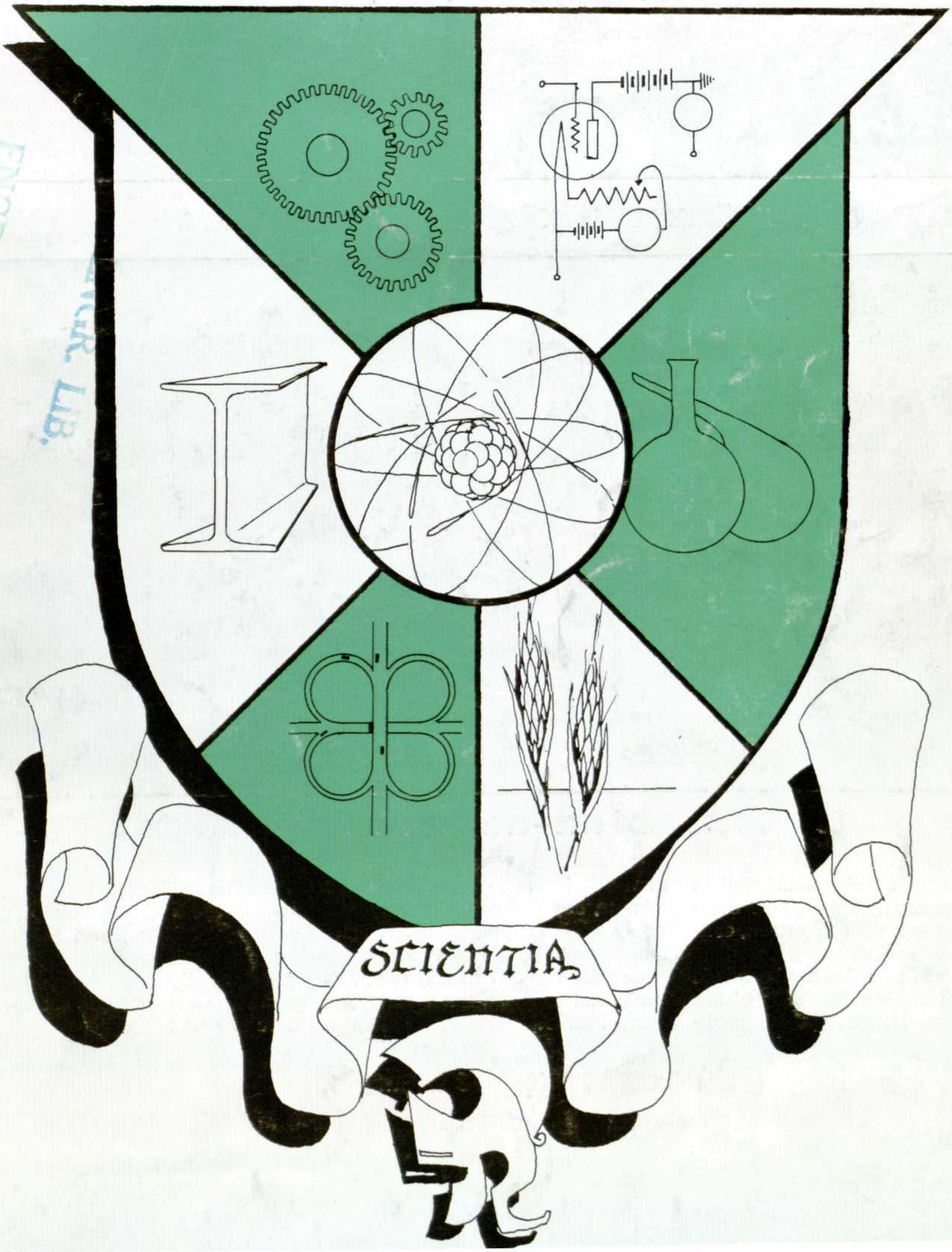
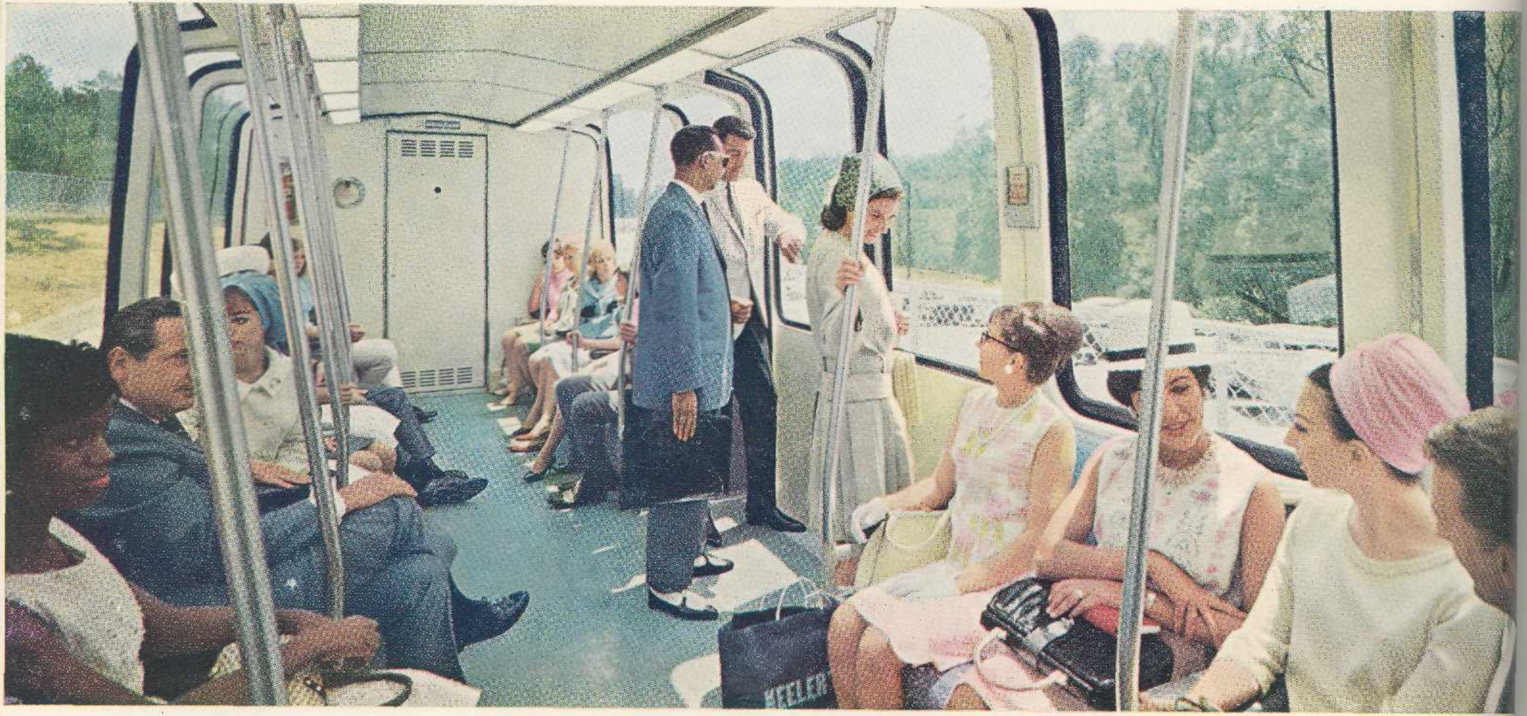
NOVEMBER,1965
25¢

SPARTAN engineer

member of ECMA



Revolutionary new Westinghouse mass transit system



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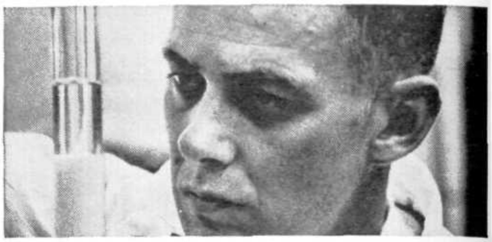
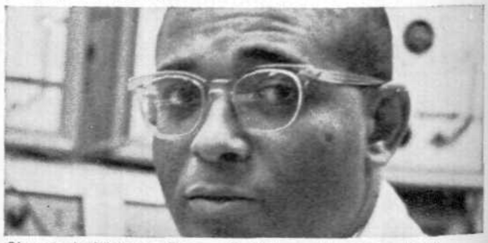


Squibb Division: Malcolm H. Von Salza (Ph.D., U. of Wisconsin) is a Senior Research Scientist at the Squibb Institute for Medical Research.

Winchester-Western Division: James P. Silver (B.S.M.E., Washington U.), a Senior Machine Designer at the East Alton, Ill., plant, is designing ammunition manufacturing equipment.

Metals Division: Larry Dix (Met. E., U. of Missouri) is a Senior Laboratory Metallurgist at the Brass Operations plant in East Alton, Ill.



Chemicals Division: George D. Vickers (Hampton Institute), research analyst at the Research Laboratories in New Haven, Conn. is studying the structure of organic compounds by nuclear magnetic resonance.

Corporate: Errold D. Collymore, Jr. (Michigan State) is a personnel staff assistant. He selects, screens, tests, evaluates and interviews professional job candidates.

Ecusta Paper Division: Richard Seiler (Chemical Engineering, Louisiana Poly.) is a Senior Chemical Engineer at the Research and Development laboratory in Pisgah Forest, N.C.

Olin

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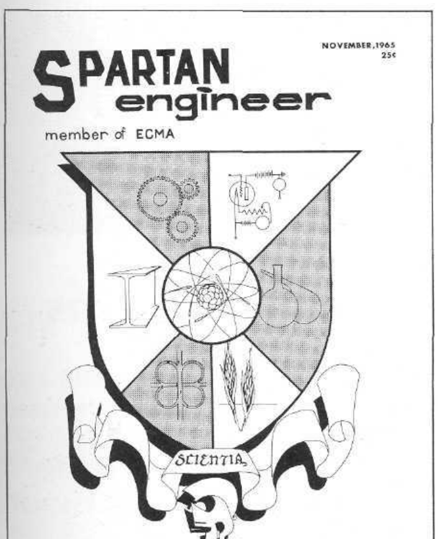
SPARTAN engineer

VOLUME 19 **NUMBER 1** **NOVEMBER,1965**



This cover by Tom Mc Clure is a representation of a crest of the College of Engineering with all of the majors included.

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Member, Engineering College Magazine Associated
Chairman: J. B. Bisset
Louisiana Polytech Institute, Ruston, Louisiana
Publisher's Rep.: Littell-Murray-Barnhill, Inc.
369 Lexington Ave., New York 17, N.Y.
737 N. Michigan Ave., Chicago, Ill.

Published four times yearly by the students of the COLLEGE OF ENGINEERING, MICHIGAN STATE UNIVERSITY, East Lansing, Michigan 48823. The office is on the first floor of the Engineering Bldg., Phone 517 355-3520.
Subscription rate by mail $1.00 per year. Single copies 25¢.

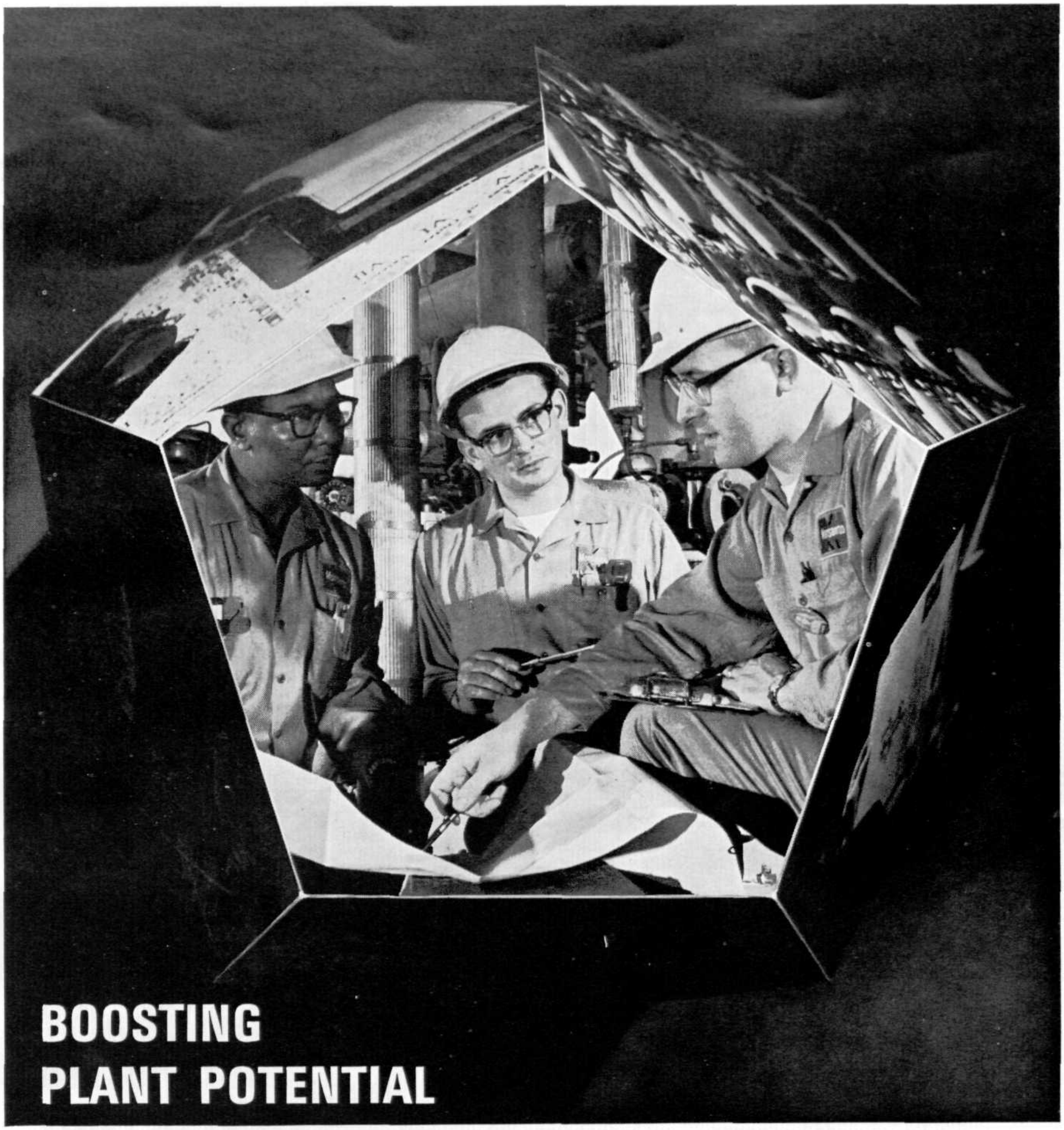
Editorial..

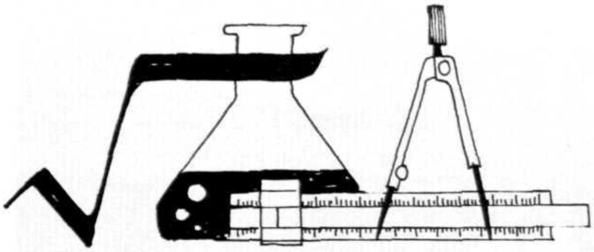
THE DRAFT

Since July of this year the quotas to be filled by the Selective Service System of this Country have been rising at an ever-increasing rate. We have come from a call of 1,700 in February and words of abolishing the Draft to a call of over 45,000 in December. This can be easily understood in the context of our rising participation in the war in Vietnam. However, what is so difficult to comprehend is why President Johnson and the Selective Service have decided to threaten the college student with induction into the Armed Forces.

This is not meant to disparage the current administration's foreign policy, or the Selective Service itself, or defending one's country through service in the Armed Forces of the United States. Indeed, the service does have its time and place -- after graduation.

We have often been graced with such glowing names as the "Hope of Tomorrow" and the "Leaders of Tomorrow" from people occupying important positions within the government. Why don't they treat us as they speak of us? They don't show any thought. They are willing to take us right out of the classroom for induction. Aren't they aware that to be leaders we must be educated? Don't they know that only a small percentage of those who interrupt their education by two years or more, return to school? Let us finish our education first. We will be more valuable to our Country as well as ourselves.


BOOSTING
PLANT POTENTIAL



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The Udylite Corporation
Ch., Ch. E., M.E., E.E.

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November 23
U.S. Army Tank-Automotive Center
M.E.

Brown Engineering Corp., Inc.
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Vickers Inc. Division, Sperry Rand Corp.
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Deering Milliken Service Corp.
Ch.E., E.E., M.E.

November 29
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C.E.

U.S. Army Engineers Waterways Experimental Station
E.E., E.E., Physics

December 2
Sundstrand Corp.
M.E., E.E.

