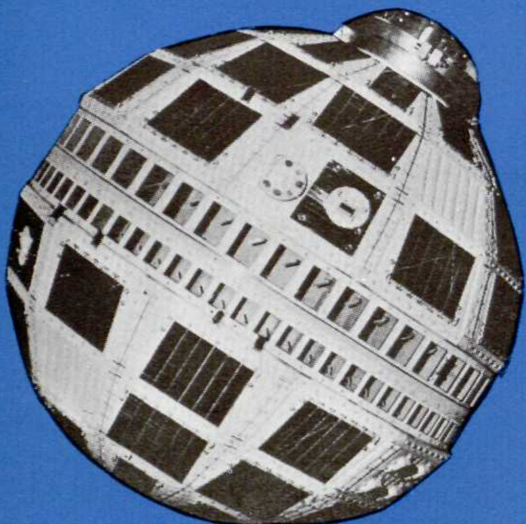
may, 1963

spartan ENGINEER

25¢



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Spartan Engineer

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Dean's Letter

OUR SENIORS have just completed their parts in the annual hunt for college ivory—the campaign conducted by U. S. industry to guide the potential engineering graduate into the profession. This year, as for several past, has seen our campus attract representatives of more industrial companies and governmental agencies than visit any other institution in the state.

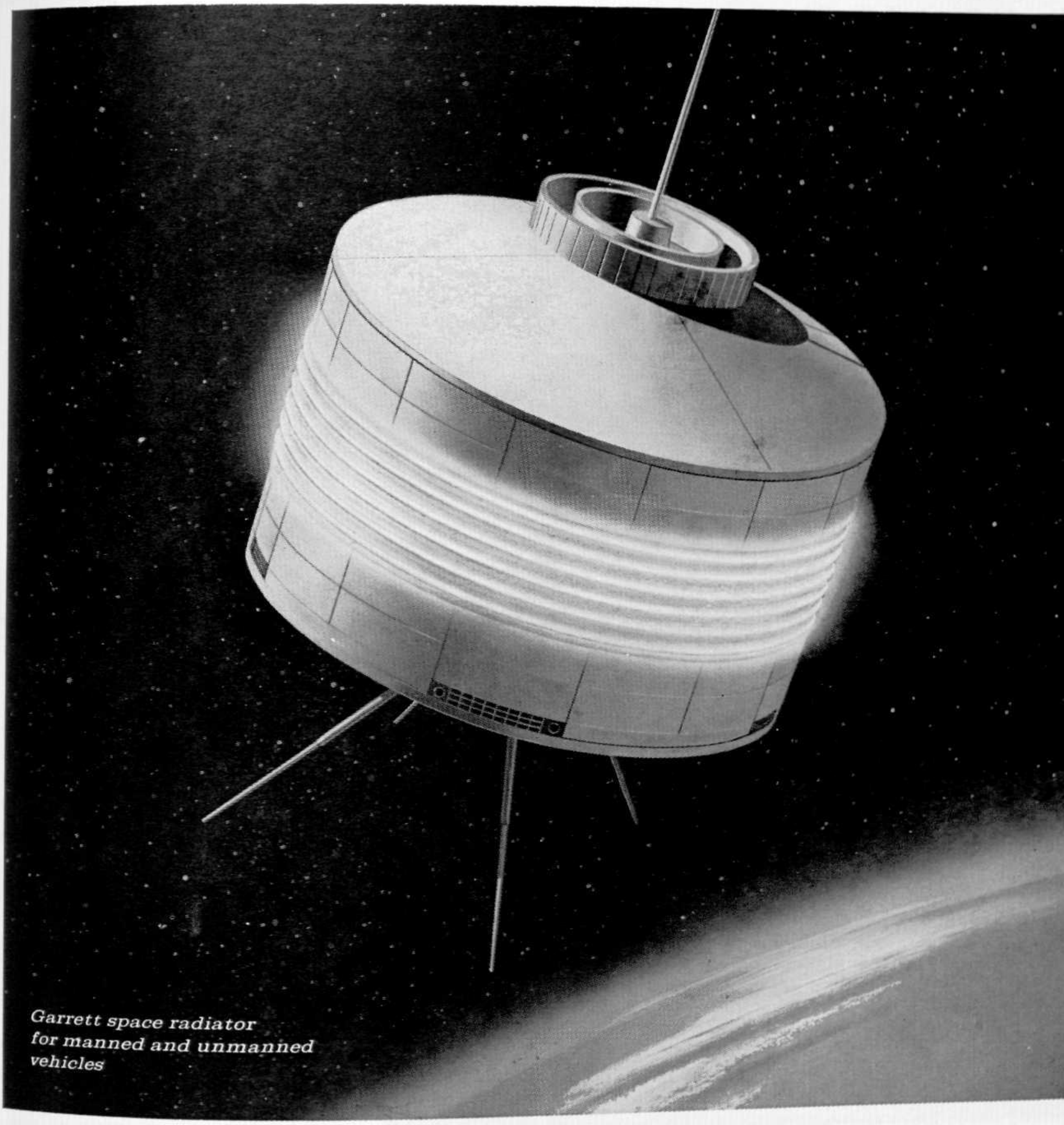
What do these men look for in the seniors they interview? We believe the foremost quality desired is "teachableness," or a willingness and ability to continue the learning process. How do they measure this quality? Certainly the first quantitative criterion applied is that of the student's grade-point average. A good average is at least an indication that he has learned in the past and should be able to continue the learning process in moving into our technical profession in the future. Interest in possible graduate study, in company-sponsored technical and business training programs, in the technical advantages offered by the geographical locale of the company's operations, all demonstrate to the ivory-hunter that a senior wishes to continue learning.

A good point average, however, is not all that is desired by the interviewer. After assuring himself of academic abilities, he next looks to personality, appearance, responsiveness, ability to speak. The interviewer knows that these qualities, not too well measured by the point average, have a major bearing on the future of an engineer—he must work with and supervise others—will he be a smooth-working member of the company team?

Many of these latter capabilities are present in a student before he even arrives on our campus as a freshman, and we must admit that often we only offer opportunity for exercise and polishing of these qualities. However, we would like to point out that the point average is the ticket of admission to the interview room—without this a graduate has lessened opportunities to demonstrate his other winning qualities or personality.

And even though such a mundane subject as salary should not enter, a good point average *has* been known to put more beef in the salary offer, which usually leads to more beef on the table at meal time.

J. D. RYDER



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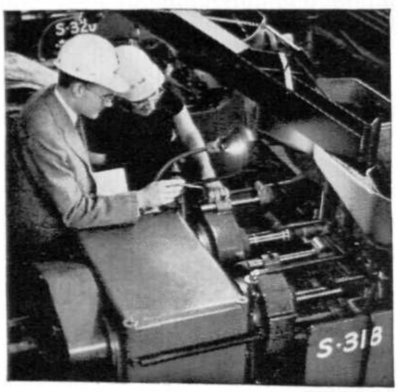

