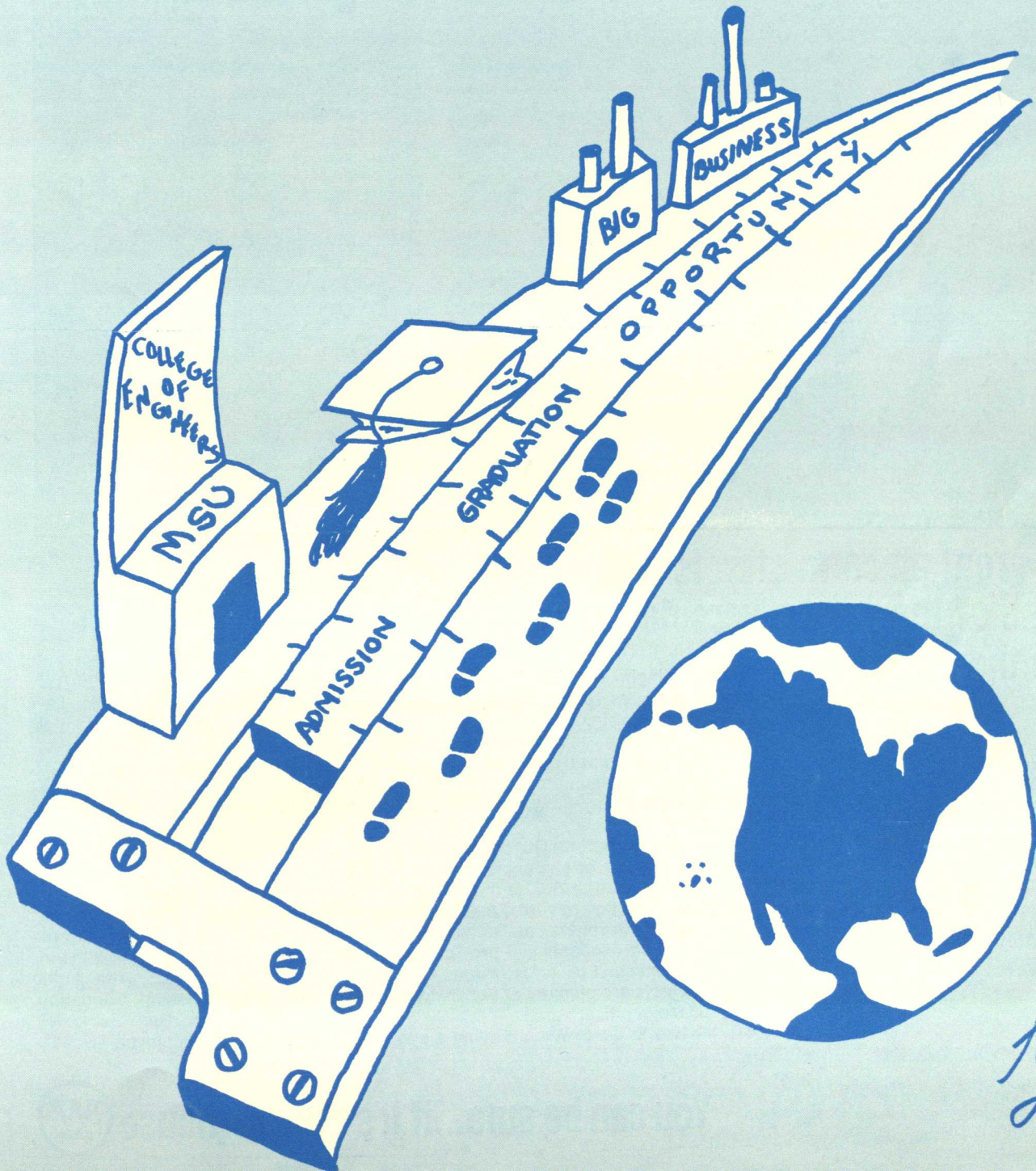


SPARTAN ENGINEER

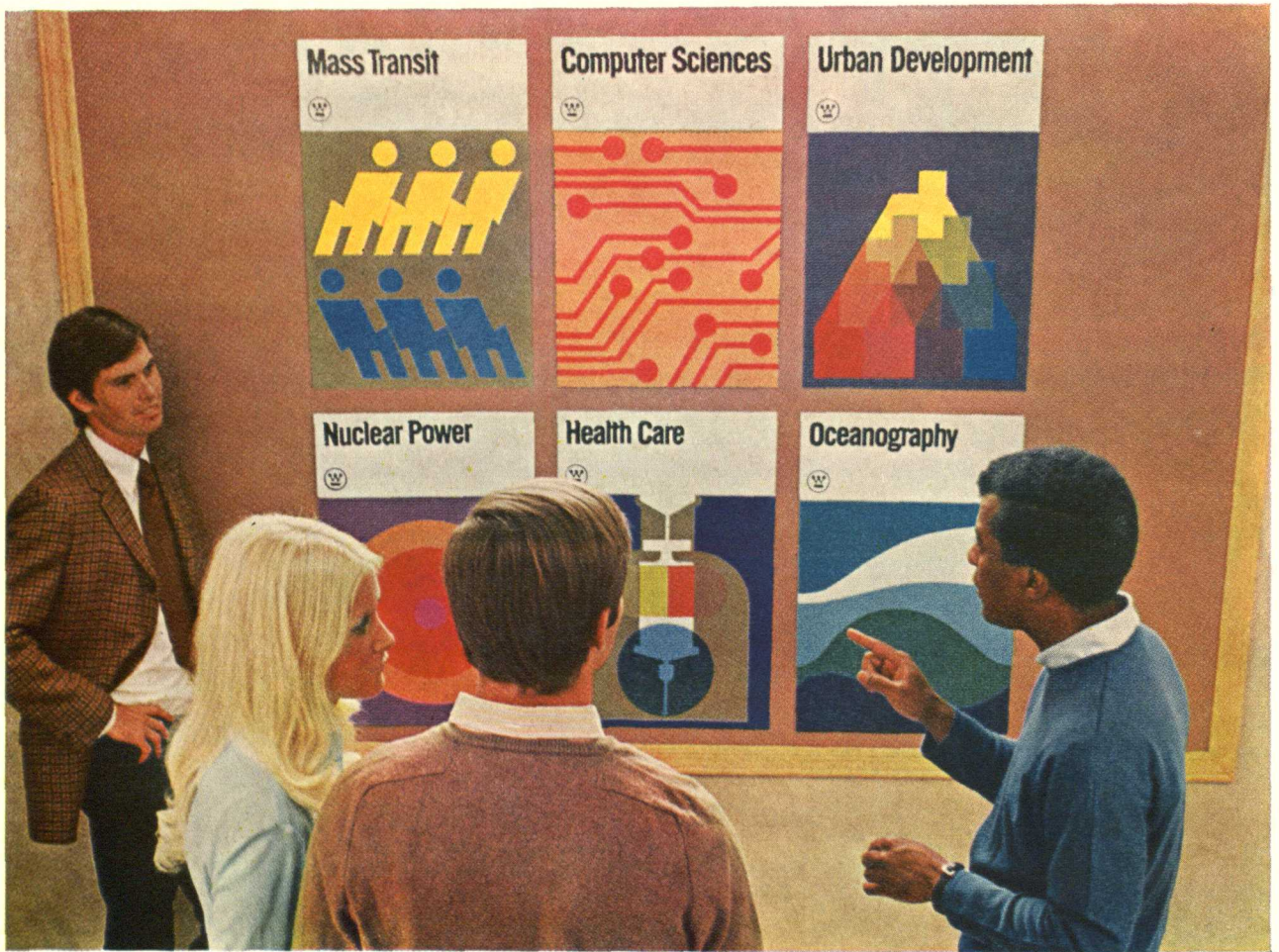


MARCH, 1970

25¢



If you want to engineer
a better world...



a great place to start is with
one of the most diversified companies
in the world.

Westinghouse thinks its responsibilities are as big as its capabilities—and that's big.

And when you're in everything from computers to urban development, to medical science, to mass transit, to oceanography—there's action. For example...

Transportation: Our computerized transit systems can operate on a 90-second schedule, and meet the transportation needs of many cities.


Urban Development: Our new construction concepts will provide better communities across the country. Projects are planned or underway in 30 major cities.