U.S. Naval Avionics Facility
E.E.

December 3
Standard Brands, Inc.
M.E., Ch.E., Ind. E., Chem., Biochem.

January 13
Pittsburgh Plate Glass
Carnation Company
Packaging Corp. of America

January 17
Sylvania
Continental Can Corp.
American Bosch Arma

January 18
Leeds & Northrup Co.
Ohio Edison
Pennsalt Chemicals
Allegany Ballistics Laboratory
Interlake Steel Corp.

January 19
B. F. Goodrich
Union Carbide

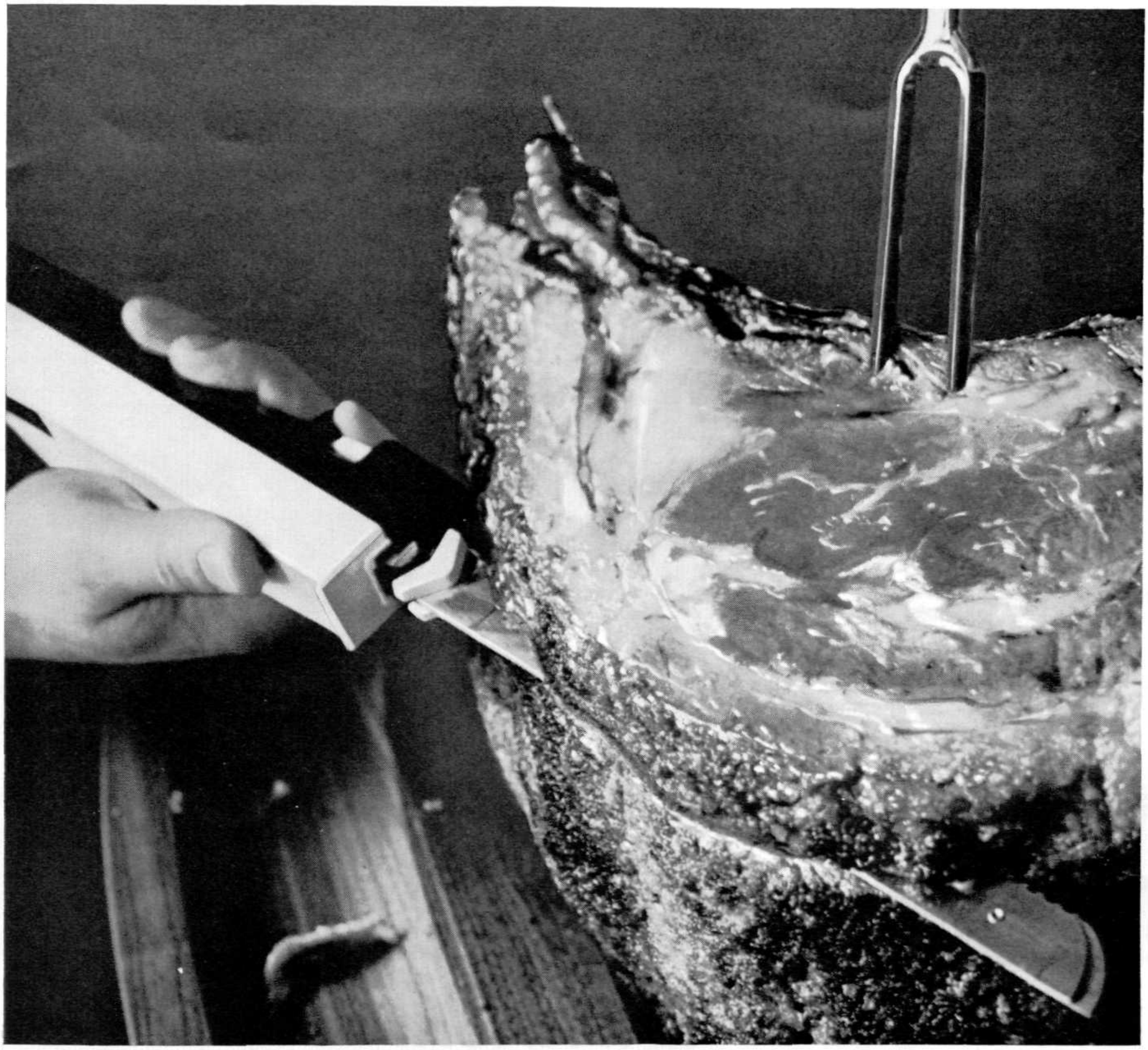
January 20
Prestolite Company
Armstrong Cork Company
General Telephone and Electronics Laboratory

January 21
Wyandotte Chemical Corp.
United Aircraft

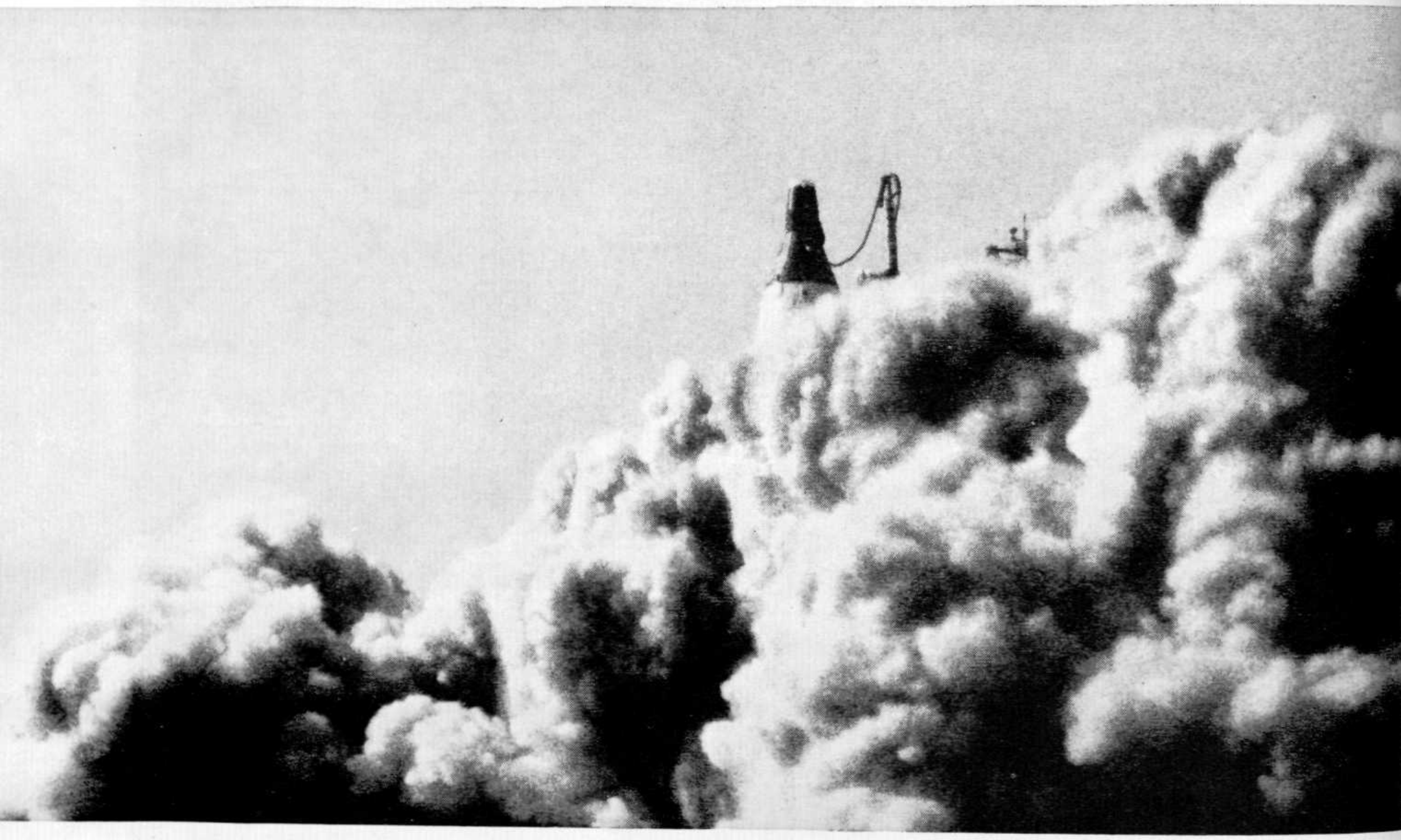
January 25
General Radio Co.
Consumers Power
Fairbanks Morse Inc.

January 27
Allied Chemical Corp.

January 31 and February 1
North American Aviation Inc.



If you still think glass is just glass,



ask NASA.

Ask NASA about the windows on the Gemini spacecraft —formed from glass specially designed by Corning.

They not only provide mechanical and thermal protection, but also increase visual transmission beyond the theoretical 92 per cent to 99 per cent. Ask, too, about the high-speed glass memories that help guide Gemini to in-space rendezvous and re-entry.

And ask about the glass resistors, as thick as telephone poles, which serve as dummy loads and power dissipating terminations at tracking stations.

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Young engineers seeking challenge, opportunity, and advancement are invited to write to Corning's Career Development Manager.

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From the Dean's Desk

Dean J. D. Ryder

Our New Programs- Why

It has been said that engineering knowledge is growing at the rate of about ten percent per year. Obviously, it is not possible to expand the engineering curriculum at a similar rate and provide the seniors with a curriculum which is forty-five percent larger than the one in existence when they became freshmen. This rate of technological growth is posing tremendous questions for all the engineering colleges.

In contrast, during the cycle of development, refinement, and utilization of reciprocating steam engines there was ample time, in fact several hundred years, for training of engineers in the development and application of this aspect of technology. Today we have seen the rocket motor, which was not much more than a figment of Goddard's imagination in 1923, phenomenally developed in the last twenty years to the two and one-half million horsepower level of Saturn V. Radar was developed from a mere idea in 1932 to the device that won the Battle of Britain in 1940. The transistor came out of the laboratory in 1948 and was in application by 1953.

Each of these inventions has called for the development of a complete new academic discipline, frequently requiring tremendous amounts of research to provide the fundamental knowledge which must underly the application. For instance, it has been said that in 1948 germanium was one of the lesser-understood chemical elements. Because of its importance to the transistor and because of the huge economic potential of that device, it is now believed that we know more about germanium than we do about any of our other chemical elements.

What does this mean with respect to the program which our students are today undertaking in the College of Engineering? We cannot continue to expand our program in step with the advance of new technology because of economic and social limits on the period of time which our society can justify in the education of its younger generation. However, the pressures placed on engineering education by the advancement in all technical fields are having a beneficial effect in requiring study of the engineering-education process and its basic philosophy. Our progress is a result of such pressures.

Students at Michigan State University are immersed in an atmosphere of dynamic education of many types. An engineering student, associating with other students on the campus, cannot avoid becoming aware of the educational philosophies and objectives of students projecting their futures into many diverse fields. The College of Engineering cannot remain aloof and point its program differently; it knows that the objective of university education should be the preparation of a young man or young woman for forty years of a productive, useful, and enjoyable life. Engineering must look beyond the preparation of its graduates for immediate usefulness in a field of technology to the usefulness of that graduate for his whole lifetime as well. Thus the teaching of a technology or application, which may become obsolete a few years after graduation, should be challenged by a student as inefficient use of his time on this campus.

Our Engineering College and others have been searching for the common dènominator which will lead to selection of appropriate curricular material which can be of benefit over a student's professional lifetime. We have attempted to find that material in mathematics and the basic and engineering sciences, since it seems probable that Newton's laws of motion will be more useful ten years after graduation than will be knowledge of the test code for an engine or motor. In addition we have recognized that the scope of engineering education is now so broad that to specialize a student in one aspect may be to deny him opportunity in other more challenging areas later in his lifetime. Thus we find the emphasis on mathematics as a tool and a language, the engineering sciences, and engineering methods which will furnish the raw materials for ideas, concepts, and designs for many years after graduation.

Added to the above is the transition which students now in the College of Engineering are witnessing in the change of our programs from a former high level of credit hour requirements to the level which approximates the requirements in the rest of the University. Our step has been cheered by industry and other engineering educators as well. Soon after our reduction was announced, two universities which had been conducting five-year Bachelor of Science programs in engineering, announced that they were returning to the more conventional four-year programs. Several other schools have reduced their credit hour requirements also and this indicates that our change was in the direction of the trend.

The reduction in required hours reflected the philosophy that over some years the College had ceased requiring various courses in engineering applications, and that it was time the credit hours were taken out as well. We also desired that engineering students have every opportunity for extra-curricular activity, and for broadening of their programs through self-chosen electives, that are available to students in other Colleges on this campus. Through increased efficiency in the teaching of the necessary areas in engineering, we have been able to carry out the reduction and introduce new upper school programs without appreciable loss on the technical side. At the same time, the number of hours devoted to free electives has been increased, and because of the general lowering of requirements from the eighteen-nineteen credit level per term to the fourteen-sixteen credit level, there exists many opportunities for the student to sample additional courses offered elsewhere on the campus, without taking on heavy overloads.

All of this reflects the desire of this College for its engineering graduates to be thoroughly grounded in that knowledge which we believe will be of value over the next forty years. We also desire that our graduates be well-rounded citizens capable of applying their engineering abilities in both the technical and social areas. This means that the days are past when an engineering specialist could withdraw into his own realm and become merely a servant of technology. Rather, the engineer now will be called upon and must be capable and willing to apply his abilities in solving not only the technical problems, but also those which in the past have been viewed as in the political, economic, or social realm as well.

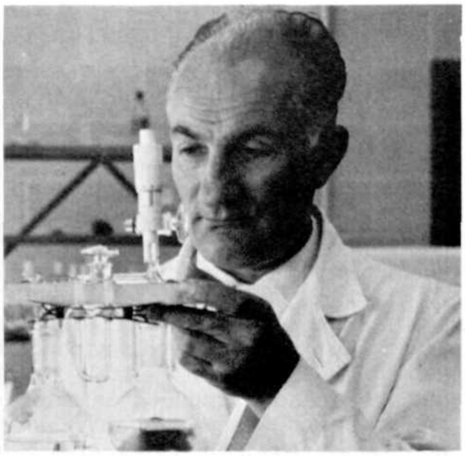
SE

Coming soon:

A DESCRIPTION OF THE NEW CURRICULUM

BIOLOGICAL RECOVERY OF WASTE WATER

by Dr. K. L. Schulze



The quality of our surface waters, rivers, and lakes, and even that of our ground water, is decreasing from year to year. Fish kills occur in the Red Cedar River, the river which winds its way through the campus of Michigan State University. Swimming beaches on Lake Erie, Lake Huron, and Lake Michigan, have to be closed every year.

There is general agreement that pollution by municipal and industrial wastes is the main cause of this deterioration. If it becomes necessary to put a priority on any phase of Michigan water problems, it now appears that Water Pollution should have that priority. By polluting and defiling the sources of our water supplies, we are sowing the seeds of national destruction. We are creating a crisis by our self-seeking short-sightedness.

What do we actually do with our municipal waste water, for instance? Let us use our own campus and the city of East Lansing as examples. The sewage from these two sources amounts to about five million gallons per day, and is treated at the East Lansing sewage treatment plant. After passing through a bar screen, the raw waste water is pumped into four primary settling tanks, where the heavier solids sink to the bottom, and are then pumped out as sludge. This form of primary treatment is capable of removing about thrity-five per cent of the incoming pollutional load.

The next treatment step consists of ten aeration tanks where the major part of the polluting material is oxidized by the activity of bacteria, in the presence of air. The air is blown into the liquid by two large compressors. The effluent from these aeration chambers is channeled into four final settling tanks, to remove those suspended solids which have been formed in the aeration tanks. The overflow from the final settling tanks is called Final Effluent, and is discharged over two cascades into the Red Cedar River. This type of treatment is called the Activated Sludge process. It represents our most complete treatment process to date, and is capable of removing eighty to ninety per cent of the pollutional material contained in the original raw sewage.

Actually, the East Lansing plant is too small to handle the waste load properly, and the efficiency, therefore, is considerly lower than that. The same problem arises in many a town where the population is rapidly increasing year by year. This old plant will be abandoned shortly and a new plant will take over.

Anyway, normally ten to twenty percent of the incoming pollutional load is placed as a burden on the river. Due to the ever-increasing population we have just mentioned, this burden will inevitably likewise increase and there is no doubt that in the future such so-called secondary waste treatment methods will not be sufficient any more.

Tertiary, or third stage treatment methods will have to be developed with the aim of removing the many different types of water contaminents to a much higher degree than we are now practicing, and this is where Dr. Schulze's work begins. In 1964 he started a project to which he gave the title, "Biological Recovery of Waste Water."