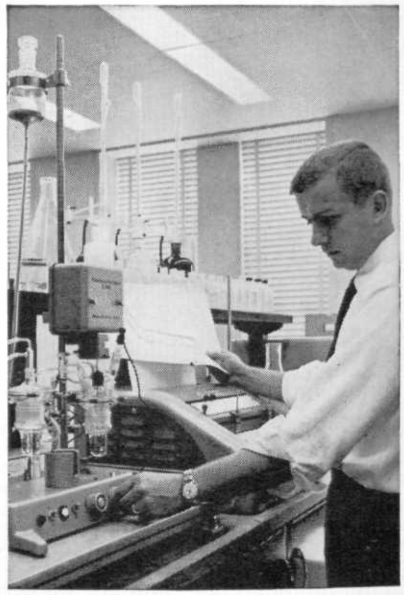

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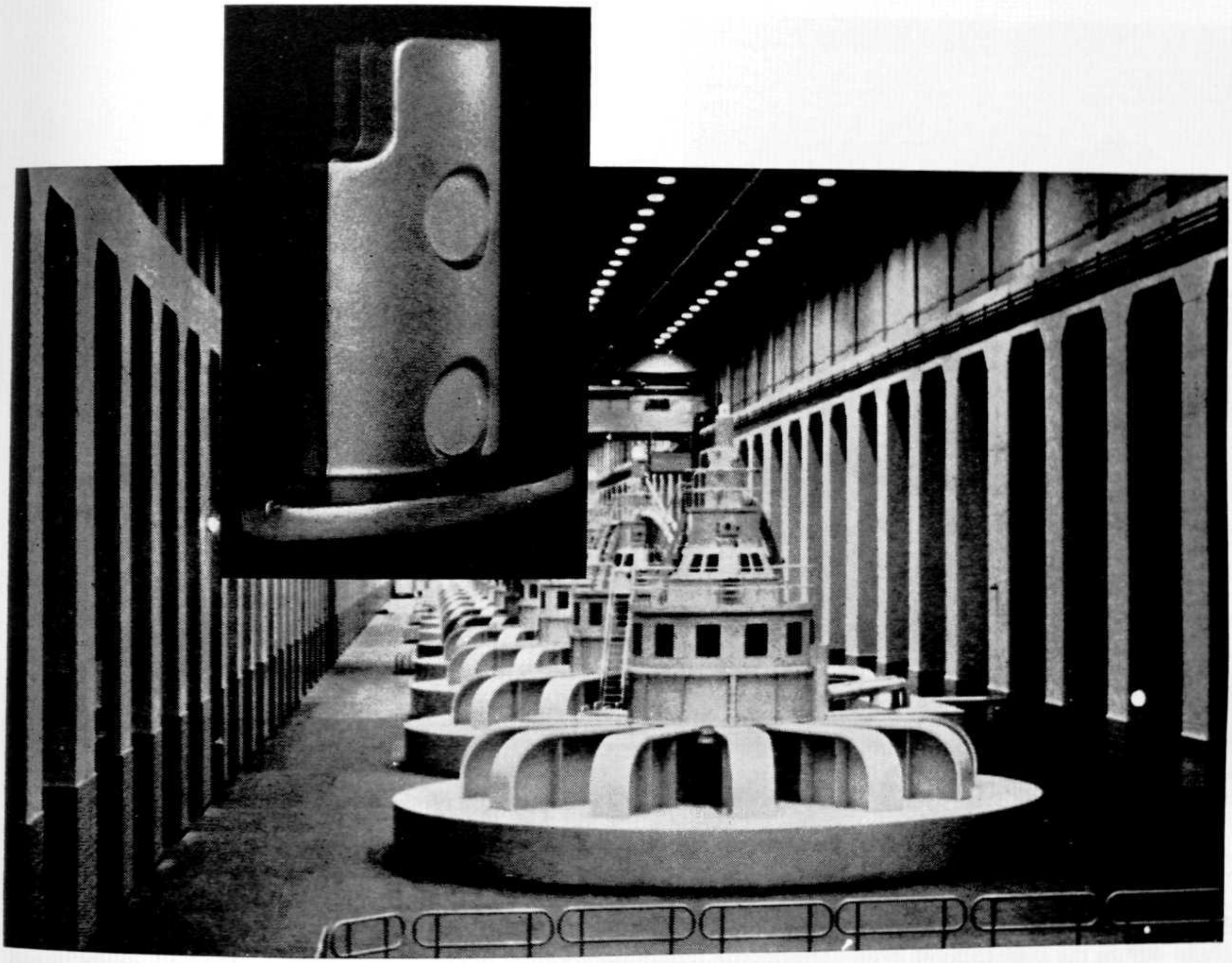

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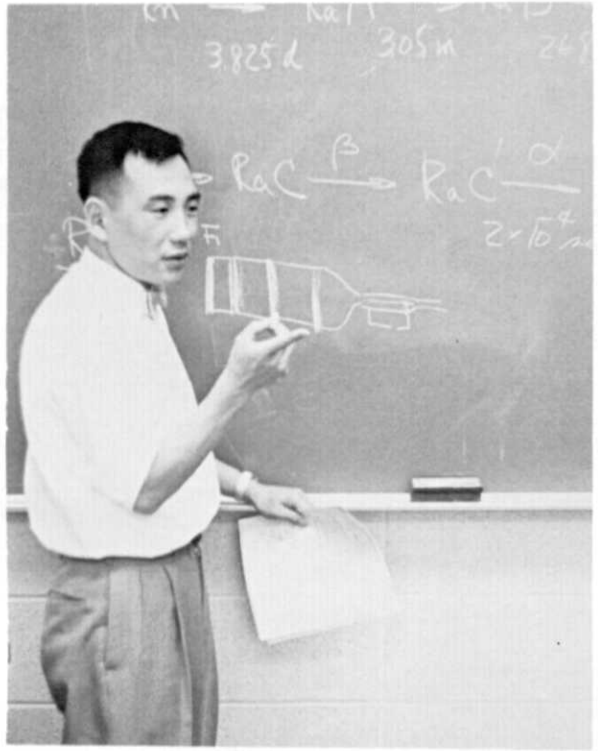


Dr. Shosei Serata

FACULTY REVUE

by John B. Locke

It is not at all unlikely that Dr. Shosei Serata's personal experience during the atomic bomb drop on Hiroshima greatly influenced his current interest in radioactive materials. These interests involve research on environmental radiation and the safe storage of highly radioactive wastes in underground formations.

Dr. Serata, now an assistant professor of civil and sanitary engineering at MSU, began his education in Japan. He spent six years of study in colleges in Japan and received his Masters degree in civil engineering from Kyoto University in 1952. In the next year, he came to the United States and studied at the University of California at Berkley for four years to receive another Masters degree for sanitary engineering. In 1959, Dr. Serata was awarded his doctorate in civil engineering from the University of Texas.

Utilizing this educational background, Dr. Serata is presently engaged in two research projects. One of these is the study of the stress field of underground formations, a project related to the underground disposal of high-level radioactive wastes. This study has been sponsored by the National Science Foundation since September of 1961. The objective of this project is the possible use of salt beds deep in the earth to store radio-active wastes. Salt beds are likely spots because of their high thermo-conductivity and since the salt within these deposits is in a plastic state. This is caused from three-dimensional compression. The viscosity of the salt will allow it to fill in and seal up any cracks or fissures which might occur and prevent the radioactive vapors from escaping. Also, these depositories are economically made. The importance of a project of this sort is impressed by the fact that in 40 years, about a billion gallons of radioactive waste will have to be dealt with.

The second of Dr. Serata's research projects involves environmental radiation. This includes radioactive fallout in the atmosphere and rain water, cosmic rays, radioactivity in milk, etc. Along with six graduate students under him, Dr. Serata is trying to discover all the means by which this radioactivity may reach the human body. This presents a new branch to the engineering field: that of "bio-engineering," or the study of environment in relation to human health. In connection with this, Dr. Serata is looking for radiation biologists to aid in the teaching of courses and research.

Dr. Serata noted many differences between students in Japan and those in the U.S.: "Students here in the United States are very conservative, secure, and relaxed instead of the riots and revolts which are present in Japan." He also found a difference in the type of curriculum offered to the student. Japan's system is based on the complete control of the student and each one must take all of his courses in a certain department. Japanese students are not allowed to add subjects from other departments. Here, on the other hand, an engineering student might be carrying courses from the engineering department and simultaneously taking classes in chemistry, math, or English. Dr. Serata stated that MSU should be very proud of its progressive curriculum and he hopes that other countries may follow our example.

Little did Dr. Shosei Serata realize that day almost 18 years ago that someday he would be working for Japan's wartime enemy. Research into finding a safe method for disposing of radioactive waste from nuclear power plants was the furthest thing from his mind then.

He was just 16, and serving at the Japanese Naval Academy on an island about 10 miles south of downtown Hiroshima. It was 8:15 a.m. August 6, 1945, a clear and very warm summer day in Japan. The sky was peaceful until they heard the drone of the American B-29 bomber.

But that was routine. The B-29's were flying overhead almost constantly. Most major Japanese cities were already reduced to rubble by conventional bombs. However, this would be a day the 33-year-old scientist would never forget. This B-29 was special. It was carrying a death-dealing package. Its target: Hiroshima.

Dr. Serata, then a slightly built lad with dark hair and eyes was in his first hour class in an academy building. "We were thinking about fighting to the last man; that we were right and America wrong," he recalled. "We had no doubt we would be the eventual victor. We were very young. The B-29 was very high in the sky and fast. We couldn't see it. We heard it though, which was quite normal and usual."

Ten miles away the bomb was dropped from the belly of the huge plane, spelling out death for 78,150 persons. Another 13,083 would be missing forever and 37,425 maimed and injured. History was in the making.

