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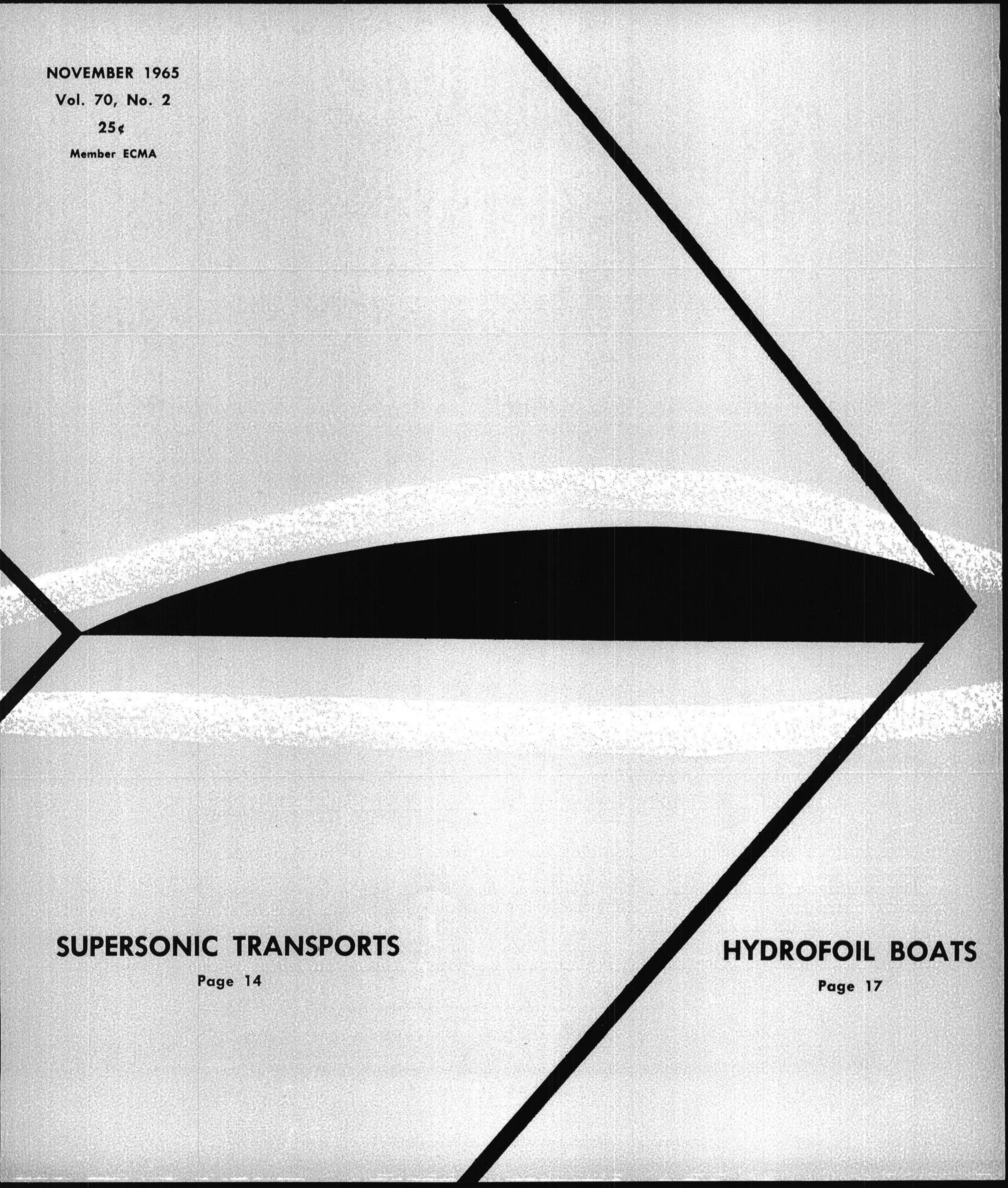
THE WISCONSIN ENGINEER

NOVEMBER 1965
Vol. 70, No. 2
25¢
Member ECMA



SUPERSONIC TRANSPORTS
Page 14

HYDROFOIL BOATS
Page 17

Revolutionary new Westinghouse mass transit system

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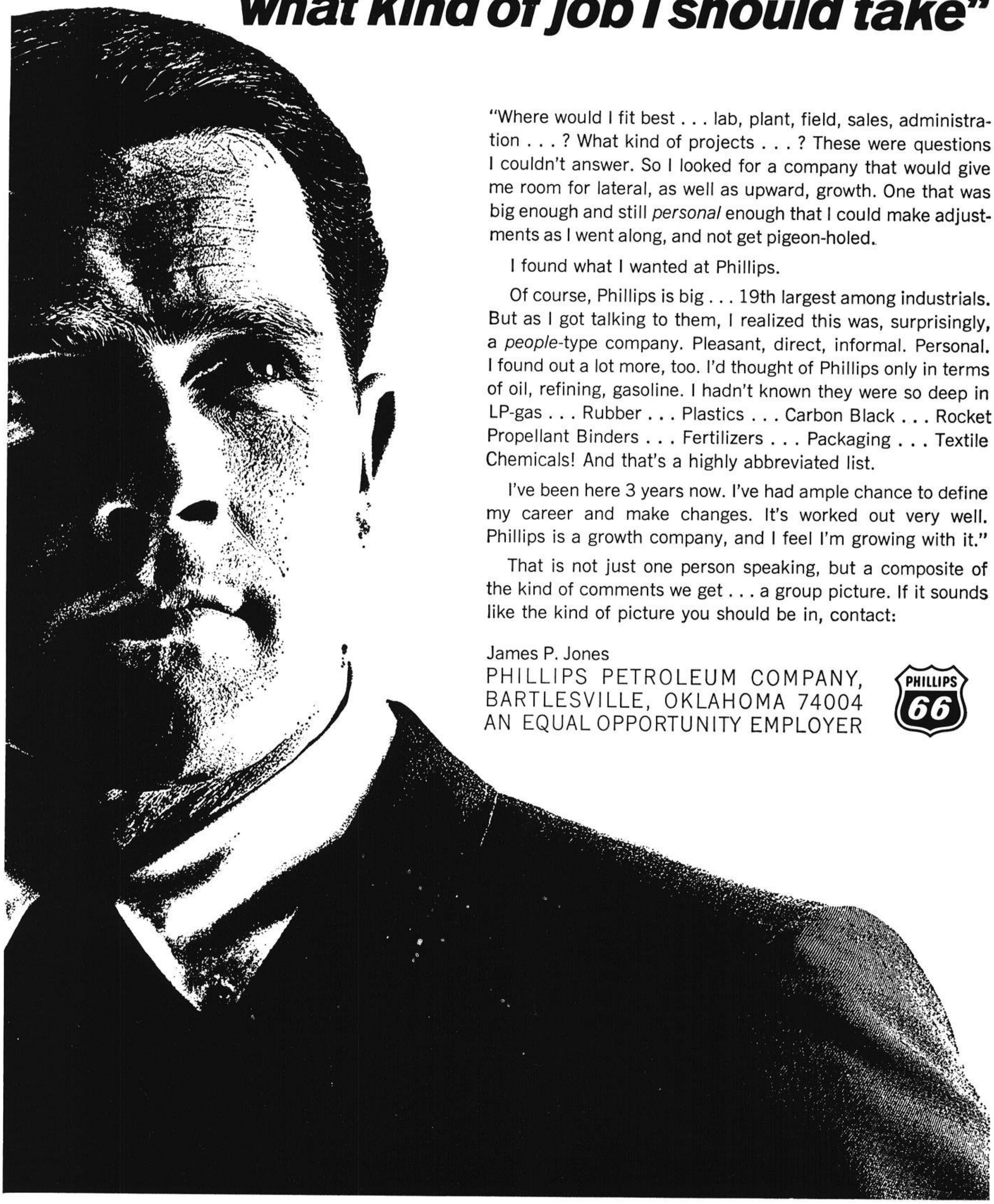
"At graduation I still wasn't sure what kind of job I should take"



"Where would I fit best . . . lab, plant, field, sales, administration . . . ? What kind of projects . . . ? These were questions I couldn't answer. So I looked for a company that would give me room for lateral, as well as upward, growth. One that was big enough and still *personal* enough that I could make adjustments as I went along, and not get pigeon-holed.

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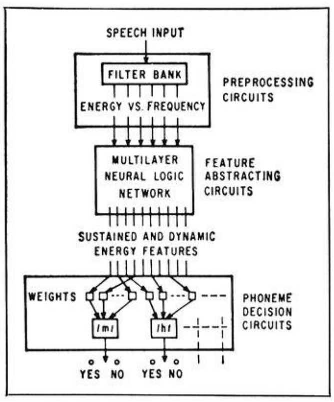
Engineering and Science at RCA

Neural Networks

For a long time machines that recognize speech have stimulated the imagination of scientists, from the engineer to the linguist, both because of their potential usefulness to communication technology and for the formidable technical challenge they represent. Several years of research at RCA have resulted in notable successes in this field by using networks of electronic neurons (simulated nerve cells) to identify phonemes—the smallest practical units into which speech sounds can be divided without losing their identity. These neural networks operate on the several outputs of a spectrum-analyzing filter, dynamically examining the spectrum and making decisions as to phoneme identity.



During recent investigations, 18 consonant sounds (for example, /m/ as in "mad" and /h/ as in "hid") and 10 vowel sounds were identified with 86% to 99% reliability when uttered by any of 6 speakers. Machine recognition of consonants is, in general, much more elusive than that of vowels, since the identity of consonants is hidden in the transient behavior of the spectrum to a much greater extent than in its steady-state nature, as is the case with vowels. Vowel characteristics, however, usually are more speaker dependent. The recognition performance obtained represents, by a considerable margin, the best results achieved to date by any investigator.

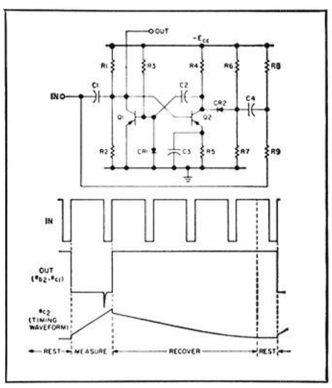
A "neuron," as used in these networks, is a simple computing element exhibiting the characteristics of fan-in and fan-out, an input threshold, and a specified analog relation between output and input when the input exceeds threshold. An array of several hundred neurons used in speech analysis is structured in layers; the first layer receives 20 parallel inputs from the spectrum filter, and by interconnections among its member neurons makes elementary decisions about the shape of the spectrum. The many outputs of the first layer pass, in turn, to a second and then to successive layers, which make ever more sophisticated judgments both of the instantaneous characteristics of the spectrum and of the nature of its changes with time. Finally, binary logic networks make decisions as to the most likely identity of the phoneme.

In speech processing, neural networks perform with great simplicity, limited-accuracy operations on a large number of simultaneous inputs, and maintain continuously analog measures of the reliability of each decision by virtue of the analog properties of the computing elements. These properties, so well suited for speech analysis, are just those required for solving pattern recognition problems in general. It is not surprising then, that neural networks also show exciting promise in the fields of visual and other kinds of pattern recognition, as well as speech.

Reference—A. L. Nelson, M. B. Herscher, T. B. Martin, H. J. Zadell, J. W. Falter, "Acoustic Recognition by Analog Feature-Abstraction Techniques," Proc. of Symposium on Models of Perception of Speech and Visual Form, 14 Nov., 1964, Boston, Mass.

A Novel Frequency Divider for TV Sync Generators

An economical, efficient and high-performance frequency divider circuit for use in new RCA color TV broadcast equipment has been developed. The circuit is a monostable multivibrator with a unique ability to adjust its timing period to be proportional to the period of the input trigger pulses. The circuit uses only two transistors, and it has the ability to divide an input frequency by a constant for a wide range of input frequencies. It is also quite immune to power supply variations and requires no precision capacitors. The circuit requires no externally-applied AFC voltage for regulating the timing period, such as would be required in this application with an ordinary monostable divider.



The two periods of a cycle of operation, as shown in the waveforms, are first, "measure," and then a "recover." When the circuit is in the rest or "stable" state, Q1 is saturated and Q2 is turned off. Once triggered by an input pulse, Q2 is placed in a constant current conducting mode which causes C2 to discharge at an essentially constant rate. This action is terminated by the next succeeding pulse which leaves the voltage across C2 at a value directly related to the time period between the pulses. The capacitor voltage is thus a measure of the pulse repetition interval. The second pulse, which terminates the measure period, also causes regenerative circuit action which turns Q2 off. Succeeding input pulses cause no further circuit action until C2 charges (through R4) to the point where diode CR2 can again conduct. The first trigger pulse following the "recover" period causes the cycle to reoccur.

A constant frequency division ratio is maintained over a wider input frequency range than was previously possible as a result of the self-adjusting timing feature. A new color sync generator, which uses this type of circuit in the frequency divider that relates the horizontal and vertical scanning frequencies, is proving to be highly successful. A 525:1 divider chain is used which requires only 8 transistors. If a chain of binary stages were used, 22 transistors would be required. Also, a modified form of this circuit is used to relate the horizontal scanning frequency to the color TV subcarrier frequency.

Reference—A. J. Banks and F. I. Johnson, "Novel Frequency Dividers for TV Sync Generators," 1965 IEEE International Convention Record, Part 2.