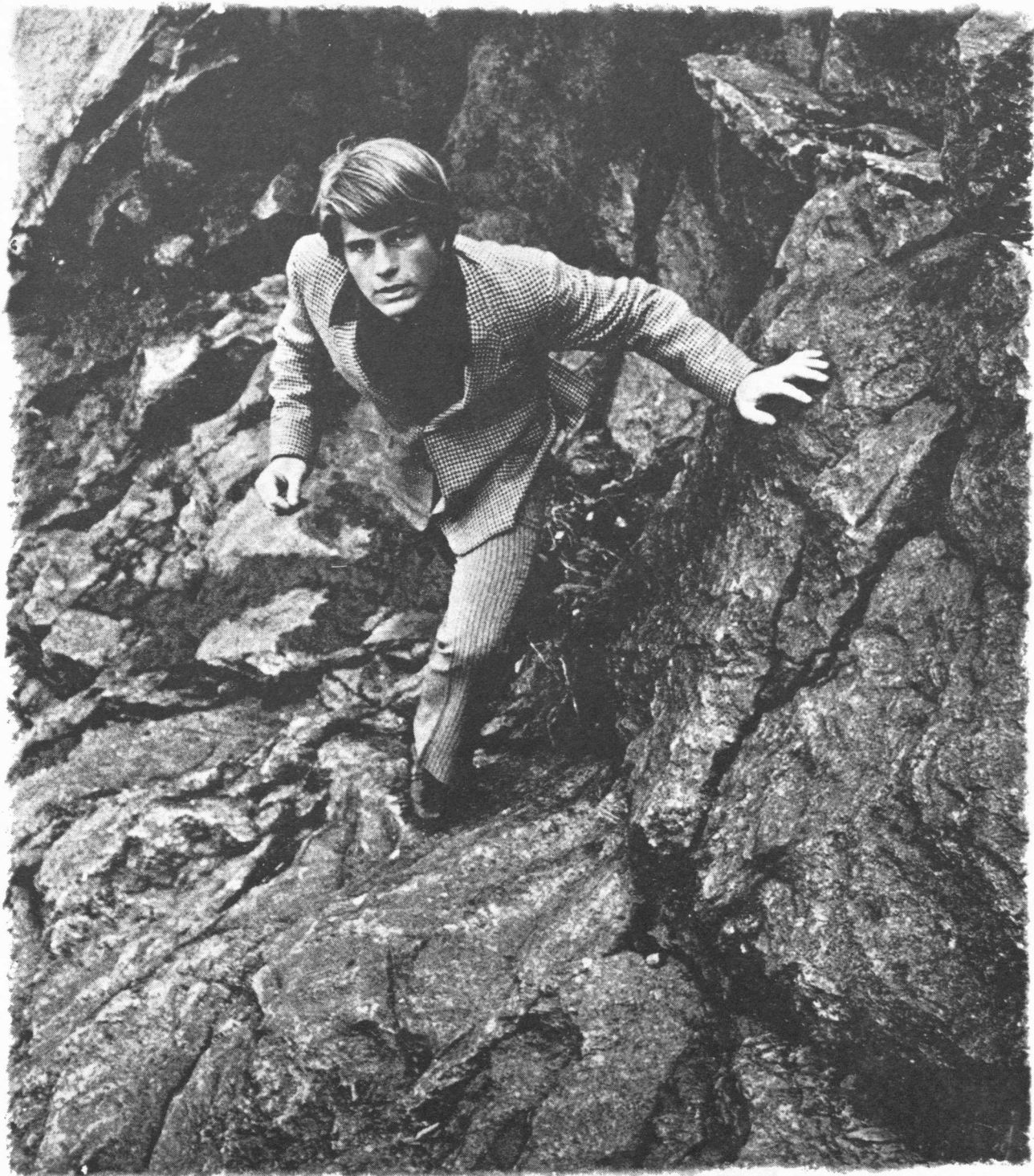
Health Care: We are using a sys-

tems approach to provide better medical care for more people. Example: electronic equipment that lets nurses monitor the hearts of eight patients simultaneously.

Nuclear Power: Westinghouse leads the way in nuclear power generation. Seven nuclear plants in operation, 34 in various stages of design. We're working on a breeder reactor to keep us ahead.

That's a sampling. We're just getting started. If you'd like to help us engineer a better world, talk with our campus recruiter. Or write Luke Noggle, Westinghouse Education Center, Pittsburgh, Pa. 15221. An equal opportunity employer.

You can be sure...if it's Westinghouse 



Working for us is no bed of roses!

It's a tough, demanding job from the very beginning. Practically the very day you join Western Electric we start giving you real responsibilities. You'll have your own decisions to make. Your own problems to solve.

In return we offer the chance to do thinking that may make your head spin — but will certainly

make it grow; the satisfaction of real achievements personally achieved; and the knowledge you're contributing something tangible to the world's largest and most advanced communications network.

Oh yes. One parting thought. If you're tempted by what *does* look like a bed of roses, remember: roses have thorns.



Western Electric
An Equal Opportunity Employer



Take a lesson from a tennis pro.

A tennis champion's powerful backhand looks as smooth and unhurried as a ballerina's graceful bow. How's he do it? By being in the right position in plenty of time.

"Remember this about the backhand," the pros advise. "Get both feet around pointing toward the sideline. And always make sure the right foot's forward, so your body doesn't cramp your swing."

Getting into proper position early is good advice for college seniors, too. Here's the first step:

When companies interview on your campus, make sure they interview you. When the Timken Company representative stops by, don't let him go without seeing you.

He'll fill you in on our work (maybe your work) with the aerospace, automotive, construction, chemical industries. Our openings in production, engineering, sales, finance, metallurgy.

So you won't get caught flat footed when it's your turn to make your move. The Timken Roller Bearing Company, Canton, Ohio 44706.

Timken® bearings sold in 133 countries. Manufacturing in Australia, Brazil, Canada, England, France, South Africa and U.S.A.

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THE TIMKEN COMPANY MANUFACTURES TAPERED ROLLER BEARINGS, FINE ALLOY STEEL AND REMOVABLE ROCK BITS.

The Octoputer

RCA's many-tentacled computer does time sharing plus regular computing. It's a generation ahead of its major competitor.

Once there were only monster computers that did big batch jobs like payrolls. Then came the whirling dervishes of time sharing that let a lot of people work at once. Now there's a new kind of creature that does time sharing and batch work together. So lots of people can use it — efficiently.

It's the Spectra 70/46. The Octoputer. There's nothing else quite like it on earth or under the sea.

The Octoputer's arms are long and strong. It sits in the middle of your company and reaches helping hands out in all directions. Suddenly, your company works harder. More of your people use the computer — solving more problems, finding more facts, writing more programs.

And it does your big batch jobs in its spare time.

The Octoputer does a real armload of work for a handful of change. Check the bills from your time-sharing services.

See if it's not more efficient to do the same work on your own Octoputer. And get batch processing, too. One more thing. The Octoputer concentrates on remote computing because that's what you're going to need — that's where the industry is going. We got there first

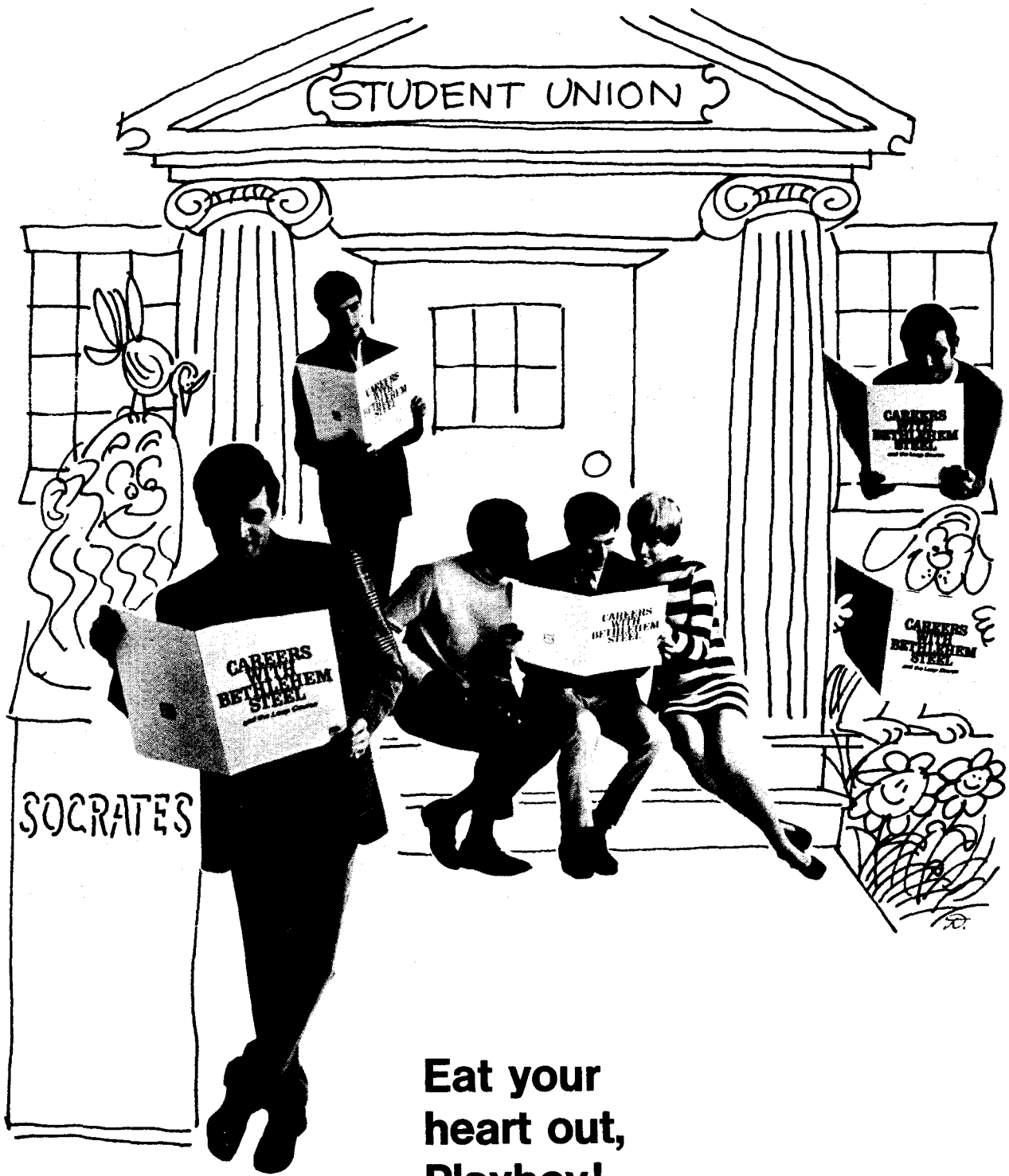
because communications is what RCA is famous for. It'll keep us ahead of our competition.

It can keep you ahead of yours. Step up to the Octoputer and shake hands hands hands hands hands hands...

RCA
COMPUTERS



For career information visit your College Placement Office.



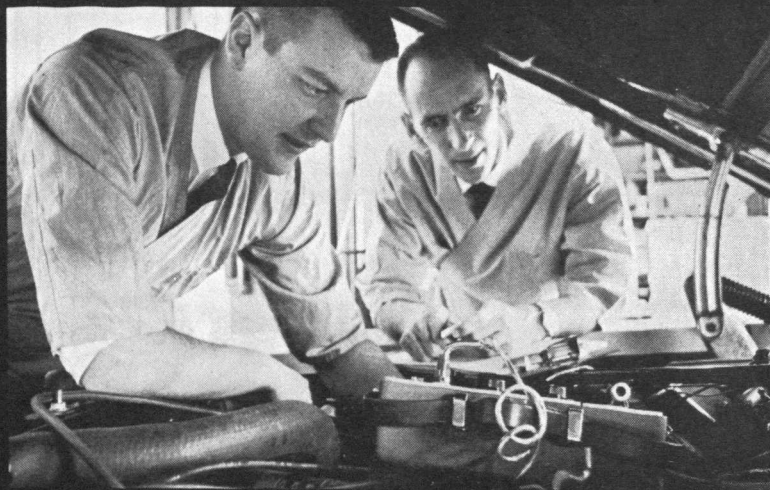
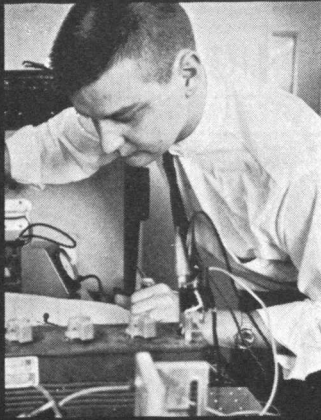
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heart out,
Playboy!**

Even sans full-color centerfold, our perky publication has plenty of SA—Senior Appeal. Remember the swinging title, "Careers with Bethlehem Steel and the Loop Course." Pick up a copy at your placement office, or write: Manager of Personnel, Bethlehem Steel Corporation, Bethlehem, PA 18016.