"It was just like someone taking a flash picture in front of your face," said Dr. Serata. "The room filled with a blue light. We didn't do anything. We thought maybe some transformer by the window exploded. Then about 20 seconds later the shock wave hit the island, the whole building shook and we heard the explosion. We thought the bomb was dropped by the open window."

The boys were herded out of the building by the instructor and into an air-raid shelter. "We were quiet," he continued. "Nothing happened. We came out of the shelter about 15 minutes later. We saw this high flying atomic cloud directly overhead. It was beautiful. We went back to the class. In the morning we heard a lecture and in the afternoon we had physical training, mainly digging holes to meet the American landing."

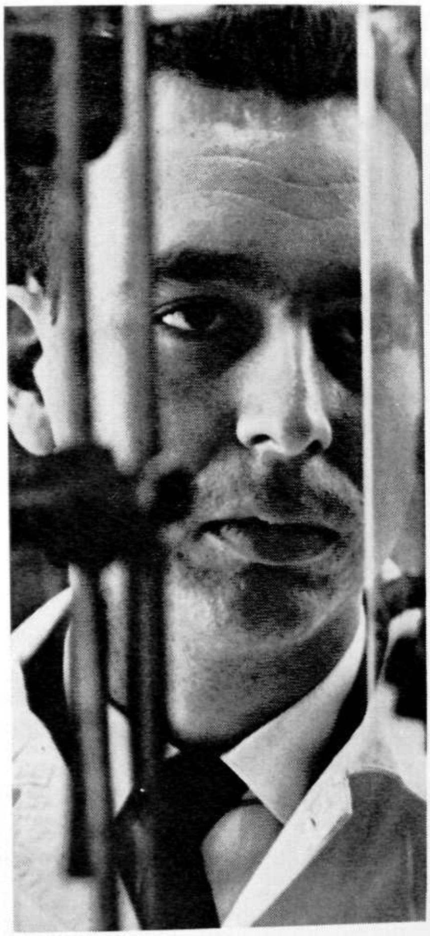
A large hill protected the naval academy at the north end of the island and blocked out the view of the port of Hiroshima. "At night the whole sky over the hill and toward the city was a bright red," he recalled. "For three days and nights we saw this red color in the sky. We figured it must have been a big bomb that was dropped."

What happened at Hiroshima was not revealed to the boys at the naval academy. They learned for themselves when they were sent on their way to their homes. The only indication they had that something was wrong was when they were issued white linen sheets with eye holes to carry with them. They were instructed to cover themselves with the sheets and run to the shelter if the air mass shifted toward the island.

Again on August 9, 1945, another atomic bomb was dropped, this time on Nagasaki where 73,884 were killed. Japan surrendered August 14, 1945.

Instinct told Dr. Serata the end was near for Japan. Fear gripped him. He remembered the propaganda sessions. Americans would come and assault the women and kill the men. He was just a boy. When he did see the first American occupation forces, he was surprised. They were nothing like they had been told. In fact, he explained, they treated the people better than their own army had. Two weeks later they were on their ways to their homes. They landed at the port of Hiroshima. Homes there were twisted off their foundations. They walked for a half-day toward the center of the city and the railroad station.

"The smell was terrible. The center of the city where the destruction was worst, everything was burned or melted," he said. The railroad station was destroyed along with the rest. They sat on concrete blocks for the rest of the afternoon. For several months after that, Dr. Serata was ill.



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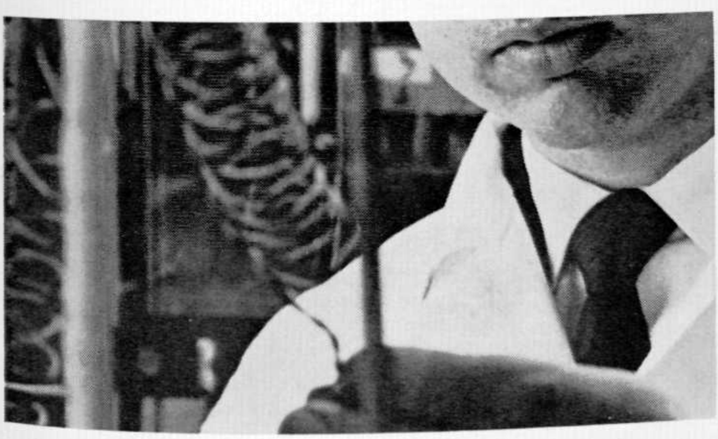

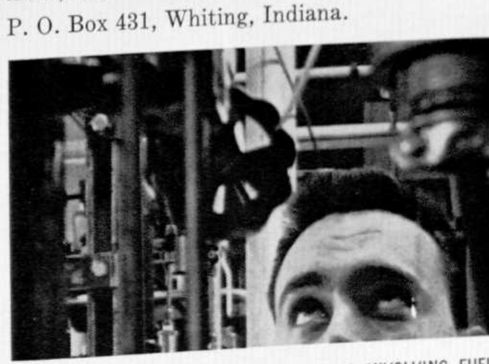

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DIFFRACTION

edited by John Callahan

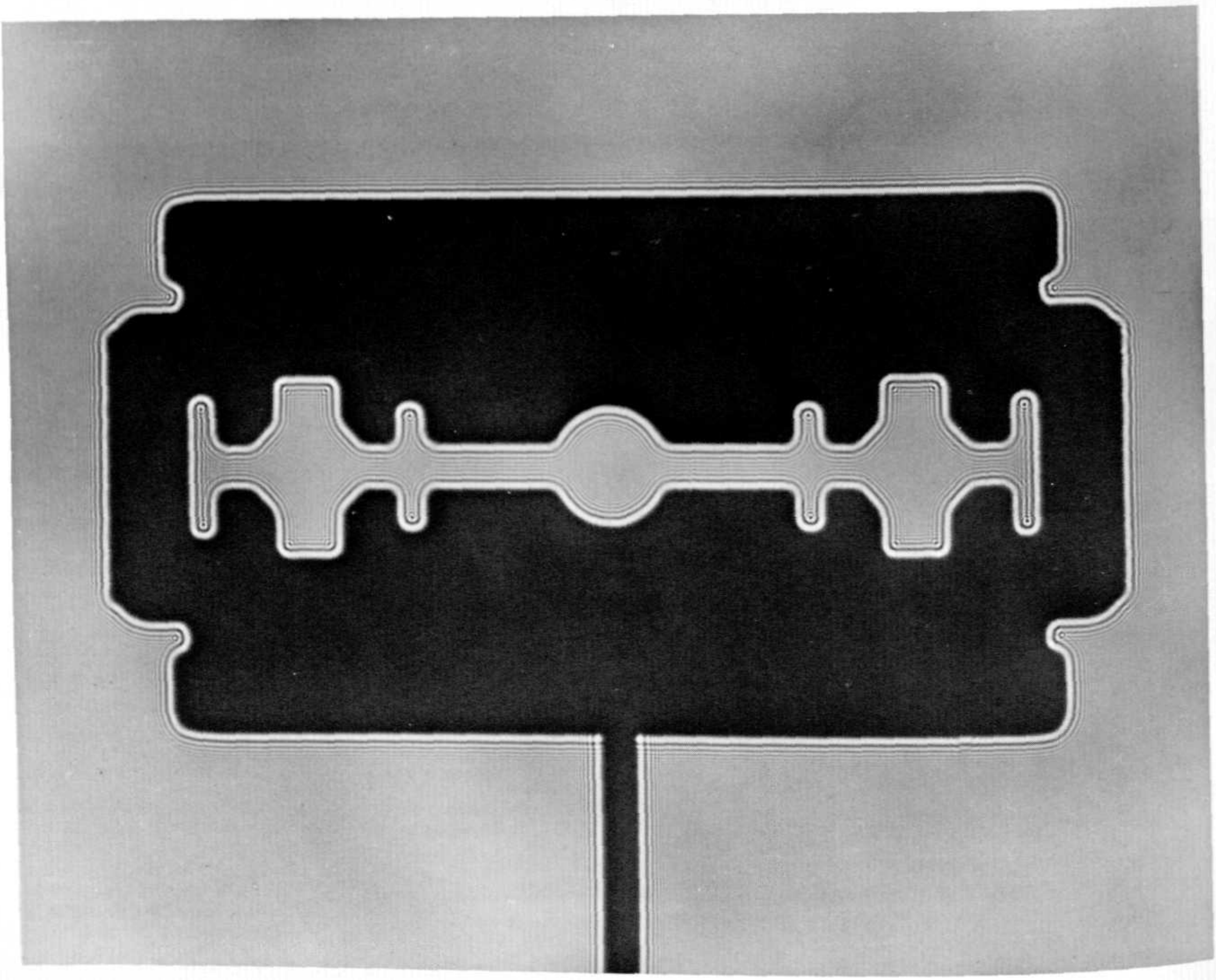


Fig. 1. The diffraction of light around the fine edge of a razor blade.