Transistorized Portable "Victrolas"

Although transistors have previously enjoyed widespread use in portable receivers and military communication equipment, only recently have solid-state devices made any significant penetration into line operated home instrument equipment. Advancing device technology has made transistor circuitry cost competitive with equivalent tube circuitry, while providing improved reliability, instant warm-up, lighter weight and cooler operation.

In low-cost phonographs using single stage tube amplifiers, high-output pickups are required. Such pickups are quite stiff mechanically, require a high stylus force, and thus track marginally. These low-cost amplifiers ordinarily use "transformerless" power supplies with the attendant design problems of minimizing hum and shock hazards.

RCA Victor's new transistorized portable phonographs use multistage DC-coupled circuits providing ample power gain for use with pickups of higher compliance and smoother frequency response. Record wear and tracking are thereby improved. The higher efficiency of the output stage and the elimination of the heater-power requirement result in a cooler amplifier—and make possible the use of a secondary winding on the phonograph motor for the power supply. The resulting isolation eliminates the shock hazard and makes possible the application of conventional grounding techniques.

To minimize costs and improve reliability, this amplifier has been designed to be built on a printed circuit board. The need for a separate supporting chassis has been eliminated by mounting the printed board under the turntable on the record changer motorboard, allowing the output chokes and filter capacitor to extend through the motorboard. The motorboard serves both as a heat sink and mounting for the output transistors. Volume and tone controls are mounted on the motorboard, and all inter-connecting cables and wiring are integral with the record changer assembly.

Reference—J.A. Tourtellot, RCA technical report.

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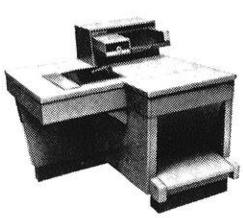

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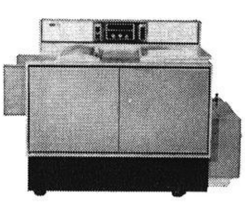

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LATE NEWS

ASEE REPORTS ON GOALS OF ENGINEERING EDUCATION

In a preliminary report on the goals of engineering education, the American Society for Engineering Education has recommended that the first professional degree in engineering should be a master's degree awarded after 5 years of college study. If the recommendation is generally adopted, the master's degree will replace the 4-year bachelor's degree as the prerequisite for entering the engineering profession. Although the 4-year program would be continued, the bachelor's degree would rate as an "introductory" engineering degree.

The recommendation results from the demands on the practicing engineer for increasingly higher levels of professional competence, according to Dr. Eric A. Walker, President of The Pennsylvania State University. Dr. Walker is Chairman of ASEE's national Committee on the Goals of Engineering Education which formulated this and other recommendations after 4 years of painstaking study. Participating in the work were 180 study committees representing engineering schools and industrial employers of engineers. The huge investigation also included an exhaustive questionnaire submitted to 4,000 practicing engineers, visits to 169 schools of engineering, and an intensive study of five sample schools. Support was provided by a grant of $307,000 from the National Science Foundation.

Among its other recommendations, the preliminary report proposes increased liberal education for engineers to better prepare them to accept new and varied responsibilities in modern society.

According to the report, the analysis, synthesis, and design of systems must be given greater emphasis in engineering curricula because of the increasing complexity of modern engineering design projects in contrast to simple machine and component design of the past.

The report urges practicing engineers to teach part-time at engineering schools and faculty members are encouraged to gain more practical experience in industry.

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ARTICLES

THE WISCONSIN ENGINEER

The Student Engineer's Magazine Founded in 1896

FEATURES

THIS MONTH'S COVER

An after-hours creation of the Editorial Staff, this foil section is shown with the shock wave encountered by a SST (page 14) and the stream lines characteristic of a hydrofoil (page 17).

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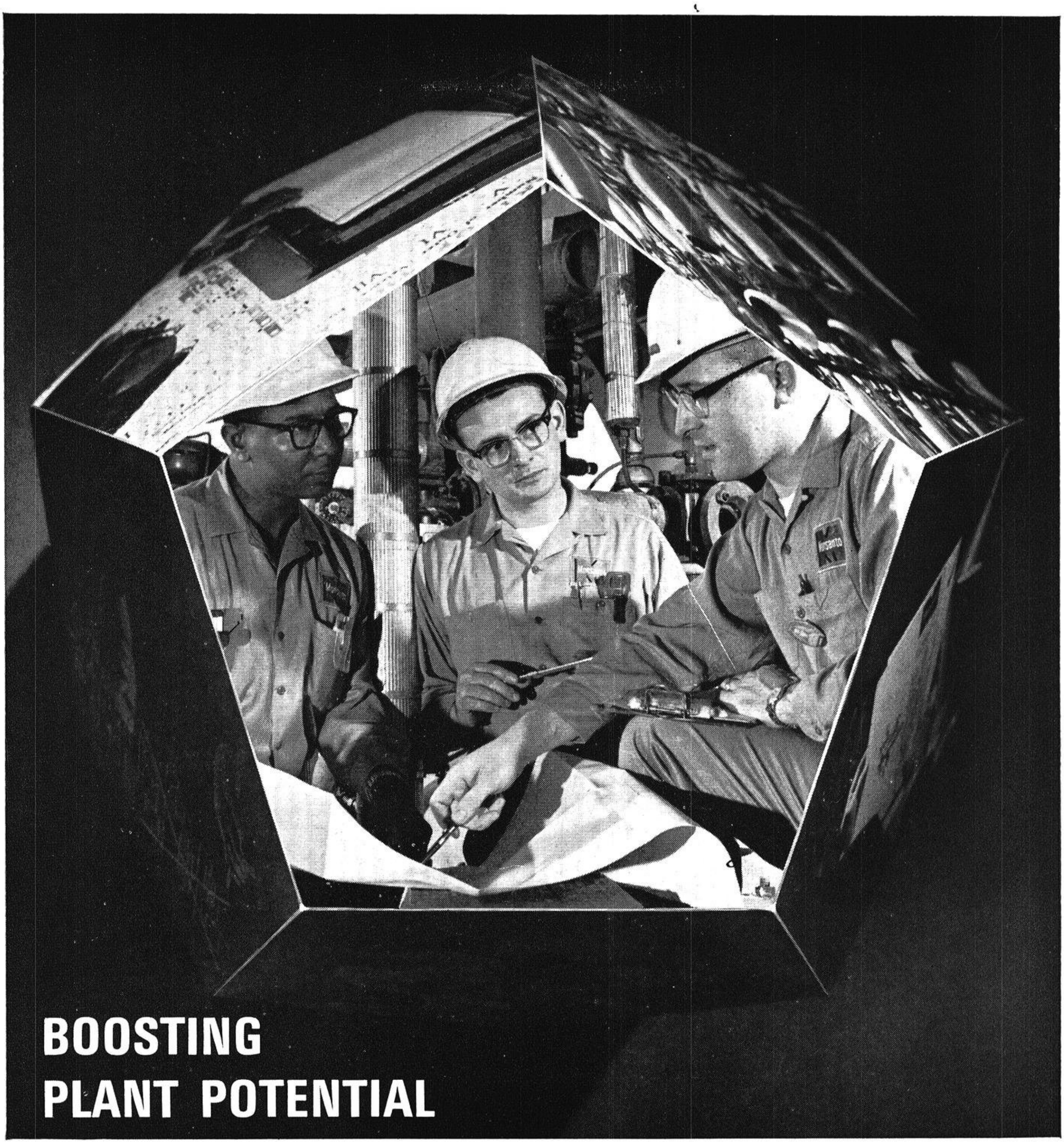
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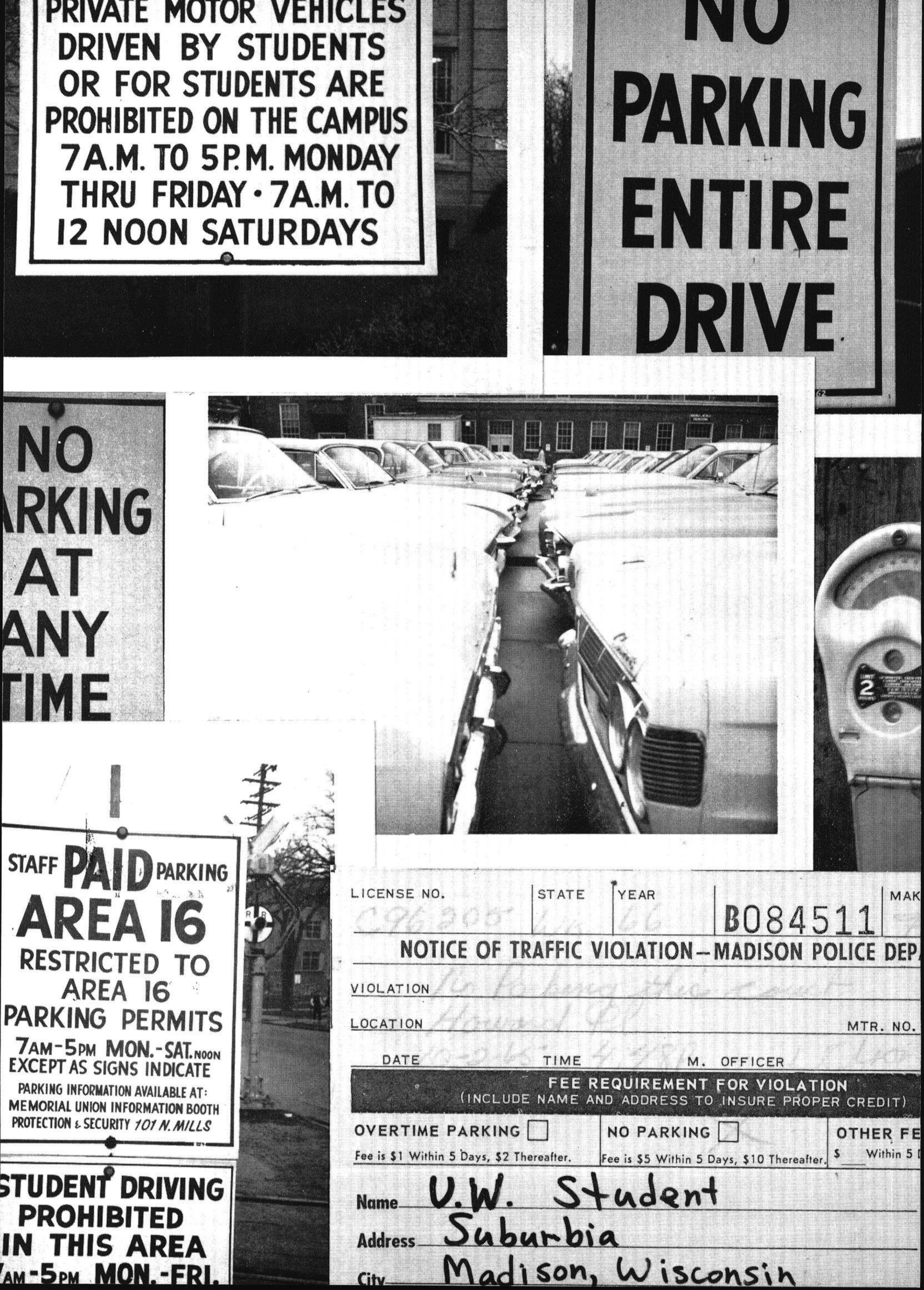
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Rambling with the Editor

CARS, CARS, EVERYWHERE!

Without a Place to Park

The montage opposite is becoming all too familiar to us. A rapidly expanding urban university has accompanying growing pains, and at Wisconsin, like many other schools, parking is a headache. Faculty and staff personnel numbers naturally increase with the enrollment. And a larger percentage of the growing number of students is bringing cars to school.

Why so many more student cars? Some are certainly here for pleasure alone, but hundreds are a necessity. Insufficient University housing facilities, in addition to ridiculously high rents in the campus area, have forced students to find housing in privately-owned facilities all over Madison and the surrounding area. Also, to help pay educational costs, a growing number of students have part-time jobs requiring transportation. Public transportation is often inadequate. The problem is simply this: Where are the cars going to be parked while their drivers are attending classes? Space is at a premium and the situation becomes more complicated daily.

The University is doing all that it can, but is often stymied by lack of funds, and as a result often finds itself unable to provide sufficient faculty/staff parking, let alone student facilities. New buildings rise where parking lots once existed. Lot 60 and the shuttle buses have been accepted and are certainly a tremendous aid. Many students living in the campus area used the overnight area in Lot 60 to park their cars during the week, or whenever they were not immediately in the overnight area. Chancellor Fleming soon arranged for a substitute lot near Picnic Point, but it is at best a stopgap, unlighted and therefore hardly secure.