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Where will Matt Tate be tomorrow?

Wherever the project leads, Matt Tate is on his way. Board . . . bench . . . conference table. This young engineer sees them all at Delco. He was there when the project came from the car division. He'll be there when the model shop builds his prototype. He'll be looking over the shoulders of draftsmen, mechanics and stylists. The project's his. From start to finish. Step by step, skill by skill, Matt Tate's growing with the job. The question is . . . can you say the same? Take a good hard look at how your career shapes up, compared with Matt's and his colleagues' at Delco. We need men who want every week to be a little different. For details, call collect. Area Code 317/459-2808. Or write: Mr. C. D. Longshore, Supervisor, Salaried Employment, Dept. 500, Delco Radio Division of General Motors, Kokomo, Indiana.

**DELCO
RADIO**



AN EQUAL OPPORTUNITY EMPLOYER
DIVISION OF GENERAL MOTORS
KOKOMO, INDIANA

Editorial

I have heard random comments on the topic of job hunting. Some companies guarantee a draft deferment; others use fantastic fringe benefits like free country club membership, while still others offer unbeatable retirement programs. All of these offers deserve consideration, but what is it that really makes one job superior out of all those available? Too many graduates are basing their decision on cold, hard cash.

I feel that too often, better jobs go unfilled because the starting price isn't equal to that of multi-million dollar corporations. When a person takes a job based on only money, that's probably all he is going to get from the position. If a company has only money to offer, there must be something sadly lacking. Some of the more rewarding effects of a job could be responsibility, producing a needed service, prospects of advancement, and the contact between you and experienced people well established in industry. If you settle for money, you are likely to find yourself trapped in a glamorous put-on, with no future.

My thoughts are to think and plan for the present, but with options towards what the future will offer. Don't be bribed or dazed by money, but match offered positions with your intended goals, and the money will take care of itself.

A handwritten signature in black ink that reads "Arthur Bell III". The signature is written in a cursive style with a horizontal line under the name.

BRAIN SPRAINER

There are five cabins on Marsh Lake. Each cabin is a different color; each of the cabins' owners is of a different nationality, and each man drinks a different beverage, shoots a different shell, and hunts a different duck. Knowing the following:

1. The Englishman lives in the red cabin.
2. The Polishman shoots only bluebill ducks.
3. Bourbon is the beverage used in the green cabin.
4. The German drinks vodka.
5. The green cabin is on the immediate right of the brown cabin.
6. The hunter who uses Winchester shells shoots mallards.
7. Remington shells are used by the man in the yellow cabin.
8. Beer is consumed in the middle cabin.
9. The Norwegian lives in the first cabin on the left.
10. The man who shoots Federal shells lives in the cabin next to the cabin of the man who shoots red head ducks.
11. Remington shells are used in the cabin next to the cabin where canvas backs are hunted.
12. The hunter who uses Western shells, drinks gin.
13. The Norwegian lives next to the blue cabin.

Questions: a) Who shoots Teal?
b) Who drinks Scotch?

Answers on page 28.

GROWTH



As the nation's fifth largest municipal utility, the Board of Water and Light is growing. Our new Delta Power Generating Plant with an ultimate capacity of 1,500,000 kilowatts is an example. Scheduled for completion in 1972, Delta will turn out more than three times the combined power of our present generating stations.

As we expand our facilities, more top engineering personnel will be required to provide the knowledge and planning to ultimately serve the Lansing area community.

The use of electricity doubled in the last decade. If this trend continues in the next ten years, the Board will probably do as much building and work as it has in the past 75 years. We have the challenge for a young engineer to work and grow with the Board of Water and Light.

When you start considering an engineering future, visit the Personnel Department at 123 West Ottawa, Lansing, Michigan.

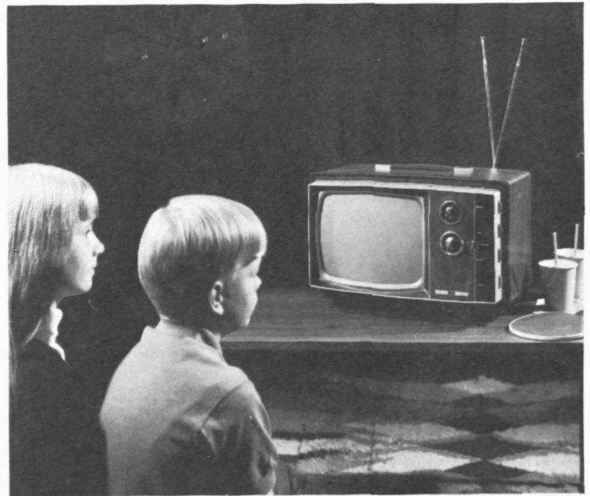


BOARD OF WATER AND LIGHT

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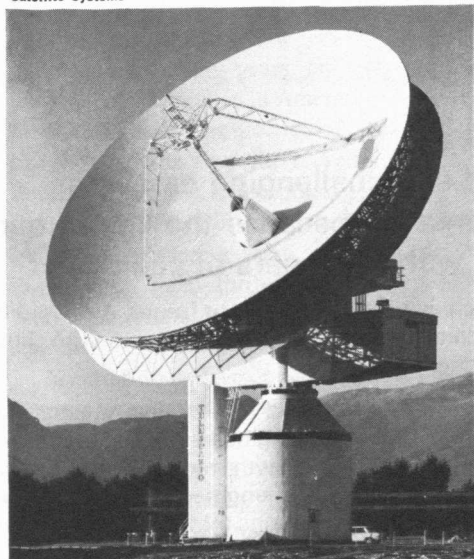
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You'll find a future at Philco-Ford

Your future will be as bold and as bright as your imagination and ambition make it.

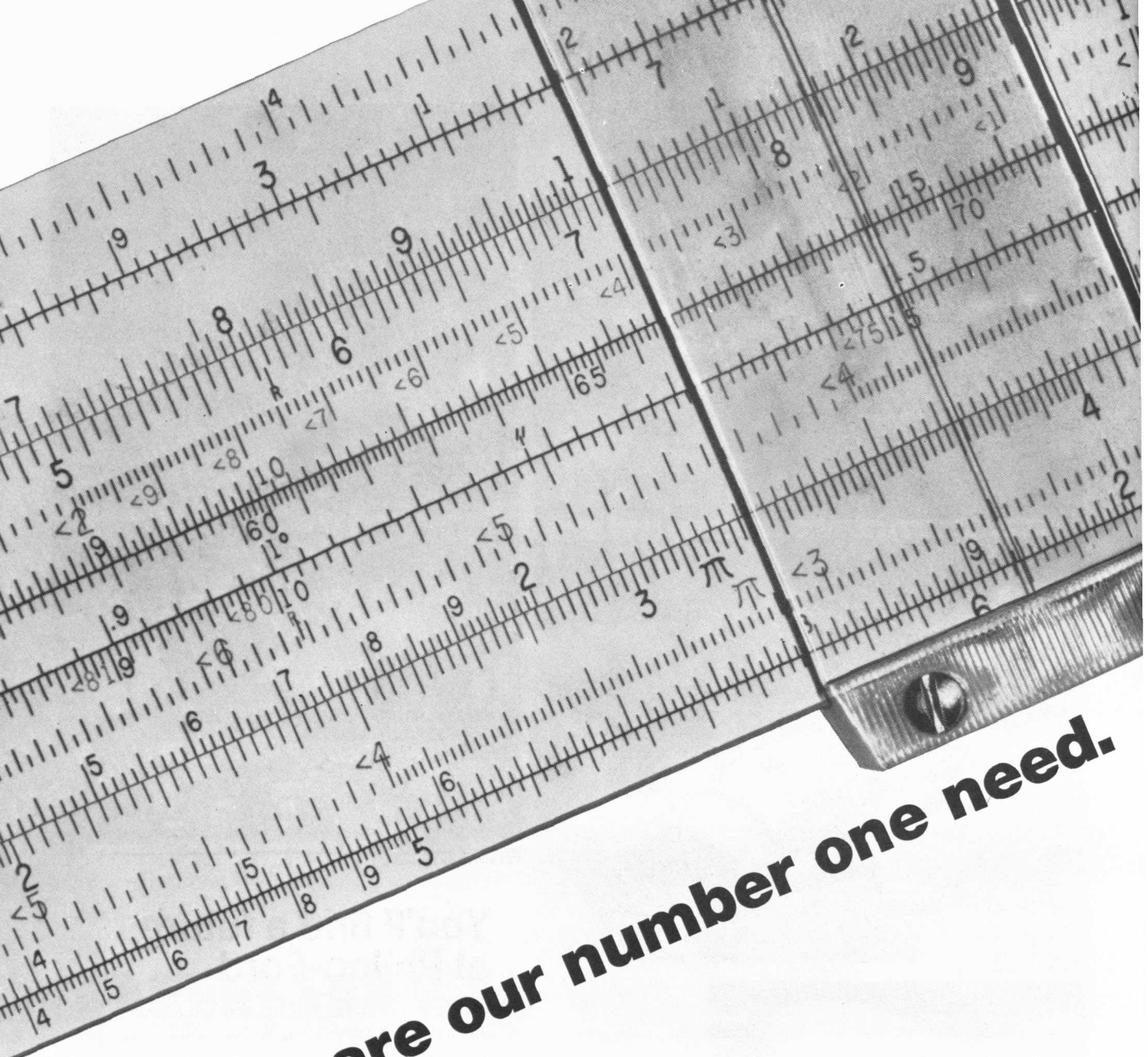
Your future will be as challenging as your assignments . . . and you might work on anything from satellites, to communications systems, to microelectronics, to home entertainment or appliances. It's your chance to be as good as you want to be. You will build an experience bank that will prepare you for many opportunities.