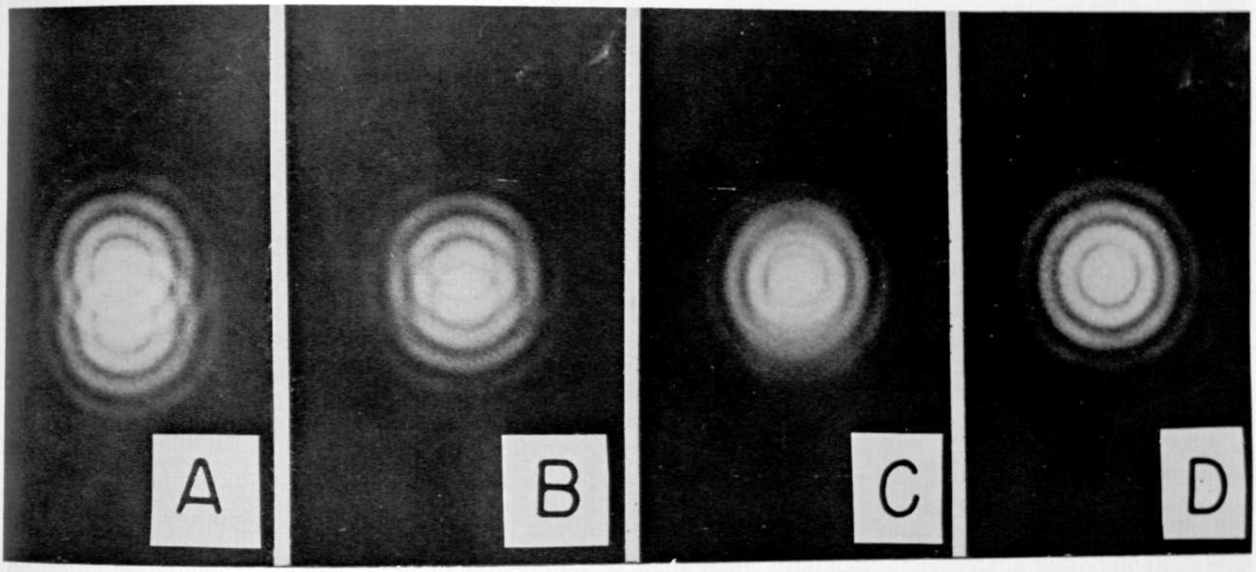


Fig. 3. Diffraction patterns produced by two disks which are approaching each other. When the centers are less than one radius apart, as in C, it becomes impossible to determine whether one or two disks produce the diffraction pattern.

Diffraction is sometimes defined as the bending of a light beam around an obstacle placed in its path. This definition is a good place to start because it emphasizes that the basic postulate of geometrical optics -- that is, that light travels in a straight line in a homogeneous medium-- is not enough to explain the behavior of optical systems completely. On the other hand, the bending is not just a change in direction, and a better definition might be the more general one that diffraction is the effect produced by limiting the extent of a wave front.

The simplest way to observe the phenomenon is to introduce a knife - edge between a point source of light and a screen, and then examine the edge of the shadow closely. When this is done, not only is light observed in the shadow area, but the illumination at the edge appears as alternate fringes of light and dark. The diffraction fringes appearing around the shadow of a razor blade are shown in Figure 1.

If, instead of inserting a knife-edge into the beam, we insert a circular aperture, diffraction takes place all around the edge, and the distribution of light passing through our aperture is found to consist of a bright center core of measurable size, surrounded by luminous fringes.

Optical scientists differentiate between two types of diffraction, called Fraunhofer and Fresnel diffraction, depending on the location of source and screen, but this is not important for our present purposes. What is important is that any lens with a finite aperture limits the wave fronts passing through it, and thus optical images consist of diffraction patterns. The typical diffraction pattern formed when a lens images a point source is shown in Figure 2. Since this pattern is generated in the lens, even an infinitely small luminous element will be imaged as the finite pattern we see here. It will pay us to examine carefully both this pattern and the notion of imaging a luminous point, since both are very important in image evaluation.

In the first place, we can consider object space to be an array of luminous points, differing only in their luminance. If this is so, then by determining the manner in which the lens images one point, we can specify the performance of the lens -- simply because there are nothing but points in object space. This is the concept which lies behind the use of the modulation transfer function, which is now so widely accepted as a measure of lens performance.

Actually, lens-makers have understood this for a century or more, and have tested their lenses by studying visually the images of luminous points. The essential difference between this "star test" and the transfer function is only that the latter is an analytical expression of the intensity distribution in the point image, and this needs no discussion here.

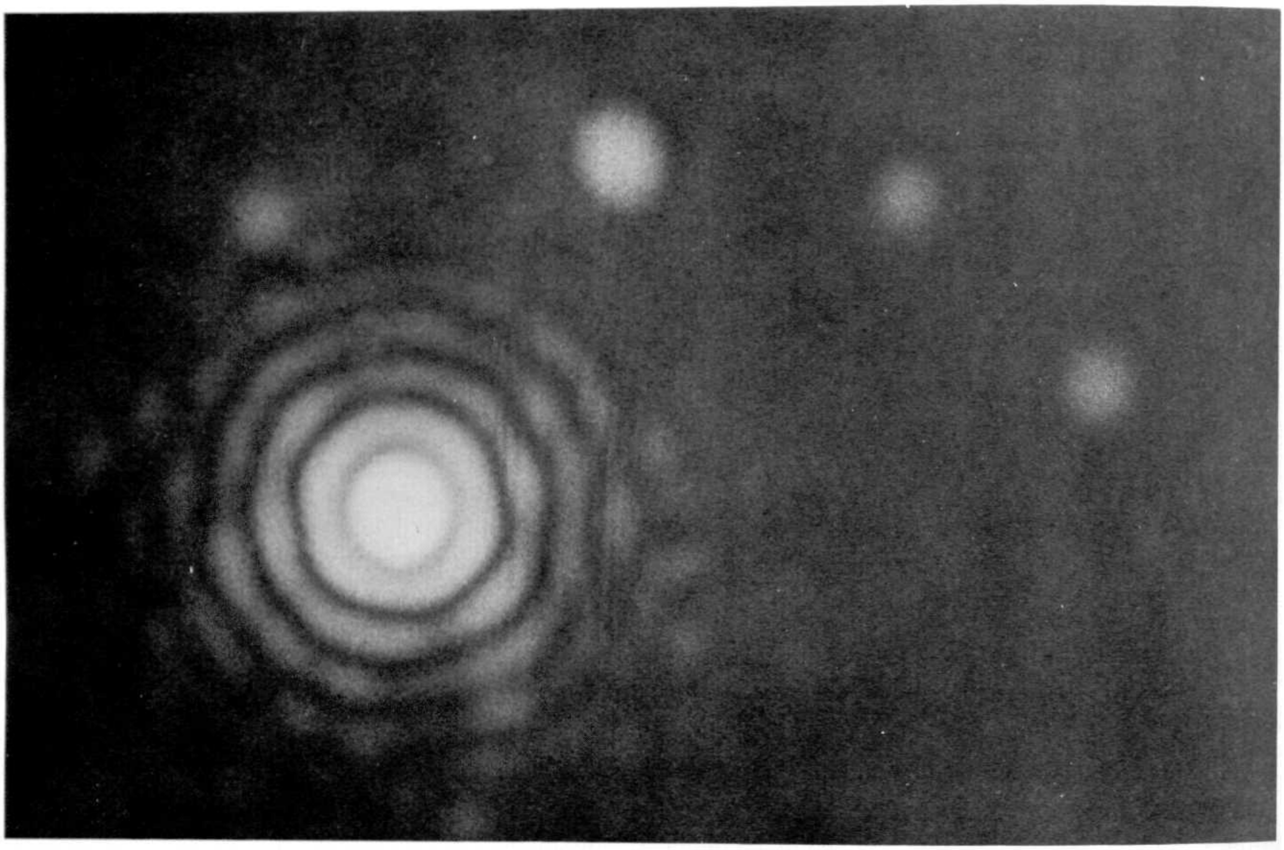


Fig. 2. No lens can form a perfect image.