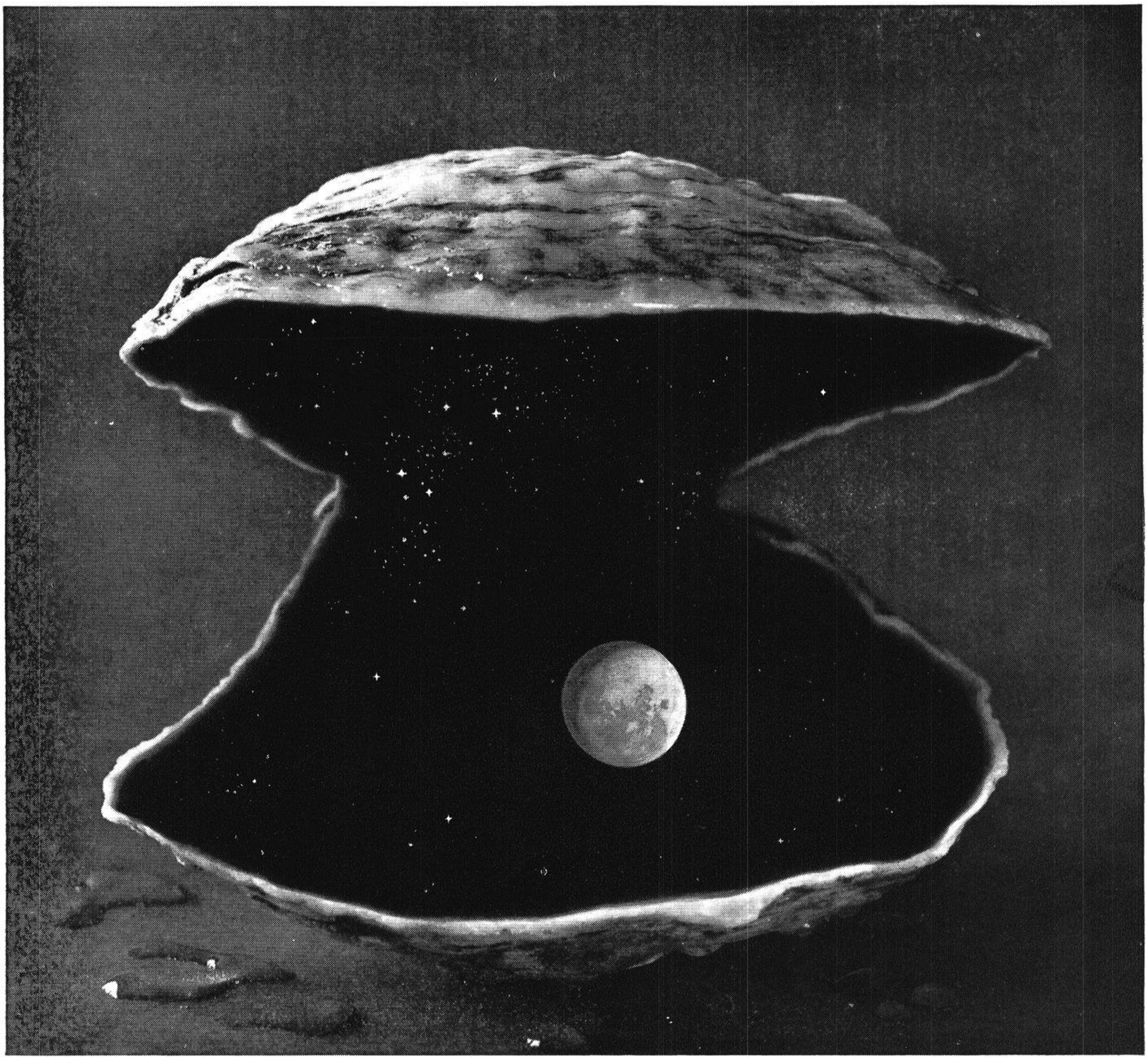
The City of Madison, far from being famous for swift legislation (take for instance the Auditorium, Monona Causeway, or the University Avenue Expressway), has discussed the campus area parking situation. Judging from past action, discussion will probably continue until doomsday, with no decisive action occurring in the interim. We think that City Hall should be able to come up with something constructive. Their first move should be elimination of the two-hour non-metered limits on city streets. They don't keep the cars moving, but rather cause dirty chalky hands for hundreds of people.

Most students don't vote though, so why sweat their demands, when bona fide constituents come to council meetings and propose, among other things, complete bans on student cars. We noted with interest that among the most vocal at a recent council meeting was the wife of the 1966 *Badger* Official Photographer. Mrs. Leidner apparently believes that she has a greater right to park her car in the Lake Street Ramp or on Lathrop Street than we do. This is absurd, even if you want to equate taxes and benefits. We buy our clothes and food in Madison stores, and pay rent to a Madison firm, indirectly filling the city coffers. Furthermore Mrs. Leidner, this magazine is paying your husband $4.00 to take our picture for the *Badger*. We'll park in front of your house when we have the opportunity, for we'd like to see some of the vandalism you talked about.

One of the few bright lights in this dark cloud is the cooperation exhibited by the students. Car pools, bus riding, and distant storage are not particularly desirable, but they do ease the parking bind. Perhaps it will be these students who will eventually formulate a situation? If we shout loud enough and long enough, someone might hear us. We know from experience that tact won't work, because we're "only a bunch of wild college kids."

—R. J. Smith

(Next Month—Our caustic pen will strike out at a now famous Skid Row furrier)



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The SST—Supersonic Transport

A current report on the design and development of air transportation for the '70s

By FREDERICK H. BELZ

IN THE field of commercial aviation there is a new star on the horizon—the Supersonic Transport, or SST. Whether or not this star will shine brightly depends on if the SST can be developed into a competitive aircraft. If this can be accomplished it will be the first big step forward since the subsonic jet aircraft replaced the piston-powered aircraft. Development work has begun at Lockheed Aircraft Company and Boeing Aircraft Company since President Johnson announced that the United States Government would support these two companies in developing SSTs. A supersonic transport is also being developed in Europe. The Anglo–French project began in 1962 and has progressed steadily. The European aircraft will be smaller and slower than its two American counterparts but this difference may make it possible for both American and European SSTs to survive in the competitive field of commerical aviation.

SST LANGUAGE

Variable span: A wing which can be adjusted by changing the angle with respect to the aircraft.
Mach Numbers: A Mach number is the ratio of the aircraft speed to the localized speed of sound.
Prototype: The original model from which others are copied.
Payload: The weight of cargo or number of passengers which an aircraft usually carries.
Airframe: The structure which determines the aircraft configuration and which is used for mounting of all aircraft component parts.
Variable Area Turbine: A turbine whose effective blade area can be adjusted by mechanical means.
Aircraft Skin: The external metal covering of the aircraft.
Ground Monitor: A device which monitors all of the aircraft functions and positions while being located in a ground tracking station.

THE PRESENT STATE OF DEVELOPMENT OF THE SUPERSONIC TRANSPORT

The development of the SST is mainly in the planning stage. A ground test prototype has been fabricated for the Anglo–French Concorde, but the two American manufacturers involved are still working on planned designs and small-model testing. Nevertheless, progress is being made toward a mid-1970 completion date.

At the present time Lockheed and Boeing are engaged in competitive development of the SST in the United States. The particular models of the SSTs being developed differ greatly, as the Lockheed model will utilize a fixed deltawinged configuration while the Boeing model will utilize a variable-span swept-back wing. A speed of Mach 2.7 to Mach 3.0 has been chosen for the American SSTs as this speed shows the best possibilities for economical operation.

The Boeing Model 733

The present plans for the Boeing SST call for an aircraft which will be able to carry 150 to 227 passengers, at a speed of Mach 2.7 (1800 mph) and an altitude of 70,000 feet. The aircraft will have four jet engines mounted on a variable span swept-back wing. The external configuration of the proposed aircraft is shown in Fig. 1. Note the variable wing positions which will be available to stabilize the aircraft at a variety of speeds and altitudes.

The design specifications for the Model 733 are as follows:

- Wing Type—Variable-span swept-back
- Aircraft Weight—408,000 lb with 227 passengers
- Payload—150 to 227 Passengers
- Engines—Four turbojets
- Speed and Cruising Altitude—Mach 2.7 and 70,000 ft
- Estimated Aircraft Purchase Price—$20,000,000

The present goals of the Boeing project are to make the SST safe, reliable, and competitive with subsonic jet aircraft. The present estimated variable costs, such as cost per seat mile flying at cruising altitude, are quite favorable. Fixed costs, such as landing costs and maintenance, are estimated to be four times as high as comparable subsonic jet costs. These high fixed costs, along with many others, are the problems which Boeing must solve.

The Lockheed Model L-2000

The Lockheed Company, one of the smaller manufacturers of commercial aircraft, faces many obstacles in the development of their SST. One of the greatest will be the reluctance of the airlines to accept Lockheed equipment. Most of the airlines are now flying Boeing jets, and they have had very favorable results. If Lockheed hopes to sell their SST they must convince the airlines that their SST is far superior to Boeing's.

The Lockheed plans call for a Mach 3 (2100 MPH) aircraft. Payload for the aircraft will be 214 passengers, and four jet engines will be used for power. The aircraft will have a double-delta shaped wing with underslung engine enclosures. Lockheed development plans should be helped by their recent development of a high speedmilitary reconnaissance aircraft, the A-11.

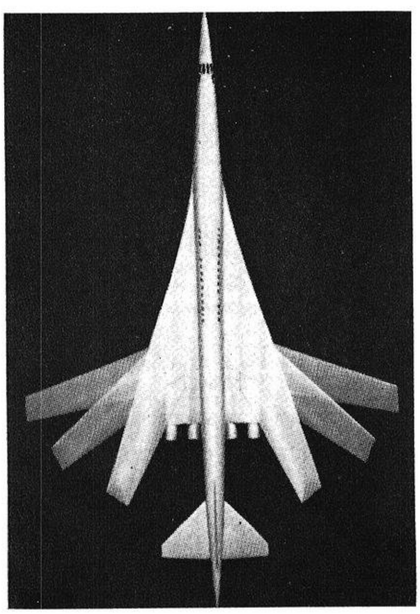


Figure 1.—Plan view of Boeing 733. Note variable span/swept wings.

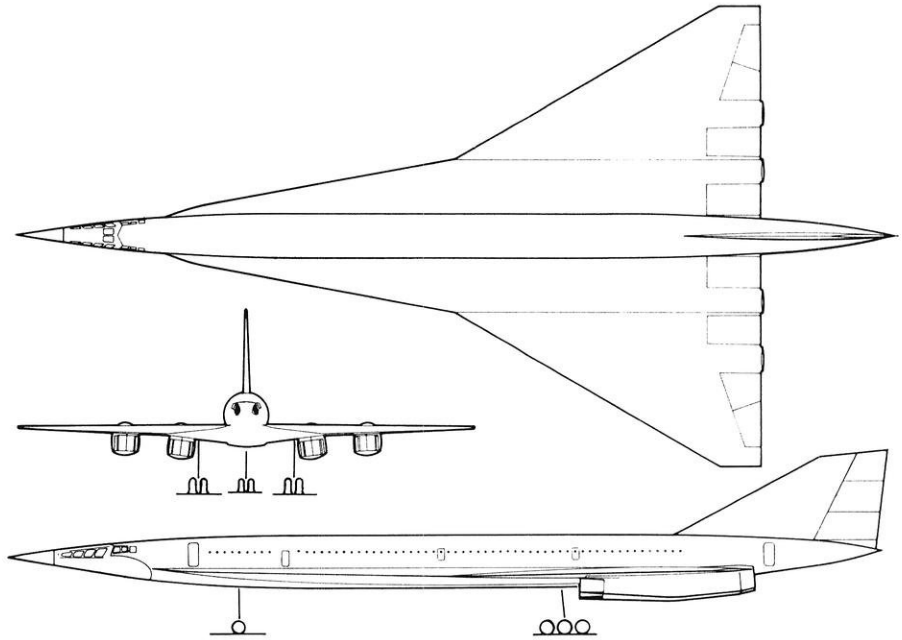


Figure 2.—Artist's sketch of Lockheed's Model L-2000. Note double delta-wing configuration.

The specifications for the Model L-2000 are as follows:

Wing type—Double delta
Aircraft Weight—450,000 lb.
Payload—214 passengers
Cruising Speed and Altitude—Mach 3 and 75–80,000 feet
Engines—Four turbojets
Estimated Purchase Price—$20,000,000

Present Lockheed goals call for complete development within a seven to ten year period.

The Anglo–French "Concorde"

In the so-called race to develop the SST, the British Aircraft Corporation Sud Aviation Company team has a considerable lead. Plans have been made for a 1967 flight, and regular service is scheduled for 1972.

Static tests are now being conducted on the prototype fuselage and the engines have recently undergone first tests. Present plans call for a 118 passenger, Mach 2.2 aircraft. A delta wing and adjustable nose section will be two of the distinguishing features of the aircraft.

The specifications for the Concorde are as follows:

Wing Type—Single delta
Aircraft Weight—326,000 lb.
Engines—Four turbojets with afterburners, 35,000 pounds thrust each
Estimated Purchase Price—$13,-500,000
Payload—118 passengers

The present goals of the Anglo–French team seem to be mainly to get a workable model off the ground as soon as possible. If the team can develop a competitive aircraft and begin passenger service two or three years before United States manufacturers, they will be in a very favorable business position. Business will be drawn away from United States manufacturers, and American prestige and Balance of Payments may both suffer. However, if the team is not successful, they may have one of the most costly and unsuccessful business ventures in history.

DEVELOPMENT OF AIRCRAFT COMPONENTS

The area of component development is a very important part of all the SST programs. As a chain is no stronger than its weakest link, so an aircraft is only as dependable as its least dependable component. Many specialists will use their knowledge to develop components which will make the SSTs safe, reliable aircraft.