Final effluent from the East Lansing plant is used as the raw material. A small centrifugal pump delivers a constant flow of the pretreated sewage into a supply tank in the River Laboratory Building to the South of the East Lansing Sewage Plant. From the supply tank, three variable speed pumps feed the experimental tanks with a continuous flow of pre-treated waste water. The first set of tanks consists of three glass aquariums. These were started in May, 1964, and have been in continuous operation for the one and a half years since. The first aquarium has a fifteen gallon capacity, and is equipped with an arrangement of fibre-glass screen, three air-diffusers, airflow meter, thermometer, dissolved oxygen metering electrode, and three fluorescent lamps. The lamps are operated by a timer so that they are on fifteen hours a day, and off nine hours a day thus imitating day and night conditions. The fiberglass meshwork is the characteristic feature of the tank, and it is this that he believes to be the most active part of the system. The pieces of screen are mounted vertically, and parallel to each other at half inch distances, somewhat similar to the way the plates in a car battery are arranged.

This provides a large amount of surface for the development of a fascinating community of small organisms which is called, "Epiphyton." It consists mostly of bacteria, diatoms, protozoa, rotifers, and worms. Apparently this biological community has a remarkable capacity for cleaning up polluted water.

In fact, our data show that with this tertiary treatment method it is possible to remove 85 to 95 per cent of the pollutional load, which has remained after the secondary treatment by the plant outside this building. To check on the quality of the tertiary treatment effluent a second tank was installed behind this tank.

This second tank contains a bottom layer of about two inches of gravel, several species of aquatic plants collected from Lake Lansing and the Red Cedar River, and two pairs of guppies. The idea was simply to find out whether such a tertiary treatment would be effective enough to maintain normal aquatic life in the treated sewage, on a long-term basis. So far, our experience has shown this to be the case. Originally, one pair of guppies was placed in the tank, and they produced offspring which grew up, and they in turn produced offspring, and now this is the third generation of guppies, and they are about to produce their young fish in the next month. Dr. Schulze would like to stress that these fish have never received any outside food. They exist entirely on the living food produced in this tank. In fact, the aquarium has maintained itself in an excellent condition over the eighteen months since it was connected to Tank One. The only thing that has to be done is remove the excess of young guppies and the excess of plant growth. Every three weeks relatively large amounts of Potamogeton, Ceratophyllum, Elodea, and Vallisneria have to be taken out to prevent crowding.

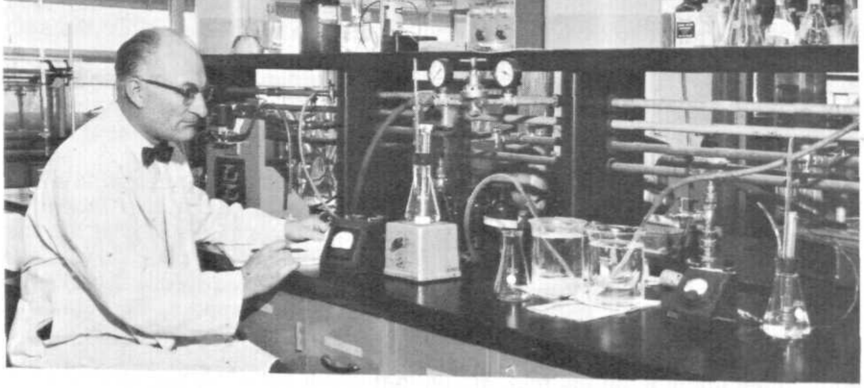
This reminds us of an intriguing side-aspect of Dr. Schulze's project. The U.S. Department of Defense maintains a research laboratory at the Brooks Air Force Base in Texas, where a group of scientists is studying ways to grow Algae and Lemna Minor on space vehicles to produce a food supply for astronauts. Lemna Minor is the botanical name for a small water plant known as Duckweed. It so happens that this Duckweed grows in the tertiary treatment tank to such an extent that it is necessary to remove half of the growth every two weeks. Since it is being considered as food for astronauts, Dr. Schulze felt that he should try it at least once. He washed a handful of it in tap water and ate it raw. To his surprise it had a very pleasant mild taste, similar to lettuce. He said that he would not mind eating it regularly as a salad. Anyway, he never expected that this potential food for astronauts would be a by-product of my tertiary treatment process.

After these encouraging results from the small aquariums, he became a little more ambitious this summer and increased the scale of the experiment from ten to fifteen gallons to 200 gallons.

This new tank corresponds to the previous reactor tank except that it is larger and that two blocks of plastic foam are used instead of fiberglass screens. This new tank has now been in operation for about five weeks, and it is not only producing an excellent effluent, but it is harboring some intersting fish life. Two blocks of plastic foam create three compartments in this tank.

In compartment one, he placed two goldfish and compartment three was stocked with one shiner, one dace and one bluegill. In other words instead of guppies we are now using representatives of Michigan fish life. This was done about four weeks ago. The results are surprisingly good. All fish are doing very well, in spite of the fact that they do not receive any outside food and have to live in nothing but treated waste water. In fact the goldfish in the first compartment are growing so fast that this indicates an abundance of food being produced. The effluent from Tank A discharged into a second tank, B of the same size. This tank corresponds to the small tank Two, and like Tank Two it has a gravel bottom with a good stand of aquatic plants in it. However, instead of guppies, a large-mouth Bass, two Minnows, and a Bluegill were put into the tank. These fish were provided by the Department of Fisheries and Wildlife here at Michigan State University, a department which has shown a wonderful cooperative interest in this project. Again no outside food is given these fish.

Just as all the other fish, they must exist on whatever food organisms they can find in their environment. So far they are in excellent shape, although Dr. Schulze has a feeling that the large-mouth bass is pretty hungry most of the time.

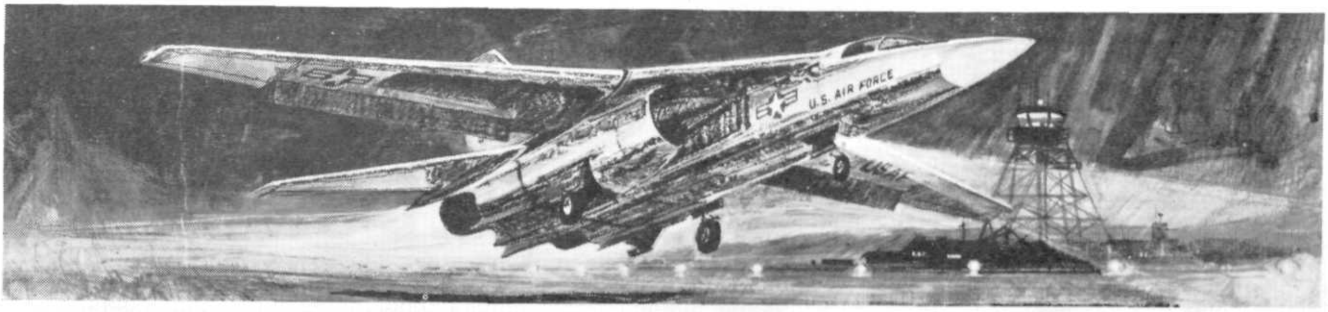


In general, Dr. Schulze would say that the biological recovery of waste water has been demonstrated as a reality by these experiments, and he would like to emphasize that it is nothing but treated sewage that flows through these tanks. There is no dilution by tap water, river water, or lake water, being used in the process.

He has been asked such a type of tertiary treatment could be developed for large scale use on a State-wide or even a Nation-wide basis. He is certainly going to try to develop this process through a series of pilot plants until it reaches a stage where its practical possibilities can be fairly well judged. So far the project has been supported only on a very limited scale by several small grants from the Institute of Water Research. It is hoped, however, that substantial federal grants can be obtained in the future. Next, the interested visitor usually brings up the economical viewpoint by stating that on a large scale such a process would cost a lot of money. This is certainly true. But, if we have enough money to shoot people to the moon, he feels we also should have enough money to solve our water problems.

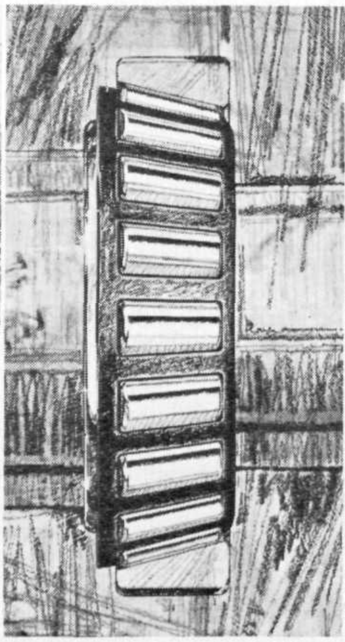
As you will probably realize there are many problems connected with this project which can only be solved in cooperation between several scientific disciplines such as microbiology, zoology, botany, chemistry and physiology. This will become clear by just mentioning the fact that we have here a continuous flow culture of the whole food chain from bacteria to protozoa to algae to crustaceans to higher plants to snails and to fish.

This opens up the possibility of investigating the long term effects of small residual concentrations of detergents or pesticides or metals etc., on all these forms of life. There is no doubt in my mind that the approach shown here, combining biology and engineering, will lead in time to a complete recovery of our waste water and to a drastic reduction of the pollutional load on our water resources. Dr. Schulze can foresee the time when all our waste treatment plants will be implemented by a series of ponds producing edible fish and a sparkling clear effluent of clean reusable water.



MOVEABLE WINGS. The Air Force-Navy F-111 supersonic tactical fighter, being developed by General Dynamics/Fort Worth, borrows another principle from the birds. Wings fold back for high speeds, extend perpendicular to the fuselage for slow speeds, maximum lift. The nose wheel and main landing wheels hit the runway on Timken® bearings.

America's newest hardware rolls on Timken® bearings



THE SHERIDAN. This new XM-551 developmental U.S. Army assault vehicle can fire conventional rounds or *a Shillelagh through its 152 mm combination* launcher. Timken tapered roller bearings keep the vehicle's track wheels gung-ho.

TAPERED DESIGN. In 1899, Henry Timken patented the tapered roller bearing. *Though improved many* times, its basic design is little changed. Reason: it's the one bearing design that can take crushing radial and thrust loads in any combination. In giant military machines that tumble over rough terrain, this fact is all important.

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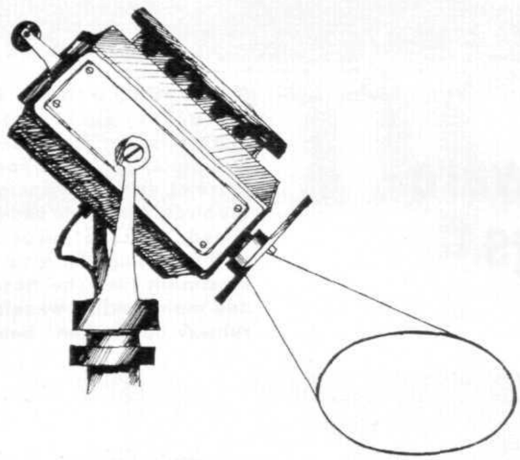
OLDSMOBILE TORONADO



edited by Susan Goodsell

Front-wheel drive design, though not a new concept, has been improved and is being utilized in the Oldsmobile Toronado, called the most unique American automobile in many years.

To be produced as a 6-passenger hardtop coupe, the Toronado features unusual interior space for passengers and luggage, outstanding driving traction and handling characteristics, and distinctive styling. It is 211 inches long, 52.8 inches high, and is built on a 119-inch wheelbase.

Toronado design objectives have been achieved through the elimination of the transmission hump and driveline tunnel, the development of an advanced torsion bar suspension system, and the location of all power train components under the hood, well forward of the passenger compartment.

The engine is situated as usual fore and aft under the hood, but is offset slightly to the right of center.

The transmission's torque converter is attached conventionally to the rear of the engine. The remaining section of the transmission is turned around and mounted along the left side of the engine, facing forward. A link chain assembly transfers power from the converter across and through the transmission gear sets to a differential unit bolted to the front of the transmission, which in turn splits the torque between two front drive axles.

Its power plant, called the Toronado V-8, is a modified, more powerful version of Oldsmobile's 425 cubic inch engine, and is rated at 385 horsepower. Performance increases result from improved engine breathing and new, more efficient carburetion.

A 4-barrel carburetor, the Quadrajet, developed for Oldsmobile by Rochester Products division, provides increased air induction. Primary stages are 22% smaller, using a triple venturi for finer, more stable mixture control providing improved idling and increased economy. Secondaries are 44% larger, also utilizing more precise fuel control called 'air valve metering' which insures correct air-fuel ratios during acceleration and high performance operation. The new, more simplified design uses a single fuel reservoir with just one inlet needle and

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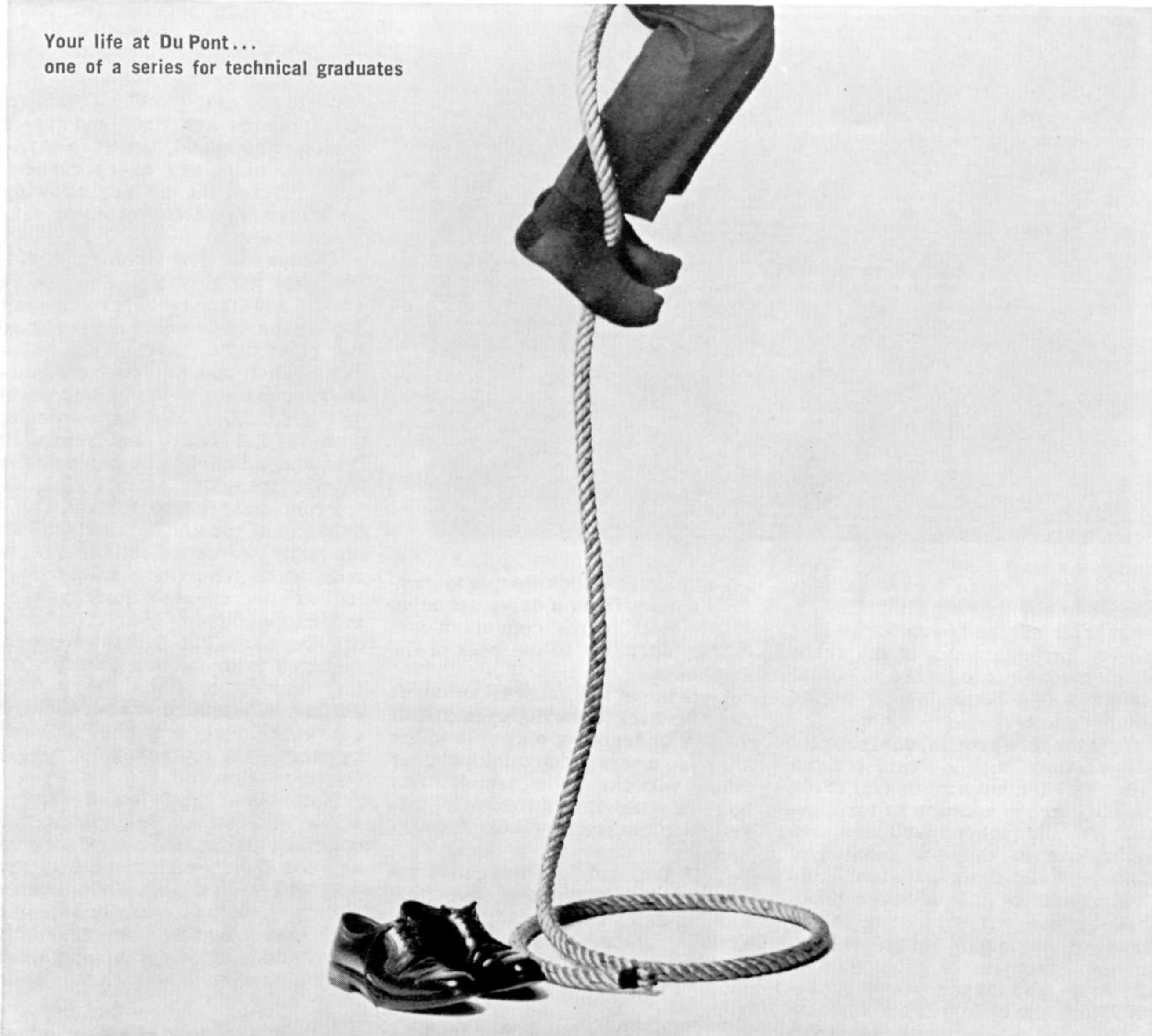

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CONTINUED FROM PAGE 18

one float to assure a constant fuel supply in any driving situation.

Overall engine operation is improved through a new choke which is mounted in the intake manifold where it can better sense engine temperatures.