Your future begins now with a letter to College Relations, Philco-Ford Corporation, C and Tioga Streets, Philadelphia, Pa. 19134.

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If you are interested in a career at Monsanto, ask your placement director for more information and see the man from Monsanto when he visits your campus. Or write to: Manager, Professional Recruiting, Department CL 815, Monsanto, St. Louis, Missouri, 63166.

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Electronic Music....

here
to
stay

by Nick Bassel

Electronic music is not new—it has been quite popular in Europe for many years, but only recently has it found widespread acceptance in America.

The first electronic music was known as *Musique Concrete*. In this art-form, everyday natural sounds, such as doorbells, jangling keys, thunder, tearing paper, etc., were recorded on magnetic tape; then these sounds were altered by possibly filtering them, clipping the sound waves, or re-recording them through several generations of taping, until the results bore little resemblance to the original sounds.

Another early development was the utilization of special electronic musical instruments, such as the Theremin and the Ring Modulator. The Theremin bears the unique property of being the only musical instrument which is played without being touched by the performer. It is played by waving the hands in front of two antennae protruding from the instrument. The proximity of the right hand to the antenna on one end of the instrument, changes the pitch of the musical note by detuning an oscillator (body capacitance), which has the antenna in its tank circuit. The left hand similarly controls a blocking oscillator which in turn controls the volume of the instrument. The

sound of the Theremin has been compared in timbre to a woman's voice, and also reminds some listeners of the "musical saws" of yesteryear.

Recently, there has been an unprecedented interest in electronic music in this country. Every day, more and more appears in phonograph records, advertising, movie scores and the theatre. One outstanding example is the electronic score in "Hair".

Electronic music represents an exciting medium for the composer because of the extreme flexibility available to him in the construction and grouping of sounds of infinite descriptions.

Most major universities have an electronic music studio, and Michigan State has recently acquired an excellent Moog Studio. There are several systems available, but the Moog system is one of the best and by far the most popular.

A brief description of the Moog system follows:

There are four basic units, all functionally interrelated:

1. The Synthesizer is the sound generating and processing unit consisting mainly of oscillators, amplifiers, filters, controllers, envelope generators and simple mixers.
2. The Main Mixer, which combines and controls signals through two microphone inputs, eight line inputs and four line outputs.
3. The tone recorders and monitors (speakers and headphones), which provide recording, immediate monitoring, overdubbing when desired and playback.
4. The patch panel, by means of which any desired interconnections of the components are achieved.

Because the final realization of a musical composition might require many generations of tape, it is imperative that all the components, especially the recorders, be of the very finest quality.

The Synthesizer

The design characteristics of a Moog synthesizer are: modular construction, and voltage-control.

Voltage, as utilized in the synthesizer, is found in three forms: DC, fluctuating DC and AC. The simple basic principle of voltage control is as follows:

An increase in voltage-level applied to:

1. An oscillator will increase its pitch (frequency).
2. An amplifier will increase its amplitude (gain).
3. A filter will increase its filtering effect, etc.

Each module has switches and potentiometers for various results, and several modules have "control inputs",

Continued on page 26

Dan Schmidt, Missouri '64, met the challenge in mining at St. Joe



Since he graduated from the University of Missouri at Rolla, Dan found opportunity for progress at St. Joe. He's Plant Engineer at St. Joe's ultra-modern Fletcher mine. There he's responsible for some of the most sophisticated equipment to be found in any mine-mill complex on earth. He works with a young, aggressive team in a company that's tops in the industry. □ Dan and his wife Carole and their two sons find life pleasant in Southeast Missouri. He hunts, fishes and competes in

softball and tennis. They live in the country but they are only 90 minutes drive from big city attractions such as major league baseball in St. Louis. □ St. Joe has challenging opportunities for people with the ability and the drive to meet them. They are located in Southeast Missouri, Pennsylvania, Upper New York State and New York City. □ You may find your challenge and your future with St. Joe.

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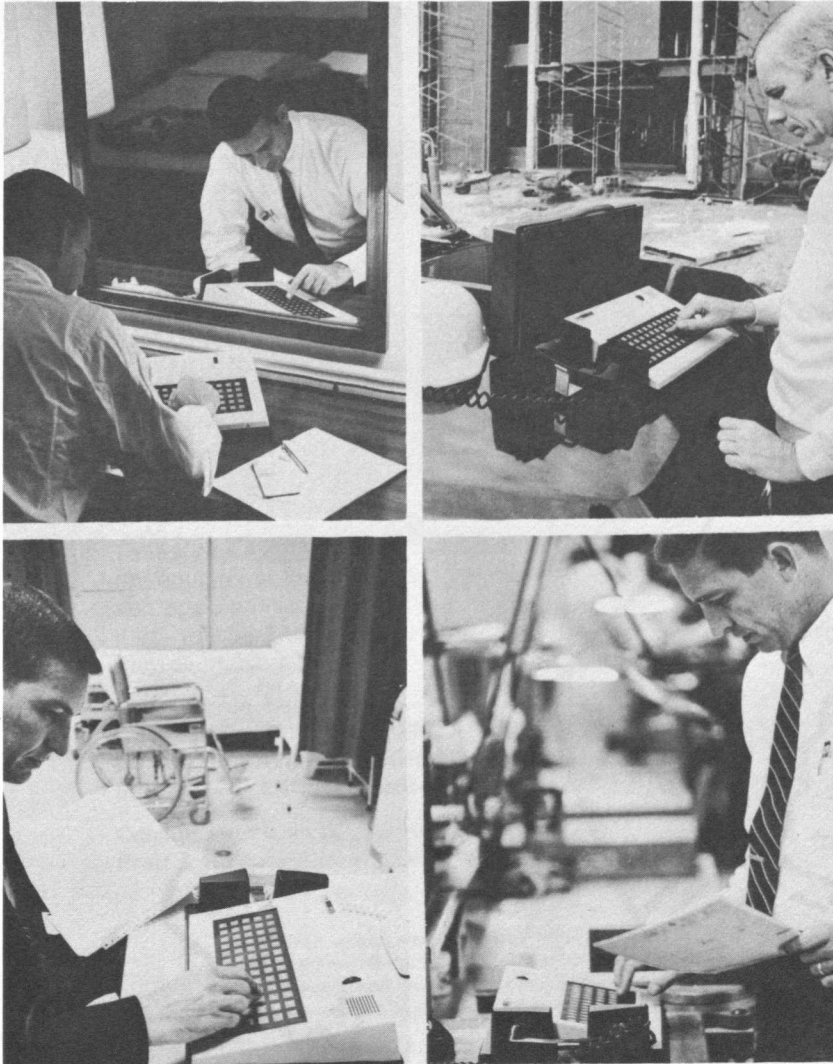
NEW PRODUCTS . . .

... THE IBM TERMINAL

A portable terminal introduced by IBM will allow salesmen, insurance agents and others to "talk" to their home office computers from any standard telephone—even one in a roadside booth.

Built into an attache case, the new IBM 2721 portable audio terminal will rent for \$20 a month. Users can enter alphabetic and numeric information into an IBM System/360 with audio response capabilities and get computer-compiled spoken responses to their inquiries.

In a manufacturing plant, workers could use the terminal to enter information on jobs in progress and to track the status of jobs moving from one department to another. Inventory clerks could use it to determine the nearest warehouse stocking desired parts and then order them through the 2721 terminal.



A salesman in a hotel room (upper left) might place an order, verify the status of a shipment or check the inventory level of a product. A construction superintendent (upper right) could enter and receive labor, material and equipment information.

Hospital personnel (lower left) might use the terminal to confirm a patient's medical insurance coverage, while a shop floor supervisor could enter information on work progress and track jobs moving from one department to another.

Salesmen on the road could communicate with a central computer from a hotel or a roadside phone booth to place an order or to check the status of a shipment.

Engineers and students could use the new terminal to solve mathematical problems. Department store clerks could verify a customer's credit, while bankers and stockbrokers could determine account and loan status and check stock quotations.

The terminal has 60 keys—26 letters, 10 numerals and 24 special characters and controls. These can be adapted for specific applications with the use of plastic keyboard overlays.

The 2721 operates continuously for at least eight hours on rechargeable batteries, or can be plugged into any 110-volt AC line. It has a battery charge indicator and an automatic charger.

The terminal measures 16 by 9 by 4 inches and weighs less than 10 pounds. It is supplied with an attache-style carrying case. Storage space is provided for the power cord, auxiliary earphone, extra keyboard overlays and the acoustic coupler that covers the telephone mouthpiece during transmission.

The terminal communicates with System/360 Models 25, 30, 40, 50, 65, 75 and 85 through an IBM 7770 audio response unit. Purchase price is \$600.



CAVU*

*CEILING AND VISIBILITY UNLIMITED

At Pratt & Whitney Aircraft "ceiling and visibility unlimited" is not just an expression. For example, the President of our parent corporation joined P&WA only two years after receiving an engineering degree. The preceding President, now Chairman, never worked for any other company. The current President of P&WA started in our engineering department as an experimental engineer and moved up to his present position. In fact, the majority of our senior officers all have one thing in common—degrees in an engineering or scientific field.

To insure CAVU*, we select our engineers and scientists carefully. Motivate them well. Give them the equipment and facilities only a leader can provide. Offer them company-paid, graduate education opportunities. Encourage them to push into fields that have not been explored before. Keep them reaching for a little bit more responsibility than they can manage. Reward them well when they **do** manage it.

Your degree can be a B.S., M.S., or Ph.D. in: **MECHANICAL • AERONAUTICAL • ELECTRICAL • CHEMICAL • CIVIL • MARINE • INDUSTRIAL ENGINEERING • PHYSICS • CHEMISTRY • METALLURGY • MATERIALS SCIENCE • CERAMICS • MATHEMATICS • STATISTICS • COMPUTER SCIENCE • ENGINEERING SCIENCE • ENGINEERING MECHANICS.**

Consult your college placement officer—or write Mr. William L. Stoner, Engineering Department, Pratt & Whitney Aircraft, East Hartford, Connecticut 06108.

CAVU* might also mean full utilization of your technical skills through a wide range of challenging programs which include jet engines for the newest military and commercial aircraft, gas turbines for industrial and marine use, rocket engines for space programs, fuel cells for space vehicles and terrestrial uses, and other advanced systems.