Engines

The engines for the United States SSTs will pose a large problem to designers in the aircraft in-

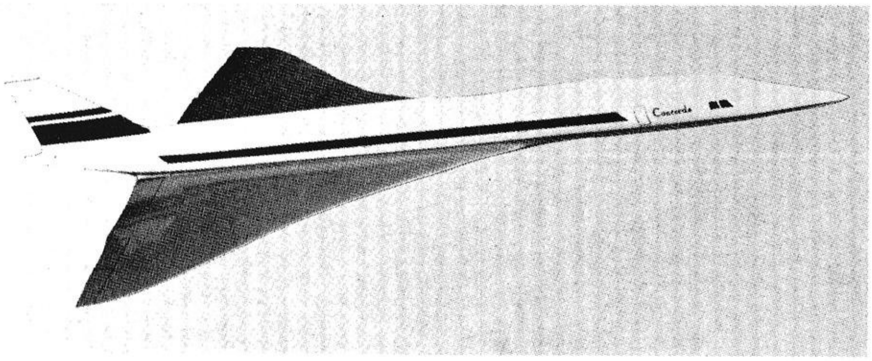


Figure 3.—Proposed Concorde, to be built by the manufacturers of the famous "Caravelle."

dustry. Preliminary tests have indicated that a straight turbo-jet—with no afterburner or turbo-fan—will be the best choice for the SST engines. Light weight, large thrust (estimated 50,000 lb), economy, and ability to operate at a variety of speeds and altitudes are just a few of the design criterion. The engines which are being developed for military aircraft will not be applicable because they are too heavy and cannot be operated economically. The engine for the SST will have to be built "from the ground up."

The problem of weight is one of the problems which the United States engine designers must try to solve. This could prove to be difficult as quality and reliability cannot be sacrificed for light weight. One proposed solution to the problem is to develop a light weight compressor. The new compressor would be of all welded constuction with an emphasis placed on unit construction and unit balancing. It is estimated that a weight saving of 200 lb. per engine, or 800 lb. total, could be attained while quality and reliability would remain the same or improve. The total weight saving for the aircraft would be 800 lb. for the engines, 250 lb. of airframe, and 500 lb. of fuel load. While the development costs of the compressor are estimated to be about 10 million dollars, the weight saving is estimated to bring about a saving of 25 million dollars in operating costs for a fleet of 200 SSTs over a ten year period. Another solution to the weight problem would be the development of lighter structural components. Some work is being done in this area but present indications are that the alloys now in use will be the most suitable for engine fabrication.

Economy and ability to adapt to a wide range of operating conditions is another problem for the engine designer to solve. The proposed solution to this problem will be the use of a variable-area turbine, which will allow the engine to operate efficiently at most speeds, and will help to prevent engine overheating during periods of high reverse thrust.

The engines for the Anglo–French Concorde have already been built and given a first test. Because of the lower speed and have been constructed similar to altitude requirements, the engines present jet engines. The engines are rated at 35,000 pounds of thrust, and feature air cooled turbine blades, a variable geometry air intake for efficiency, and a thrust reverser.

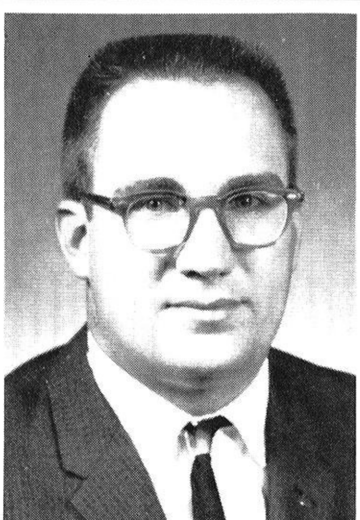
Wings

The wings for the SST differ considerably between competing manufacturers. The Lockheed L-2000 and the Concorde will have a lightly loaded delta platform while Boeing will use a heavily loaded variable-span wing. Flight tests of the B-70 and TFX will guide Boeing and Lockheed in making the decision to continue as planned, or to change over to the more appealing design. Because of the advanced state of the Concorde project, the Concorde is committed to use of the delta platform.

Boeing's variable-span wing may turn out to be one of the bright spots in American SST development or it could cause Boeing to lose its leadership in the jet transport field, depending on how well the wing works out, and if the airlines can be convinced of its reliability. By making the span variable, Boeing hopes to cut down landing and take-off speeds and to develop an aircraft which will land with a horizontal attitude. Efficient operation and stability at low speeds are also plus-features of the wing. At the present time the main drawback of the wing is the safety and reliability. A highly reliable system must be developed to pivot the wings and the joint must have adequate strength at any wing position. Problems of excessive roll and pitch-up have also been encountered during model testing.

Lockheed Aircraft Co. and the British–French team are firmly convinced that the delta wing,

(Continued on page 30)



Fred Belz, married and the father of one, commutes to the campus daily from Janesville. He will receive his BSME from the university this January. Fred has been a missile technician for the U.S. Air Force and also was a personnel man for Libby, McNeill, & Libby. Fred was the 1965 Recording Secretary for the Society of Automotive Engineers and plans on working in the R & D field after graduation, possibly in jet aircraft.

HYDROFOIL BOATS
Their Design and Use

These fast-moving craft are beginning an important revolution in sea surface transportation

By WALTER R. MARKS

HYDROFOILS are to certain water craft what wings, or airfoils, are to aircraft. Existing aircraft technology has greatly speeded the development of hydrofoil boats. Although the first attempts at building hydrofoil craft began as early as 1891, little success was achieved until World War II, when the Germans launched several models. In the few years since then, hydrofoil craft have become commercially established and hold promise for future military use.

HYDRODYNAMIC ACTION OF HYDROFOILS

Since hydrofoils function similarly to airfoils, many of the analytic techniques of aircraft science are applicable to these water wings. The utilization of a higher density fluid, water, has the advantage of greatly reducing the necessary foil area. Water does, however create problems which are unique.

The net force acting on a hydrofoil is usually resolved into two components for analysis. The component of force in the direction of motion is called the drag, while the component normal to the direction of travel is known as the lift. The lift is the vertical force which supports the craft. The drag is the force tending to retard the forward motion of the craft.

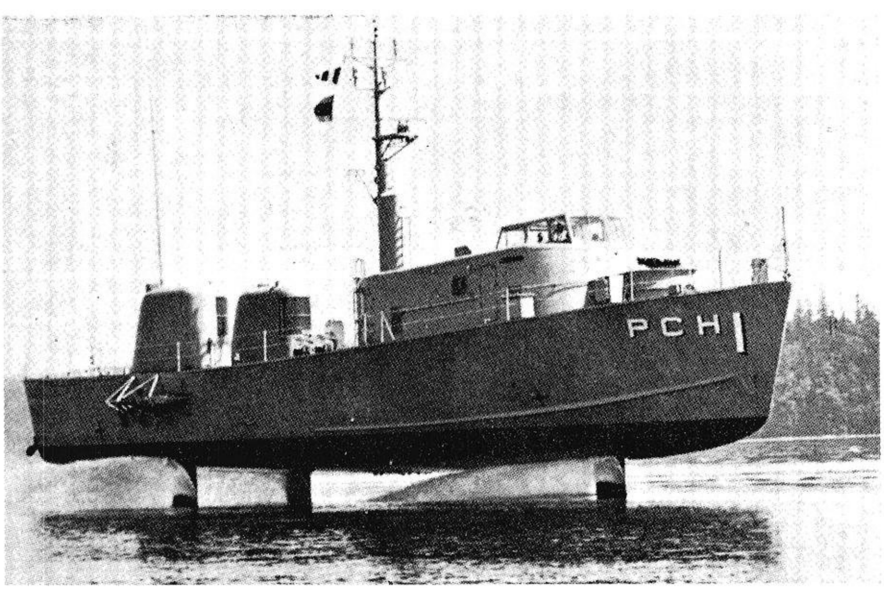


Figure 1.—Hydrofoil patrol craft developed by the United States Navy.

Lift

Lift and drag are the results of pressure forces acting along the surface of a hydrofoil section and friction forces which arise at the hydrofoil surface due to its motion through the water. Assuming that all fluid friction is in the direction of travel, the lift on a hydrofoil section is equal to the cyclic integral, or sum, of all of the vertical forces on the surface due to pressure. For a unit width of uniform cross section, this is mathematically expressed as: $\text{Lift} = \int P_L dA_L$, in which L indicates the vertical direction, P_L is pressure, and A_L is the foil area over which the pressure is taken.

Drag

There are two main factors contributing to hydrofoil drag. The most obvious one is simpl efluid friction. The second drag-producing factor is due to the pressures acting on the foil. This component

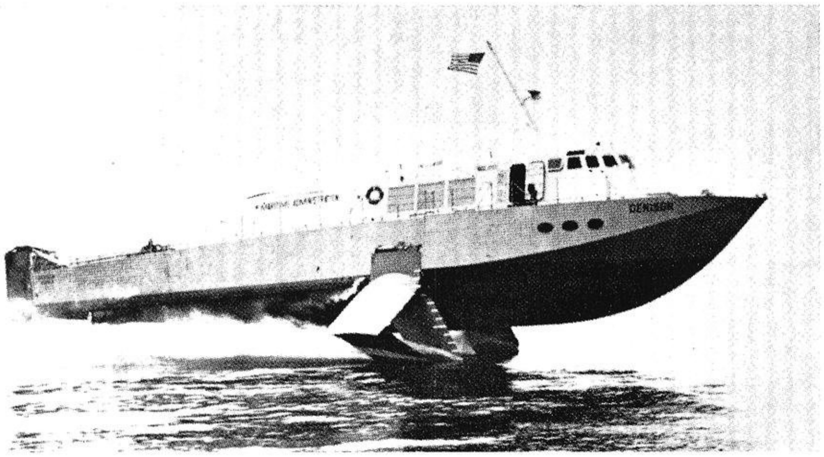


Figure 2.—Federally-sponsored craft will be prototype for commercial models.

of the drag is analogous to lift, and is mathematically defined as: $Drag_P = \int P_D dA_D$.

At high speeds a phenomenon called separation occurs which has a pronounced effect on the drag as shown in figure 3. The point of separation is a point on the foil section at which a wake begins. A wake is a region of high-velocity, random fluid motion which dissipates energy. This wasted energy would otherwise have been converted into a pressure increase downstream from the point of separation. The decrease in pressure on the tail end results in decreased lift.

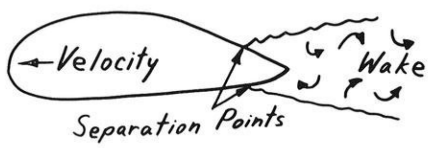


Figure 3.—Separation on a hydrofoil section.

The preceding concepts serve for a qualitative analysis of hydrofoil action. For quantitative results, empirical data must be relied upon because mathematical solutions of hydrofoil lift and drag are currently impossible. The lift and drag forces are calculated with equations that include coefficients of lift and drag plotted graphically as functions of the angle of attack for a particular type of hydrofoil section.

Interference

The coefficients of lift and drag are determined for sections of hydrofoil in an undisturbed flow region. If two or more hydrofoils operate close together, the coefficient of lift is reduced by a process called interference. In a ladder type hydrofoil arrangement, the increased velocity over a lower foil speeds the flow under the foil above it and reduces the pressure on the undersurface. Pressure energy is converted to kinetic energy, and this reduced pressure decreases the net lift. By similar reasoning, the top surface of a lower foil experiences a higher pressure than it would without interference, and subsequently contributes less to the lifting force.

Cavitation

The problem of cavitation is extremely important in hydrofoils as well as all other hydraulic machinery in which very low local pressures accompany extremely high fluid velocities. Cavitation is the formation of vapor bubbles, or cavities, in a fluid. These bubbles form when the pressure drops to the liquid vapor pressure. They are identical with bubbles in a boiling liquid except that boiling is the result of thermally raising the liquid vapor pressure above the atmospheric pressure.

The vapor bubbles themselves are not harmful, but if they enter a region of higher pressure and collapse against the surface of a hydrofoil, they create extremely large compressive stresses on the foil's surface. These stresses eventually cause the hydrofoil surface to erode, reducing the foil's efficiency as well as its mechanical strength. Cavitation can also be quite noisy.

Supercavitation

Cavitation would necessarily place a limit on hydrofoil speed if it were not for an ingenious method of overcoming this barrier. Since the presence of vapor bubbles on a surface is harmless, certain hydrofoils are built to operate at high speeds and large angles of attack so that the entire top surface is covered by one large bubble, or cavity, shown in figure 4, which collapses downstream from the foil and does no damage. The bottom surface maintains a high enough pressure to entirely avoid cavitation. Hydrofoils of this type are shown as supercavitating hydrofoils. Supercavitating foils put speeds of over 100 mph within the realm of possibility, whereas subcavitating foils could never go much beyond about 55 mph.

TYPES OF HYDROFOIL STRUCTURES

After consideration of the action of hydrofoils, the next logical problem is that of successfully applying them to water craft. The two basic types of hydrofoil structures are the surface-piercing type and the fully-submerged type.

Surface-piercing hydrofoils are the simplest type. They are built to be self-regulating, which means that if the lift on a foil structure is not sufficient to support the weight above it, it sinks and more foil surface area comes into action until equilibrium is reached. Conversely, if the foil plows into a large wave, the foil lifts itself out again. Two surface-piercing foils, the "V" and the ladder are illustrated in figure 5.