A large, low profile, dual snorkel air cleaner with a resin treated filtering element supplies air to the carburetor. In addition to furnishing air, the tapered snorkels also contribute to the suppression of noise, while their efficient, thin design allows for a lower hood.

Toronado engine output is increased by larger intake valves, an increased throat dimension in the head, and larger, less restrictive intake manifold branch areas; also, a high-life profile camshaft and larger valve lifters.

Teamed with the Toronado V-8 engine as standard equipment is the specially adapted version of Oldsmobile's Turbo Hydra-Matic transmission. In function and controls, it is basically the same as the standard three-speed Turbo Hydra-Matic, but in construction and power transfer, it is completely new.

Transmission power flow has to be reversed so that driving torque can be applied to the front wheels. This is accomplished by dividing the standard Turbo Hydra-Matic into two units.

The variable stator torque converter is attached conventionally to the rear of the engine. However, the gear sets and controlling elements are rotated 180 degreees, are enclosed alongside the converter and extend forward along the left side of the engine. A 2-inch wide, multiple link chain rotates counter-clockwise, transferring torque from a drive sprocket at the rear of the converter to a driven sprocket at the rear of the gear sets.

Instead of a long drive shaft running back the entire length of the car underbody, a simple spline shaft connects transmission gear output with the differenetial. Eight bolts fasten the differential directly to the front of the transmission.

The Toronado's differential has been specifically designed for this car. It uses a planetary gear set rather than the standard ring gear pinion, allowing for its slender, more compact design. Differential torque is split between two front drive axles; one connected to the planetary gears, the other to an internal sun gear.

While the car is moving straight ahead, gears are fixed and rotate at the same speed, but when turning, the planetary gears revolve with differential action, allowing the drive axles to rotate at different speeds.

Torque is fed from the differential directly to the left drive shaft, and through a cross shaft under the engine oil pan over to the right drive shaft. Each axle-drive shaft has inboard and outboard constant velocity universal joints so the shafts have upward, downward, forward and rearward freedom required for independent front suspension.

Front suspension for the Toronado is of torsion bar design. Two specially hardened steel torsion rods work from each lower control are to special anchors mounted in a cross support near the middle of the car. The cross support, mounted with rubber cushions to the frame, contains single bolt anchor adjustments whereby the carrying height can be adjusted by increasing or decreasing torque on the torsion rod.

Both upper and lower control arms are heavy stampings and specially calibrated shock absorbers for fast reacting stability are mounted at an angle. Wheel caster and camber can be easily adjusted with an eccentric cam assembly in the upper control arm, rather than by the conventional shim method.

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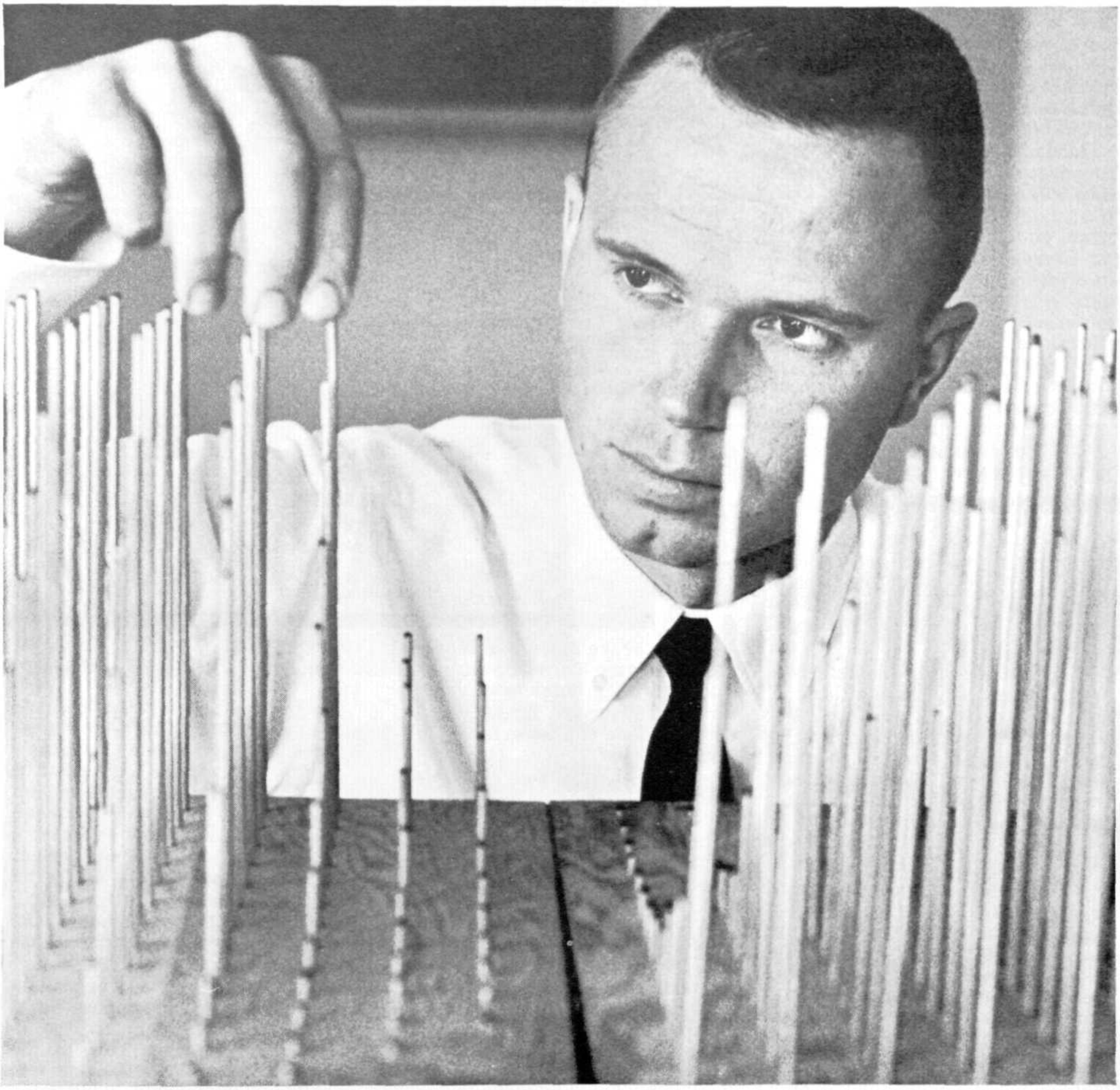

Special agent plots overthrow of hidden enemy.

The hidden enemy is vapor in automobile fuel lines. Causes vapor-lock that stalls cars on warm days.

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STANDARD OIL DIVISION STANDARD AMERICAN OIL COMPANY

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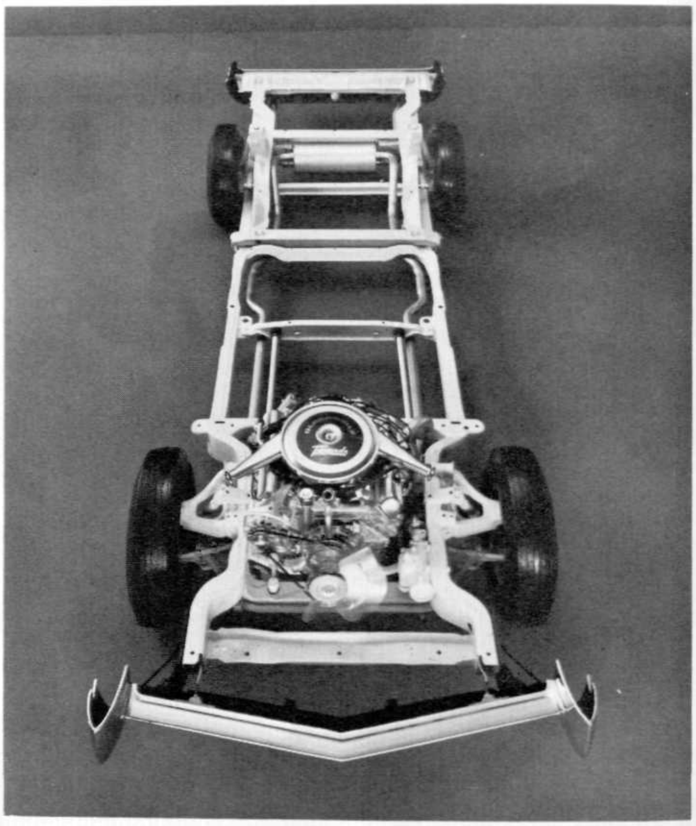


A rugged stabilizer bar across the front between the lower control arms, keeps Toronado's front end flat and level when cornering.

Integrally designed steering knuckles and plane arms are simplified one-piece forgings.

Standard power steering for the Toronado is responsive and precise with an overall ratio of 17.8 to 1. Lock-to-lock is about 3 1/2 turns, compared to nearly 5 turns for conventional steering. Proper steering column angle is achieved with a flexible, constant speed universal joint that also isolates vibrations.

A special shock absorber mounted from the frame cross-member at the front to the steering linkage intermediate rod, adds to the car's outstanding steering control characteristics.

Supporting front suspension and power train components is a perimeter "stub" frame terminating with a rear cross bar that supports forward eyes for the rear springs. Box section construction is used for better beaming and torsional rigidity.

Rear suspension consists of a stamped U-channel axle with 'dead' spindles bolted on for the rear wheels. The axle is cushioned by two single leaf springs and four shock absorbers. The leaf springs are anchored with rubber bushings and are fastened with shackles to an integral underbody frame at the rear.

Two horizontal and two vertical shock absorbers are used to dampen rear spring wind-up, for maximum controlled braking, for the elimination of wheel hop, and generally, for smoother, quieter ride. Oldsmobile's Toronado is the only automobile to use four rear shock absorbers.

A new brake drum has been designed for the Toronado with case fins providing quick heat dissipation for improved brake life and reduced fade characteristics. Enlarged brake linings (11x2-3/4" front and 11x2" rear) are used with self-adjusting primary and secondary shoes.

Impressive looking 15" wheel spiders have functional openings offset into the air stream, so that the air flows through the openings and over the cast brake drum fins. Tires are 8.85x15.

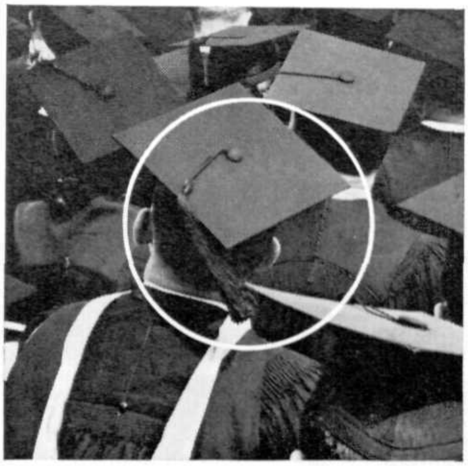
An interesting mechanical innovation for the Toronado is a new self-equalizing accelerator cable that operates the carburetor. The simple throttle device includes a spring-loaded downshift detent to retain the 'kick-in' feel when passing.

Another new feature in the Toronado is a quiet, draft-free ventilation system that eliminates corner-vent windows and exhausts air under the rear seat and up through louvered outlets below the back window. This assures a quieter passenger compartment and reduces wind noise. When the side window is partially opened, air is drawn from the car in the same manner as with a corner-vent, with less noise.

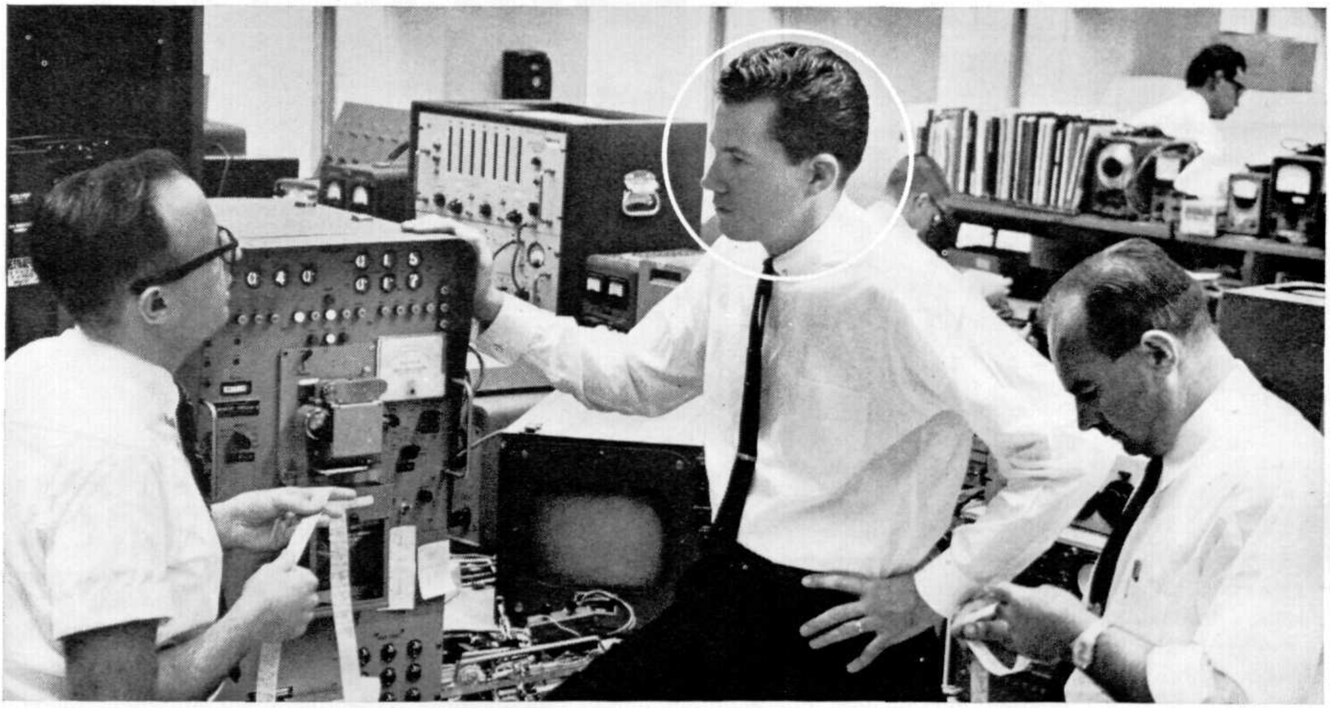
Air inlets in the Toronado's cowl sides and instrument panel provide more uniform air distribution. The upper inlets in the instrument panel are blower-fed, enabling comfortable ventilation at low car speeds when ram air is less effective.

Toronado also has a retractable head lamp system which is completely automatic, operating entirely from engine vacuum. When the head lamp switch is pulled on, the lamps automatically raise to the open position in seconds. Pushing the switch to the park or off position automatically retracts the lamps. A large vacuum reserve tank (600 cu. in.) insures three full cycles with the engine off. Parking lamps operate independently.

SE



John Lauritzen wanted further knowledge



He's finding it at Western Electric

When the University of Nevada awarded John Lauritzen his B.S.E.E. in 1961, it was only the first big step in the learning program he envisions for himself. This led him to Western Electric. For WE agrees that ever-increasing knowledge is essential to the development of its engineers—and is helping John in furthering his education.

John attended one of Western Electric's three Graduate Engineering Training Centers and graduated with honors. Now, through the Company-paid Tuition Refund Plan, John is working toward his Master's in Industrial Management at Brooklyn Polytechnic Institute. He is currently a planning engineer developing test equipment for the Bell System's revolutionary electronic telephone switching system.

If you set high standards for yourself, educationally and professionally, let's talk. Western Electric's vast communications job as manufacturing unit of the Bell System provides many opportunities for fast-moving careers for electrical, mechanical and industrial engineers, as well as for physical science, liberal arts and business majors. Get your copy of the Western Electric Career Opportunities booklet from your Placement Officer. And be sure to arrange for an interview when the Bell System recruiting team visits your campus.

