchange. This type of right-of-way analysis has not yet been refined for a recovery rate aplication; more work has been planned on it in the future.

Extent to Which the Owner is Made Whole (2)

Whether the owner is made whole—whether affected property owners were placed in as good a financial position as they would have been had their property not been taken—is determined by comparing the before and after property values. In order to make this comparison, the entire remainder must be sold. By comparing the appraised value before the taking to the total amount which the owner received from the property (payments made by the State for property taken and expected damages, plus the sale price of the entire remainder), it is possible to determine whether the owner was damaged by or benefited from the transaction, and the extent of the damage or benefit.

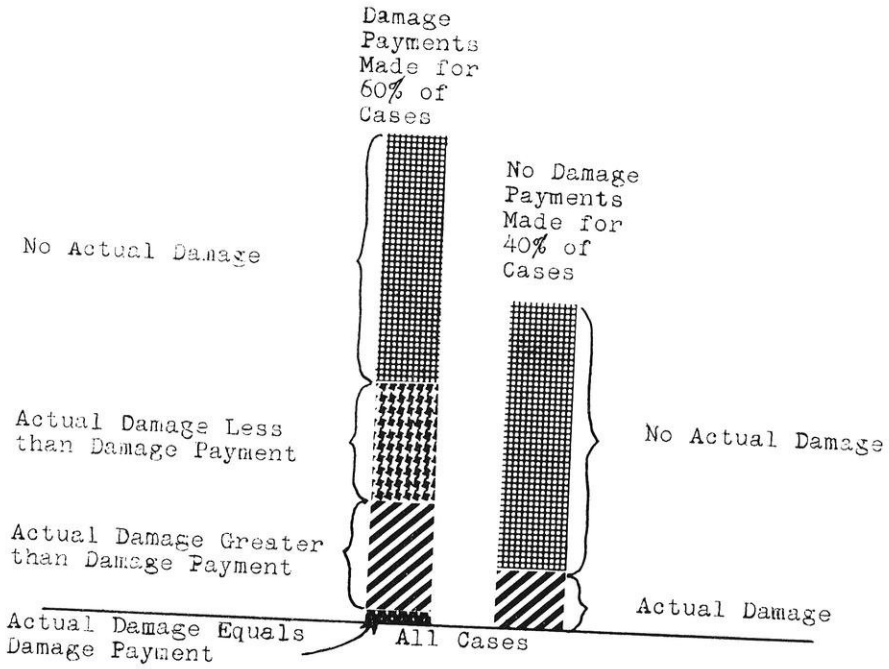


Figure 3.—Comparison of Damage Payments With Actual Damages

By January of 1964 the Bureau of Public Roads had the necessary information in 647 such cases. It was found by analysis, that four out of five owners received at least adequate compensation. Remaining owners received less money for damages than they were entitled to. The median owner received 112 percent of the value of the entire property (including improvements) before taking.

Estimated and Actual Damages. Of those cases studied by the Bureau, 60 percent of the owners received damage payments. Only half of these actually suffered damages and a fourth sustained less damage than they were compensated for. A fifth of those studied received less compensation than they deserved (see Figure 3).

Damage Payment Compared to Total Payments. Damages accounted for 28 percent of the total right-of-way payments made by the States. Nearly half of the cost of vacant lands was for damage payments. After further study, it has been shown that the owners of vacant lands have prospered far better than others.

Owners of vacant land received a total of 129 percent of the value before partially taking for right-of-way, while owners of residential property received only 107 percent and the average for all other uses was 115 percent. Shown in Figure 4, vacant parcels also received fewer losses (11 percent to 23 percent).

Comparing Total Values. When the results of 647 cases studied by the Bureau were totaled, some rather startling results were obtained. The total appraised values of the properties before acquisition was 15 million dollars. Their owners were paid a total of 4 million dollars for the property taken for right-of-way, and another 1.6 million dollars in damages. When the remaining property was sold, the owners received a total of 15.3 million dollars. Even when adjusted for the general increase in land values between the acquisition and time of sale, the expected market value, according to the damages paid, is only 10.2 million dollars. By simple subtraction, it can be seen that the property owners, as a group, realized a profit of over 5 million dollars (see Table 1 and Figure 5).

The results obtained by totaling do not, however, indicate that no damages should be paid. In fact,

(Continued on page 30)

Not Just an Ordinary CHEV TRUCK

Copy and Photos Courtesy G.M. Engineering Journal

Figure 1.—View of Truck

TURBO-TITAN III

The new Chevrolet Turbo-Titan III combines highly advanced styling with the unique characteristics of the gas turbine engine and the proved potential of an existing chassis design (Fig. 1). Coupled with a 40-ft. stainless steel trailer, the unit has a 50-ft. overall length, gross vehicle weight of 48,000 lbs., and an operating gross combination weight of 76,800-lb. capacity.

Styling and Cab

Mounted on a slightly modified truck chassis, the modernistic cab has a power tilting mechanism. At a touch of a switch, the cab lifts forward to reveal the gas turbine engine.

The cab also has power operated wing-type side windows, hinged at the top. When the key is inserted in the door, the windows lift open providing easy access to the cab.

Mounted beneath the windshield are retractable square lens headlamps (Fig. 2-bottom). They are vertically mounted within the large functional air intakes in two banks of three lamps each. The bottom lamp in each bank is an extra turnpike lighting system that floods the road ahead with light. Front turn signals also are retractable, disappearing into the smooth contour of the cab when not in use (Fig. 2-bottom right).

Inside the cab (Fig. 2-top), the dial steering system is mounted on a pedestal in front of the driver in place of the conventional steering column and wheel. Twin dials mounted on a vinyl padded panel operate at a feather touch to control the truck's power steering. An auxiliary pump, driven from the propeller shaft, provides emergency steering power if the main pump should become inoperative while the vehicle is in motion.

The quadrant for the automatic transmission also is mounted on this panel, as is the turn signal indicator. The pedestal pivots fore and aft and the panel also tilts for the most comfortable driving position.