The fully-submerged foil utilizes a mechanism usually a hinged flap on the rear end, for changing its angle of attack to vary the lifting force. This system requires a complex control mechanism, but is justified by its smoother ride.

THE APPLICATION OF HYDROFOILS TO VESSELS

Controlling Mechanisms

The control of a hydrofoil craft is necessary for passenger comfort. Surface-piercing hydrofoils are self-controlling, but this type of self-control is responsible for vertical heaving, a major difficulty in rough seas. Extreme vertical accelerations can become intolerable to those aboard the craft. Further difficulties arise because this heaving sometimes takes place out of phase with the waves.

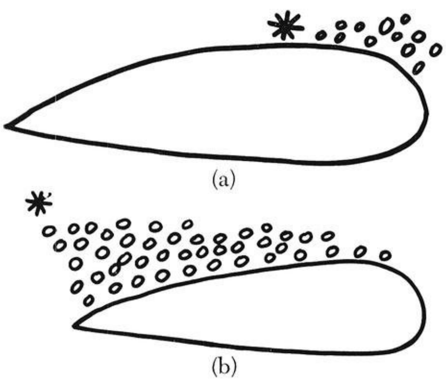


Figure 4.—(a) Cavitation, (b) Supercavitation.

When a surface-piercing hydrofoil overtakes a wave from behind, it digs into the rear end of the wave instead of rising with it. Furthermore, when coming out of the wave, the foil rises as the water surface drops. This action is in direct opposition to the desire to maintain a fairly constant strut submersion depth. This difficulty comes from the water velocity and the negative of the foil velocity combining to form a relative velocity of the water with respect to the foil resulting in negative angles of attack during the first half of the wave and positive angles of attack during the second half. Material such as seaweed or paper floating on the surface can foul the hydrofoil and stop proper action and cause further problems.

Submerged foils are not as rugged as surface-piercing foils, but they do perform much better in rough water. The simplest type of control system for submerged foils consists of arm-mounted skis which skim over the water's surface ahead of the craft and change the foils' angle of attack by means of mechanical linkages from the arms to the foils. This type of arrangement has the disadvantages of being vulnerable to damage and being bulky, particularly for larger vessels.

To overcome these problems and to gain better control, more complex control systems are used. These control systems utilize electrical control loops, with their major differences being the types of sensors they use. Two of the more practical types of sensors now available are a strut-mounted pressure transducer and a bowmounted sonar system. In addition, a radar sensing device is under development by the United States Navy. The demands placed upon these sensors are quite exacting. The table below shows some of these demands as stated by Mr. Owen H. Oakley, Department of the Navy.

Table 1.—Desired Characteristics of Sonic and Radar Sensors

Ht. capability	0 to 30 ft.
Accuracy	2 in.
Resolution	2 in.
Response time	.05 sec.
Life	2000 hr.

Struts

Another problem unique to hydrofoil craft is that of providing supporting struts which connect the foils to the hull. There are several factors which dictate strut construction. The struts must certainly be long enough to carry the hull above the largest anticipated waves without requiring that the control system sacrifice passenger comfort by riding up and down the waves with excessive vertical accelerations. But great strut length poses certain difficulties, including the height that the boat must fall if the power fails or a foil breaks, and the power lost due to thicker, sturdier strut cross sections beneath the water line.

The use of long struts raises a further complication. An ordinary ship is evenly supported by the surrounding water, but a hydrofoil craft suffers severe bending moments due to its entire weight being concentrated at the strut locations. Since the concentrated moments at the junctions of the struts and hull are proportional to the strut length, a further limitation is placed on the strut length.

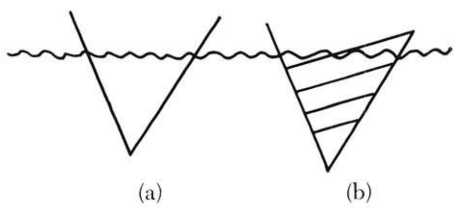


Figure 5.—Surface piercing hydrofoils: (a) V-type, (b) Ladder type.

In addition to these problems in strut design, the problems of drag and cavitation also arise.

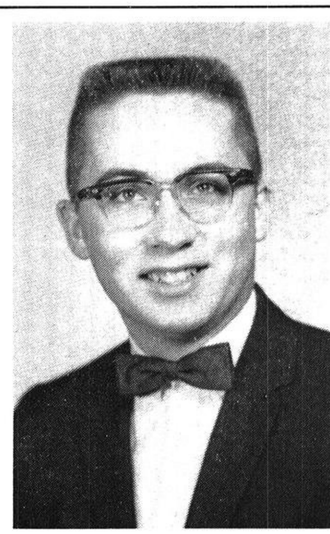
Strut location can vary considerably between different craft. The only absolute limit on strut and foil location is that there must be at least one foil in front of the boat's center of gravity and one behind it; provision must also be made for lateral stability.

Materials for Foils and Struts

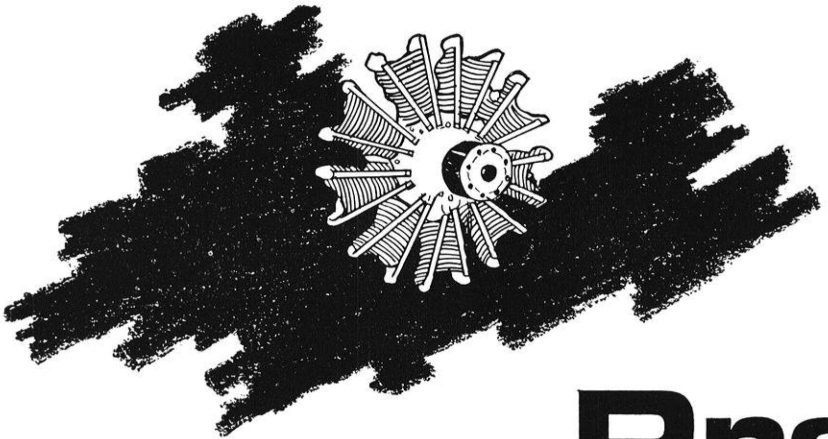
Because of cavitation at high speeds, materials are of great importance in foil and strut design. Besides having a high resistance to cavitational erosion, the materials must have sufficient mechanical stregth to keep the submerged cross-sectional areas to a minimum, and sufficient machinability, formability, and weld-

(Continued on page 32)

Walter Marks wrote this article prior to receiving his BSME from UW last June. His home is Brookfield, Wisconsin. An interest in boating (and fishing) combined with a mechanical design major gave Walt the inspiration to write this article. A member of Tau Beta Pi, Phi Kappa Phi, Pi Tau Sigma, and ASME, Walt has had summer jobs with Harnischfeger, The Falk Corporation, and Giddings and Lewis. He is currently working towards his Master's Degree here at UW, in ME (mechanical design) of course!

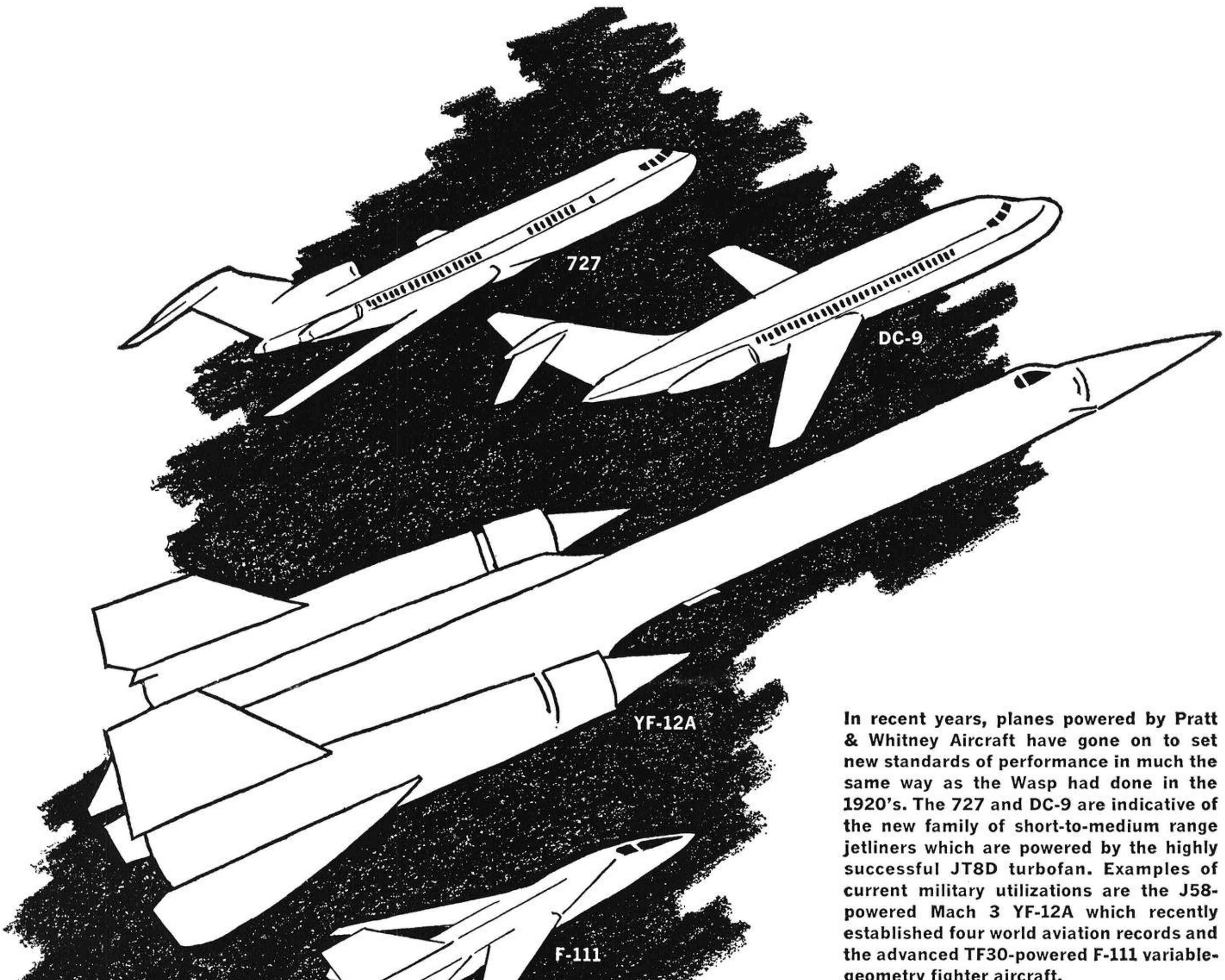


Past

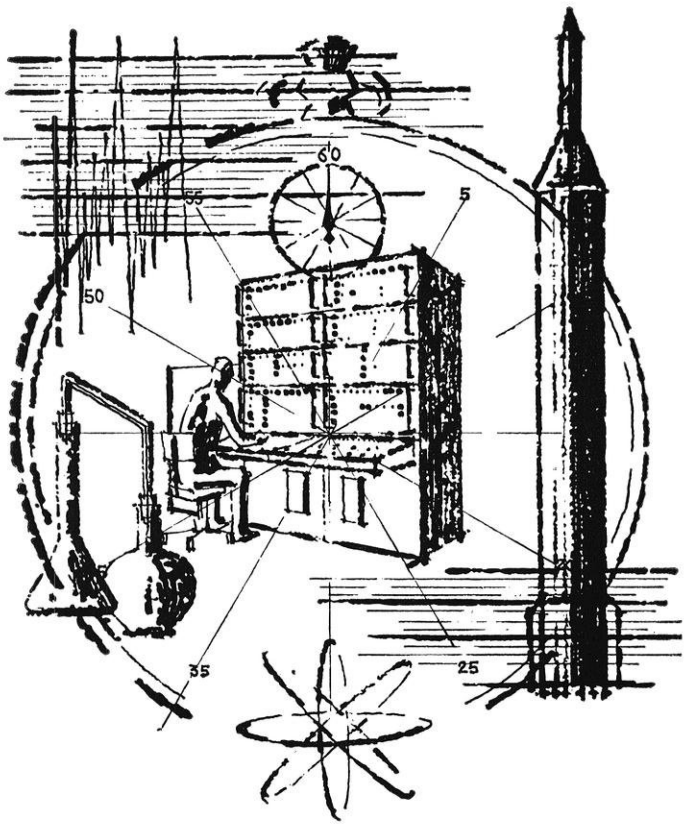


The Company's first engine, the Wasp, took to the air on May 5, 1926. Within a year the Wasp set its first world record and went on to smash existing records and set standards for both land and seaplanes for years to come, carrying airframes and pilots higher, farther, and faster than they had ever gone before.

Present



In recent years, planes powered by Pratt & Whitney Aircraft have gone on to set new standards of performance in much the same way as the Wasp had done in the 1920's. The 727 and DC-9 are indicative of the new family of short-to-medium range jetliners which are powered by the highly successful JT8D turbofan. Examples of current military utilizations are the J58-powered Mach 3 YF-12A which recently established four world aviation records and the advanced TF30-powered F-111 variable-geometry fighter aircraft.



SCIENCE HIGHLIGHTS

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

MOTOR MAGAZINE REPORTS ROAD TEST OF ROVER–B.R.M.

Is fuel consumption of the gas turbine car promising enough for the average motorist?