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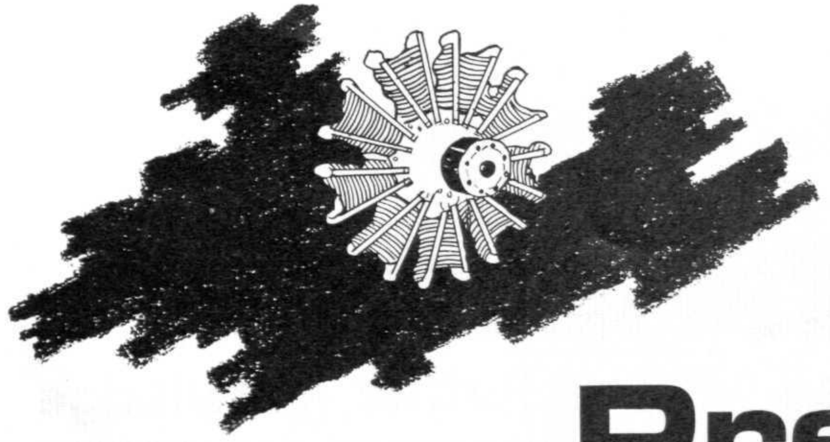
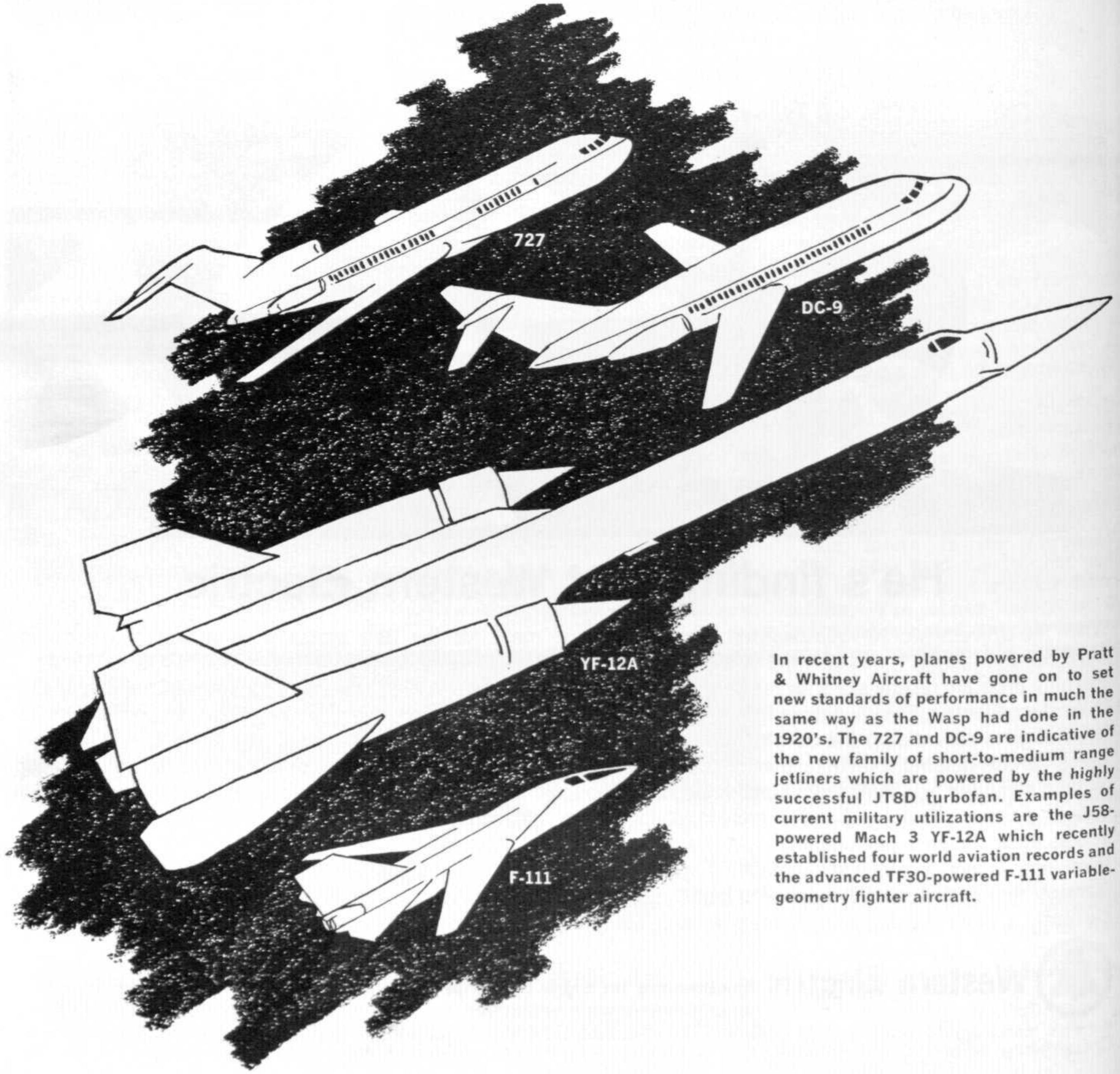
Past



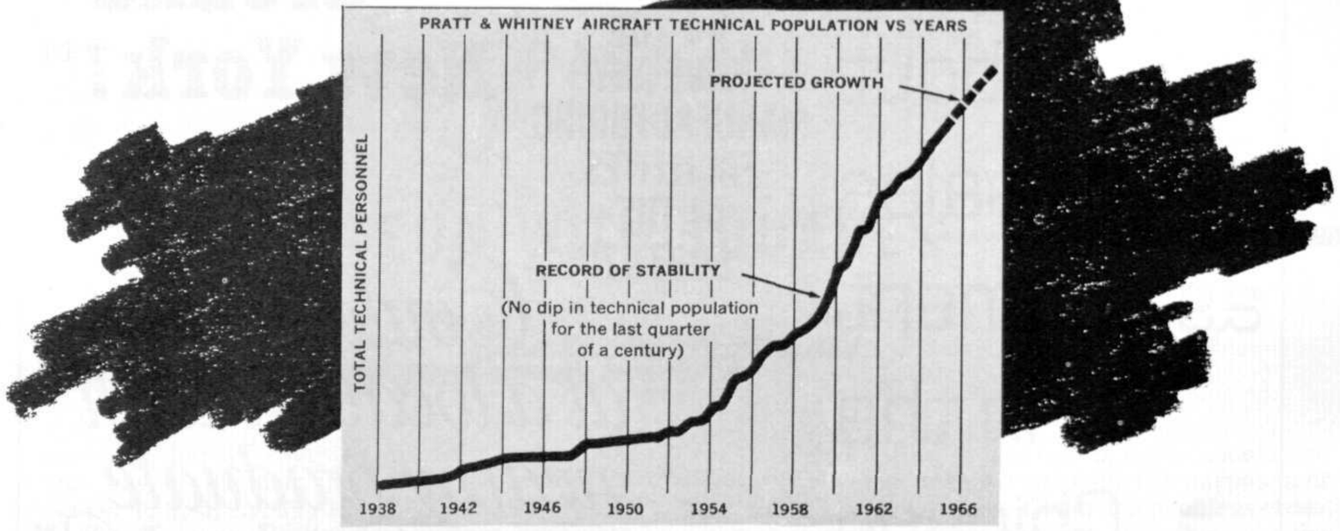
The Company's first engine, the Wasp, took to the air on May 5, 1926. Within a year the Wasp set its first world record and went on to smash existing records and set standards for both land and seaplanes for years to come, carrying airframes and pilots higher, farther, and faster than they had ever gone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

and ~~the~~ Your Future



Take a look at the above chart; then a good long look at Pratt & Whitney Aircraft—where technical careers offer exciting growth, continuing challenge, and lasting stability—where engineers and scientists are recognized as the major reason for the Company's continued success.

Engineers and scientists at Pratt & Whitney Aircraft are today exploring the ever-broadening avenues of energy conversion for every environment . . . all opening up new avenues of exploration in every field of aerospace, marine and industrial power application. The technical staff working on these programs, backed by Management's determination to provide the best and most advanced facilities and scientific apparatus, has already given the Company a firm foothold in the current land, sea, air and space programs so vital to our country's future. The list of achievements amassed by our technical staff is a veritable list of firsts in the development of compact power plants, dating back to the first Wasp engine which lifted the United States to a position of world leadership in aviation. These engineering and scientific achievements have enabled the Company to obtain its current position of leadership in fields such as gas turbines, liquid hydrogen technology and fuel cells.

Should you join us, you'll be assigned early responsibility. You'll find the spread of Pratt & Whitney Aircraft's programs requires virtually every technical talent. You'll find opportunities for professional growth further enhanced by our Corporation-financed Graduate Education Program. Your degree can be a BS, MS or PhD in: **MECHANICAL • AERONAUTICAL • ELECTRICAL • CHEMICAL ENGINEERING • PHYSICS • CHEMISTRY • METALLURGY • CERAMICS • MATHEMATICS • ENGINEERING SCIENCE OR APPLIED MECHANICS.**

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LAY THAT SLIDE RULE DOWN,

OR

"Using The Gears Between the Ears!"

PART ONE

FUN WITH SQUARES,

OR

"Beatniks Aghast!"

There is hardly anything more commonplace in our way of life than the infinite succession of integers, 1, 2, 3, ..., 11, 12, 13,..., 21, 22, 23,.... Yet, our Western civilization did not have this arithmetical notation in general use until about the time of Columbus. Thus, our most intelligent forefathers of seven life spans ago often labored tediously and all but vainly in solving problems easily mastered by a sixth-grade student of today.

We all understand how the integers follow endlessly, each a single unit greater in absolute value than its predecessor. We often do not understand, however, how easily the natural order of the simple integers may be made to do marvelous things for us if we handle them properly. For instance, by leaving out all even-number integers, we may establish the equally infinite sequence, 1, 3, 5, 7,..., 2n-1,... . Then by making a summation of the terms in the series, TABLE I below, we arrive at the squares of the integers. Along the first line of the table appear the first ten integers. The second line represents the first ten odd numbers. The third line values are found by performing a running addition of the odd numbers from the line above. These terms, uniquely enough, also represent the squares of the corresponding integers from the first row.

TABLE I
Squares of Integers From 1 to 10 by Additive Processes

	1	2	3	4	5	6	7	8	9	10
n	1	2	3	4	5	6	7	8	9	10
(2n-1)	1	3	5	7	9	11	13	15	17	19
$\sum_{1}^{n}(2n-1)$ n2	1	4	9	16	25	36	49	64	81	100

Persons skilled in the use of desk calculators use the reverse of this discovery for purposes of extracting square roots. Given the problem of determining the square root of 169, they put the number onto the lower register of the machine and then begin to subtract the succession of odd numbers. The upper register, of course, keeps track of the number of operations that have been performed. The results yielded by successive steps are indicated in Table II-A, below:

TABLE II-A
Square Roots by Calculating Machine

Operation	Initial Value, Lower Register	Subtrahend	Final Value, Lower Register
1	169	1	168
2	168	3	165
3	165	5	160
4	160	7	153
5	153	9	144
6	144	11	133
7	133	13	120
8	120	15	105
9	105	17	88
10	88	19	69
11	69	21	48
12	48	23	25
13	25	25	0

The implication here is clear. The accumulated sum of the first 13 odd numbers is 169. This also happens to be -- or better yet, has to be -- the square of 13!

The skill of the experienced user of the desk calculator does not stop there. Assume the example of determining the square root of 159. He proceeds just as before, and we pick up his work in Table II-B on the tenth operation:

TABLE II-B
Square Roots by Calculating Machine-Refined

Operation	Initial Value, Lower Register	Subtrahend	Final Value, Lower Register
10	78	19	59
11	59	21	38
12	38	23	15
13	15	25	999990

In this example, the lower register is heard to "roll over" a long series of nines inasmuch as the subtrahend is larger than the minuend. The desk calculator merely does what it can to show a negative number on the lower register.

The undaunted operator recognizes his mistake by the sound of the roll of the lower register and immediately corrects his error by putting 25 units back into the machine in a process of addition rather than subtraction. This restores the line given in Table II-B after 12 operations. He then moves the carriage of the machine one decimal place to the left and begins the sutractive process anew as in Table II-C, below. The shift of the carriage has the effect of introducing a factor of ten between the lower register residues and the consecutive odd numbers being subtracted. The difference in place is picked up automatically by the upper and lower registers.

By this time we are too well educated in the process to attempt to subtract 3.5, the next subtrahend, from a minuend of 0.5 as represented by the balance remaining on the lower register. And as you may have guessed, 12.5 approximates the square root of 159 to three significant figures. We shall have occasion at some later time to look at another method for approximating the square roots of numbers.

TABLE II-C
Square Roots by Calculating Machine With Decimals Added

Operation	Initial Value, Lower Register	Subtrahend	Final Value, Lower Register
12	38	23	15
12.1	15	2.5	12.5
12.2	12.5	2.7	9.8
12.3	9.8	2.9	6.9
12.4	6.9	3.1	3.8
12.5	3.8	3.3	0.5

If we restudy TABLE I for a minute, we may discover the germ of an idea that suggests the origin of the calculus. Should we inquire, how does the function $y = x^2$ vary when $x = 5$? By inspection of line three above, we see that y increases 9 units between 4 and 5, and increases 11 units between 5 and 6. Or, we may assume that y is changing an average 10 units per unit change of x. Expressed in calculus, $y = x^2$, $dy/dx = 2x$; for $x = 5$, $dy/dx = 10$. Further inspection of TABLE I along line two shows that the "second difference" between the successive squares is simply 2, and it holds for the entire range of x. Expressed in calculus, $d^2y/dx^2 = 2$, a constant for all x.

How may the foregoing be put to work for us? We have merely chanced upon an identity, a mathematical tool which holds for the general case and, therefore, may be applied to any particular case. Probably the most familiar identity in the study of mathematics is the example from trigonometry.

$$(\sin^2 x+\cos^2 x)=1.$$

There are a great many more indentities that are equally well known and useful.

The one suggested in TABLE I may be established in may ways. The simplest method likely being

$$(x + 1)^2 = x^2 + 2x = 1$$

Thus we may proceed from 10^2 to 11^2 by the simple expedient of adding $(2x + 1)$, or 21, to 100, the square of 10. We recognize the square of 11 at once as being 121.

If we rewrite the identity used previously to read,

$$(x + 1)^2 = x^2 + x + (x + 1)$$

we may use the new form in more difficult assignments. Firs we note that the squares of consecutive integers differ by the sum of the two integers under consideration $(x + 1)^2 - x^2 = x + (x + 1)$. The following is a demonstration of the prowess of this variation of the original identify.

$$91^2 = 90^2 + 90 + 91 = 8{,}100 + 181 = 8{,}281.$$

Similarly, we may use another identity,

$$(x - 1)^2 = x^2 - x - (x - 1).$$

Solving for 99^2 with the new relationship, $99^2 = 100^2 - 100 - 99 = 10{,}000 - 199 = 9{,}801.$

There are endless variations:

$$(x + 2)^2 = x^2 + 4x + 4$$

$$102^2 = (100 + 2)^2 = 10{,}000 + 400 + 4 = 10{,}404.$$

And, $(x - 2)^2 = x^2 - 4x + 4$

$$98^2 = (100 - 2)^2 = 10{,}000 - 400 + 4 = 9{,}604.$$

Repeated application of examples involving use of the simpler relationships spelled out above will help you develop new mathematical skills.

Another very useful identity deserves mentioning at this time.

$$(x + 1/2)^2 = x^2 + x + 1/4 = x(x + 1) + 1/4$$

Thus, $1.5^2 = (1)(2) + 1/4 = 2.25$

And, $7.5^2 = (7)(8) + 1/4 = 56.25$

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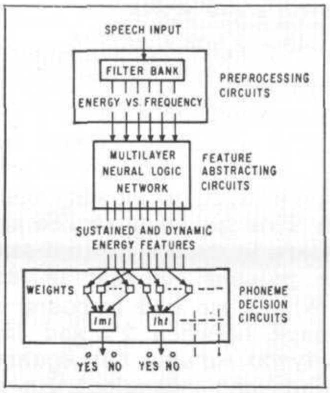
Engineering and Science at RCA

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.

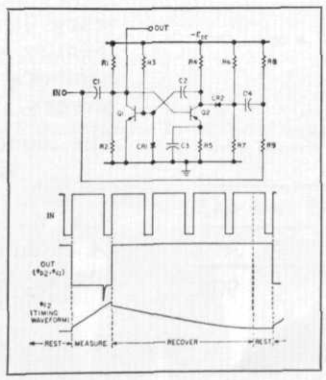
A "neuron," as used in these networks, is a simple computing element exhibiting the characteristics of fan-in and fan-out, an input threshold, and a specified analog relation between output and input when the input exceeds threshold. An array of several hundred neurons used in speech analysis is structured 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.

CONTINUED FROM PAGE 28

Were we to imagine the example immediately preceding as applying to 75^2, then the answer would be just 100 times greater than the value obtained for 7.5^2.

Therefore, $75^2 = (7)(8)100 + 25 = 5{,}625$
$95^2 = (9)(10)100 + 25 = 9{,}025$
And $205^2 = (20)(21)100 + 25 = 42{,}025$

Proceeding in another vein, if we investigate the successive square of integers in the range from 20 to 30 some additional interesting properties are discovered. We already realize that the square of 25 is 49 units greater than the square of 24, and that the square of 26 is 51 units greater than the square of 25. Hence, the square of 26 is 100 units greater than the square of 24. In TABLE III below, these several squares appear while the strange but beautiful relationship of one to one another is indicated.