But if the point image describes the performance of the lens, what can we say about the imaging properties of lenses? Immediately, it is apparent that, because of diffraction, no lens can ever form a "perfect" image, if by perfect we mean that a point in object space is reproduced as a true point in image space.

Instead, the best which can possibly be done is to image the point as a diffraction pattern. By convention, when we talk about "perfect" lenses, we mean lenses in which this level of performance has been reached. If the lens is less than diffraction limited, the disk of light in the star image becomes even larger, and often departs markedly from circular. In fact, even in lenses which are diffraction limited on axis, the star image is generally degraded from the diffraction pattern elsewhere in the field.

The size of the diffraction disk can be calculated, and the result is to be found in all optics textbooks. The calculation was first carried out in 1834 by a Cambridge professor named George B. Airy and for this reason the pattern is often called an Airy disk.

For our purposes, the result of the calculation is most conveniently written in the following form:

$$\underline{r} - 1.22 \quad (f/d)$$
$$- 1.22 \quad (\underline{f}\text{-number})$$

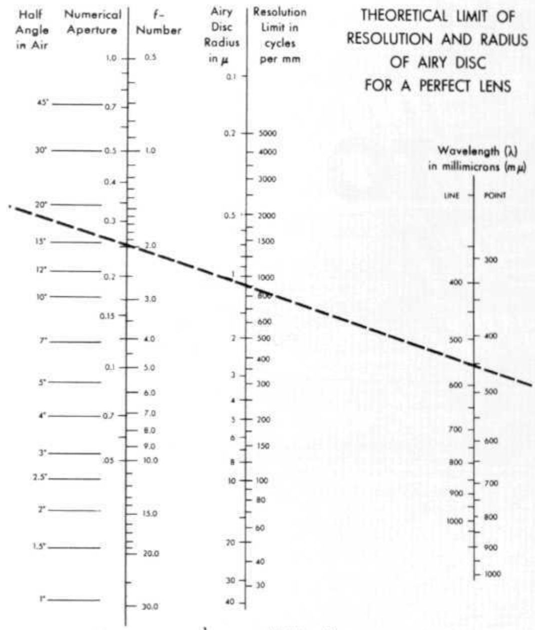
Where r is the radius of the central core of the pattern and is the wavelength of the light, f is the focal length of the lens and d is the diameter of its entrance pupil, so that the quantity f/d is the f-number. The central core of the pattern contains nearly all the light -- 84 percent, to be exact -- and for most purposes we can ignore the fringes.

We have now to examine the practical consequences of this well-known formula, remembering that the larger the diffraction disk, the further is the image from being an exact reproduction of the object. Two principal results are immediately apparent. They are, simply, that the size of the Airy disk is increased either if the wavelength of light is increased or if the lens is stopped down.

This means that optical images should preferably be formed with light of short wavelength. Microscopists have done this for many, many years, but for most other types of optical systems, the use of blue and ultraviolet light is not particularly practical.

The other result indicated by the diffraction formula is that for best results a lens should be used at maximum aperture, that is, with the smallest f-number possible. Whether or not in practice the best images will be obtained at maximum aperture, depends on the type of optical system and type of imagery involved.

In practical photography, the effects of diffraction are probably not very important. In the first place, most commercial photographic lenses are designed so that at maximum aperture they are no longer diffraction limited, and the star image is an enlarged



$$\text{Numerical Aperture} = \frac{1}{2(f\text{-number})} = \sin(\text{Half Angle})$$

$$\text{Airy Disc Radius} = \frac{1.22\,\lambda\,(f\text{-number})}{10^3}$$

$$\text{Resolution Limit in cycles/mm} = \frac{10^6}{\lambda\,(f\text{-number})}$$

Fig. 4.

blur. This is done because the extra speed is generally well worth the image degradation entailed. However, it does mean that most photographic lenses will improve on being closed down a stop or two, until the image actually becomes diffraction limited. Further stopping down will then degrade the image, but even this is not important. In the first place, further stopping down improves the depth of field and may improve the flare characteristics, both of which will appear to make the final picture sharper. And in the second place, for most practical purposes the size of the Airy disk even at minimum lens aperture is still small compared with the useful detail. For these reasons, the effects of diffraction are not usually important in photography if the negative is 35mm size or larger.

Where the imagery of very small detail is important, then diffraction also becomes important. The time-honored measure of the ability of an optical system to image tiny detail is its resolving power, which is properly defined as the ability of the system to image as separate two luminous points which are closely adjacent. Since each of the points will be imaged as a disk of finite size, if they are moved toward each other the images merge before the points do. This is another phenomenon which is illustrated in all optics textbooks, and Figure 3 has been reproduced from "The Principle of Optics" by Hardy and Perrin, with the kind permission of the authors and McGraw-Hill. You can see that in the third pair it becomes impossible to tell from the image whether or not the object was a pair of points. The limit of resolution is reached when the center of one disk coincides with the edge of the other; that is, the centers are separated by a distance equal to one disk radius. This criterion was suggested by Lord Rayleigh and is often called the Rayleigh limit.

The reciprocal of this distance is called the resolving power of the lens. Nowadays, resolving power is out of fashion for the quite good reason that its indiscriminate use for all sorts of imaging problems led to wrong answers. Within its limits, however, resolving power is still a useful index of the ability of a lens or optical system to handle small detail. It is therefore of interest in such fields as microscopy and microphotography.

For a given wavelength of light, the resolving power is readily calculated from the diffraction equation. However, in fields other than astronomy, it is customary to replace the luminous points with luminous lines, and the diffraction equation corrected for this case is r - (f-number). The critical distance is now merely times the f-number. Assuming that the wavelength is 1/2000mm, then the resolving power, 1/r, is at once 2000/f-number, in lines per millimeter. Also, since the numerical aperture is approximately one over twice the f-number, the resolving power of a microscope objective is 4000 NA, also in lines/mm.

Calculations like this are useful for rapidly estimating the ability of an optical system to handle a particular task. To facilitate them, my colleague R. L. Lamberts has devised a nomogram (Figure 4), which enables the size of the Airy disk and the resolving power to be read off with a straightedge. A similar nomogram for micro-objectives has been published by Richards of American Optical.

BROOKLYN TO STATEN ISLAND

This striking view shows the sweep of the 20 foot wide catwalks, dramatized by the late afternoon sun, which also silhouettes a cargo vessel passing through the Narrows.

Take 145,000 miles of pencil-thick galvanized steel wire weighing more than 38,000 tons, add such ingredients as a milewide body of water, two towers nearly 700 feet high, catwalks, anchorages, eye-bars, floating-sheave towers, spinning wheels and tramways, mix well with experience and skill and you have the recipe for spinning the four main cables of the Triborough Bridge and Tunnel Authority's new Verrazano-Narrows Bridge.

Arranged in pairs, the 35 7/8-inch-diameter cables each will stretch 7,205 feet from the east end of the new bridge in Brooklyn to the west end on Staten Island, and will support the weight of the world's longest suspension span, 4,260 feet across the Narrows, plus two 1,215-feet-long side spans and the millions of vehicles the bridge will carry.

Spinning the cables is a big order, even for the experts of United States Steel's American Bridge Division, a company which has in recent years spun the cables for such world-famous suspension bridges as the Triborough, Bronx - Whitestone and the Throg's Neck, all in New York; the San Francisco-Oakland Bay; the Delaware Memorial near Wilmington; the Walt Whitman in South Philadelphia; and the Mackinac, which connects Michigan's Upper and Lower Peninsulas.

As it assembled an impressive array of spinning equipment to fill this order, American Bridge constructed two 20-foot-wide catwalks from one end of the suspension bridge to the other. These skyhigh platforms for the spinning crews are complete with handrails, communications systems and tramways to carry the spinning wheels.

The spinning equipment itself--doubled in quantity because there are four main cables in the Verrazano - Narrows Bridge instead of the two usually found in a suspension bridge -- consists of the following items:

Four sets of racks for reels of the .196-inch-diameter bridge wire; four "compensating" floating - sheave towers, containing moving pullies and counterweights which help maintain a constant tension on the wire; eight spinning wheels; and four endless steel haulage ropes, driven by diesel engines and carrying two spinning wheels each.