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**U
A**
DIVISION OF UNITED AIRCRAFT CORPORATION
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**The boat on the left
is riding on water.
The boat on the right
is riding on Polyox.**

When Union Carbide's Polyox resin is pumped out the bow of a boat, friction resistance between the water and boat is greatly reduced.

And the boat blurs ahead at record speed. With less than record effort.

It works so well, as a matter of fact, international yachting and rowing competition rules politely call Polyox only one thing. Patently illegal. Totally contrary to purity of sport and all that.

On the other hand, Polyox is the latest wrinkle in maritime technology. The newest way to get bursts of speed out of ships like ice breakers and rescue boats. Maybe the best way.

We're looking in a thousand different Polyox directions at once.

How about the "slippery water" theory for getting water into a burning house faster?

Or pushing concrete up a hose that's 12 floors high? Or pumping more water through an irrigation system? Or making a two-foot sewer pipe do the work of a three-foot pipe?

Or...?

Polyox resin is one discovery on the verge of becoming 10,000 discoveries.

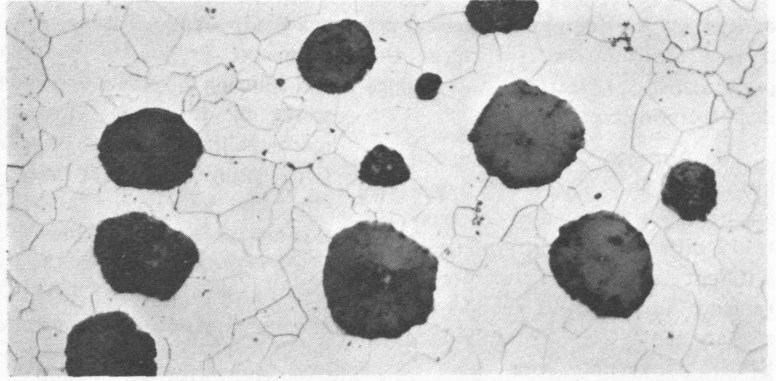


THE DISCOVERY COMPANY



For further information on our activities, write Union Carbide Corporation, 270 Park Avenue, New York, New York 10017. An equal opportunity employer.

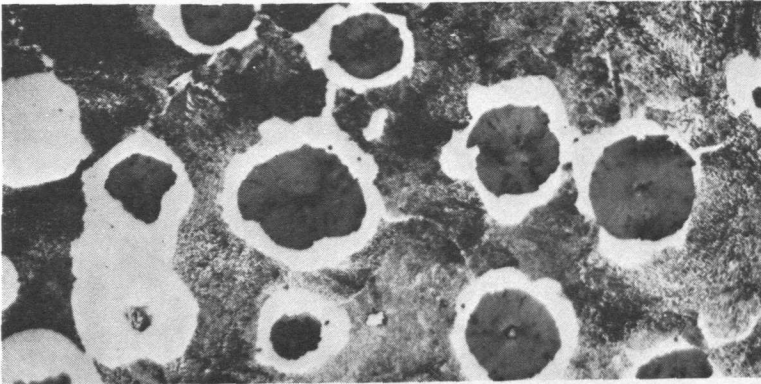
Wade Anderson is the chairman of The American Foundryman's Society Student Chapter. Information on joining this organization is available from him or Dr. Womeschal, the group's advisor.



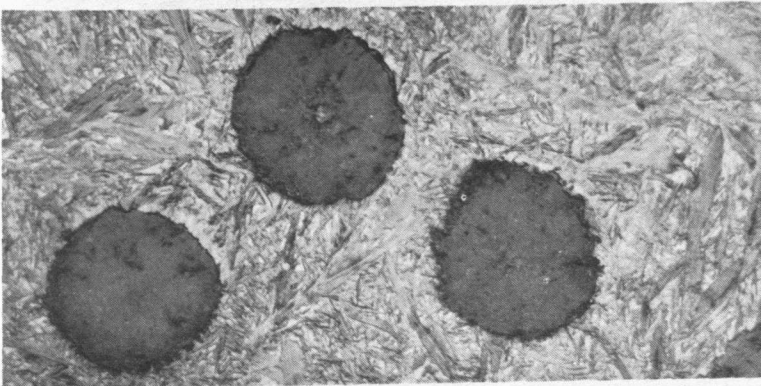
Microstructure of the Ductile Iron—Annealed (Mag. 250x)

The Development of the Cast Connecting Rod

MICROSTRUCTURE OF THE DUCTILE IRON



Top—As-Cast (Mag. 250x)



Bottom—Quenched (Mag. 500x)

by Wade Anderson

An
Important Achievement
For The
Foundry Industry

Virtually every major component in the modern V-8 engine can be produced as a casting. It is important then for the foundry to continue improving the utility and reliability of engine castings. This has been done by continually upgrading the entire range of foundry operations, from the basics like melting, molding and coremaking, to sophisticated systems for quality control and reliability. By marrying the technology of metal casting and engine

component development, new ways are being found to improve the performance of castings and reduce manufacturing costs.

The ArmaSteel* connecting rod was introduced in 1962 in a Buick V-6 engine. Since that time it has expanded to 12 different engines, produced by 6 different engine manufacturers and ranging up to 472 cubic inches displacement. Over 70 million ArmaSteel connecting rods have been produced.

The cast connecting rod is very competitive with its forged counterpart as evidenced by its widespread acceptance. It has higher reliability and versatility, for instance in large truck engines. The major savings are in machining. Pearlitic malleable iron, the final structure, possesses excellent machining qualities.

The rods start as piles of selected steel scrap, alloys, and scrap iron. They are melted in a cupola together with fluxes and coke. The metal is tapped at 2700 F into an electric holding furnace for testing and alloying. The metal (2.60% C, 1.40% Si, 0.42% Mn, balance Fe) is poured into ladels and then into green sand molds. Several rods are produced per mold. The rods are shaken out of the molds, and cleaned off before being sent to the annealing furnaces.

The rods are now white iron, meaning all the carbon is combined with the iron as iron carbide. They are annealed at 1750 F for 18 hours in atmosphere-controlled kilns. The rods are then cooled rapidly in air. This insures the formation of dense pearlite and uniformly dispersed temper carbon.

The connecting rods are austenitized in a second furnace at 1600 F. Then immediately quenched in oil, resulting in a martensitic matrix. Tempering follows in a third furnace. They are tempered at 1150 F to 1180 F for 3 or 4 hours. Finally they are heated to 900 F and pressed to insure flatness. The rods are then sent to a shear where the gates are removed and the fins trimmed. The final structure is a matrix of tempered martensite with graphitic temper carbon.

Machining consists of grinding the faces of the wristpin boss and the

crankpin end. Boring the inside diameters, drilling the two bolt holes and splitting the crankpin diameter. The secret of the cast connecting rods machinability is the dispersion of temper carbon. First, it breaks up the chip, and second, acts as a lubricant; this lubricating action allows lower tool loads permitting higher cutting speeds and feeds, boosting tool life and eliminating burr removal operations.

Throughout production sample checks are made, from inspection of the scrap before melting to final inspection of the product. A number of rods are picked between each operation and examined for hardness and microstructure. Various methods of testing are used of the finished rods. All are subject to magnaglo, sonic and ultrasonic testing. Some random samples are given X-ray inspection.

The rods are magnetized in two directions in Magnaglo (black light) inspection. This insures detection of surface defects. The rods passing this test go on to the sonic and ultrasonic tests. These verify the casting's internal soundness.

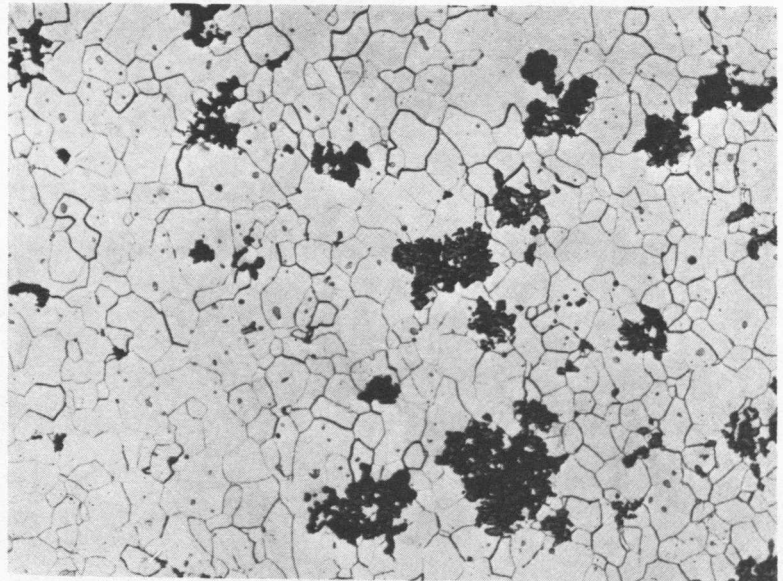
Random samples are X-rayed continuously as an in-process control

and as a test of the other testing methods performance.

There are four basic reasons for the acceptance of cast connecting rods:

- 1) Greater design freedom (forging vs. casting)
- 2) Improved machinability of pearlitic malleable iron
- 3) Ability to cast parts to closer finish dimensions
- 4) Proven reliability in service

*ArmaSteel is a General Motors trade name.



Microstructure of a ferritic malleable iron. This shows the graphite flakes that contribute most of the metal's machinability.

Venture: Cook exhausts to clear the air.

The problem: minimize the part the internal combustion engine plays in air pollution.

The primary goal: reduce auto exhaust emissions dramatically through some simple, inexpensive but effective method.

The solution? Five years of research and development work by scientists, engineers and technicians at Du Pont have produced a non-catalytic emissions control device called the exhaust manifold reactor. It has achieved the best control of auto emissions by any system known to date.

Mounted in place of the conventional exhaust manifold, the reactor is an insulated outer shell with a tubular core. Exhaust gases, mixed with injected air, are held in the high-temperature zone of the inner core until they are almost completely oxidized.

The principle of finishing the combustion process in the exhaust system is not a new one. But what is new is the effectiveness of Du Pont's device.