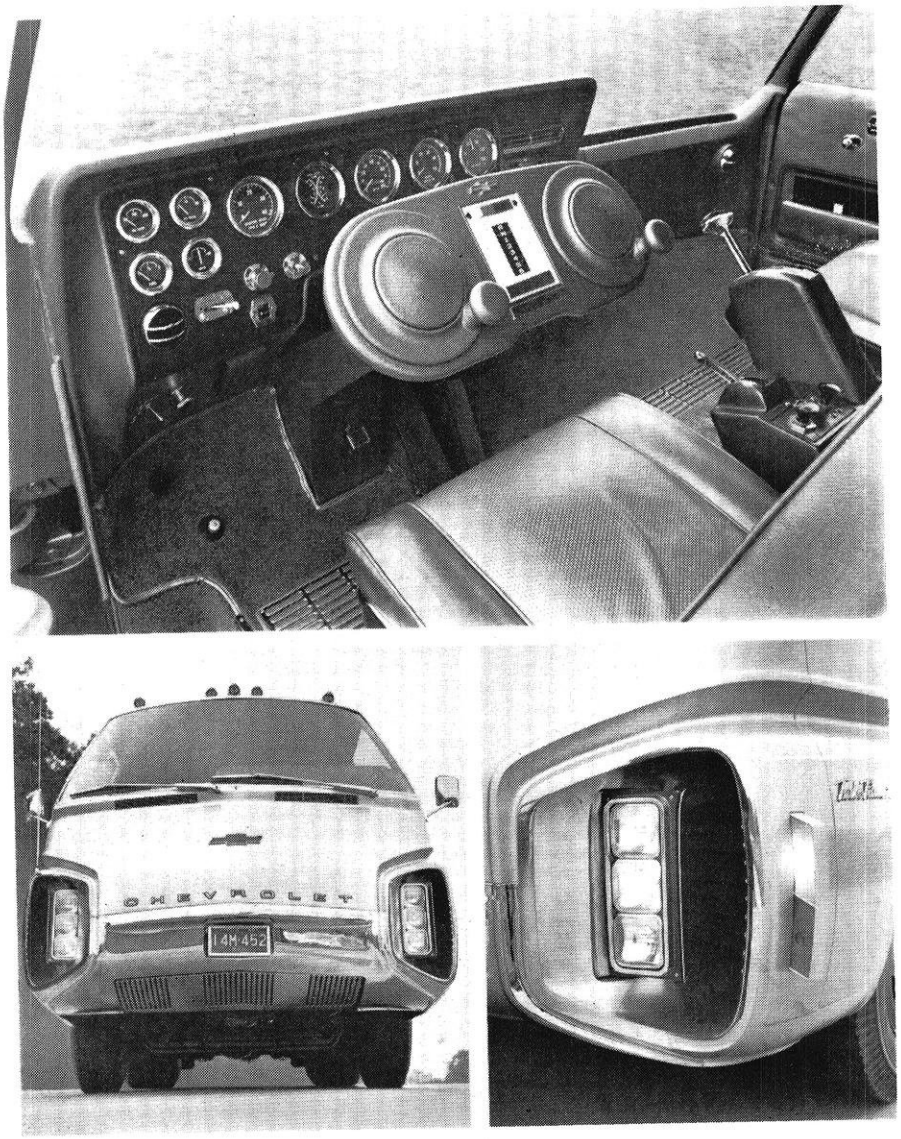


Figure 2. —See text.

Engine Design

The GT-309 engine is based on more than 15 years of research and development and is a fifth generation powerplant developed by the GM Research Laboratories. Successfully operating predecessors include turbines on the GM Firebirds, the Turbo-Cruiser bus, two Chevrolet Turbo-Titan trucks and 15 prototypes built by Allison Division for military and industrial users. The GT 309 produces 280 hp at an output shaft speed of 4,000 rpm, geared down from the power turbine engine and shaft speed of 35,000 rpm. Torque characteristics of a turbine engine are quite different from those of a reciprocating internal combustion engine.

Highest torque of the GT-309 is delivered at stall, an attractive feature for heavy-duty truck applications. The GT-309 has a maximum torque rating of 875 lb.-ft. The colder the day the more powerful the GT-309. Ambient air tempera-

(Continued on page 26)

Something Borrowed . . .

the image of the engineer

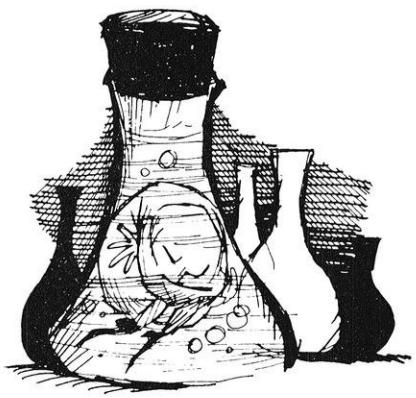
drawn and written
by tom eaton, b.art.'63

Who is the man designs our pumps
with judgment, skill and care,
Who is the man that builds 'em
and keeps them in repair,
Who has to shut them down be-
cause the valve seats disappear?
The bearing-wearing, gearing-
tearing mechanical engineer.

Who builds a road for fifty years
that disappears in two,
Then changes his identity, so no
one's left to sue,
Who covers all the traveled roads
with filthy oily smear?
The bump-providing, rough-on-
riding highway engineer.

Who is the man who'll draw a plan
for everything you desire,
From a trans-Atlantic liner to a
hairpin made of wire,
With "ifs" and "ands," and "how-
e'ers" and "buts," who makes
his meaning clear?
The work-disdaining, fee-retain-
ing consulting engineer.

Who takes a transit out to find a sewer to tap,
Who then with care extreme locates the junction on the map,
Who is it goes to dig it up and find it nowhere near?
The mud-bespattered, torn and tattered civil engineer.



Who thinks without his products we would all be in the lurch,
Who has a heathen idol which he designates Research,
Who tints the creeks, perfumes the air and makes the landscape drear?
The stint-evolving, grass-dissolving chemical engineer.

Who buys his juice for half a cent and wants to charge a dime,
Who, when we've signed the contract, can't deliver half the time,
Who thinks a loss of twenty-six per cent is nothing queer?
The volt-reducing, load reducing electrical engineer.

Who takes the pleasure out of life and makes existence hell,
Who'll fire a real good looking one because she cannot spell,
Who substitutes a dictaphone for coral tinted ear?
The penny-chasing, dollar-wasting, efficiency engineer.

Reprinted with permission from KANSAS ENGINEER, University of Kansas, Lawrence, Kansas.

"CHEV TRUCK"

(Continued from page 23)

ture has the same effect on reciprocating engines, but to a lesser degree because of the smaller amount of air they require.

Engine Operation

The GT-309 has the same basic operational components as previous turbines. These include a compressor, gasifier, power turbine, and regenerator. The gasifier turbine is mounted on a common shaft with the radial flow compressor. The power turbine is geared to the output shaft. Air is drawn in by the compressor, compressed, and ducted to the combustion chamber.

The compressed air, together with fuel sprayed into the chamber, produces combustion with temperatures of approximately 1,700 F. The gases, under high pressure and temperature, pass through nozzles against vanes in

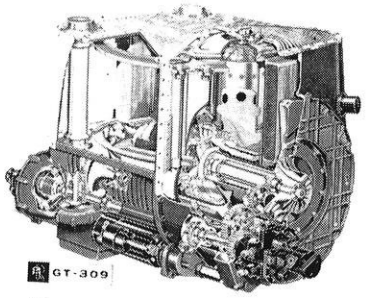


Figure 3.—Engine Cutaway.

the gasifier turbine, driving the turbine and compressor at a design speed of approximately 35,700 rpm.