Considering only one of the four cables, here is what happens during the spinning operation: At each anchorage, two wires are drawn from their respective 24-ton capacity reels, threaded through the compensating towers, attached to steel eye bars imbedded in the anchorages, and looped around the double grooves of the four-foot-diameter spinning wheels. The diesel engines then start moving the endless haulage rope, which in turn pulls the two spinning wheels towards each other from the opposite ends of the bridge on parallel paths along the tramway system above the catwalk.

As it moves up the catwalk from the shore to the top of one tower, from the first tower down over the middle of the catwalk spanning the Narrows to the top of the second anchorage, each wheel is carrying two ever-lengthening loops of wire which, as they extend and reach the opposite shore, actually become four wires, the top and bottom parts of the elongated loops. Two of these wires -- those fastened to the steel bars at the near shore --are called the "dead" wires and the two being unwound from the reels as the spinning wheels move.

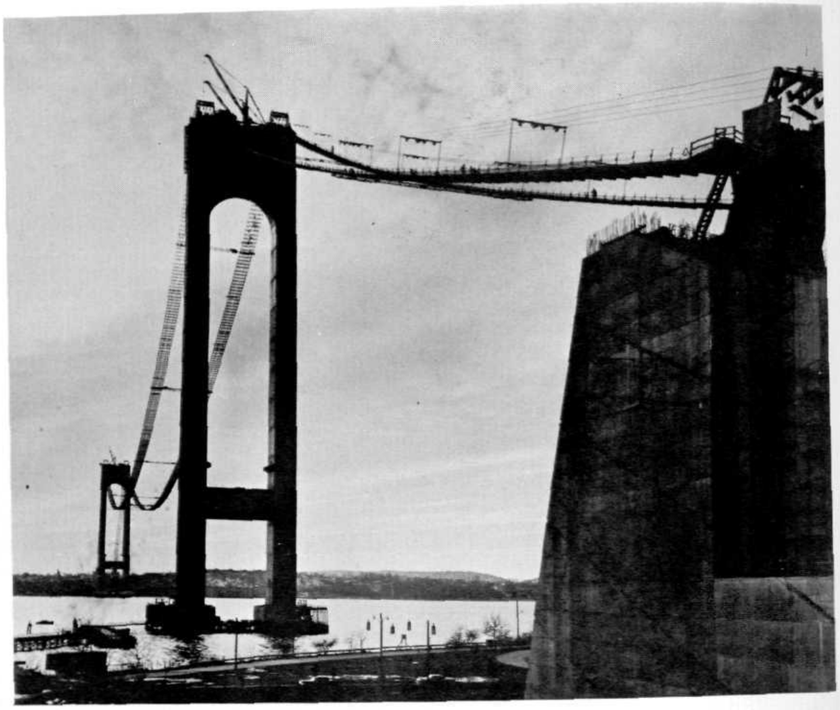
When the spinning wheels reach the end of their 12-minute, 7,205-foot journey, the loops are removed, and fitted around another anchorage connection. For the return journey the spinning wheels shuttle back and each carries two additional loops toward the beginning anchorage.

When the double grooved wheels have made enough trips to form the two halves of one of the 61 strands of wire in each main cable, the leading ends of the two wires are spliced to the trailing ends to make up two continuous "hanks." The two hanks are then bound together to form the strand.

Since two spinning wheels carrying four wires each are operating simultaneously, four strands are being spun at the same time for one cable. Above the second catwalk, a duplicate operation is proceeding. When the two sets of

Continued on page 20

RIGHT – A look at the catwalks used as platforms during cable spinning operations.



Continued from page 18

four strands have been completed, the wheels are set to work spinning the adjoining cables while the finished strands are adjusted carefully to fit the predetermined pattern the cables must follow.

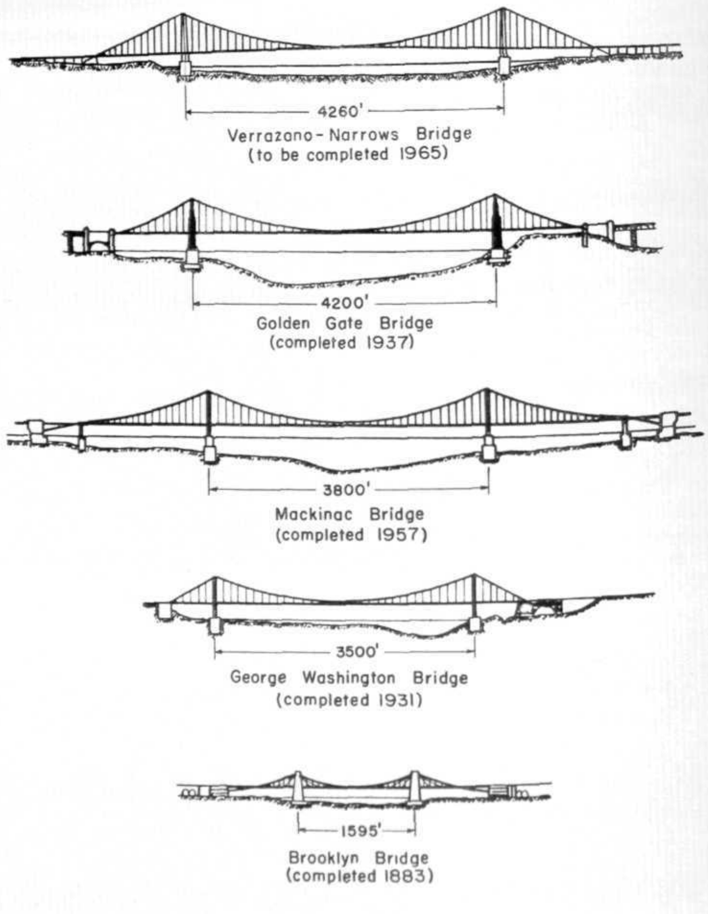
The spinning crews will continue spinning four strands and adjusting four above each catwalk until the six-month-long job is completed--with one exception. Strand No. 37 in each cable will be spun individually as part of the meticulously planned arrangement of strands.

When all 26,108 wires per cable are in place, the cross section of cable will appear as a hexagon due to the arrangement of the strands. Special hydraulically-powered compacting machines will then be used to squeeze them into their final round shape. Stainless steel bands are placed at regular intervals to maintain roundness until a continuous wrapping of additional galvanized wire girdles the cables to insure that their shape remains unchanged despite heat, cold and the varying loads of traffic over the years.

To the average spectator, spinning of the Verrazano-Narrows Bridge cables may seem repetitive and routine as the wheels make their journeys up the side span catwalks, pass each other at the center of the main span, then continue on to their destinations. But to the bridge men it is a constant challenge to make sure that everyinch of those 145,000 miles of wire is in its proper place and doing its fair share of the work of supporting the massive weight of the bridge. And it's a challenge they will be meeting 15 hours a day, five days a week well into the summer of 1963.

MAIN SPAN COMPARISON

World's Great Suspension Bridges



TOP ENGINEER

The outstanding freshman engineering student at Michigan State University last year was -- a girl.

Mrs. Carolyn Williams, 19-year-old daughter of Mr. and Mrs. James L May, 820 Forest, Royal Oak, "outengineered" 549 males and three other females to win the "outstanding freshman" award presented during the recipient's sophomore year by Tau Beta Pi, engineering honor society for men.

A metallurgical engineering major, she earned a 3.89 (out of a possible 4 point, or all A) average last year and was active in the American Foundry Society and the American Society for Metals. She won the Tau Beta Pi award on the basis of both her scholarship and activities.

She has a 3.82 average this year and hopes to pursue further extracurricular engineering activities.

"What," she asks in a soft voice, "does being a girl have to do with being an engineer?"

She liked mathematics and science in high school and chose to study engineering largely on that basis. Her father is a mechanical engineer, but, she says, made no attempt to influence her in her choice. Nor, she says, did her husband, Robert G. Williams, an MSU graduate who is a practicing metallurgical engineer.

A February bride, Mrs. Williams plans to complete her education even though she has married.

She has six younger brothers and sisters. An older brother is also studying metallurgical engineering -- at Henry Ford Junior College.

When -- and she says she hopes it will be some years hence -- she has children of her own, she says she's want to spend time with them but return to engineering when they no longer needed her.

Her "outstanding freshman engineer" award comes to her from a venerable chapter of a venerable society. Tau Beta Pi was founded in 1885 at Lehigh University. The second chapter was founded at MSU in 1892 and is the present Michigan Alpha chapter.

CRYSTALS

edited by John Locke

Quartz out of a can will replace natural quartz crystals in communication equipment for Bell Telephone system.