In individual tests of up to 100,000 miles, emission levels have been below 30 ppm hydrocarbons and 0.6% carbon monoxide, compared with 1970 standards of 180 ppm hydrocarbons and 1.0% carbon monoxide. And reactors now being tested have further reduced carbon monoxide emissions to 0.26%.

The reactor system can be adapted to any gasoline-burning automobile engine. And soon metals research should develop the low-cost materials needed to make the reactor economical for all new cars.

Innovation—applying the known to discover the unknown, inventing new materials and putting them to work, using research and engineering to create the ideas and products of the future—this is the venture Du Pont people are engaged in.

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STRENGTH

One of the outstanding properties of Malleable Iron Castings

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

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

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

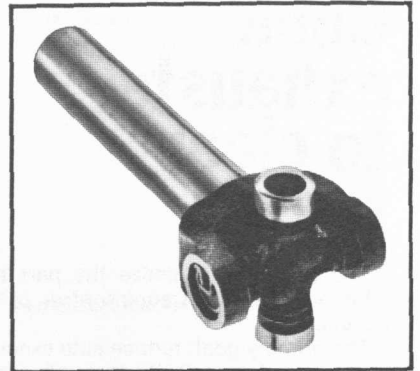
Yield strength represents the point at

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

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

Strength and Cost— Malleable iron has been described as providing more strength per dollar than any other metal. There are many factors which contribute to this

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

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The Contributions of Edsel Murphy to the Understanding of the Behavior of Inanimate Objects

by D. L. Klipstein

I. INTRODUCTION

It has long been the consideration of the author that the contributions of Edsel Murphy, specifically his general and special laws delineating the behavior of inanimate objects, have not been fully appreciated. It is deemed that this is, in large part, due to the inherent simplicity of the law itself.

It is the intent of the author to show, by references drawn from the literature, that the law of Murphy has produced numerous corollaries. It is hoped that by noting these examples, the reader may obtain a greater appreciation of Edsel Murphy, his law, and its ramifications in engineering and science.

"As is well known to those versed in the state-of-the-art, Murphy's Law states that "If anything can go wrong, it will." Or, to state it in more exact mathematical form: $1 + 1 = 1 + 1\pi$ (1) where $x\pi$ is the mathematical symbol for hardly ever.

Some authorities have said that Murphy's Law was first expounded by H. Cohen when he stated that "If anything can go wrong, it will—during the demonstration." However, Cohen has made it clear that the broader scope of Murphy's general law obviously takes precedence.

II. GENERAL ENGINEERING

II.1. A patent application will be preceded by one week by a similar application made by an independent worker.

II.2. The more innocuous a design change appears, the further its influence will extend.

II.3. All warranty and guarantee clauses become void upon payment of invoice.

II.4. The necessity of making a major design change increases as the fabrication of the system approaches completion.

II.5. Firmness of delivery dates is inversely proportional to the tightness of the schedule.

II.6. Dimensions will always be expressed in the least usable term. Velocity, for example, will be expressed in furlongs per fortnight.

II.7. An important Instruction Manual or Operating Manual will

have been discarded by the Receiving Department.

II.8. Suggestions made by the Value Analysis group will increase costs and reduce capabilities.

II.9. Original drawings will be mangled by the copying machine.

III. MATHEMATICS

III.1. In any given miscalculation, the fault will never be placed if more than one person is involved.

III.2. Any error that can creep in, will. It will be in the direction that will do the most damage to the calculation.

III.3. All constants are variables.

III.4. In any given computation, the figure that is most obviously correct will be the source of error.

III.5. A decimal will always be misplaced.

III.6. In a complex calculation, one factor from the numerator will always move into the denominator.

IV. PROTOTYPING AND PRODUCTION

IV.1. Any wire cut to length will be too short.

IV.2. Tolerances will accumulate unidirectionally toward maximum difficulty of assembly.

IV.3. Identical units tested under identical conditions will not be identical in the field.

IV.4. The availability of a component is inversely proportional to the need for that component.

IV.5. If a project requires n components, there will be n-1 units in stock.

IV.6. If a particular resistance is needed, that value will not be available. Further, it cannot be developed with any available series or parallel combination.

IV.7. A dropped tool will land where it can do the most damage. (Also known as the law of selective gravitation.)

IV.8. A device selected at random from a group having 99% reliability, will be a member of the 1% group.

IV.9. When one connects a 3-phase line, the phase sequence will be wrong.

IV.10. A motor will rotate in the wrong direction.

IV.11. The probability of a dimension being omitted from a plan or drawing is directly proportional to its importance.

IV.12. Interchangeable parts won't.

IV.13. Probability of failure of a component, assembly, subsystem or system is inversely proportional to ease of repair or replacement.

Continued on page 27

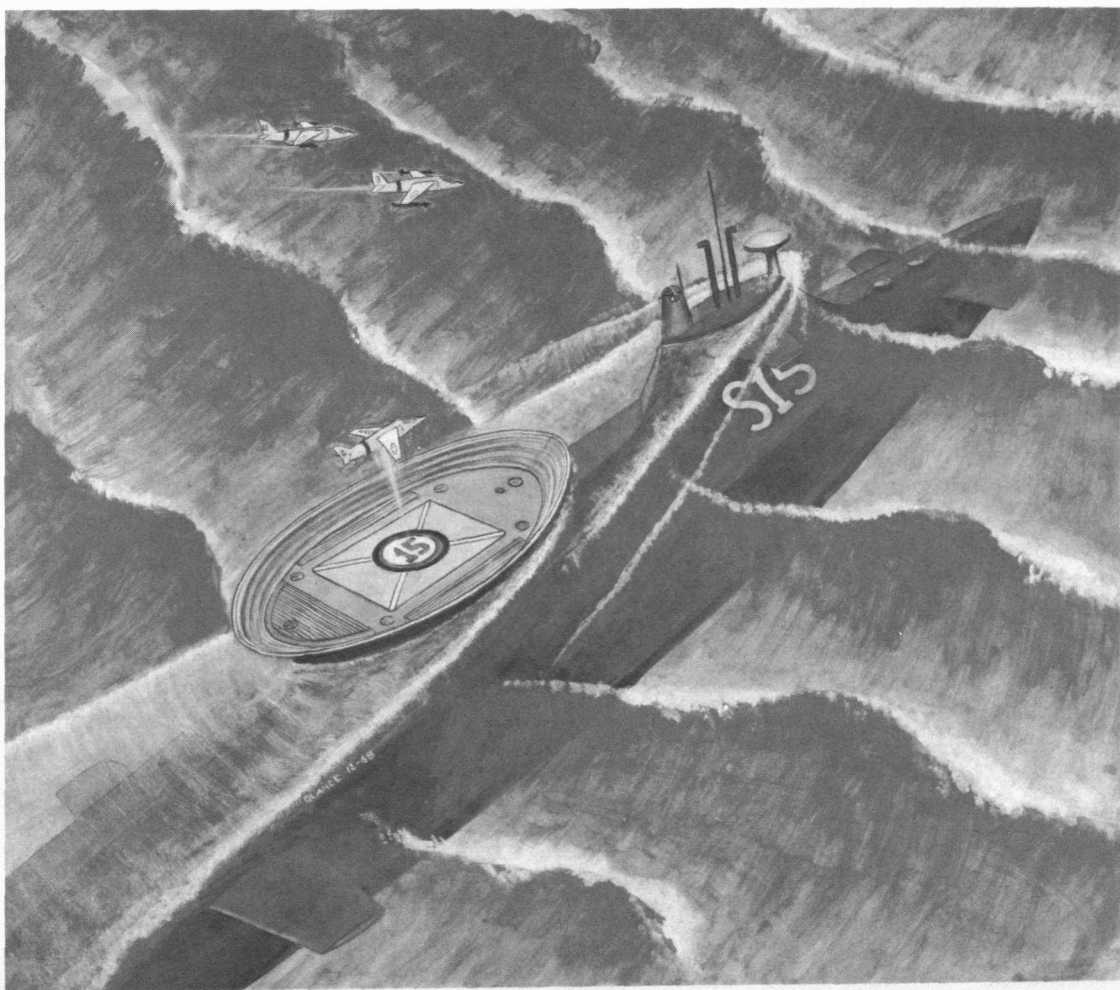
TIME FOR A MILD EVOLUTION IN CARRIER DESIGN

by Patrick M. Glance

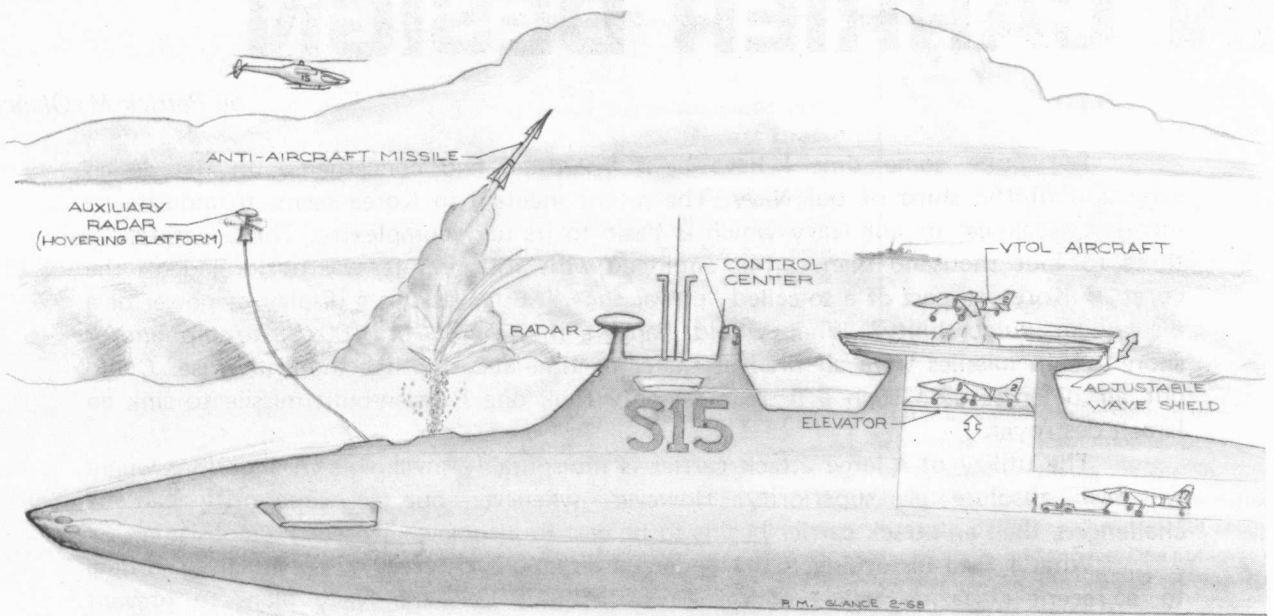
For quite some time I have been interested and concerned with the design evolution of the ships of our Navy. The recent incident in Korea seems to indicate an inherent weakness in our Navy which is basic to its new complexity. The Enterprise, a three to four thousand man carrier equipped with 100 aircraft, was positioned off the coast of Korea as part of a so-called "power show". But was this a display of power or a display of vulnerability? What would happen if 20, 50, or 100 air-to-ship and/or shore-to-ship missiles were all fired at the same time at a ship like the Enterprise? Could our air defenses stop such a barrage? It only took one Russian-built missile to sink an Israeli destroyer.