The power turbine is directly behind the gasifier but not connected to it. After driving the gasifier turbine, the high velocity gases from the nozzles strike against the buckets of the power turbine to drive it at various speeds ranging from stall to design speed of 35,000 rpm.

The regenerator is located so that one-third of its circumference and area is located, at all times, in the high pressure chamber and two-thirds of it in the exhaust plenum. Compressed air discharged by the compressor is heated as it is driven through the porous regenerator area located at that moment in the high pressure plenum.

Gas temperature coming out of the turbines is about 1,200 F. The regenerator absorbs enough heat to bring exhaust gas temperatures down to the 300 to 500 degree range, about half that of a diesel engine. More than 90 per cent of the recoverable exhaust system heat is salvaged. This reduces the amount of fuel needed to produce the high temperature, high velocity gas to drive the turbines. The regenerator eliminates the need for mufflers and silencers, serving as an insulating blanket to keep not only the heat but also most of the turbine noise from reaching the outside of the engine.

In most gas turbine designs, power is delivered only through the power turbine, while the gasifier turbine is used only to drive the compressor. The GT-309 has a performance advantage over its predecessors and most competitors with power transfer, a feature conceived jointly by GM Research Laboratories and Allison Division.

Engine Braking

This system makes use of a gear train to couple the gasifier turbine and compressor to the output shaft. A variable coupling, or clutch, engages or disengages this drive to permit the transfer of only a scheduled amount of power.

During vehicle deceleration, power transfer provides two to three times more braking power than a comparable gasoline or diesel engine. In effect, it couples the output shaft to the turbine compressor but with about a 10-to-1 gear multiplication.

A further important feature of power transfer is that the vehicle can use engine braking incessantly without adverse effects. All heat created in the engine is immediately ejected into the atmosphere.

Since the power transfer train extends from the front to the rear of the engine, portions of the gear train can be used to provide both a front and a rear accessory drive. A pulley at the front end drives a complex made up of the alternator, the power steering pump, and the shrouded fan drawing air through the transmission-engine oil cooler. The rear power take-off drives the air conditioning compressor.

Electrical System

The GT-309 has a fairly conventional electrical system. The battery-powered starting motor, driving through the power transfer gear trains, activates gasifier turbine and compressor to about 4,000 rpm as fuel is turned on and the single spark plug ignited.

Cranking continues until the gasifier turbine reaches an idling speed of about 15,000 rpm. Minimum operational speed of this unit is about 18,000 rpm. The combustion process of this engine can be continuous and self-sustaining. In deceleration, however, the fuel supply is shut off to provide engine braking. A continuous spark is used in the GT-309 to burn any inadvertent fuel accumulations.

Transmission

Coupled with the GT-309 by a special aluminum adapter is a conventional Allison automatic transmission with torque converter and hydraulic retarder sections omitted. The GT-309 can operate with power turbine and output shaft stalled. In addition, the turbine concept is an excellent torque converter without the power loss and cooling requirements associated with these units. Thus, the torque converter section of the transmission is not needed. Because of the power transfer feature in engine braking, the hydraulic retarder of the transmission also is not necessary. The remainder of the transmission is a conventional Allison six-speed unit.

Chassis

Chassis design is conventional in all respects. The frame is made up of two 10-1/16 by 3-1/2 by 5/16 heat treated channel section side rails with conventional cross members. The front suspension features a 15,000-lb. capacity I-beam and the rear suspension a 34,000-lb. capacity tandem bogie. These are spiral bevel two-speed units with ratios of 7.17 and 9.77-to-1. Only the 7.17-to-1 ratio is used since it is most compatible with the operating speed and power output of the engine.

Rear leaf springs are rated at 17,000-lb. capacity at the ground. Full air brakes include a 17-1/4 by 3-1/2 in. unit in front and self-adjusting 15 x 7 in. units at the rear axles. Super-wide, single 18-19.5 tires of 16-ply rating are on the rear wheels. Front tire size is 10.00-20.

Twenty-five hundred dollars in cash awards to engineering and metallurgy students.

The Forging Industry Educational and Research Foundation announces a $2,500 award competition for the best paper on the subject "The Principal Technical Development Needed by the Forging Industry in the Next Decade." First prize, $1,000, plus eight other awards totaling $1,500.

Competition is open to senior and graduate engineering and metallurgy students. Length of the paper, 3,000 to 3,500 words. Deadline for completed paper: June 1, 1966.

Winner and his faculty advisor will also receive an all-expense-paid trip to Colorado Springs, Colorado, where the award presentation will be made at the 1966 meeting of the Foundation.

For full details fill in and mail the coupon or write:

The President

Forging Industry Educational and Research Foundation

55 Public Square • Cleveland, Ohio

Name_____

Address_____

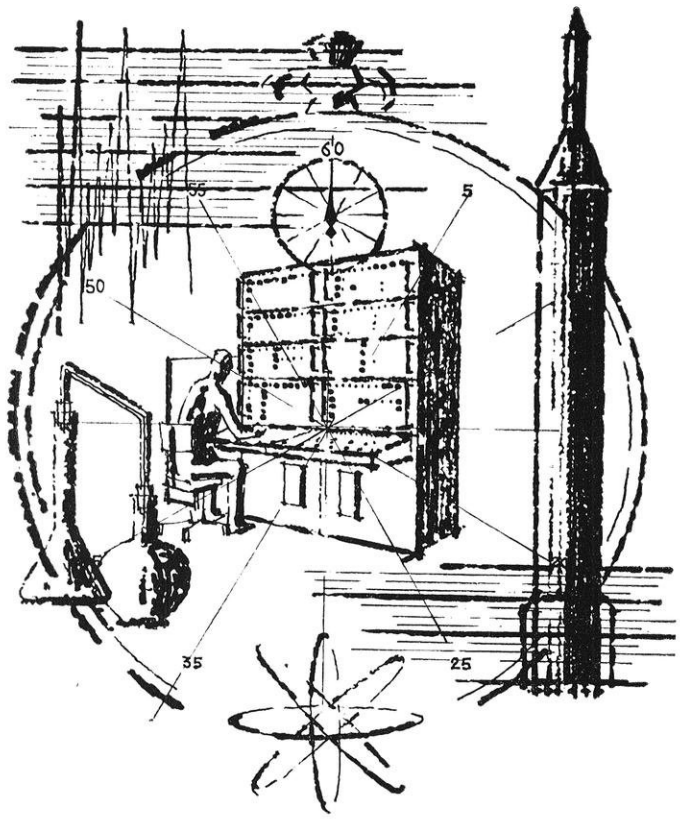
_____

School_____

_____

Faculty Advisor_____

For your immediate information, a new 16-millimeter sound and color film, *TO BE FORGED,* describes the forging process, design considerations and production methods . . . the applications and advantages of forged parts. Length 18 minutes. Made available by Forging Industry Association, this film is on loan free from Modern Talking Picture Service, Inc. Check your telephone directory for the office nearest you.