This is one of the questions treated in the current issue of *Motor* magazine, whose editors drove the famous Rover-B.R.M. turbine racing car for a week on highways and city streets in England.

The magazine's test showed excellent mileage by American standards at highway speeds of about 40 to 50 miles an hour—almost 25 miles per American gallon. Mileage was good at the high speed of 100 miles an hour—about 17.5 m.p.g. But at low speeds, consumption increased significantly, tests showed.

The latter figure is not surprising since the car was designed for racing, the magazine commented. The car maintained an average speed of almost 100 m.p.h. for a total distance of 2370 miles during the 24-hour running of the Le Mans endurance race in France last June.

Motor, a leading British periodical, pointed out that the car is unique, built for a particular purpose for a particular driver, Graham Hill, champion racing driver.

"It doesn't in any way represent the sort of car that either of its parent companies (the Rover Co. Ltd. and the Rubery Owen Organisation Ltd.) would offer for sale but it still has tremendous significance," the editors wrote. "So far as we know it is the first time that a detailed independent investigation of a turbine car has been published.

"The fact that we were able to take it away for a week without supervision and use it for ordinary road motoring . . . shows that the company has confidence in the reliability of its product."

"The Rover turbine prefers paraffin (kerosene) although it will consume other fuels from petrol (gasoline) to diesel oil in an emergency," the editors wrote.

"With the latest ceramic heat exchangers, wich are fitted to this engine, we found that fuel consumption at high speeds is very moderate; for example, it does 21 m.p.g. (British Imperial gallons) at 100 m.p.h. and there are very few sports cars indeed which will equal this figure. In the region 40–50 m.p.h. it returns figures around 30 m.p.g., and by far the best results are obtained by dropping below this speed as little as possible. The reason for this is the high idling consumption."

The editors figured that at a steady 20 m.p.h. (which can be achieved only by using the brake against the engine) consumption is about 12.45 miles per American gallon and at 10 m.p.h. about twice that.

As an overall figure, they settled upon almost 12 miles per American gallon. For touring, they settled upon more than 18 m.p.g., reckoning consumption for speeds between 30 m.p.h. and maximum, less five per cent allowance for acceleration.

A chart showed best mileage at a speed of about 45 m.p.h.

Acceleration lag is another question the average motorist asks about the gas turbine. The editors found it to be "pronounced."

"It is essential to anticipate by at least two seconds the need for full power," they wrote. "This leads directly to the one great modification necessary in driving techniques—the left foot must be used for braking, the right for acceleration and the two must be played against each other simultaneously. We found no difficulty in learning this technique. . . ."

The car accelerated from zero speed to 50 m.p.h. in nine seconds, the editors found, "about the same as an M.G.B. or a Porsche SC."

The 10-page, two-article report describes not only road test results but the complete operation of the engine and structure of the car.

On another page, results of 126 road tests are compared, including results from the tests of a number of American cars.

Editor's Note: A copy of the article cited above is available in the *Wisconsin Engineer* office, 333 ME, (262–3494).

TWO-MILE LASER BEAM FOLDED INTO 10 FEET

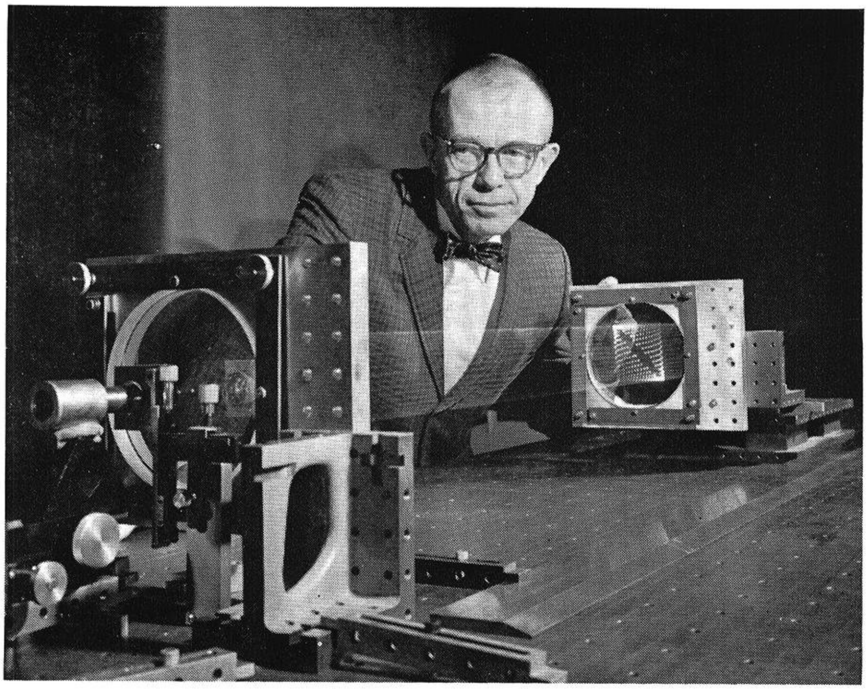
A two-mile long laser beam has been folded into a 10-foot space by reflecting it over a thousand times between two mirrors. Because the points of reflection on the mirrors do not overlap, information can be modulated onto the light beam, stored and retrieved 10 microseconds later.

This experiment opens the way for optical delay lines used as high-speed, sequential, computer memories. The experiment also provides an excellent means of measuring very small losses in lenses and other optical materials.

Such an optical delay line could store 10,000 bits of information which could be read out serially one bit every nanosecond. Because light waves are dispersionless (all component frequencies travel at the same velocity), information modulated onto the laser beam would not be distorted in the delay line.

To get the maximum number of reflections without interfence between light beams, researchers bent two spherical mirrors into slightly cylindrical shapes. This caused the horizontal radius of curvature of the mirrors to differ slightly from the vertical. As a result, the light spot—the point where a beam hits the mirror—moves with each reflection to form a Lissajous pattern.

A Lissajous pattern—commonly seen on an oscilloscope—results when two sinusoidal signals of different frequencies are plotted together, one on the horizontal, the other on the vertical position. When the vertical and horizontal positions vary at only slightly different rates—as in the optical delay line—the Lissajous pattern is an ellipse along one diagonal of the mirror's square area. This ellipse varies slowly through a circle, then back to an ellipse along the other diagonal.



A laser beam is folded into a small space by reflecting it back and forth between two mirrors. Harry Schulte of Bell Telephone Laboratories adjusts one of the mirrors so that the reflection points do not overlap but, instead, form a Lissajous pattern of slowly changing ellipses. Scientists have delayed the beam 10 microseconds by reflecting it over 1000 times. For this photograph, the mirrors were moved close together and the beam was reflected only about 400 times.

By controlling the angle of the entering light beam, a region free of spots can be left in the mirror's center for the output beam. Several beams, in fact, can be reflected back and forth at the same time if they enter at different angles or at different frequencies. Thus, one mirror system can store more than one set of information.

The maximum number of beam reflections is limited by the area of the mirrors and by the scattering loss of the mirrors. (Diffraction losses are reduced to negligible amounts because of the mirrors' converging power.) During 1000 reflections (10 microseconds delay) the beam's power is reduced by scattering only 20 db. This indicates that two or three thousand reflections (delays of 20 or 30 microseconds) are feasible.

NASA'S LARGE SOLID MOTOR TEST ACHIEVES OBJECTIVES

A 260-inch diameter solid fuel rocket motor developed 3.5 million pounds thrust in a recent test and all results were apparently successful.

The largest motor ever fired was built for the National Aeronautics and Space Administration by the Aerojet–General Corp. near Miami, Fla.

Engineers said preliminary results showed that the motor recorded a total action time (or near peak thrust) of 112 seconds, out of a total burning time of 124 seconds. A pressure of 600 pounds per square inch and a top temperature of 5500 degrees Fahrenheit was developed inside the steel casing.

The motor, bolted in place nozzle-end upward, was tested in a 180-foot pit lined with concrete. The motor itself was 60 feet long and was topped by a 20-foot-high nozzle. Made of special maraging steel casing, the motor contained 1,680,000 pounds of solid propellant cast in one piece.

It was ignited by another rocket motor, of 250,000 pounds thrust capacity. The igniter motor broke free of its tether, rose several thousand feet upward and landed a few hundred yards from the pit.

Scientists of NASA and Aerojet said the results of the test advanced technology and demonstrated feasibility of large solid propellant motors for use in future space launch applications. The test was made with a "half length" motor; a full length motor would develop about seven million pounds of thrust. The test series includes one more firing by Aerojet of a similar size motor early next year.

NEW CONCEPT PROMISES TO TAME 17,000 "KILLER BRIDGES"

Who has not driven across the metal lattice work of an open grid bridge during wet weather and felt the sudden and sickening loss of behind-the-wheel control?

The familiarity of this terrifying experience is easy enough to understand; highway authorities report there are more than 17,000 such open grid bridges under the jurisdiction of nearly every municipality in America.

And increasingly, many are coming to regard open grid bridges as "killer bridges" for they produce skidding accidents which are directly responsible for some 20 deaths and 150 personal injuries each month.

This estimate of their toll—compiled from national newspaper clippings and confirmed by bridge authorities—does not include the multi-million dollar losses through litigation, property damage and salary stoppage.

The explanation for why these bridges kill and maim with such regularity has been scientifically demonstrated. Studies conducted by independent testing groups indicate that tire traction on metal open grid bridge surfaces is reduced by nearly a third compared to conventionally paved surfaces during wet weather.

Fortunately, a new concept developed by an Ohio company seems to offer a way for converting the very liability of these killer bridges into a skid-resistant asset—and at comparatively small cost.

The technique is deceptively simple. It involves no more than welding ⅜″ diameter steel studs in a planned pattern on the grating utilizing a semi-automatic welding technique.

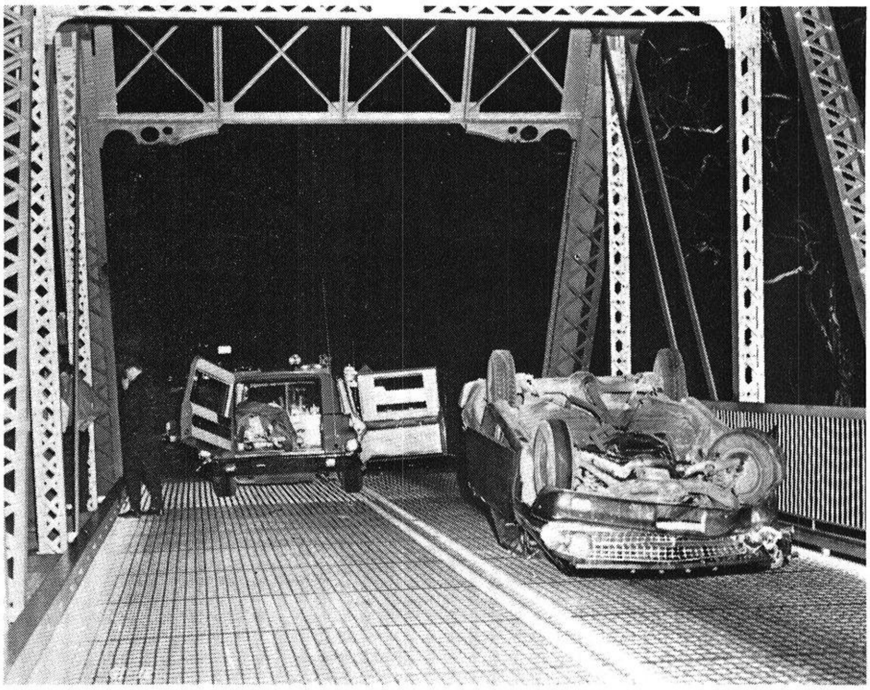
This concept was given its first exacting test in Cincinnati, Ohio, when local officials became concerned by an exceptionally high accident rate on their Vine Street bridge.

After installation, the steel studs eliminated virtually all weaving and skidding. The year following the installation, no accidents at all occurred on the Vine Street span.