Thus the integers that are equally far removed from 25 have squares that differ by even hundreds. Furthermore, the number of hundreds difference corresponds with the number of units that the integers are removed from 25. Now, assuming all the squares up to 25 are known, one may find the square of any other integer from 26 through 75 by using an identity which we write as follows:

$$x^2 = (100)(x - 25) + (50 - x)^2$$

First, proving the identity

$$x^2 = 100x - 2500 + 2500 - 100x + x^2 = x^2$$

TABLE III

Properties of Squares of Integers

From 20 to 30

n-5	n-4	n-3	n-2	n-1	n	n+1	n+2	n+3	n+4	n+5
20	21	22	23	24	25	26	27	28	29	30
400		+			500			=		900
	441		+		400		=		841	
		484		+	300		=	784		
			529	+	200	=	729			
					576+100=676					
					625					

Hence, $38^2 = (100)(38 - 25) + (50 - 38)^2$
$= (100)(13) + (12)^2 = 1{,}300 + 144 = 1{,}444$

And, $69^2 = (100)(69 - 25) + (50 - 69)^2$
$= (100)(4\ (44) + (-19)^2$
$= 4{,}400 + 361 = 4{,}761.$

Notice how the square of negative nineteen is a positive number and forces the identity to yield results for numbers larger than 50.

A similar, but less wieldy, identity may be written with 50 Occupying the "pivot position" held by 25 in the example above:

$$x^2 = 200(x - 50) + (100 - x)^2$$

The range of application lies between 50 and 150, providing the first fifty squares are at hand. The existence of the identity may be established by expanding the right-hand side.

$$x^2 = 200x - 10{,}000 + 10{,}000 - 200x + x^2$$

A move advantageous method for finding squares of larger number is presented below:

$$(2x)^2 = 4(x)^2$$
$$(3x)^2 = 9(x)^2$$

Where a number is divisible by two or three, the square of a smaller number may be determined and then multiplied by four or by nine, whichever is applicable, for purposes of obtaining the square of the larger number. Multiplication by nine is most easily done by multiplying by ten first, and then subtracting the number from ten times itself.

For example, $(93)^2 = 9(31)^2 = 9(961)$
$= 9610 - 961 = 8649$

Applying the previous method,

$$(144)^2 = 4(72)^2 = 9(48)^2$$

where either 48 or 72 may be squared by an earlier device. We may readily visualize,

$$48^2 = (48 - 25)100 + (50 - 48)^2$$
$$= (23)100 + 4 = 2{,}304$$

And, $9(48)^2 = 23{,}040 - 2{,}304 = 20{,}736.$

The subject of the identity

$$x^2 = (x - 25)100 + (50 - x)^2$$

could be dropped at this stage, perhaps having proved its worth in yielding all squares between 25 and 75 for the mere price of knowing the first two dozen squares. This idea was kicked around for a number of years in such a limited state of usage until it was pointed out that an identity knows no limits. Where we had imposed arbitrary limits of usage between 25 and 75, the identity went blithely on turning out squares of numbers for anyone who consulted its orcle powers. Take the example of the square of 114.

The identity states:

$$(114)^2 = (114 - 25)100 + (50 - 114)^2$$
$$= 8900 + (64)^2$$

Now no one is expected to know the square of 64 in an offhand way, but there is nothing to keep one from applying the identity one more time!

$$(114)^2 = 8900 + (64)^2$$
$$= 8900 + (64 - 25)100 + (50 - 64)^2$$
$$= 8900 + 3900 + (14)^2$$
$$= 12{,}800 + 196 = 12{,}996$$

Interest in the squares of larger numbers opens several new avenues for use. We can arrange the problem of squaring a number such as 114 in this format:

$$(114)^2 = (100 + 14)(128 - 14)$$
$$= (100)(128) + (14)(128) - (14)(100) - (14)(14)$$
$$= 12{,}800 + (14)(28) - (14)(14)$$
$$= 12{,}800 + (14)(14)(2) - (14)(14)$$
$$= 12{,}800 + (14)(14) = 12{,}800 + 196$$
$$= 12{,}996$$

The general rule we have evolved is

$$(100 + a)^2 = (100)(100 + 2a) + a^2$$

which becomes upon expansion,

$$10{,}000 + 200a + a^2 = 10{,}000 + 200a + a^2$$

and thereby proves the identity.

Taking another example with this powerful new rule,

$$(151)^2 = (100)(202) + (51)^2$$
$$= 20{,}200 + 2{,}601 = 22{,}801$$

CONTINUED TO PAGE 32

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Returning to the example of $(114)^2$, we wish to evolve still another general method for finding the square.

$$(114)^2 = (111)^2 + (111 + 112) + (112 + 113) + (113 + 114)$$

Each pair of bracketed numbers increases the quare of 111 to the next larger integer. Moreover, the sum of the three bracketed quantities is precisely three times the middle or average bracketed term. Knowledge of the binomial expansion theorem makes it possible for us to write,

$$(111)^2 = 12{,}321$$

to which we add, $3(225) = 675$

$$(114)^2 = (111)^2 + 3(225)$$
$$= 12{,}321 + 675 = 12{,}996$$

Notice how additive processes replace multiplication. The intent throughout the use of these methods is to substitute a simpler, safer, and surer way of getting mathematical results. The secret is in recognizing an algebraic process that simplifies the problem in hand.

The question might arise, "Why so much fuss about the square of numbers?" But in defense, call on more and more identities, and use the squares of numbers to produce many other useful products. For example,

$$(x + 1)(x - 1) = x2 - 1$$

And, $17 \times 19 = 18^2 - 1 = 323$

Or, $1.7 \times 19 = \frac{18^2}{10} - 1 = 32.3$

Again, $(x + 2)(x - 2) = x2 - 4$

And, $17 \times 21 = 19^2 - 4 = 357$

Notice how easily one can mix decimal fractions with whole numbers. These methods, as with the slide rule for which they propose to substitute, tend to treat every number in terms of the significant figures that are given. Thus, 114, 11.4, 11,400, 1.14 and 0.000114, all, can be treated as the same number insofar as mental computation is concerned. But just as in using the slide rule or a table of common logarithms, it is up to the user to locate his decimal place at the end of his calculation.

In summary, be the master of the method, rather than letting the method be the master of you. Keep it flexible and fit it to each circumstance by calling upon the most useful application. After a time you will catch yourself using these methods to check answer obtained by conventional means.

A given identity may be useful in one sense one time and in the opposite sense the next. The last appearing examples are specific applications of the more general identity,

$$(a + b)(a - b) = (a^2 - b^2)$$

where we have been using <u>b</u> as a small integer. Writing the identity in the opposite sense,

$$(a^2 - b^2) = (a + b)(a - b),$$

find the annular area between a pair of concentric circles 12 and 20 inches in diameter. Let d and D equal the diameters of the smaller and larger circles, respectively.

$$A = \pi D^2/4 - \pi d^2/4 = (n/4)(D^2-d^2)$$
$$= (\pi/4)(D + d)(D - d) = (\pi/4)(20 + 12)(20 - 12)$$
$$= (\pi/4)(32)(8) = 64\,\pi \text{ sq. in.}$$

Or, find the net cross-sectional area of a water pipe with an 8-inch outside diameter and a 7-inch inside diameter.

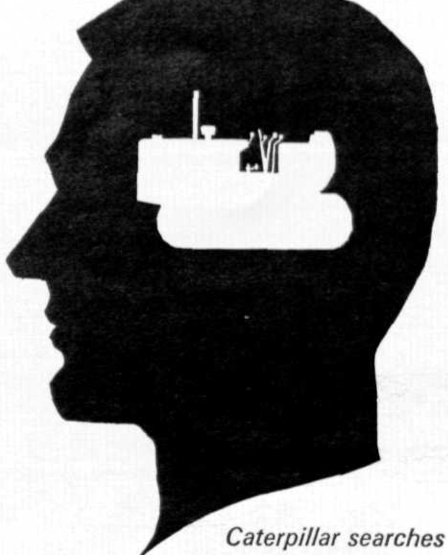
$$A = (\pi/4)(D + d)(D - d) =$$
$$= (\pi/4)\,(8 + 7)(8 - 7) - 15\pi/4 \text{ sq. in.}$$

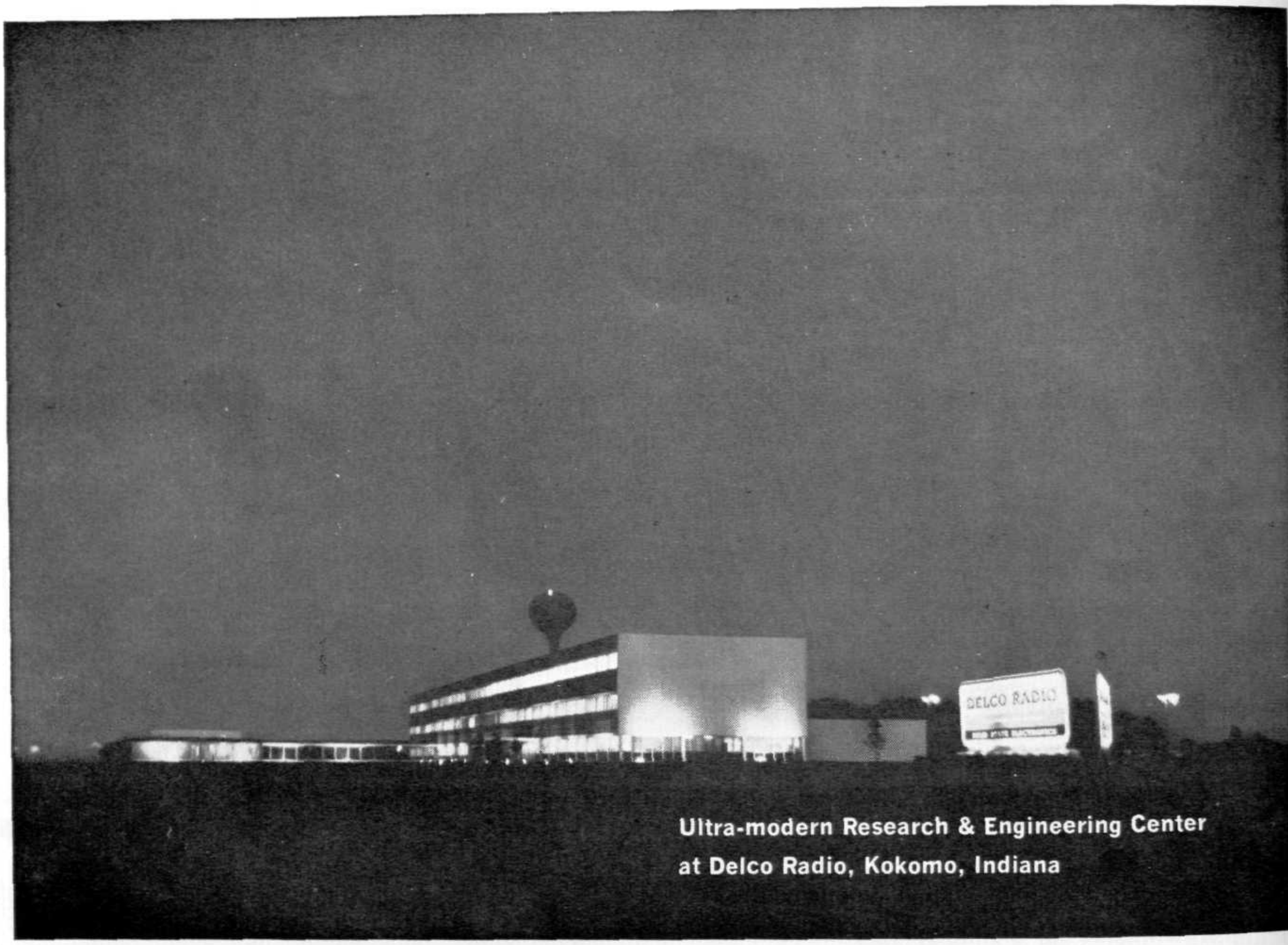
The above answers can be further simplified, but it is not our purposes to go into such discussion at this time. Other parts of LAY THAT SLIDE RULE DOWN will better serve these purposes.

* *

Madison, Wisconsin
January 20, 1964

Professor Paul J. Grogan, Chairman
Department of Engineering
University Extension Division
The University of Wisconsin





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EXTENSION OF

THE PYTHAGOREAN THEOREM . . . .

by Thomas Heppenheimer

The study of higher-dimensional geometry is one of the important topics studied in higher mathematics. This study is usually carried on using vectors and matrices as the fundamental tools, and while desired results can be established in a rigorous manner through the use of these tools, this approach rarely leads to an intuitive appreciation of the subject on the undergraduate level. That is, while the study of higher-dimensional geometry is carried on through appropriate extensions of the basic concepts of plane and solid geometry, the use of vectors and matrices rarely results in undergraduates intuitively understanding the motivations for the extensions. Thus it is difficult for many undergraduates to treat the geometry of n dimensions, $n > 3$, with anything like the "feel" with which they approach problems in, say, solid geometry.

A careful study of the theorem which is the main topic of this paper may aid in the understanding of higher-dimensional geometry. This theorem was first discovered by Grassman; the statement and proof given in this paper was discovered independently by the author. This new proof relies entirely upon the very familiar concepts of the Pythagorean theorem and the axiom of mathematical induction.

Consider the Pythagorean theorem. It may be stated in the following very general form: In the XY-plane we may take any line and select two arbitrary points A and B on the line, thus cutting off a line segment of finite length. We may project this line segment on the coordinate axes; then the square of the length of the line segment AB is equal to the sum of the squares of the lengths of the projections of AB onto the coordinate axes. (Fig. 1.)

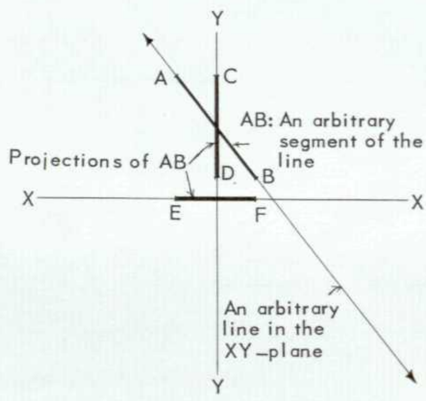

Fig. 1. The Pythagorean Theorem: $(AB)^2 - (CD)^2 - (EF)^2$

Now let us examine this statement with an eye toward generalizing it. Consider the XY-plane; it is a 2-space. A generalization is an n-space, or, what is the same thing, an (n+1)-space. We shall see it is more convenient to use the second term. Then a subspace of one lower dimension is an n-space. Now consider the coordinate axes; they may be thought of as coordinate n-spaces. For under Cartesian geometry the (n+1)-space is spanned by (n+1) independent variables and an n-space is spanned by n independent variables; a coordinate n-space would be generated by setting any one of the (n+1) variables equal to zero and allowing the remaining n variables to range through all real values. This procedure, applied to 2-space, leads to coordinate lines or axes; in 3-space to coordinate planes; and in 4-space to coordinate 3-spaces. It can be seen that there must always be exactly (n+1) such coordinate n-spaces.

The arbitrary line in 2-space generalizes to an arbitrary n-space in (n+1)-space. The analogue of the line segment bounded by two selected points is a section or piece of that arbitrary n-space bounded by some definite, known boundary. In the Pythagorean theorem, the length of the line segment AB is of fundamental importance. This length can be found using methods learned in high school, but these methods do not generalize easily. A method more suited to our purpose is integration over the arbitrary line in 2-space, the end points fixing the limits of integration. This method easily generalizes into iterated integration over the arbitrary n-space, with the boundary of the piece fixing the limits of integration. This necessarily implies that the boundary must be everywhere integrable. And just as we must find the length AB in the 1-dimensional case, so in the n-dimensional case we find the amount of n-space contained in the bounded piece, which will be called the "hypervolume". This hypervolume has the same fundamental importance as does the length in the case of the line.

Finally, a reasonable generalization of the idea of projecting the line segment AB onto the coordinate axes is projecting the bounded piece of n-space onto the (n-1) coordinate n-spaces. Then the extension of the Pythagorean theorem is the following, which will be referred to as the N-Pythagorean Theorem.