SCIENCE HIGHLIGHTS

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

NEW ABSTRACT SERVICE COVERS STEEL DESIGN AND CONSTRUCTION

A new abstracting service for designers of steel structures, entitled "Steel Abstracts for Construction," has been initiated by the Committee of Structural Steel Producers and the Committee of Steel Plate Producers, American Iron and Steel Institute. The first issue includes 24 pages with 53 abstracts of articles from 18 U. S. and foreign technical publications in construction.

The abstracts are intended to provide reference on the mass of information currently published on structural steel analysis and design and on steel construction. Three main subjects are covered: examples of progressive design in steel; new or improved procedures of analysis, design or construction; and application of new types of structural steels and steel plate products to conventional design concepts.

The first issue includes abstracts in four categories—research and design, buildings, bridges and miscellaneous structures. Typical titles are "Behavior of Composite Beams," "Designing with Cable Hung Roofs," "Orthotropic Plate Deck in Highway Bridges," and "Water Towers with Central Shafts."

Abstracts are arranged to be clipped for standard 3 x 5 card filing systems and key words are given for information retrieval. Addresses of publications containing the original articles are provided so complete texts can be obtained.

For a copy of "Steel Abstracts for Construction" write to Committee on Structural Steel Producers or Committee of Steel Plate Producers, American Iron and Steel Institute, 150 East Forty-Second Street, New York, New York 10017.

STUDY OF SUMMER EMPLOYMENT FOR ENGINEERING STUDENTS RELEASED

The Engineers Joint Council* announces the publication of the proceedings of its Conference on Summer Employment for Engineering Students, which was held in New York last November 18. Also released is the final report of an EJC survey of engineering educators, employers, and students on the subject of summer employment. The preliminary results of this survey constituted the basis for extensive discussion at the November conference.

The proceedings volume contains addresses by ten leaders of the engineering community, together with questions and answers of the conferees and a summary of the EJC survey.

Copies are available from Engineers Joint Council, Dept. P, 345 East 47th Street, New York, N. Y. 10017, as follows:

Proceedings of Conference on Summer Technical Employment for Engineering Students, 84 pages, $1.00 handling charge if ordered separately, no additional charge if ordered with the survey below.

Summer Employment of Engineering Students, 48 pages, $5.00 prepaid. (price includes copy of conference proceedings)

* Engineers Joint Council is a federation of thirty-seven professional societies

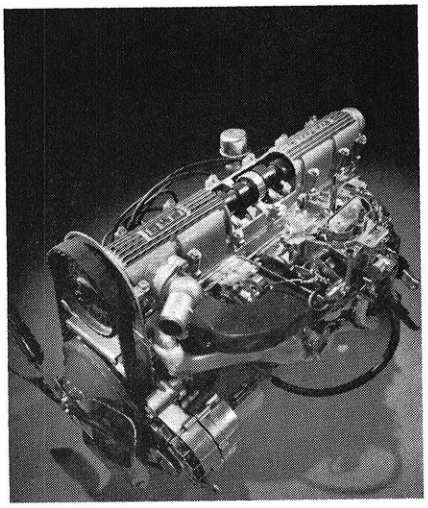
representing over half a million members. EJC serves as a common focal point through which the engineering profession brings its resources to bear on common problems and common areas of service.

NEW OVERHEAD CAM SIX-CYLINDER ENGINE

One of the major engine developments in the automotive industry in recent years was the introduction of a completely new six-cylinder, overhead cam engine by Pontiac Motor Division of General Motors.

The in-line, 230-cu. in. engine features a belt-driven overhead camshaft using a rocker arm and an automatic hydraulic lash adjuster. The fiber glass reinforced rubber timing belt replaces the conventional chain to drive the camshaft. The belt is installed outside the crankcase and connects the camshaft, crankshaft, and accessory drive sprockets.
sprockets.

With a single-barrel carburetor, the engine provides 165 hp at 4,700 rpm. The compression ratio is 9.0:1. An optional high-output unit includes the Quadrajet four-barrel



carburetor with a compression ratio of 10.5:1 and a rating of 207 hp. This carburetor features small primary venturis used in conjunction with large secondary air valves to control secondary fuel flow. This combination provides excellent low speed operation at both part and full throttle.

Another feature of the engine design is a new die cast aluminum accessory drive housing which contains the fuel pump, oil pump, and distributor. The entire housing is removed easily for rapid servicing.

ASTRONAUTS VISIT UW

The Wisconsin Society of Professional Engineers (WSPE) and its Southwestern Wisconsin Chapter were hosts to Astronauts James Lovell and Donald Slayton at a banquet which highlighted the Wisconsin engineers' observance of National Engineers Week Feb. 20–26. The banquet was held Feb. 24 in Madison's Loraine hotel with more than 400 WSPE members and their wives and guests in attendance. Main speakers on the program at the banquet are seen here. They are, from left, WSPE Pres. Erhardt C. Koerper. Astronaut Slayton, Gov. Warren Knowles, University of Wisconsin Prof. Eldon C. Wagner, civil engineering, a past president of the American Society of Civil Engineers (ASCE), Astronaut Lovell, and Dean Kurt F. Wendt of the UW College of Engineering at Madison.

FUN IN THE SUN

Collegians spending their Easter recess in Ft. Lauderdale are recruited by Systems Engineering Laboratories, Inc.

(Continued from page 22)

two out of five affected owners did actually suffer damages and one of these two received either insufficient compensation or no payments at all for damages.

The results do point out though, that great care and much study are needed in the future in order to curb this wasteful spending.

REFERENCES

(1) Broderick, George V. and Floyd I. Thiel. "An Evaluation of Partial Taking of Property for Right-of-Way." *Public Roads*, 33 (June, 1964), 38–44.

(2) Broderick, George V. and Floyd I. Thiel. "Highway Severance Damage Studies—Some General Findings." *Highway Research Record Number 54—Land Acquisition 1963*. Washington, D.C.: Highway Research Board of the National Academy of Sciences—National Research Council, 1964, 68–92.

(3) Cribbins, P. D., W. T. Hill, and H. O. Seagraves. "Economic Impact of Selected Sections of Interstate Routes on Land Value and Use." *Highway Research Record Number 75—Indirect and Sociological Effects of Highway Location and Improvement*. Washington, D.C.: Highway Research Board of the National Academy of Sciences—National Research Council, 1965, 1–31.