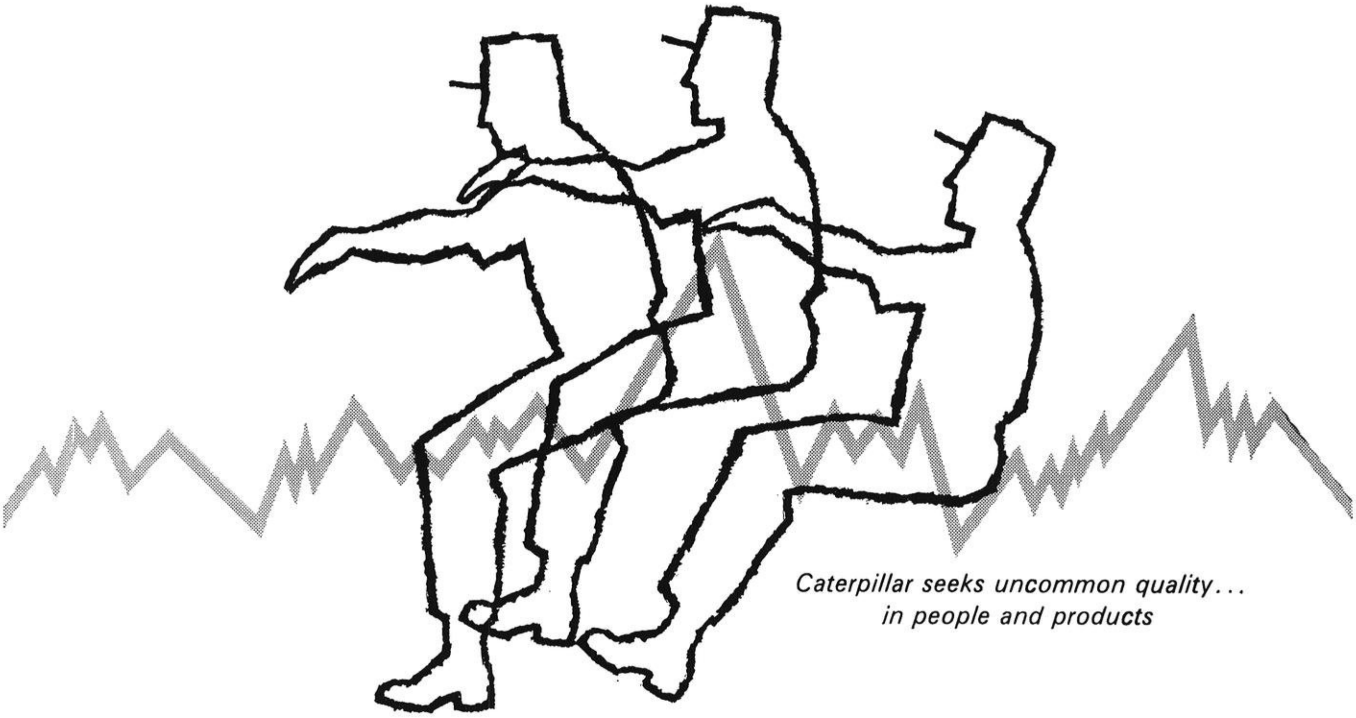
THIS . . .

Photo shows a closeup of non-skid studs being welded in place.

. . . PREVENTS THIS



Accidents such as this are unreasonably common on open grid bridges during wet or icy weather.


Caterpillar seeks uncommon quality...
in people and products

Are these the Ghost Riders in the sky?

LADIES OF THE COURT IN ANCIENT CHINA ARE ALWAYS THOUGHT OF AS BEING VERY DAINTY AND DEMURE — BUT THEY MAY WELL HAVE RESEMBLED TODAY'S OUTDOOR-TYPE GIRL MORE THAN WE REALIZE. SOME OF THEIR RECREATION WENT FAR BEYOND THE QUIET DIGNITY OF SINGING FOLK SONGS BESIDE A POOL FILLED WITH LOTUS BLOSSOMS.

HOW DO WE KNOW THIS? BY THE PAINTED MORTUARY CLAY FIGURE OF A WOMAN PLAYING POLO.....

This figurine, from the T'ang Period (619-907 A.D.) of China, established the active participation by women in a sport that is played entirely by men today. Notice, too, that the Chinese ladies rode astride the horse, not sidesaddle as European and American ladies did up to 50 years ago. Riding a horse may have changed, but the clay in the figure remained the same throughout time.

Proof again of the amazing permanence of clay.

Like the ancient figurine above, Dickey Pipe is made of clay. It, too, is unaffected by the passage of time. Modern manufacturing methods are used to make strength an inherent part of the pipe. The clay itself is immune to attacks of acids and alkalis found in today's sewers. The pipe is glazed to improve flow characteristics. And the patented Dickey Coupling is made of urethane, a resilient material providing tight, yet flexible joints. All of these advantages make Dickey Perma-Line Coupling Pipe your best bet for sanitary sewers...low-cost, trouble-free, permanent.

Dickey sanitary glazed clay pipe

If it's made of clay it's good . . . if it's made by Dickey it's better

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SST

(Continued from page 16)

already used successfully at supersonic speeds on small aircraft, is best for use on the SST. Strength, stability, and reliability are some of the advantages. Aircraft control surfaces are also simplified by use of the delta wing, for the elevator and ailerons can be combined. The main disadvantage of the delta wing is that the aircraft must land with a nose high attitude. This position of the aircraft seriously hampers the vision of the pilot. The proposed solutions to this problem are to droop the nose section, as has been done withe Concorde, or to install closed circuit Television cameras in the wheel-wells. At the present time, the area of wing development is one of the more encouraging areas. The development of two entirely different configurations should lead to an optimum design.

Fuselages

The fuselage for the SST will be one of the most difficult design areas because of the combination of high speeds, high altitudes, and the heat generated by skin friction. The fuselage development for the Concorde has been much simpler than the development will be for the United States SSTs. By the choice of a speed of Mach 2.2 the designers of the Concorde avoided the high temperatures caused by skin friction. As a result, conventional aluminum alloys were used for fabrication and the previously used refrigeration systems did not need major modifications. With a speed of Mach 2.7 to Mach 3 the American manufacturers will have to use Titanium for the aircraft structure, and will also have to design high capacity refrigeration systems to keep the passenger and fuel compartments at tolerable levels of temperature.

Passenger Compartment

In the planning area of the passenger cabin many designs have been proposed. Several seat layouts have been proposed but nothing has been finalized. The final configurations will probably be chosen after the prototypes have been successfully tested. Economy will be the prime concern when the layout for the passenger cabin is chosen. Since flight times will be shorter than for subsonic jets, passengers will be asked to give up some of the luxuries in order that an economical passenger carrying potential may be achieved. Things such as in-flight movies, dinners, and first class service may be discontinued. In order to be competitive, cabin space must be utilized to its fullest extent and no excess weight should be carried.

Flight Deck

The flight deck of the SSTs is an area where space must be minimized, and efficiency and safety of operation must be maximized. All three flight deck layouts are planned for a three man crew (Pilot, Co-pilot, and Engineer). The layouts will all feature a good arrangement of gauges, controls, and warning lights. A proposed layout for a SST flight deck is shown in Fig. 4. This particular layout uses movable seats for the pilot and engineer. In this way the Engineer can move forward without leaving his seat, and the pilot can slide back to monitor the flight engineers panel when necessary.

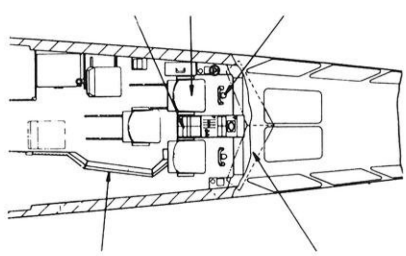

Figure 4.—Flight deck arrangement. Note sliding seats.

Aircraft Skin and Airframe

The skin and airframe for the two American SSTs will be fabricated from Titanium. Titanium was chosen because of its high strength at high temperatures and because of its resistance to fatigue failures. Present plans for the two SSTs call for a hoop type fuselage structure with external stringers for ridgidity. In tests recently completed at Lockheed Aircraft the results indicated that a titanium alloy, number 8–1–1 duplex annealed, will be best for use in the SST's pressurized cabin. The plans for the Anglo–French Concorde indicate that the skin and airframe will be constructed using aluminum alloys. Titanium sections may also be used in the area of higher skin friction such as the nose section and leading edges of the wings. The fuselage will be cylindrical in shape and will have closely spaced longitudinal stringers to maintain ridgidity.

Aircraft Systems

The systems for the SSTs will be very similar to systems used for subsonic aircraft. Because of the high speed and high costs of the SSTs, a ground monitor system may be used. This system would monitor and record all essential aircraft functions, thereby providing a detailed record for all flights. The ground monitor would be of its greatest value if an aircraft crashed or sustained a mechanical failure during a flight. If a failure occurred, the monitor could be set up to automatically inform the pilot and indicate the corrective action.

A radiation monitoring system may be necessary for the SST since the health of the passengers and crew may be endangered by ionizing radiation. During periods of normal radiation the passengers and crew will be unaffected, but during periods more intense radiation, such as those caused by sunspots or solar flares, a hazard may exist. During these periods of high radiation the aircraft will have to operate at lower altitudes, where the radiation level is lower. At the present time these periods of high radiation can be accurately forecasted, but an aircraft monitoring system may be installed as a factor of safety.

THE FINANCIAL PICTURE

The area of finances is one where all three of the manufacturers face difficult obstacles. Along with the prospect of stiff competition from the sub-sonic jets, the manufacturers also face the problem of obtaining adequate development funds. The Concorde project has been plagued by financial problems since infancy and at the present time only iron-clad agreements are preventing a French withdrawal from the project. The American manufacturers also have a problem, as the

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SST

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Government has agreed to pay only seventy-five percent of the development costs. The twenty-five percent portion placed on the manufacturers may cause undue financial burdens, resulting in a slower development program.

Present Finances Fair

The present financial state for all of the SSTs could be classed as fair. The money for development is being provided but the problems are far from solved. The big problem seems to be whether or not the SST can operate competitively. Present figures from U.S. manufacturers indicate that fixed costs for the SST will be four times as high as for a comparable subsonic jet, while variable costs should be equal for both aircraft. Fixed costs include landing and take-off expenses. maintenance, and depreciation. Variable costs are the costs per mile traveled, or the cost per seat-mile. The high fixed costs could put the position of the SST very much in jeopardy as increased fares would be needed to cover the increased costs. Some passengers will be willing to pay the increased fares, but the number which are willing may not be great enough to promote large scale SST service. If, however, the manufacturers can find a way of cutting these high fixed costs, the SSTs may completely dominate long range aircraft flights.

Future Finances?

The financial futures of the SSTs will depend on the governments which are supporting the programs, and on the ability of the manufacturers to come up with competitive operating cost figures. Airlines may buy only a few SSTs or they may buy many. It all depends on whether or not the aircraft can be profitably operated.

The future for the American manufacturers is very uncertain. No orders have been placed for aircraft by the government or airlines, and the financial outlook appears to be one of slow moving subsidized development. If, however, either of the companies can come up with some attractive operating cost figures, the program might be accelerated in order to cut down the Anglo–French lead in the race to build the SST.

The future financial state for the Concorde cannot be predicted. A total of 45 aircraft have been ordered by nine airlines, but this small number of sales would not begin to cover the cost of development. Only time will tell whether the development of the Concorde was a good financial investment.

FUTURE OF THE DEVELOPMENT PROJECT

The future of the development projects will depend greatly on the world situation during the next seven or eight years. If England and France continue to support the Concorde project, it will have a good chance for a successful completion. However, should either France or Britain be unable to support the project, it may never be completed. The projects in the United States also stand a good chace of being completed. Recent developments indicate that the United States Government is planning to support both Boeing and Lockheed in their programs of SST development.

END

HYDROFOIL BOATS

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ability. The more successful materials include stainless steels; tool steels; alloys of aluminum, nickel, titanium and copper; refractory alloys; and the nonmetallics Pyroceram, epoxy-glass laminate, and nylon. In addition, claddings of Hastelloy and titanium and coatings of neoprene, epoxy, and polyurethane show much promise.

Propulsion Systems

The design of a suitable propulsion system for the hydrofoil craft is another problem. The main criterion for the engine is that it must be capable of developing a very large horsepower and have a minimum of weight. Gas turbines, lightweight diesel engines, and gasoline engines meet these qualifications, but, due to the fire hazard of gasoline, the possibility of using gasoline engines is eliminated. Gas turbines claim the following advantages over diesel engines: lower weight and size, simpler construction, and the availability of higher horsepower sizes. Diesels, however, have a greater power range. Currently, ordinary propellers are used almost exclusively with both types of engines. Other thrust devices considered include air jets, water jets, and screw propellers, all of which exhibit a lower efficiency. A secondary propulsion system is needed for hull-borne operation in port, since the larger systems are unwieldy at very low speeds.

Hulls

After consideration of the foils, struts, and propulsion systems, the final item to select is the hull on which these operate. The hull shape is streamlined like an ordinary high-speed boat in order to gain enough speed to clinb out of the water onto the foils. The hull structure, however, is a bigger problem. Since the hulls of hydrofoil boats must be light, most of them are made of aluminum alloys. Titanium and fiberglass are envisioned for future usage. The hull must be constructed to be able to sustain the impact of a "crash landing" should a foil break or the power fail and also be able to withstand the large bending moments caused by the struts.

Hull-borne operation in high seas is a final problem in the craft's design which is not immediately apparent. Because of the foils' anchoring effect, the ship's superstructure must be able to withstand the intensified impact of crashing waves.

USAGE OF HYDROFOIL CRAFT

Because of their superior performance, hydrofoil craft are rapidly expanding in naval and commercial usage. Most of the earlier hydrofoil work was done to develop high-speed military craft, but in recent years commercial hydrofoil boats have developed the fastest.

Naval Craft

The United States Navy foresees possible usage of hydrofoil boats in all applications of small, fast craft, including PT boats, landing craft, mine sweepers, and antisubmarine patrol craft (see Figure 1). Although there are no hydro-

(Continued on page 36)

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HYDROFOIL BOATS

(Continued from page 32)

foil boats functioning in regular Navy service at the present time, there are several models either under development or in use on an experimental basis. A typical example of these craft is the High Lander (LCVP(H)), an experimental landing craft. This boat features four retractible V-type, surface-piercing hydrofoils located at the four corners of its approximately rectangular hull. Following are some of its features:

Length	40.6 ft.
Width, foils extended	29.3 ft.
Width, foils retracted	14.1 ft.
Power	550 hp.
Speed	40 mph.
Maximum pay load	2.6 tons.