The utility of a large attack carrier is indisputably invaluable in situations where we have absolute air superiority. However, whenever our air superiority can be challenged, then an attack carrier begins to be cast in a somewhat precarious position.

What I find disturbing is the apparent direction the Navy is pursuing. According to a recent magazine article concerned with the F-111, the Navy plans to prevent



incoming enemy aircraft from approaching within missile range of attack carriers by the deployment of missile-carrying aircraft, CAP (Combat Air Patrol), in a protective ring of perhaps 150 miles. These aircraft, equipped with computerized radar, would launch air-to-air missiles (the Phoenix) to track and destroy enemy aircraft. This is all well and good unless, of course, one enemy aircraft is undetected or the enemy has more aircraft



SCHEMATIC OF A PROPOSED M.A.C. indicating various operational subsystems. The aircraft shown illustrates the landing and takeoff sequence required for air operations. The elevator is normally in "up position" and used as a takeoff/landing platform. Once an aircraft has landed, the elevator is lowered and the plane is towed off. Likewise, aircraft are towed on the elevator and raised for takeoff. Note that more than one sequence has been shown simultaneously (aircraft landing and elevator descent). However, this is not meant to imply that both events can occur simultaneously.

than we have missiles. The stakes are too high to play in a game where a three to four thousand man ship can be lost by one tactical or electronic mistake.

Yet, I am not saying that the carrier is obsolete—just that a carrier as we know it today is extremely vulnerable. One solution to this problem is to rely on smaller, less expensive, and more expendable types of ships to carry and launch aircraft. An example of this would be the use of destroyers equipped with helicopter landing platforms to launch VTOL aircraft. Of course it would require a fleet of many destroyers to carry a complement of aircraft similar to that of the Enterprise. Another type of ship that could partially replace the primary function of the attack carrier, yet be less vulnerable, is illustrated.

These sketches represent a "submarine aircraft carrier" which is capable of launching aircraft while cruising partially submerged. The partially submerged air launch capability would make the proposed ship extremely difficult to detect (in comparison to a conventional attack carrier).

I would also like to emphasize that all of the components illustrated in this weapon system are in existence today in some form, i.e., nuclear power sub, VTOL aircraft, missiles, helicopters, etc. This is why I feel that this proposal represents not a ship of the future but a ship which could be and should be in existence today. I will not labor on the details and ramifications of this proposal. Rather, by the presentation of this concept, I hope to influence the design evolution of our Navy toward its continuing excellence.



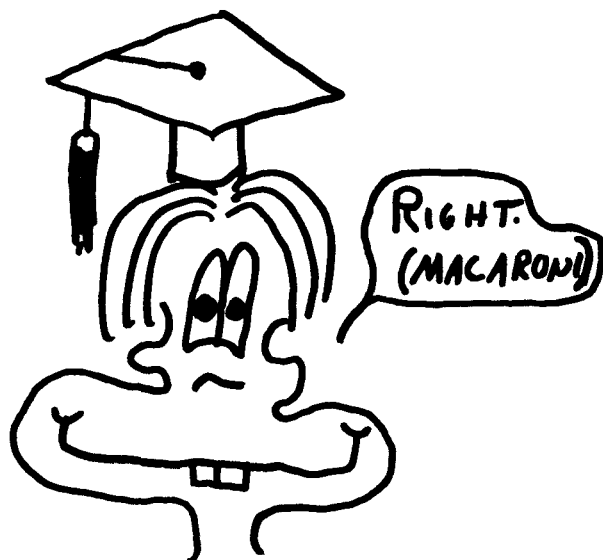
REMEMBER THAT BRIDGE YOU WERE GONNA CROSS WHEN YOU CAME TO IT?

WELL IT'S RIGHT AROUND THE CORNER AND IT'S CALLED GRADUATION.

WELL, IT'S THAT HAPPY TIME AGAIN, SENIORS! IT'S SPRING AND YOU'RE FINALLY GONNA GRADUATE..... RIGHT?



YOU'RE GETTING YOUR PIC TAKEN WITH YOUR CAP AND GOWN AND YOUR PLASTIC SMILE..... RIGHT?



YOU'RE TO JOB INTERVIEWS
AND WEEKEND TRIPS TO
OTHER CITIES TO SEE
THEIR SMOG.... RIGHT?



YOU ALWAYS WONDERED WHAT
IT WOULD BE LIKE TO
MAKE 10 GRAND A
YEAR AND PLAY THE STOCK
MARKET.... RIGHT?



YOU GET TO PAY UNCLE
SAM FOR WORKING AND
TRYING TO MAKE A
LIVING.... RIGHT?



YOU'RE GETTING A WIFE TO
SUPPORT, ANOTHER CAR, LIFE
INSURANCE, GROCERIES, RENT
AND 8 TO 5 EVERY DAY....
RIGHT?



THAT KINDA' PUTS THE
BLADE TO THOSE SAT.
NITES AT THE GABLES
.....RIGHT?

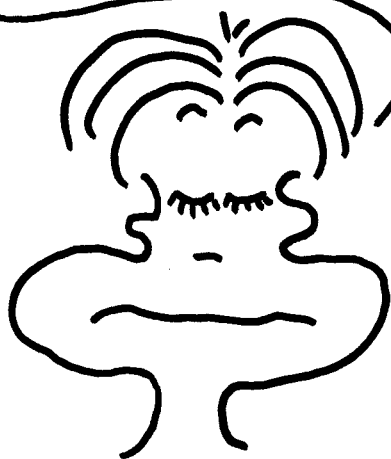


YOU'RE GONNA' BE SOMEONE
OUT THERE WITH ALL THOSE
BACKSTABBERS, REPUBLICANS,
BROWNIES AND SNOBS THAT
YOU THOUGHT YOU LEFT
BEHIND IN COLLEGE... RIGHT?



WISH YOU'D SAY SOMETHING
BESIDES, "RIGHT".

IF I FEEL LIKE A TWO-BIT
TENNIS BALL IN A 24 HOUR-
A-DAY GAME OF LIFE.



SO? WHAT'S WRONG
WITH THAT? WE ALL
GET IN THE GAME
SOMETIME.... RIGHT?



ELECTRONIC MUSIC, continued from page 11

which accept voltage contours from external sources which modify the sound product of the module, whether it be an oscillator, filter or amplifier.

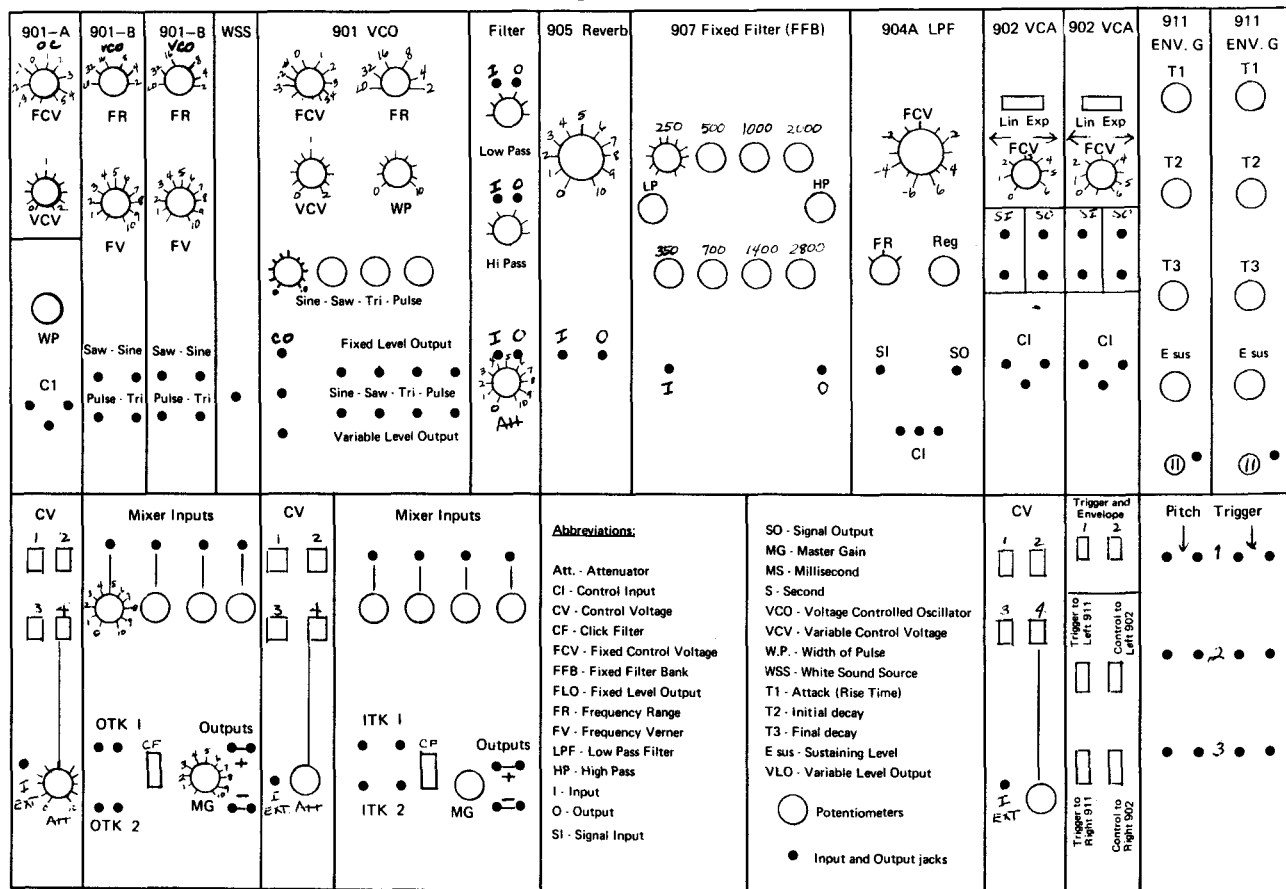
The oscillators generate four wave forms: sine, sawtooth, triangular and pulse, in a very wide range of frequencies. These can be combined by means of the mixers in any number of ways. In addition, the output of one oscillator can be used to "control" another, so that an infinite number of rounds can be achieved.