(4) Helstad, Orrin. "Recent Trends in Highway Condemnation Law." *Highway Research Record Number 54—Land Acquisition 1963*. Washington, D.C.: Highway Re-

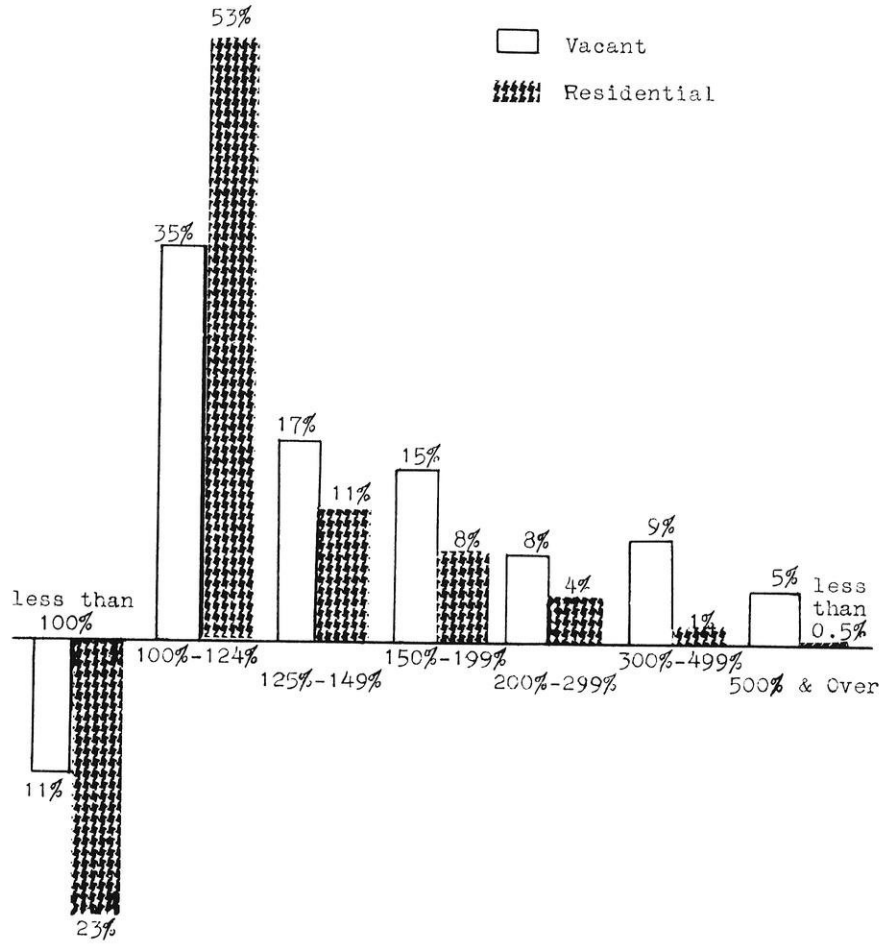
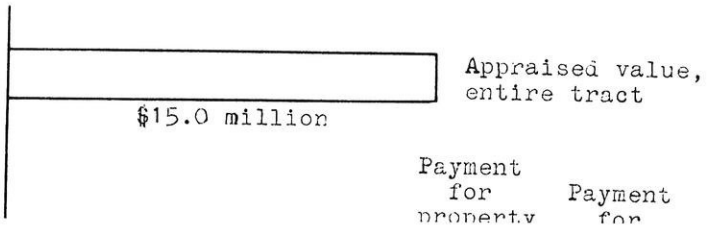


Figure 4.—Vacant and Residential Properties Extent to Which the Owner is Made Whole



"Field Notes"

Thermo Prof: "Well, is the

Dear Mary:

She: "There's

Don't sign up until you read the fine print.

PRODUCTS & SERVICES OF BELL AEROSYSTEMS

AIRCRAFT, MISSILES, GEMS

VERTICAL FLIGHT SYSTEMS — Exceptional background in V/STOL jet fighter/bomber and ducted-propeller transport development.
GUIDED MISSILES — First complete weapon system contractor responsible for management, design and production of air/ground systems.
TARGET MISSILE SYSTEMS — Fifteen years experience in design, development and production of target missile systems.
AIR LAUNCH SYSTEMS — System design and fabrication.
HEAT PROTECTION — Double-wall construction, successfully tested answer to re-entry heating. Refractory materials for re-entry.
GROUND SERVICING EQUIPMENT — Design and fabrication of complete GSE for aircraft, missiles, and rocket engines.
GROUND EFFECT MACHINES — Winning contractor for largest U.S. ACV — Navy's 22½-ton Hydroskimmer.
AIRCRAFT DESIGN — From first American jet airplane through "X" series and proven V/STOL concepts.
STRUCTURES — Lightweight heat protection and compact design.

SPACE SYSTEMS

RECOVERABLE SPACE VEHICLES — Design, test and fabrication of manned and unmanned space vehicles for controlled landings on earth or moon.
EXTRATERRESTRIAL WORKERS — Development, fabrication and evaluation of equipment for extra-vehicular manned operations in a space or lunar environment.
SPACE VEHICLES — Design, fabrication and test of satellites including deployment, maneuvering and rendezvous.
UPPER STAGES — Design, fabrication and test of space stages involving integration of structure, tankage and propulsion system.
SIMULATORS—Fixed base simulation of manned space systems for evaluation and training.

ROCKET OPERATIONS

LIQUID ROCKET PROPULSION — Rocket engines and controls, propellant tanks, positive expulsion devices, turbine pumps and pressurization systems.
HIGH ENERGY SOLID PROPELLANTS — Synthesis of new compounds for solid propellant propulsion and energy.
ADVANCED ROCKET PROPULSION — Research and development in new propellant combinations, pressurization concepts, thrust chambers, high-combustion temperatures, and materials including fluorine-oxidized propulsion system technology.
REACTION CONTROLS — Low-thrust propulsion systems providing vernier velocity adjustment, propellant settling and attitude orientation.
PROPULSION SYSTEM GROUND HANDLING EQUIPMENT — Designed and fabricated to provide check-out, functional test, and servicing of propulsion systems.
CRYOGENIC PUMPS — Fifteen years experience in design and development of pumps for liquid nitrogen, helium, oxygen, hydrogen and fluorine.
ENVIRONMENTAL TESTING OF PROPULSION SYSTEMS — Facilities for system and component testing at simulated altitude, pressure and temperature conditions from sea level to 10^{-8} Torr and cryogenic to +20,000°F.
SMALL ROCKET LIFT DEVICE — A new dimension in mobility, the optimized rocket belt is a complete one man personal propulsion system.