At this time it is uncertain what success hydrofoil craft will have in attaining usage in actual military operations. Before this can happen, they must prove their capabilities in the rough waters encountered at sea. In addition, they must be sufficiently superior to conventional craft to justify their higher costs, which are predicted to be at least twice as great as the costs of conventional craft now in use.

Commercial Craft

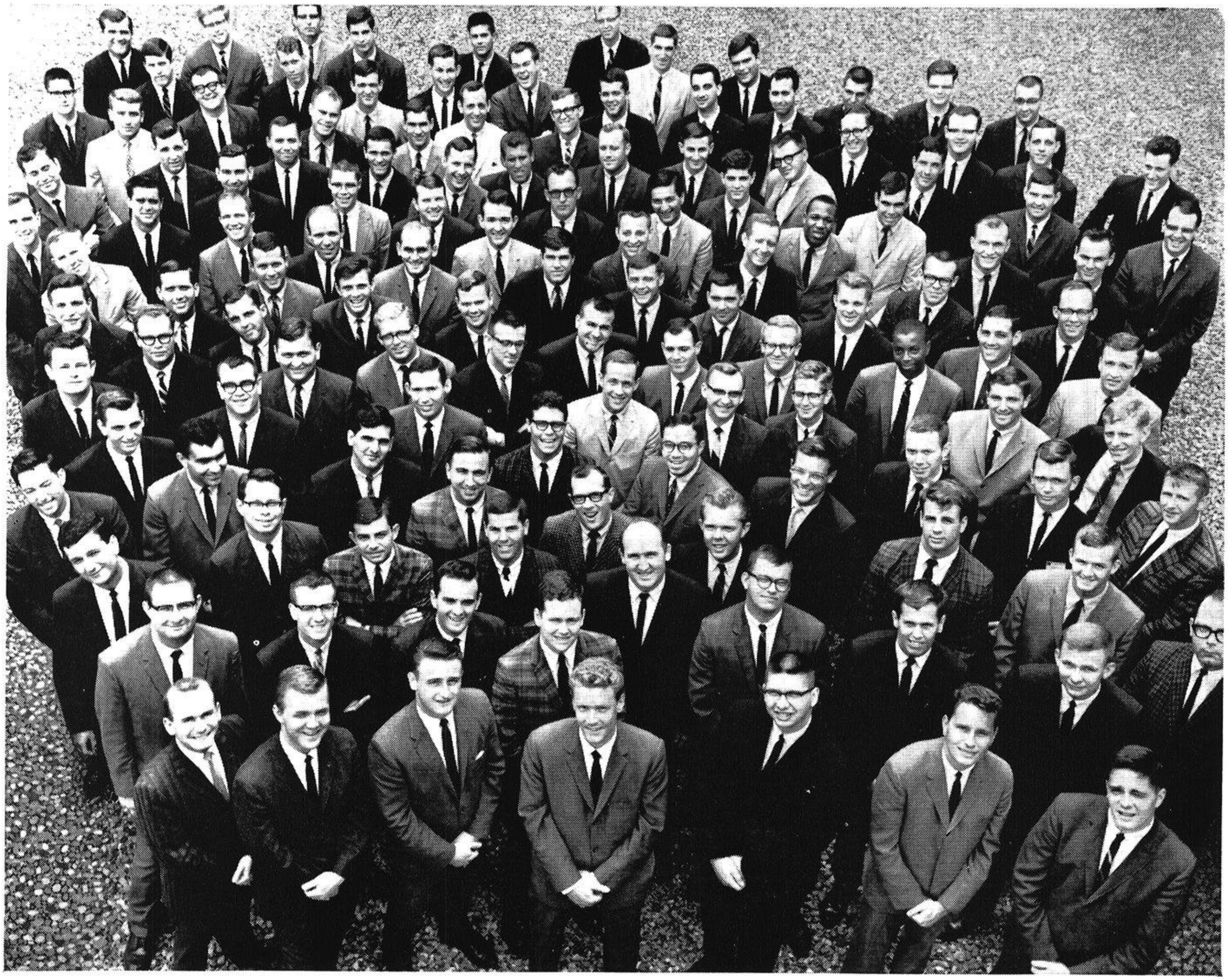
Commercial hydrofoil craft are attaining a more definite success. In this country and others, including Russia, Italy, and Japan (See Figure 2) commercial hydrofoil boats are already operating profitably. Because of its abundance of large, navigable rivers, Russia has perfected its passenger hydrofoil boats to a greater degree than any other country.

The "Meteor", a medium-sized Russian hydrofoil boat, plies the Volga River at 50 mph while carrying 150 passengers, This remarkable passenger boat is shaped like a cigar and is powered by two 1000-hp engines. A new development is the "Chaika" which is designed for shallow rivers and has a maximum foil submersion depth of 16 inches at crusing speed. It is propelled by water jets and travels at speeds up to 65 mph.

The United States has not advanced as rapidly as Russia, Europe, and Japan in hydrofoil craft development. At the present time, only two small hydrofoil boats have been certified by the Coast Guard for passenger service. This slow progress is partially due to this country's lack of calm water in highly populated areas. Calm water is necessary because the control systems for fully submerged foils are far too expensive for rough water use and the surface piercing foils in use give a rough ride on large waves. Another factor contributing to the slow acceptance of hydrofoil passenger craft is that they have to compete with well-established air, rail, and road systems of transportation.

Although the United States will probably never utilize hydrofoil craft as extensively as the European countries and Japan, greater usage of them can be expected in the future. Among the areas that hold the greatest promise of economic success for hydrofoil boats are New York City, Nantucket Sound, Puget Sound, and the Great Lakes.

END



BARREL THE OF BOTTOM

An engineer and his girlfriend were driving in the country one morning.

"Some morning!" he remarked enthusiastically.

"Yes it is," she replied.

"Some meadow."

"Yes it is."

Seeing sparkling drops of water covering the grass, he commented, "Some dew!"

"I don't."

* * *

Glasses do the strangest things to vision; especially after they have been drained and filled a few times.

* * *

The slowest thing in the world is a nudist climbing over a barbed wire fence.

* * *

"I can't marry him, Mother. He's an atheist and doesn't believe in Hell."

"Marry him, my dear, and between the two of us we'll convince him."

* * *

Freshman: "Woman's greatest attraction is her hair."

Sophomore: "I say it is her eyes."

Junior: "It is unquestionably her teeth."

Senior: "Now what's the use of use of just sitting here lying to each other?"

First Drunk: "Shay, do you know what time it is?"

Second Drunk: "Yeah."

First Drunk: "Thanksh."

* * *

What can a bird do that seven out of ten people cannot?

Make a small deposit on a car.

* * *

A small boy leading a donkey passed an army camp. A couple of soldiers wanted to have some fun with the lad. "What are you holding on to your brother so tight for sonny?" said one of them.

"So he won't join the army," the youngster replied.

* * *

Stopping at the first house on his famous ride, Paul Revere cried, "Is your husband home?"

"Yes," came the answer.

"Then tell him to dress and fight the British."

At the second, third and fourth houses he repeated the conversation. As he rode by the fifth house he again repeated the cry.

"No," was the reply.

"WHOA."

* * *

The mother entered the darkened room unexpectedly and found daughter and boyfriend in passionate embrace on the sofa.

"Well—I never!" exclaimed mother.

"But, mother, you must have!"

Engineer: "I'm not feeling myself tonight."

Coed: "You're telling me."

* * *

"You missed my class yesterday, didn't you?"

"No sir, not a bit."

* * *

Professor: "I won't begin today's lecture until the room settles down."

Voice from the rear: "Why don't you go home and sleep it off."

* * *

The doctor finished his examination of a sweet young thing. "A very difficult case to diagnose," said the doctor. "But as near as I can tell you're either going to have a baby or else you have a cold."

"It must be a baby," the chick said emphatically, "because I don't know anyone who could have given me a cold."

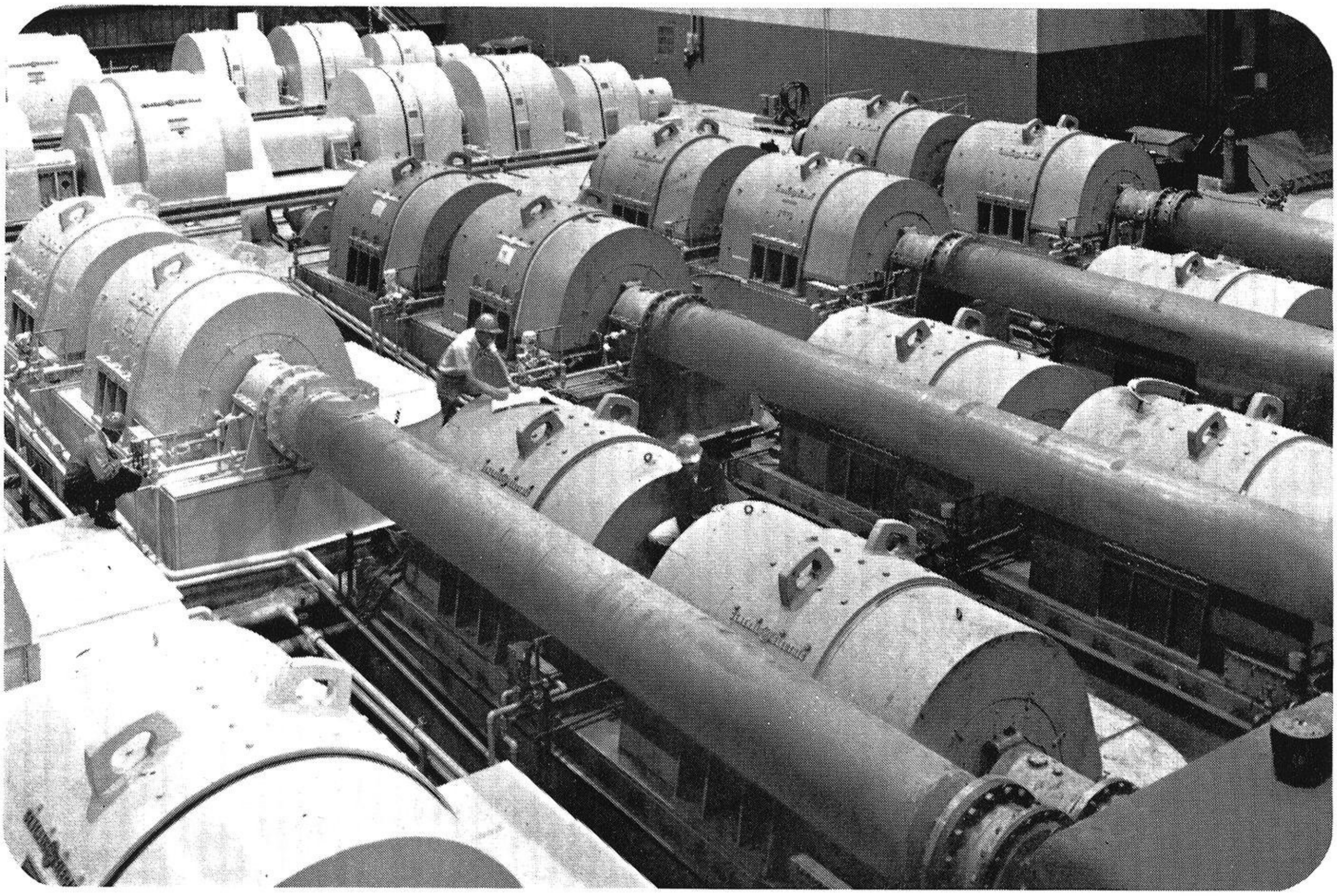
* * *

Do you know what good clean fun is?

No, what good is it?

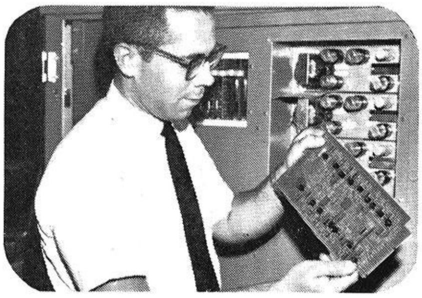
* * *

Then there was the playboy who suddenly decided to live a strictly moral life. First, he cut out smoking. Then he cut out liquor. Then he cut out swearing. Then he cut out women. Now he's cutting out paper dolls.

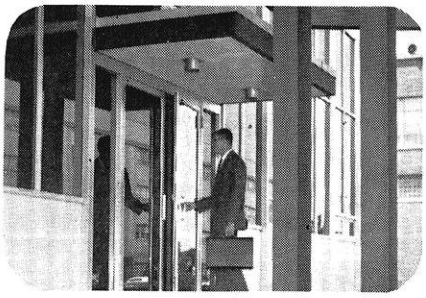


DRIVE POWER by General Electric: one section of Bethlehem Steel Corporation's new mill at Burns Harbor, Indiana.

INDUSTRY CONTROL engineer Bob Vaughn, Virginia Polytechnic Inst., worked on drives, control and the new SCR armature regulator, from design through installation.



PRINTED CIRCUIT PROCESS heart of automatic control, was checked by Glenn Keller, Lehigh U., on the Manufacturing Program at Specialty Control Department.



CUSTOMER REQUIREMENTS for d-c motors were met by Jim Johnson, U. of Cincinnati, on a Technical Marketing Program assignment at Large Generator & Motor Department.

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