The N-Pythagorean Theorem: Let E^{n+1} (read "E n plus 1") be a Euclidean space of dimension (n+1). Let E_i^n be the i^{th} coordinate n-space, $1 \leqslant i \leqslant n$. Let E^n be an arbitrary n-di-

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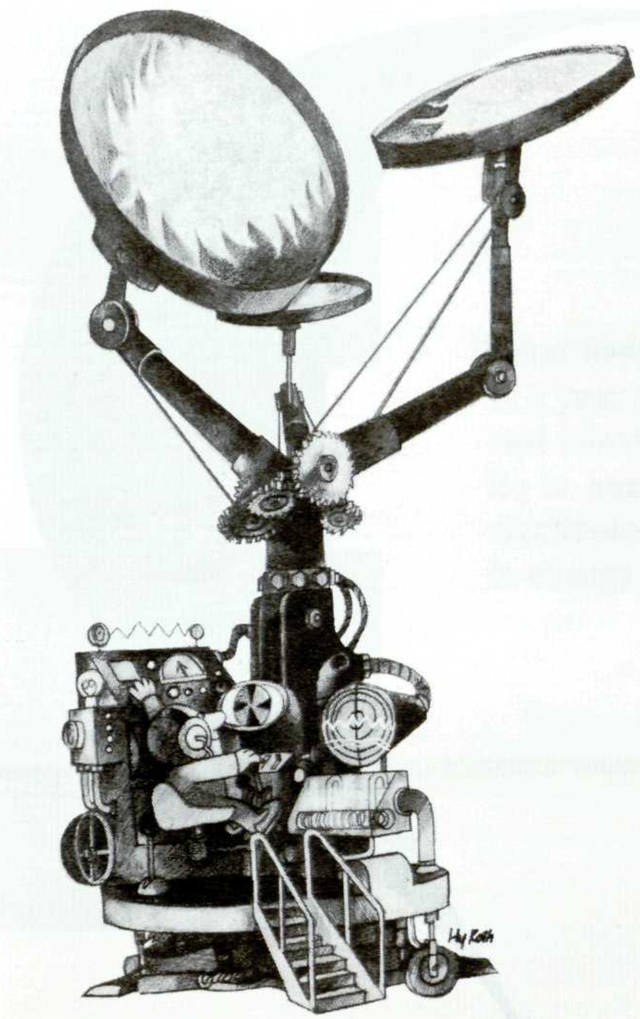
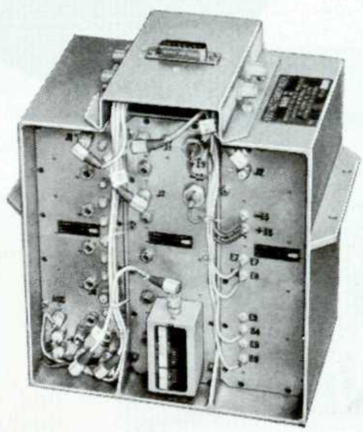


Flash it with a sun mirror . . .



. . . or command it through a Motorola Transponder*

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*Primary function is to receive command signals from Earth, and return critical in-flight communications information.

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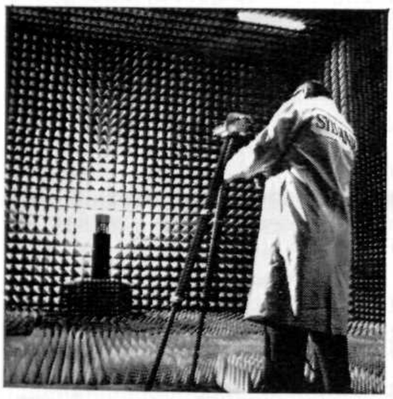

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mensional subspace of E^{n+1}, i.e. an arbitrary n-dimensional Euclidean space. Let C^n be a bounded piece of E^n whose boundary is everywhere integrable so that it is meaningful to talk of a precise hypervolume found through iterated integration. Let C^n project onto E_i^n; call the resulting projections C_i^n. Let the hypervolume of C^n be H^n and the hypervolumes of C_i^n be H_i^n. Then we have:

$$(H^n)^2 = \sum_{i=1}^{n+1} (H_i^n)^2$$

We shall prove this theorem by induction. We have established it for the case n=1; we will also establish it for n=2 and n=3 so that the reader will have an easier time following the proof for the general case.

Let E^2 be an arbitrary plane in E^3. C^2 is then a plane figure bounded by a closed curve. H^2 for C^2 is of course its area, which may be found by double integration. We can greatly simplify the proof if we consider not C^2 itself but a basic element of area (dx dy), which is a rectangle. It can be seen that if the theorem is true for this rectangle then it must be true for arbitrary C^2, provided the boundary be everywhere integrable.

Consider the plane E^2. Let us introduce a coordinate system of 2 orthogonal axes P and Q. Let P be parallel to the intersection of E^2 with the XY-plane and Q be coplanar with the Z axis. Now let our C^2 be a rectangle whose sides are parallel to the axes P and Q. Let the length of C^2 be L and the width W; let W be parallell to P. Then C2 will project onto the Xy-plane; see Fig. 2. In the projection W is unchanged but the new length is L**.

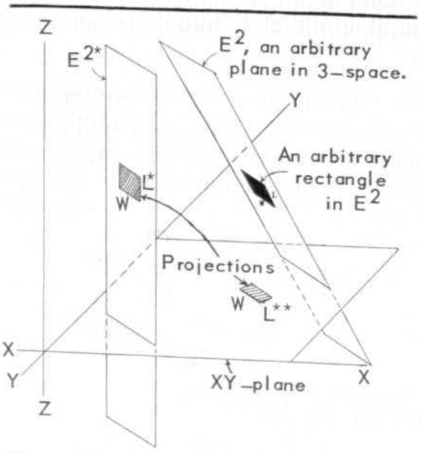


Fig. 2. Projecting a rectangle onto only 2 planes: $(LW)^2 - (L*W)^2 - (L**W)^2$

Now introduce a new plane, E^{2*}. Introduce a coordinate system of 2 orthogonal axes P' and Q'; let P' be parallel to P, Q' be parallel to the Z axis. Project C^2 onto E^{2*}; the resulting projection will also have width W, and length L*.

The lines which contain L* and L** are orthogonal, and these line segments are projections of L. Hence the Pythagorean theorem holds and we have: $(L)^2 = (L^*)^2 + (L^{**})^2$. We multiply each of these lengths by the constant W: $(LW)^2 = (L^*W)^2 + (L^{**})^2$. But these products are the areas of C^2 or of its projections. Hence the theorem is established for n=2 in the special case of projection onto only 2 planes.

But now let us bring in the XZ and YZ planes. We left them out of Fig. 2 because they were unessential; the reader may now draw them in or think about them being in. The projection in E2* is also a rectangle, and this rectangle will project onto these other coordinate planes. In these projections the length L* will be invariant; W will project to form widths W' and W''. Then the same argument from the Pythagorean theorem applies: $(L^*W)^2 = (L^*W')^2 + (L^*W'')^2$. Substituting, then, we have

$$(LW)^2 = (L^*W')^2 + (L^*W'') + (L^{**}W)^2$$

so the theorem holds in full generality for the case n=2.

Consider now the case n=3. We can draw no figure, for it is beyond the powers of any artist to draw a four-dimensional figure on a plane. Here is where the reader must really begin to exercise his imagination in following the proof, which rests heavily on the reader's ability to picture in his mind that which we will describe. It will be very helpful to keep the proof for n=2 in mind, and to look for analogies and points of similarity.

In 4-space we have four coordinate 3-spaces. If the axes are lettered X, W, Z and W, then these coordinate spaces are the XYZ, XZW, YZW and XYW. Consider now the arbitrary 3-space E^3. Span E^3 with a coordinate system of 3 orthogonal axes P, Q and R. Orient P so as to be parallel to the intersection of E^3 with XYZ. Now, as before, we will not be dealing with the arbitrary solid in E^3 whose volume can be found be triple integration, but with a cubical element of volume whose sides are respectively parallel to the axes P, Q and R. Let the length L be in the direction P, the width W and thickness T in the direction Q and R respectively. Either of these axes--let us say Q--must be coplanar with the W axis. It does not matter which axis is chosen, but once a choice is made we must be consistent.

Now introduce a new 3-space, E^{3*}. Span it with a coordinate system of 3 orthogonal axes P', Q' and R'. Let P' be parallel to P and Q' parallel to the W-axis.

Our cube in E^3, C^3, will project onto both E^{3*} and XYZ. Both projections will have length L. The projection onto XYZ will have side W*T*; the projection onto E^{3*} will have side W**T**. The planes of W*T* and W**T** are orthogonal so from the validity of the theorem for n=2 it follows that $(WT)^2 = (W^*T^*)^2 + (W^{**}T^{**})^2$. We multiply by the invariant L: $(WTL)^2 = (W^*T^*L^*)^2 + (W^{**}T^{**}L)^2$. Thus the theorem holds for n=3 for projection onto only two 3-spaces.

Consider the projection onto E^{3*}, W**T**L. This cube will project onto the coordinate spaces XZW, YZW and XYW. Since Q' in E^{3*} is parallel to the W-axis and since W** is in the direction of Q' it follows that W** is invariant under these projections onto the three other coordinate spaces. Then let the projections of the side T**L be T'l', T''L'' and T'''L'''. The planes of these projections are all orthogonal so we apply the validity of the theorem for n=2 to see that $(T^{**}L)^2 = (T'L')^2 + (T''L'')^2 + (T'''L''')^2$. Multiplying by the invariant W** and substituting, we have

$$(WTL)^2 = (W^*T^*L)^2 + (W^{**}T'L') (W^{**}T''L'')^2 + (W^{**}T'''L''')^2$$

so the theorem holds in full generality for the case n=3.

The proof in the general case is now fairly simple. We know the theorem is true for some case n=k; from this fact we must deduce that the theorem is true for the case n=(k+1).

In (n+1)-space we have (n+1) coordinate n-spaces. One of these is spanned by the first n axes and only by these axes. Consider now the arbitrary space E^n; introduce a coordinate system of n orthogonal axes P_1, P_2, P_3, . . .

CONTINUED ON PAGE 46

XXX ENGINEERS

Why criticize the topless bathing suit. It's just an attempt to keep abreast of the times.

M.E. -- "What's the best way to teach a girl to swim?"

Chem. E. -- "That requires technique. First you put your arm around her waist. Then you gently take her left hand and--

M.E.--"She's my sister."

Chem. E. -- "Oh! Then you just push her off the dock."

Firth-Mortery: "Terribly sorry to hear you buried your wife last week, old boy."

Wathleywood: "Had to . . . dead you know."

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."

During an obscenity-possession trial in East Lansing last week, the prosecutors read aloud to the jury an entire 187-page book, "The Orgy Boys," seized at the store.

Next week's book will be "Fanny Hill." Starts promptly at two.

Engineer: "I'm looking for a truly beautiful girl."

Co-ed: "Here I am."

Engineer: "Okay, you can help me look."

Then there was the dumb coed who received a postcard and tore it open it see what was inside.

THOUGHTS--

There are many in this world of ours who hold that things break about even for all of us. I have observed, for example, that we all get the same amount of ice. The rich get it in the summertime and the poor get it in the winter.

--Bat Masterson

Some people are always grumbling because roses have thorns: I am thankful that thorns have roses.

--anonymous

Engineer to Co-ed: "Shall we walk or take a cab?"

Co-ed: "Let's walk. I'm too tired to get into a cab with you."

Two engineers were standing on a corner and a coed walked by. One of them said, "Her necks dirty." The other answered "Her does?"

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.

Quote from engineer after Nat. Sci. 181 lecture: "So that's it! I always figured that the stork had too small a wingspread to carry an eight to ten pound load."

History question: "For what was Louis the Fourteenth chiefly responsible?"

Engineer's answer: "Louis the Fifteenth."

An engineering professor stopped to talk to one of his students. As they were about to part the professor said: "By the way, when we met, which way was I headed?"

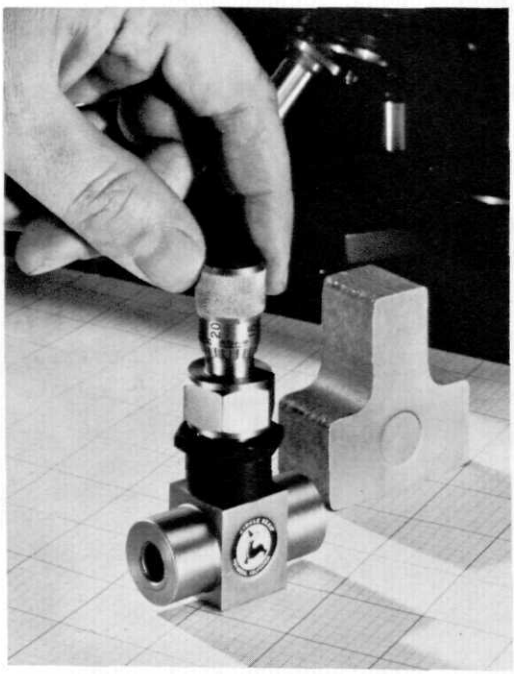
"North," said the student.

"Good," said the professor. "then I've had lunch!"

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

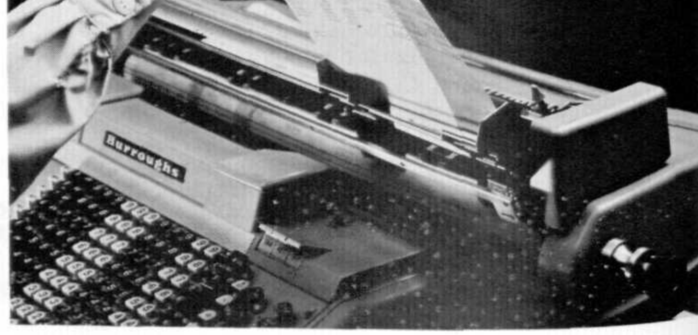
Industrial News

STUDY LAB FOR MOON EXPLORATIONS -- This unique vehicle is a mobile geological laboratory which is expected to contribute valuable scientific information for early American manned landings on the moon. Built by the General Motors Defense Research Laboratories for the U. S. Geological Survey and NASA, the 8-ton vehicle is shown doing preliminary testing in volcanic fields of Southern California. The laboratory will be used to test instruments of the type expected to be installed in U. S. space ships bound for the moon. It will also perform other simulated missions in support of future lunar landings.

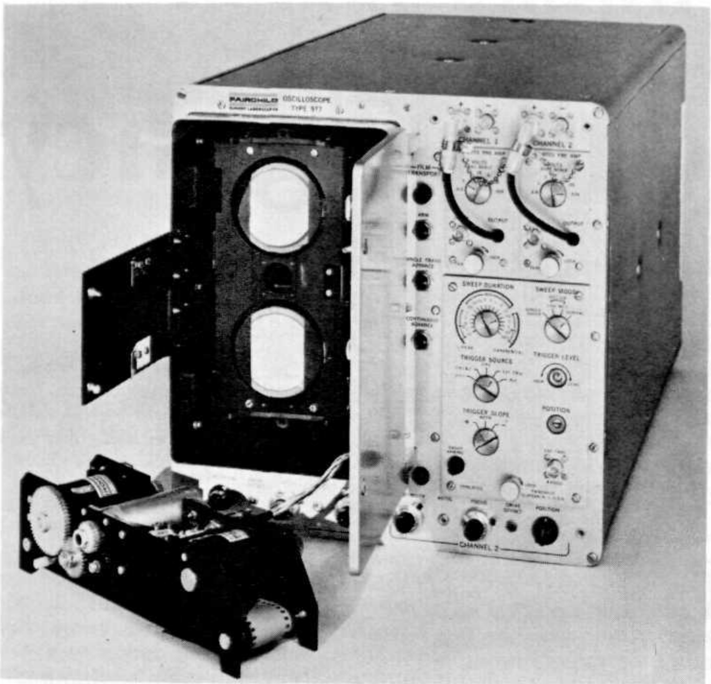


Laboratory technicians who work with minute mixtures in industry's research and development have a new instrument that can control flows of critical liquids to a microscope drop a minute. Produced from a stainless steel extrusion (right) this needle valve accurately controls liquid flows. It is made by Circle Seal Products Company, Inc. The stainless steel extrusions are supplied by Allegheny Ludlum Steel Corporation.

Prospective purchasers of accounting machines can look forward to faster and more flexible operation as a result of two significant product improvements announced by Burroughs Corporation. Using a Burroughs machine equipped with the new Automatic Form Alignment Carriage, the operator simply inserts an accounting form in the carriage between a pair of form guides. The machine grasps the form and, by sensing minute performations along its right side, aligns the form squarely to the next open posting position. Elasped time averages slightly over ½ second.