ADVANCED RESEARCH

PROPULSION AND POWER:
Chemical Propellants — Study and selection of new and promising propellants and fuel blends for high energy liquid propellant rocket engines.
Performance Calculations — New computer programs for evaluating performance characteristics of propellant and oxidizer combinations.
Nuclear Propulsion — Emphasis on non-nuclear components involving new material and control techniques for nuclear rocket engines.
Electric Propulsion — Basic studies of electric field theory and propulsion devices involving electrostatic forces.
Propellant Flame—Radiation studies to measure flame radiation temperatures and heat transmission.
MATERIALS RESEARCH:
High Temperature Materials — Research in high temperature material for rocket engines.
Space Environment Effects on Materials — Vacuum and radiation effects on polymeric materials.
NUCLEAR SCIENCES:
Radiation Testing of rocket engine components.
Nuclear Mass Flow Device — to measure mass flow rates.
SPACE DYNAMICS:
Orbital transfer and rendezvous.
Interplanetary mission studies.
Perturbation studies.

AVIONICS

HIGH PERFORMANCE NAVIGATION SYSTEM (HIPERNAS II) — Complete guidance and navigation systems for strategic and tactical missiles, aircraft and aerospace vehicles, ship and submarine navigation and drone recovery.
ACCELEROMETERS AND DIGITAL VELOCITY METERS — The BAC III-B Linear Accelerometer has a range of ±45g and weight of 0.7 lbs. Combined with the external Digital Velocity Meter it yields a precision digital system whose pulse rate is proportional to the instantaneous acceleration.
RADIO RECEIVERS — Bell's 406- and 550-megacycles receivers meet the exacting requirements of missiles and guidance systems.
AUTOMATIC CHECKOUT EQUIPMENT — A complete automatic checkout system developed for US Air Force missiles.
AIR TRAFFIC CONTROL BEACON EQUIPMENT — Adds selective identification feature (SIF) to Mark X IFF equipment operating in conjunction with ground radar sets.
RADAR SYSTEMS — Developed for both ground based and airborne applications including search, tracking, and seeker types.
BATTLEFIELD SURVEILLANCE SYSTEMS — For target location, observation of troop movements and damage assessment utilizing reliable airborne sensors, positive position-reference equipment, data links, and precise ground sensor.
MISSILE AND DRONE RECOVERY SYSTEMS — Successfully used for Regulus recovery combines features of the automatic landing system with Bell's secure command system.
SECURE TRANSMISSION SYSTEMS — Designed for control, navigation, coded communication, and data transmission to offset countermeasures in electronic warfare.
AUTOMATIC FLIGHT CONTROLS — An unique constant-altitude-hovering autopilot for Navy anti-submarine helicopters with special hydraulic servo valves, antenna drives and power systems.
AUTOMATIC LANDING SYSTEMS — Available in either land or carrier-based versions — the only ground-derived system available that affords precise and reliable aircraft control.
GYROSCOPES — The Brig II gyroscope is a two-degree-of-freedom, floated instrument designed for aerospace applications where accuracy, small size, and light weight are essential.

Receivers, Transmitters, Coders, Beacons, Power Supplies, Electromagnetic and Electrostatic Research, RF Circuit and Microwave Equipment Development, Counter-measure and Counter-counter-measure Research, Analog and Digital Computation, and Data Processing Techniques.

ELECTRONICS RESEARCH:
Non-linear circuit theory; self adaptive filters; information theory and determination of optimum codes for pulse communication; polyphase frequency multipliers; multiple frequency pumping of parametric amplifiers; electromagnetic propagation in the atmosphere of the planets; consultation.
RADIO FREQUENCY INTERFERENCE:
RFI analysis of electronic systems, e.g., voice interference detection, measurement and analysis of communications systems. Detection, measurement and analysis of interference in RTT, pulse or radar systems.
Automatic frequency measuring and monitoring equipment.
Electromagnetic propagation theory development and field experimentation, antenna system development.
Spectrum Signature Data Collection and Analysis.
Theoretical RFI prediction techniques and Mathematical modeling.
SERVICES:
Human factors analysis; studies and electronic simulation of man-machine interrelationships.
Electronic Range Operation, Data Collection, Data Reduction and Analysis.

SPECIAL PRODUCTS AND SERVICES

HIGH-SPEED DATA PROCESSING — IBM 7090 computer and complete 1401 computer system.
MANUFACTURING RESEARCH — Materials and processes modified and developed to meet specific and unusual requirements.
PRECISION MACHINING AND FABRICATION — Manufacture and assembly of complex airframe and missile components.
TITANIUM FABRICATION—Machining, hot forming and assembly of titanium parts.
MANUFACTURING SUBCONTRACTING — Airframe and missile components including complete design, test and qualification.
HYPERSPEED PUMPS — The design, manufacture and test of hi-pressure centrifugal pumps.
AIR CONVEYOR — Provides frictionless platform for material handling.
PERSONALIZED LOAD CARRYING DEVICES — Enables man to carry heavier loads with less fatigue over extended time periods.

LABORATORY CAPABILITIES

PROCESSES:
Process Development and Specifications
Vacuum Furnace
CHEMISTRY:
Inorganic, Organic, Physical and Analytical
Solid and Liquid Propellants
INSTRUMENTATION:
Standards and Calibration
Measurements
Instrument Development and Evaluation
Data Acquisition and Analysis
Human Factors
EQUIPMENT:
Shock and Vibration
Electromechanics
Hydraulics
Static, Acoustic and Environmental Test
Electronic Noise
FLIGHT PERFORMANCE:
Flight Test and Vehicle Technology
MATERIALS, METALLIC AND NONMETALLIC:
Ablative Test and Development
Adhesive Bonding Evaluation and Development
Mechanical and Thermal Properties at −453 to 5000F.
Electron Beam Welding Development
Coating Evaluation
High (< 5000F.) Temperature Oxidation Tests
Ceramic Material Development

POSITIONS ARE IMMEDIATELY AVAILABLE IN INTEGRATED SYSTEMS ENGINEERING ■ STRUCTURAL SYSTEMS ENGINEERING ■ ELECTROMECHANICAL / ELECTRONIC SYSTEMS ENGINEERING ■ MANUFACTURING RESEARCH & DEVELOPMENT.

Mr. T. C. Fritschi
Bell Aerosystems Company
P.O. Box 1
Buffalo, New York 14240

( ) Please send literature describing your job opportunities in greater detail.

( ) My resume enclosed. Let me know which opening(s) will offer me an immediate step up, based on my qualifications and what I'm now doing.

Name

Address City State Zip Code

Degree(s) When & Where Received

Major Professional field(s) of interest:

Present job title

BELL AEROSYSTEMS A textron COMPANY

An Equal Opportunity Employer (M&F)

"Field Notes"

Thermo Prof: "Well, is the theory clear to you now?"