Another source module generates "white noise", that is, all the audible frequencies in equal amplitude. The sound is

The envelope generator modules provide single voltage contours, which may be applied to voltage-controlled modules. The rise-time, initial decay time, sustained level and final decay time of the contour can be set to provide any desired result.

Most sounds created on the synthesizer are triggered either by the ribbon controller or the keyboard controller. The ribbon controller provides a continuously variable control voltage to any desired module(s) by touching the finger to a long ribbon device and sliding it up and down its length to achieve the desired effect. The keyboard is a

R. A. Moog – SYNTHESIZER



Main panel layout of MOOG synthesizer

very similar to the noise of an FM receiver tuned between stations. However, by passing this sound through filters, very exciting sounds can be generated. As can be seen from the accompanying diagram, several filters are available.

The illusion of depth is provided by a module which delays the sound for a fraction of a second, providing various reverberation and echo effects, depending on the settings of the control.

The voltage-controlled amplifier modules are signal processing instruments whose gain depends upon the magnitudes of the applied control voltages, thus providing some form of amplitude modulation. By flipping a switch, one can achieve either an algebraic or a logarithmic correspondence between the signal being processed and the control voltage.

modified 5-octave organ keyboard. The musical intervals between keys can be increased or decreased from the familiar diatonic semitone scale by the flip of a dial, for interesting and unusual effects.

Another interesting feature of the keyboard is the "Portamento" control. This control determines how long it takes to get a new voltage level from the previous one. It is continuously variable from several milliseconds to four records, and depends upon the rate of discharge of a capacitor for its operation.

Musically, this provides a "glissando" or slide between successive notes, and a very effective embellishment for certain musical sounds. Some of the most exotic effects are obtainable by means of the "Regeneration" control, incorporated in one of the filter modules. As this control is

Continued on page 27

EDSEL MURPHY, continued from page 20

- IV.14. If a prototype functions perfectly, subsequent production units will malfunction.
- IV.15. Components that must not and cannot be assembled improperly will be.
- IV.16. A dc meter will be used on an overly sensitive range and will be wired in backwards.
- IV.17. The most delicate component will drop.
- IV.18. Graphic recorders will deposit more ink on humans than on paper.
- IV.19. If a circuit cannot fail, it will.
- IV.20. A fail-safe circuit will destroy others.
- IV.21. An instantaneous power-supply crowbar circuit will operate too late.
- IV.22. A transistor protected by a fast-acting fuse will protect the fuse by blowing first.
- IV.23. A self-starting oscillator won't.
- IV.24. A crystal oscillator will oscillate at the wrong frequency—if it oscillates.
- IV.25. A pnp transistor will be an npn.
- IV.26. A zero-temperature-coefficient capacitor used in a critical circuit will have a TC of $-750 \text{ ppm}/^\circ\text{C}$.
- IV.27. A failure will not appear till a unit has passed Final Inspection.
- IV.28. A purchased component or instrument will meet its specs long enough, and only long enough, to pass Incoming Inspection.
- IV.29. If an obviously defective component is replaced in an instrument with an intermittent fault, the fault will reappear after the instrument is returned to service.
- IV.30. After the last of 16 mounting screws has been removed from an access cover, it will be discovered that the wrong access cover has been removed.
- IV.31. After an access cover has been secured by 16 hold-down screws, it will be discovered that the gasket has been omitted.
- IV.32. After an instrument has been fully assembled, extra components will be found on the bench.
- IV.33. Hermetic seals will leak.

V. SPECIFYING

- V.1. Specified environmental conditions will always be exceeded.
- V.2. Any safety factor set as a result of practical experience will be exceeded.
- V.3. Manufacturers' spec sheets will be incorrect by a factor of 0.5 or 2.0, depending on which multiplier gives the most optimistic value. For salesmen's claims these factors will be 0.1 or 10.0.
- V.4. In an instrument or device characterized by a number of plus-or-minus errors, the total error will be the sum of all errors adding in the same direction.
- V.5. In any given price estimate, cost of equipment will exceed estimate by a factor of 3.
- V.6. In specifications, Murphy's Law supersedes Ohm's.

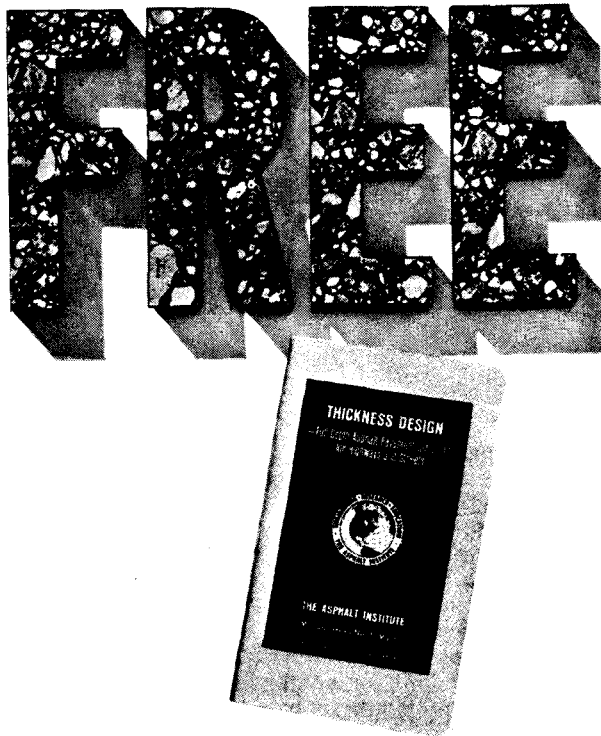
The man who developed one of the most profound concepts of the twentieth century is practically unknown to most engineers. He is a victim of his own law. Destined for a secure place in the engineering hall of fame, something went wrong. His real contribution lay not merely in the discovery of the law but more in its universality and in its impact. The law itself, though inherently simple, has formed a foundation on which future generations will build. In fact, the law first came to him in all its simplicity when his bride-to-be informed him of the impending birth of an heir to the family fortunes.



ELECTRONIC MUSIC, continued from page 26

advanced, the regeneration increases, which brings out the higher order harmonics (partials with dramatic effects upon the sounds being processed).

All the above modules, plus many others for which time and space do not allow description here, can be combined and adjusted in an infinite number of ways, and it is for this reason, that electronic music is such a stimulating experience for composer and listener alike. It is hoped that this very brief description of the electronic music composer's tools will provide some insight into the strange new music which, although it is unlikely to ever replace traditional music, nevertheless represents a stimulating new challenge to composers, and a delightful experience to all who will listen to the new sounds.



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ENGINEERS

Two men sat at the club and the one said, "Say, how is that gorgeous secretary of yours?"

"Oh, I had to fire her."

"Fire her! How come?"

"Well, it all started a week ago last Thursday on my 38th birthday. I've never been so depressed."

"What has that got to do with it?"

"Well, I came down for breakfast and my wife never mentioned my birthday. A few minutes later, the kids came down and I was sure they would wish me a happy birthday, but not one word. As I said, I was most depressed, but when I arrived at the office, my secretary greeted me with 'Happy Birthday', and I was glad that someone remembered."

"At noontime, she suggested that it was a beautiful day and that she would like to take me to lunch at a nice intimate place in the country. Well, it was nice and we enjoyed our lunch and a couple of martinis. On the way back she said it was much too nice a day to return to the office and suggested that I go to her apartment, where she would give me another martini. That also appealed to me and, after a drink and a cigarette, she asked to be excused while she went into the bedroom to change into something more comfortable."

"A few minutes later, the bedroom door opened and out came my secretary, my wife and two kids with a birthday cake, singing 'Happy Birthday', and there I sat with nothing on but my socks."

SE

When the honeymooning EE and his wife were settled in their hotel room, the bride turned to the EE and asked anxiously:

"Honey, do you still love me, now we're married?"

"Of course," replied the ex-playboy. "You know I always liked married women."

A lovely young girl named Anne Heuser Declared that no man could surprise 'er But a fellow named Gibbons Untied her Blue Ribbons And now she is sadder Budweiser.

SE

Two junior EEs who had just completed a stiff Mechanics exam were discussing it.

First EE: "How far were you from the right answer on the second problem?"

Second EE: "Two seats."

SE

The following correction appeared in a small town paper: "Our paper carried the notice last week that Mr. John Jones is a defective in the police force. This was a typographical error. Mr. Jones is really a detective in the police farce."

SE

Department of unintentional satire: Readers' Digest, a normally prim and proper magazine, has finally succumbed to public taste. A recent issue featured an article entitled "The Limits of Intimacy", which was aptly placed on page 69.

SE

Having just been shaved by a barber, the EE asked for a glass of water.

"Something in your throat, sir?" asked the barber.

"No. Just checking to see if my neck leaks," replied the EE.

Overheard at Coral Gables: "If you're gonna say no, say it now before I spend all my dough."

SE

A man on safari in Africa had a frightening experience. He lost his guide, wandered into the jungle, and suddenly he was surrounded by hostile natives with what looked like human bones in their hair. Then he remembered a trick he's seen in an old movie. He scratched in his pocket for his cigarette lighter, pulled it out, flicked it once, and a big flame popped up. The natives were impressed and stood back. Then the chief spoke up: "It's a miracle", he said. "I've never seen a lighter that worked the first time."

SE

"Hey, Mary, why aren't you wearing my fraternity pin anymore?"

"Ralph complains that it scratches his hands."

SE

A bachelor is a man that didn't have a car when he was in college.

Answers to *Brain Sprainer* on page 8:

- a) the Irishman
- b) the Norwegian

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WE KNOW...**

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