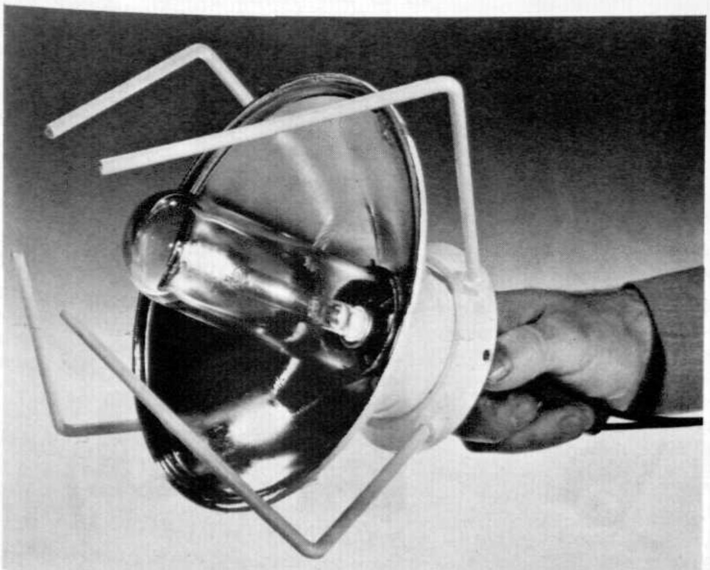


Industrial News



A unique breakthrough in extremely fast wide band transient instrumentation has been developed at Fairchild's Instrumentation Laboratories. These highly refined, ultra reliable, instruments employ two fiber optics cathode-ray tubes. The newly designed, fully compatible film transport mechanisms permits direct recording from the face of the tube. The Fairchild type 977 fiber optics recording oscilloscope represents a true breakthrough not only in reliability, but also ease of use and reliability in catching signal transient recording since the advent of the 24,000 volt cathode-ray tube.

A hardened stainless steel impact pin bent and broke, but the glass sphere didn't even crack as a result of implosion tests on a Corning Glass Works underwater float/housing at the Benthos Company of North Falmouth, Mass. In a pressure chamber, the pressure powered pin was activated by a special disc rupturing at 8300 pounds per square inch, driving the pin into the glass with a force of more than 3000 pounds. Because the glass was under compression, a condition in which it seldom fails, the sphere was barely marred. Circles show thin smears of metal film left on the surface by the high energy of the impacts.



Prototype underwater light design, made by Corning Glass Works for a Perry Cubmarine operating off Andros Island, consists of a quartz iodine lamp protected by a tubular Pyrex brand glass pressure housing. The light has been tested to pressures equivalent to a 22,000 foot ocean depth. Assembly also consists of a glass reflector, sealed lamp base and electrical connector. Metal rods protect the glass assembly from impact. Four of the lights, attached to the outer hull, are being used by the Cubmarine. By changing the lamp, lamp socket and connector, the light design can be adapted for other wattages and voltages.

HOMECOMING DISPLAY

by Thekid

Editor's Note: While in the keypunch room updating the IBM card deck of our subscription list, the keypunch punched out suddenly "GET SOME BLACK HAIR DYE AND A FALSE MUSTACHE." Upon asking the keypunch why, it punched out the tale that follows.

It isn't really my fault that the dorm got flooded, although I should have known that Herbie would have gotten the connections wrong, and I am awfully sorry that Toni got drenched and covered with chicken feathers.

My trouble started when Herbie Wilkes was chosen to head the committee in charge of building Grody Dormitory's entry in the All-University Homecoming Display Competition. While all dormitories, fraternities, and sororities put a tremendous amount of time and effort into their displays, Herbie wanted to make the greatest display of all time. To do this Herbie said he needed "specialists" to handle certain phases of the job: A social chairman to line up a sister dorm and get girls working (which would get our boys working), an accounting major to handle finances, and someone in mechanical engineering to take care of the technical "details." Naturally Herbie chose me to be the unlucky mechanical engineer.

Since our team is nicknamed the "Stalwarts" and our opponent's team the "Ospreys," Herbie's idea for the display was a thirty foot Stalwart dunking a five foot Osprey in a trough of running water ("Stalwarts Douse the Grouse" was the title Herbie wanted for the display). I knew the job would require an awful amount of work, and I would have refused to do it, except that I was going with Herbie's cousin Toni at the time, and I was afraid Toni wouldn't like it if I turned Herbie down.

There were only five nights left to build the display by the time a sister dorm had been lined up and the money gathered. I had, at the expense of falling seventy pages behind in thermodynamics, managed to get some sheet metal for the water trough and an electric motor to move the Stalwart's arm holding the Osprey in and out of the trough. Some of Herbie's minor assistants had gotten the rest of the needed materials, including six bushel baskets of chicken feathers. In Toni's words, the chicken feathers would make the Osprey "absolutely realistic."

The first night while we were building the frame, we had about fifty girls and a hundred-fifty guys willing to work. Unfortunately, there were only tools and room for about twenty to actually work, with the result that fifty girls and a hundred-twenty guys stood around having an informal mixer, while the rest of us built the frame. Still, I was heartened by the large number of people who did turn out, and my night was made worthwhile when Sandy left the group of guys clustered around her for long enough to come over to the display and ask me how the work was coming.

The second night, while we were using chicken wire to cover the frame and mold the figures, we had even more help. There were about three hundred guys from our dorm, a hundred girls from our sister dorm, a hundred more guys from other dorms on campus, and fifty girls from a nearby high school, all on the lawn and street in front of the dorm. Again, twenty of us worked on the display.

By the third evening, Wednesday, we were ready to begin stuffing the chicken wire with crepe paper, and I was hoping that with fifty or sixty kids actually working we could finish this part of the job in a couple of hours, so that I could study for a math hour test that I had to take the next morning. We were just getting started, however, when Herbie came out with a megaphone announcing, "in view of the tremendous progress already made, refreshments are available in the lobby for all workers who want to take a break." This left me with about a dozen workers (mostly freshmen boys afraid to go into an enclosed space like a lobby with girls around). About 9:00 PM Toni came out with a coke for me, talked for a few minutes about the "boss display" we were making, and bopped back toward the good record music coming from the lobby.

By Friday my grades had dropped another full grade-point, and all that remained to be done was the connection of the water and electric motor, and the coating of the Osprey with plaster and chicken feathers. Some of my regular helpers were hooking the hose connections to the trough, others were mixing the plaster and preparing to coat the Osprey, and a group of girls were painting the title on the front with various colors of spray paint. Toni was standing next to me, elegant as a queen in her Levi's and sweatshirt, talking ecstatically about us having the best display in the university. It looked as if things were going to be fine, and I felt pretty good.

Then I saw Herbie standing around doing nothing for the hundred and thirty-first time, and I made the mistake of getting mad. I told Herbie very nastily that he should go connect the water intake and output in the utility room of the dorm. To my surprise he went to do it, although he did give me a dirty look.

By now the only major thing to do was the feathering of the Osprey, and two guys had begun to work on its top and sides. Toni was all keyed up, and she hopped into the water trough and began putting feathers on the bottom. I stood back and savored the thought that my work was almost done.

Suddenly water started pouring into the trough! Herbie, who had been goofing off so much that he didn't know exactly what stage the display was in, had thought I wanted him to hook up the water and turn it on! I yelled for Herbie to turn it off, most of the people standing around just yelled, and Toni just stood there watching the water splash around her shoes.

Herbie, startled by the sudden commotion, ran outside and stepped right on the switch controlling the electric motor, and turned it on. With a whir the large figure's arm moved downward, pushing the Osprey and Toni down into the trough. Four or five of us finally moved to try to get Toni.

After we had rescued Toni, screaming, wet, and feathery, I stood in front of the display watching the water pour through the trough, and the huge Stalwart dipping the sloppy mess of an Osprey in and out of the water. Then, shook, I walked slowly into the dorm and saw the final tragedy. Herbie, being Herbie, had neglected to fasten the drainage hose in the sink, but had instead left it lying on the floor. An inch of water was flowing down the corridor from the utility room to the lobby.

So now Toni's given me back my pin, Herbie hates me, two dorms full of kids think I'm a complete incompetent, the university has threatened to remove my IBM card from the file of student enrollment, and I'm hiding from all of them in this keypunch machine. Please, if you can get a false mustache and some black hair dye, leave them on keypunch number five late some night. A guy can get very lonely with only a card reader to talk to.

EXTENSION OF THEOREM
CONTINUED FROM PAGE 40

P_n. Let P_1 be parallel to the intersection of E^n with $E_1{}^n$, the coordinate n-space spanned only by the first n axes. Consider a hypercube in E^n whose length L is in the direction P_1 and whose extent in each of the other (n-1) dimensions is in the direction of the other orthogonal axes $P_2 \ldots P_n$. Any of these axes can be chosen to be coplanar with the $(n+1)^{th}$ coordinate axis which spans E^{n+1}, but one must be chosen, and the choice must be adhered to consistently. Let us have P^2 coplanar with this $(n+1)^{th}$ axis, and let the extent of the hypercube C^n in the direction of P_2 be its width W.

Now introduce a new n-space, E^{n*}. Span it with a coordinate system of n orthogonal axes P_1', P_2', P_3', ... P_n'. Let P_1' be parallel to P_1 and then let us have P_2' parallel with the $(n+1)^{th}$ axis.

The hypercube C^n will project onto both E^{n*} and $E_1{}^n$. Both projections will have length L. Then the fact that the theorem is valid for the case of one less dimension can be used to show at this point that the theorem is true for this case, in the special case of projection onto only two n-spaces.

Now take the projection of C^n onto E^{n*} and reproject it in turn onto the other n coordinate n-spaces. Let the width of the projection onto E^{n*} be W**; this width will be invariant under these reprojections onto the n coordinate n-spaces which include the $(n+1)^{th}$ axis among the axes that span them. Once again we apply the fact that the theorem is known to hold for one lower dimension. Then multiplying by the invariant W** and substituting, we find that the theorem holds in full generality for the general case of $n=(k+1)$.

Then, under the axiom of mathematical induction, the proof is complete.

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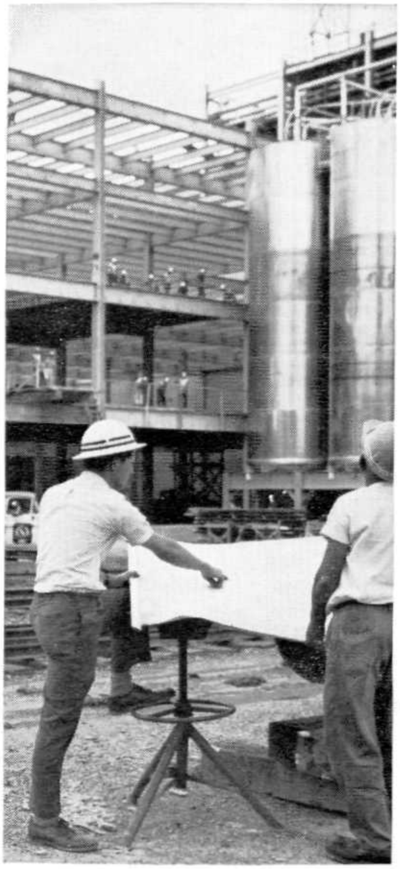
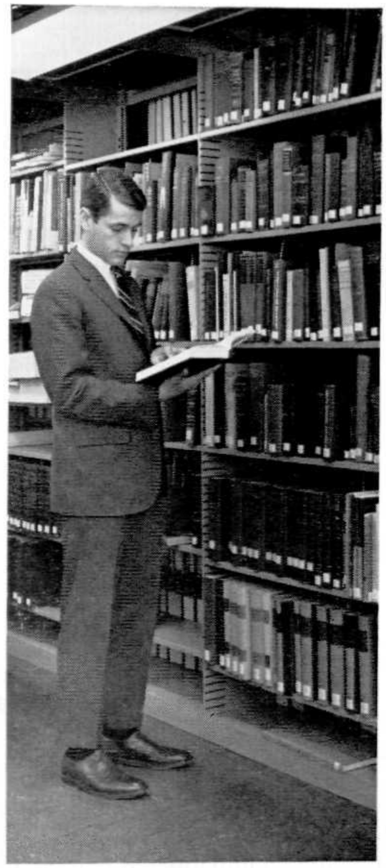
JOHN



some chemical engineers prefer to work like this...



and some prefer it like this

—we'll promote them both

You can talk to some of our chemical engineering bigwigs and come away with the impression that a man who has not yet forgotten everything he learned in freshman calculus is an impractical theorist and a shirker. (Your impression would be wrong. He doesn't mean that at all. Bessel functions were his meat at one time.)

Others of our boss chemical engineers will sound as though it is no longer decent for an educated professional to look inside a reactor personally. (He neglects to tell you how hard it was to give up a grand time as an apprentice steamfitter to enter college.)

Observe, then, that both of these types have risen to bigwigdom. It takes all kinds to run an outfit like ours. The chap who applies new directions in the solid state theory of catalysts to knock a nickel off the tankwagon price of a monomer deserves reward comparable to that of the grimy one who cuts a plant's downtime in half by relocating the filters so that the pump motors quit burning out.

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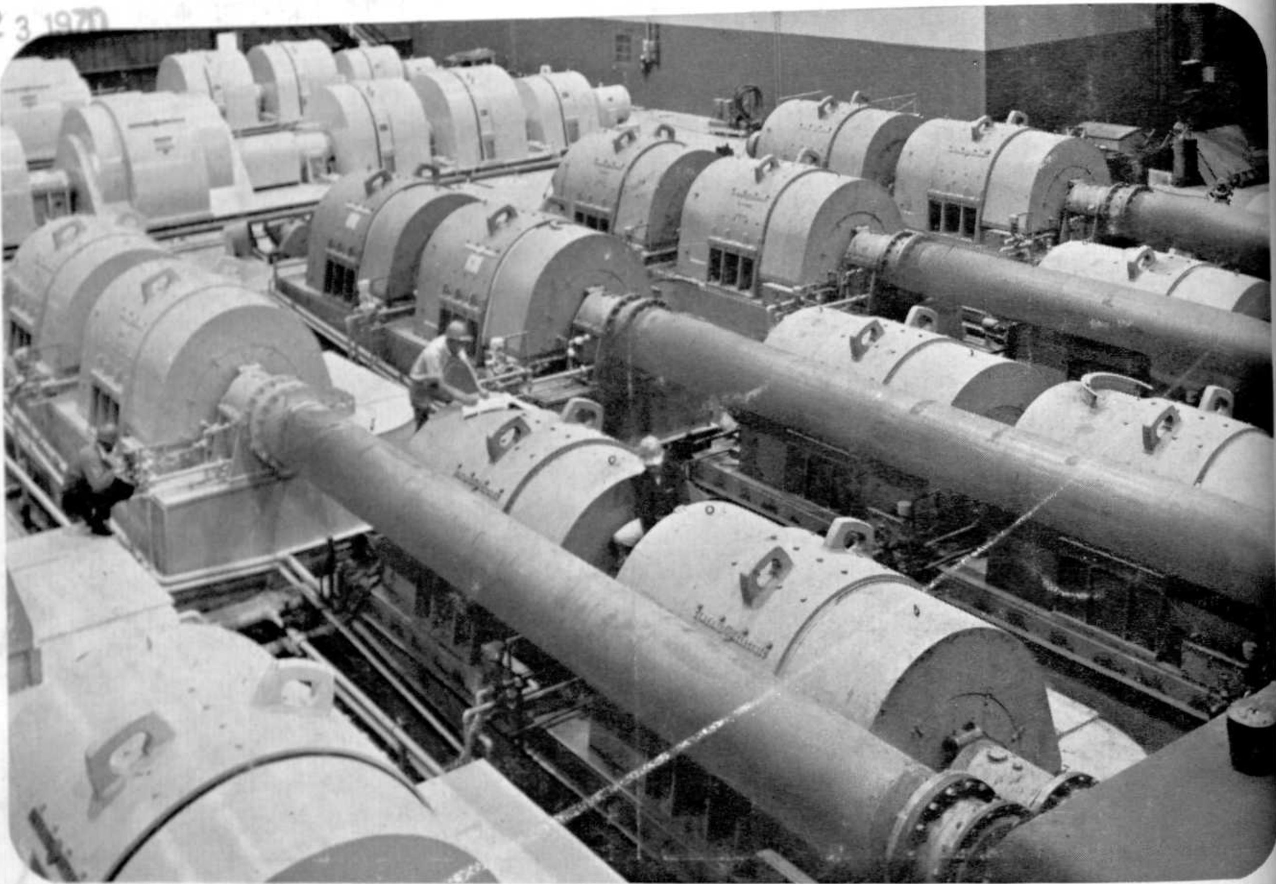

DRIVE POWER by General Electric: one section of Bethlehem Steel Corporation's new mill at Burns Harbor, Indiana.

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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