Student: "Yeah, just as though it had been translated into Hindustani by Gertrude Stein and read to me by a tobacco auctioneer."

* * *

The age of chivalry is not dead. If a girl drops one of her books, almost any boy in the class will kick it back to her.

* * *

By the time a man gets to greener pastures, he can't climb the fence.

* * *

Luke: "Gosh, but I'd like to make your dreams come true."

Lulu: "I'll slap your face if you try it."

* * *

Did you know that 80 per cent of the heat output from the Madison Gas & Electric Power Plant is used for warming the ducks' feet in Lake Monona?

* * *

" want you to do just as I tell you," said the doctor to the young lady patient.

"That's what my boy friend said," replied the girl. "That's why I'm here."

* * *

The M.E. instructor held the chisel against the rusting bolt. He looked at the M.E. student and said, "When I nod my head you hit it."

"They're burying him at noon today.

Dear Mary:

I just read in the paper that students who don't smoke make much higher grades than those who do. This is something for you to think about.

Love, Dad

Dear Dad:

I have thought about it, but truthfully I would rather make a B and have the enjoyment of smoking; furthermore, I would rather smoke and drink and have a C. In fact, I would rather smoke, drink and neck and make a D.

Love, Mary

Dear Mary:

I'll break your neck if you flunk anything!

* * *

The current emphasis on education in our university is typified by a new statement that no athlete be awarded a letter unless he can tell at a glance which letter it is.

* * *

College: a fountain of knowledge where students gather to drink.

* * *

Going to college is like sending your clothes to the laundry. You get out what you put in, but you don't recognize it.

* * *

"I drew the line at kissing,"
She said with fiery intent;
But he was a football hero,
So over the line he went.

She: "There's one thing I want to tell you before you go any further."

He: "What's that?"

She: "Dont go any further.'

* * *

"What's the hurry?"

"I bought a new textbook and I'm trying to get to class before the next edition."

* * *

"Who was driving when you collided with that car?"

"None of us. We were all in the back seat."

* * *

"More people are caused by accidents than any other way."—From a speech on safety given in New York.

* * *

A report being circulated in Munich has it that a thief recently broke into the chief propaganda office in the Russian Sector in Germany and made off with the complete results of next year's elections.

* * *

The Ski Trooper had just returned from the war, and was being interviewed. "How does it feel to be home?" queried the interviewer.

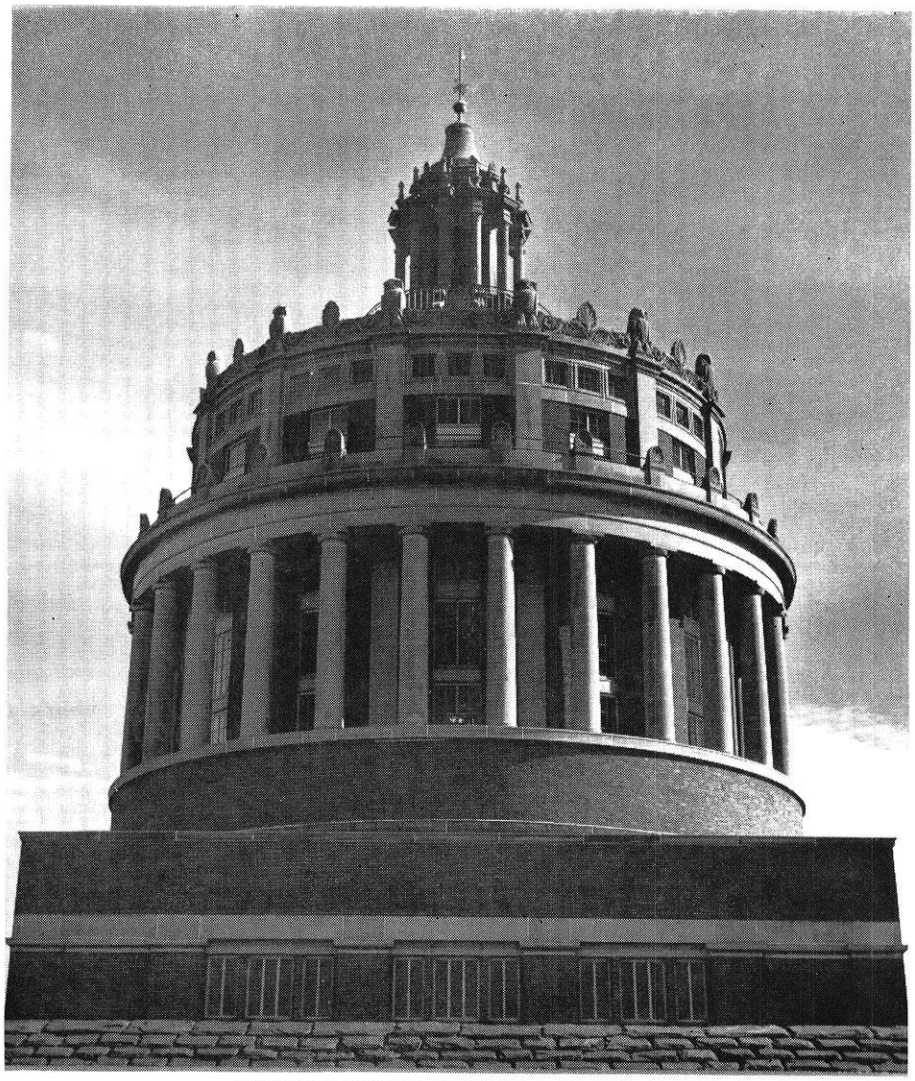
"Wonderful, wonderful!"

"Tell me, what was the very first thing you did when you got home?"

"Well, you know, I'm a married man."

"Oh, I see. Well, then, what was the second thing you did after you got home?"

"I took my skis off."



University of Rochester Library Tower as seen by the famed photographer Ansel Adams

Have your cake and eat it

Suggestion to Ch.E.s, M.E.s, and other engineers:

The University of Rochester has long committed itself to the pursuit of academic excellence and long ago attained success in that quest. Likewise, with a somewhat different conception of higher education, has the Rochester Institute of Technology earned high regard. The two institutions are quite unrelated to each other or to us, except that their fortunate presence in Rochester provides opportunity for those who join us with fresh baccalaureates to proceed right on course with the next formal stage of professional or business preparation. In Kingsport arrangements are offered by the University of Tennessee Graduate School and East Tennessee State University.

Two big factors make such plans attractive:

1. Money. It can be a great comfort when supplied regularly by a prosperous firm well aware that its fate depends on the intelligence and devotion of the people it can lure into its fold.

2. Direct personal involvement in the *realities*. The realities encountered in a company that leans as heavily as we do on engineering, science, and scholarship can be nothing but helpful to one whose motivation toward education is genuine and deep.