The synthetic quartz, a product of Bell Telephone Laboratories research, are mass-produced at the Merrimack Valley Works of Western Electric Company, North Andover, Mass. This company, one of the world's largest and first factories to mass-produce quartz crystals for communications purposes, recently went into production on a commerical basis.

This step was the successful climax of more than 50 years of experimentation and research. More important, it meant the end of United States dependence upon a foreign supply of pure quartz crystals. A strategic material, the crystals were in critically short supply during World War II.

Quartz crystals are used in radio and television transmitters, telephone communications, radar and sonar. Previously, the prime source for them was the interior of Brazil, where mining of the fist-sized crystals required for communications is done by individuals on a free lance basis, resulting in unstable supplies and high prices.

While quartz, in a variety of forms, is the world's most common mineral, the pure, colorless crystals required for communications cost about $30 a pound in the natural state.

Not only does the Bell Systems hydrothermal process for growing crystals cost less than a fraction of the price of natural crystals, but the grown variety contains fewer imperfections. Imperfections found even in the best of natural crystals and waste from slicing operations result in a loss of about 97 per cent of the material. This brings the cost of quartz in the final plates used for electronic purposes to about $94 an ounce or $1500 a pound. By comparison, gold costs $35 an ounce.

In the growth of synthetic crystal, dimensions can be controlled and much more of each crystal is usable.

Synthetic quartz crystals have a number of advantages over natural quartz crystals besides availability in any quantity and size. Precise cutting of seeds permits growing the synthetic crystals in configurations that allow more efficient sawing and shaping operations. Also, the natural crystal faces of synthetic quartz allow easier orientation of the stock for cutting into crystal units. Synthetic quartz has none of the foreign inclusions usually found in natural quartz, and it can be produced without either optical or electrical twinning. It is estimated that the present yield per pound of synthetic quartz is at least two and a half times that of natural quartz.

While scientists have been attacking the problems of making suitable crystals for half a century, it was only a few years ago that the most commercially successful hydrothermal process for making them was developed by Bell Telephone Laboratories. The achievement followed several years of research and experimentation after World War II.

In 1958, a pilot plant for converting the laboratory process to commercial production was established at the Merrimack Valley Works of Western Electric, the Bell System's manufacturing and supply company.

In telephone work, quartz crystals are the heart of equipment that permits many different telephone conversations to be carried simultaneously over the same circuit without interference. Quartz can also be used to regulate radio frequencies and as a source of ultrasonic waves.

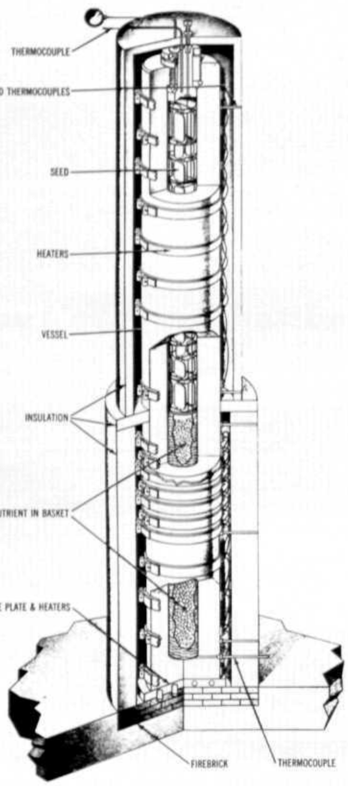
With reduced costs of crystals, made possible by the Bell system process of artificial growth, there is a possibility that the gem-like crystals may find still wider application as substitutes for other elements in electronic circuits.

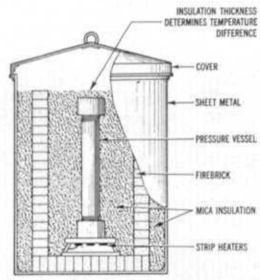
Manufacture of Crystals

The new factory grows quartz crystals of superior size and quality in a scientific rock garden, under tremendous pressure and heat.

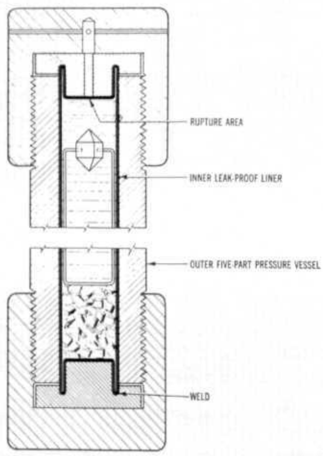
The factory contains both

LEFT – A perfect synthetic quartz crystal, grown at Western Electric's Merrimack Valley Works. In foreground are pieces of natural quartz.





Research oven with a vessel and hot plate.



Research pressure vessel with inner liner.

a growing area and a cutting room, where the artificial crystals are sliced into wafers. This is the first step in fabricating crystals to the precise sizes required for communications uses. Subsequent operations are performed elsewhere at the Merrimack Valley Works.

Only three technicians are required to operate the new factory's growing area, which is automatically controlled except for loading and unloading the crystal-growth vessels.

In the growing-area, 20 cylindrical vessels, each about ten feet long and a foot in diameter, are sunk below the surface of the floor. Into each vessel is lowered a long wire basket. "Seed" crystals of natural or artifical quartz are suspended in tiers at the top of the basket. The lower half of the basket is filled with small, inexpensive pieces of natural quartz. In this form, quartz is readily available from many sources but is unsuitable for communications purposes.

To begin the growth cycle, a weak alkali solution is poured into the vessel, which is then sealed. A heavy steel shield is lowered over the top by a crane for additional protection.

The contents of the vessel are heated to a temperature of 700 degrees and the interior pressure reaches about 25,000 pounds per square inch.

It takes about three weeks of continuous growth to produce a harvest of crystals. Under heat and pressure, the small pieces of quartz at the bottom of the basket dissolve into the alkali solution. Crystals of quartz are redeposited from solution and slowly build up on the "seed" plates at the top of the basket, where the temperature is slightly cooler.

While feasibility of the hydrothermal process was proved in the laboratory, there was a problem of converting research work into a high-volume quality product.

The hydrothermal process, though simple in concept, exposed many problems not apparent during early research. The first engineering problem was to design an effective autoclave-type growing vessel. The laboratory used relatively simple autoclaves made from welded tubes supported by capped high-pressure piping. However, production runs required a larger autoclave with a repetitive closure. While others have constructed vessels of this type for either high-temperature or high-pressure use, the combination of both presented a challenge. This unique unit had to withstand temperatures approaching 700 degrees F and pressures up to 25,000 pounds per square inch. Study showed that the range of operating temperatures approached the point where creep became a limiting factor. The large size required for production also introduced difficulties since the force to be resisted by the closure increased as the square of the diameter of the vessel. The final problem considered was the corrosive properties of the nutrient solution.

A desired ten year life for the production vessel necessitated careful consideration of the corrosive properties of the metal to be used. A chromium-molybdenum steel was chosen for its corrosive resistance and relatively high strength at high temperatures. The final size was established as a compromise between the economic advantages of large size and the technical problems associated with closure design.

Finding a successful closure was the most difficult part of the development. The pressure acting on a vessel closure 6 inches in diameter would be approximately 350 tons or 25,000 pounds per square inch. Several closure designs were tried before one was developed satisfactorily leak-proof and free of spurious crystal growth.

The equipment associated with the experimental vessels was also extensively redesigned, partially because of the great increase in size.

Since the production vessel could not be completely inverted to remove residue after a run, a special nutrient basket was designed to facilitate this cleaning. A small chain hoist is used to handle the closures baskets and seed holders.

Even building design was influenced. For ease of working, a pit

Synthetic crystals are inspected as they emerge from the growing vessel three weeks after they started growing.

was built to receive the vessels and support them so their openings would extend a foot above the floor level.

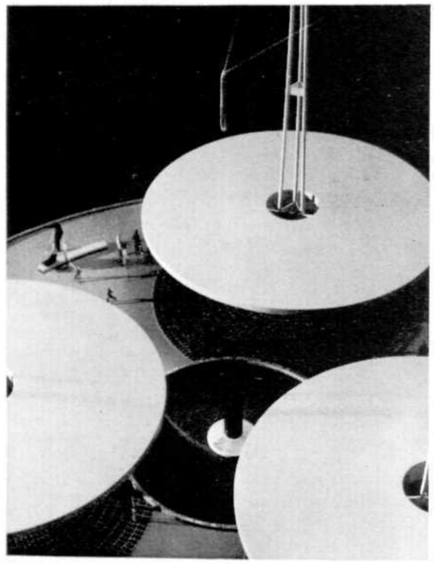
The early laboratory method of stringing seed crystals on wires was changed to eliminate a laborious drilling operation. The current design uses spring clips to support the seeds in the holder.