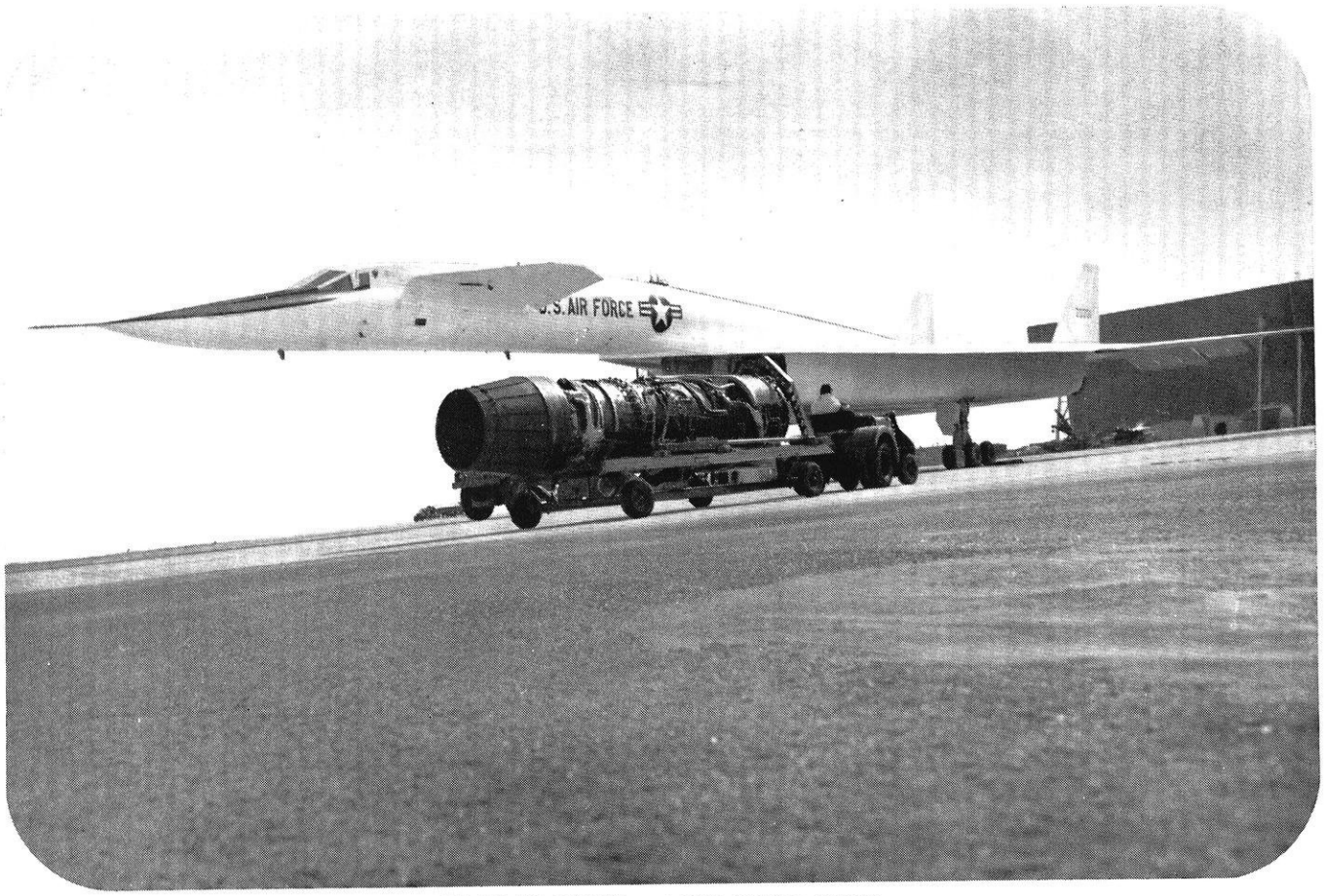
There is also a rough side:

You have to drive yourself pretty hard when you work and study at the same time. This shows you up as a candidate for tough assignments.

Ask us about the details of our incentive plans for post-baccalaureate education. Eastman Kodak Company, Business and Technical Personnel Department, Rochester, N.Y. 14650.

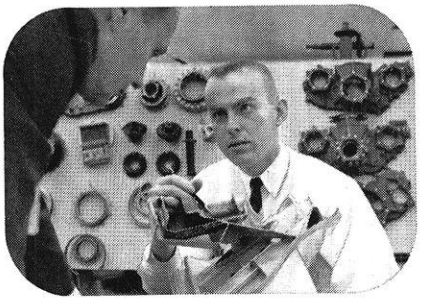
An equal-opportunity employer

Kodak

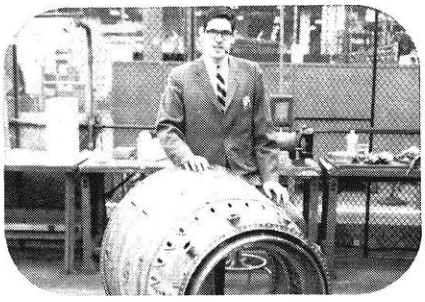


SIX G-E J93 ENGINES push USAF XB-70 to MACH 3.

JACK WADDEY, Auburn U., 1965, translates customer requirements into aircraft electrical systems on a Technical Marketing Program assignment at Specialty Control Dept.



PAUL HENRY is assigned to design and analysis of compressor components for G.E.'s Large Jet Engine Dept. He holds a BSME from the University of Cincinnati, 1964.



ANDY O'KEEFE, Villanova U., BSEE, 1965, Manufacturing Training Program, works on fabrications for large jet engines at LJED, Evendale, Ohio.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC

Achieving Thrust for Mach 3

When the North American Aviation XB-70 established a milestone by achieving Mach 3 flight, it was powered by six General Electric J93 jet engines. That flight was the high point of two decades of G-E leadership in jet power that began when America's first jet plane was flown in 1942. In addition to the 30,000-pound thrust J93's, the XB-70 carries a unique, 240-kva electrical system that supplies all on-board power needs—designed by G-E engineers. The challenge of advanced flight propulsion promises even more opportunity at G.E. GETF39 engines will help the new USAF C-5A fly more payload than any other aircraft in the world; the Mach 3 GE4/J5 is designed to deliver 50,000-pound thrust for a U.S. Supersonic Transport (SST). General Electric's involvement in jet power since the beginning of propellerless flight has made us one of the world's leading suppliers of these prime movers. This is typical of the fast-paced technical challenge you'll find in any of G.E.'s 120 decentralized product operations. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-16, Schenectady, N.Y. 12305. An Equal Opportunity Employer.

Progress Is Our Most Important Product

GENERAL ELECTRIC