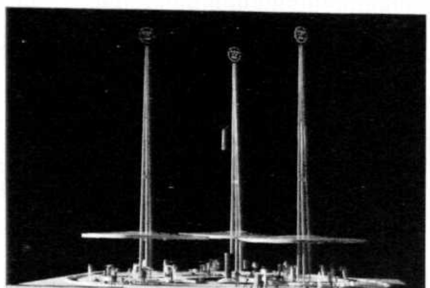
To maintain precise temperature control, it was necessary to space strip heaters along the entire length of the vessel. It was also decided to reduce insulation over the growing (upper) zone in order to promote heat loss. Since the growing end is cooler than the nutrient (lower) zone, external heat to the two areas is separately controlled. Automatic control of the electrical power supply maintains this precise temperature differential. Each zone's heaters are tied to a common power supply. Thermocouples are located in wells at the bottom of the vessel and in the closure, extending to within 3/4 inch of the inside surface. Each thermocouple controls the heat input to its zone to accuracies well within specified limits.

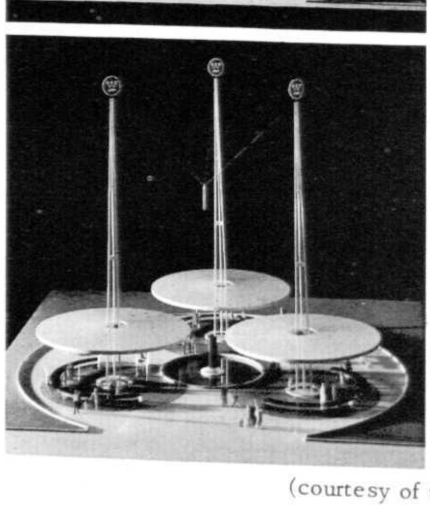
Thus Western Electric's hydrothermal process offers positive temperature control, reliable closure and built-in safety devices. With the exception of loading and unloading, the entire growing process is also completely automatic.

6939 A.D.

TIME CAPSULE







A new message to people 5000 years in the future will be buried at the 1964–65 New York World's Fair, alongside the original Westinghouse Time Capsule, which was lowered to rest 50 feet below ground on September 23, 1938, at the previous New York World's Fair.

The contents of the first capsule were selected to provide a record of the history, faiths, arts, sciences, and customs of civilization as it was in 1938. This message to the future was prepared with the cooperation of hundreds of persons including archeologists, engineers, physicists, historians, artists, and librarians.

However, man's accomplishments in the past 25 years have been perhaps the most important in history—particularly in the field of science. Our lives have been changed so significantly that the original Time Capsule, while it still records much of our present civilization, has become seriously out of date and would give the peoples of 6939 an inadequate picture of life in the 20th century. Among important accomplishments not included are atomic power, man in space, wonder drugs and polio vaccine, commercial television, and jet aircraft. Also unrecorded are World War II, the United Nations, the discovery of the Dead Sea Scrolls, and new data on the age of man and the earth.

A duplicate of the original Time Capsule will be on display at the open-air pavilion to be built by Westinghouse for the 1964–65 World's Fair. The capsule will be suspended between three pylons, 50 feet in the air directly above the eight-foot granite monument that marks the site of the original Time Capsule. A pool will reflect the image of the capsule in such a way that it appears to be at the depth of the buried capsule.

Contents of the duplicate capsule, which have been sealed inside since 1938, will be removed and put on public display in one of three open roofed areas at the base of the pylons. Exhibits under other pylons will contain materials selected for the new capsule, and a projection of life in the future.

Among the contents chosen for deposit in the 1938 capsule were some 35 articles of common use, ranging from a slide rule to a woman's hat, each selected for what it would reveal about us to archeologists fifty centuries hence. Also included were about 75 samples of representative materials ranging from fabrics, metals, alloys, plastics, and synthetics to a lump of anthracite coal and a dozen kinds of seed. Pages of books, articles, magazines, newspapers, reports, circulars, catalogs, and pictures were recorded on 3½ reels of microfilm. The printed material explains our arts, entertainments, religions, philosophies, educational systems, sciences, technology, and medicine. Also recorded on microfilm were messages to the future from three famous men: Dr. Albert Einstein, Dr. Robert Millikan, and Dr. Thomas Mann. The microfilmed material contains approximately 10 million words. A newsreel was added to show historic scenes of our times.

With the aid of representatives from the U. S. Bureau of Standards, all of these items were examined for durability to make certain that they would remain intact for 5000 years when enclosed in the capsule. Care was taken not to include any material that might produce fumes or acids capable of attacking other articles in the capsule. All liquids were ruled out and organic objects such as seeds were hermetically sealed in glass receptacles. The films were placed in aluminum containers lined with rag paper. All other objects were individually wrapped in heavy rag paper.

After packing the inner envelope of glass, the air inside was exhausted, replaced with nitrogen, and enough moisture injected to equal normal room humidity. Then the glass envelope was heated and sealed. This inner envelope of glass was placed in a Cupaloy shell, set in a water-repellent petroleum-base wax, and the cap of the capsule was secured to form an air-tight seal.

To insure that future generations would be able to locate the Time Capsule, a "Book of Record" was printed on permanent paper with special ink. More than 3000 copies of the publication were distributed to libraries, museums, monasteries, convents, lamaseries, temples, and other safe repositories throughout the world. Among other things, the book includes an ingenious key to the English language to aid archeologists of the future should knowledge of our present language be lost.

Selection of materials for the new capsule will again be handled by a special committee chosen from experts in the fields of science, industry, and education. The capsule will be made by Westinghouse of a special alloy and will resemble the original 7½-foot Time Capsule. At the closing of the World's Fair, it will rest beside the original capsule until both are recovered in 6939 A.D.

(courtesy of the Westinghouse Engineer, March, 1963)

Spartan Engineer

Welcomes you to the

JETS

11th ANNUAL

ENGINEERING

EXPOSITION

and

CONFERENCE

11th ANNUAL ENGINEERING EXPOSITION and CONFERENCE

MICHIGAN STATE UNIVERSITY
PRESENTS
THE COLLEGE OF ENGINEERING EXPOSITION
AND
THE JETS 11TH ANNUAL ENGINEERING
EXPOSITION AND CONFERENCE

Schedule of Events:

Friday, May 3, 1963

12:30 P.M. Engineering Exposition opens --all engineering exhibits and information centers are open throughout the College of Engineering Building
Information Center Telephone Number - 355-3527

Industrial Exhibits Open - Lobby

1) Consumers Power Company
2) Aluminum Company of America
3) John Deere
4) Bell Telephone
5) Bureau of Reclamation
6) Ford Motor Company

1:00 P.M. Departmental Exhibits Open - Tours will start every hour on the hour - Meet in Lobby

1) Agricultural Engineering
2) Civil Engineering
3) Chemical Engineering
4) Electrical Engineering
5) Mechanical Engineering
6) Metallurgy, Mechanics and Materials Science

Individual Exhibits Open - All departments participating

JETS Exposition Commences - Library - College of Engineering Bldg.

Society Exhibits Open - All departments represented

10:00 A.M. Presentation of Technical Papers by College of Engineering Students and JETS Club Members - Aud.

11:00 A.M. Special Presentation by Dr. Maria Z. Krzywoblocki "Space Research for the 1970's"

1:30 P.M. 11th National Engineering Exposition and Conference Awards Presentation
Speaker - Dr. Donald Frye, Ass't General Manager - Ford Motor Comp. Auditorium - 100 Engineering Building.

3:00 P.M. College of Engineering Exposition Judging of Exhibits

1) Departmental
2) Society
3) Individual

5:00 P.M. Exposition Closes

6:30 P.M. 1963 May Hop Dinner Dance - sponsored by the Engineering Council
Big Ten Room - Kellogg Center.

Sunday, May 5, 1963

9-11 A.M. Exhibitors will take down Projects.

2:15 Films: Room 146 - College of Engineering Bldg. Continuous showing

1) "Tidal Power"
2) "Engineers in the Making"
3) "Army Package Power Reactor"
4) "Engineering and Applied Science"
5) "Engineering Equipment for a New Era"

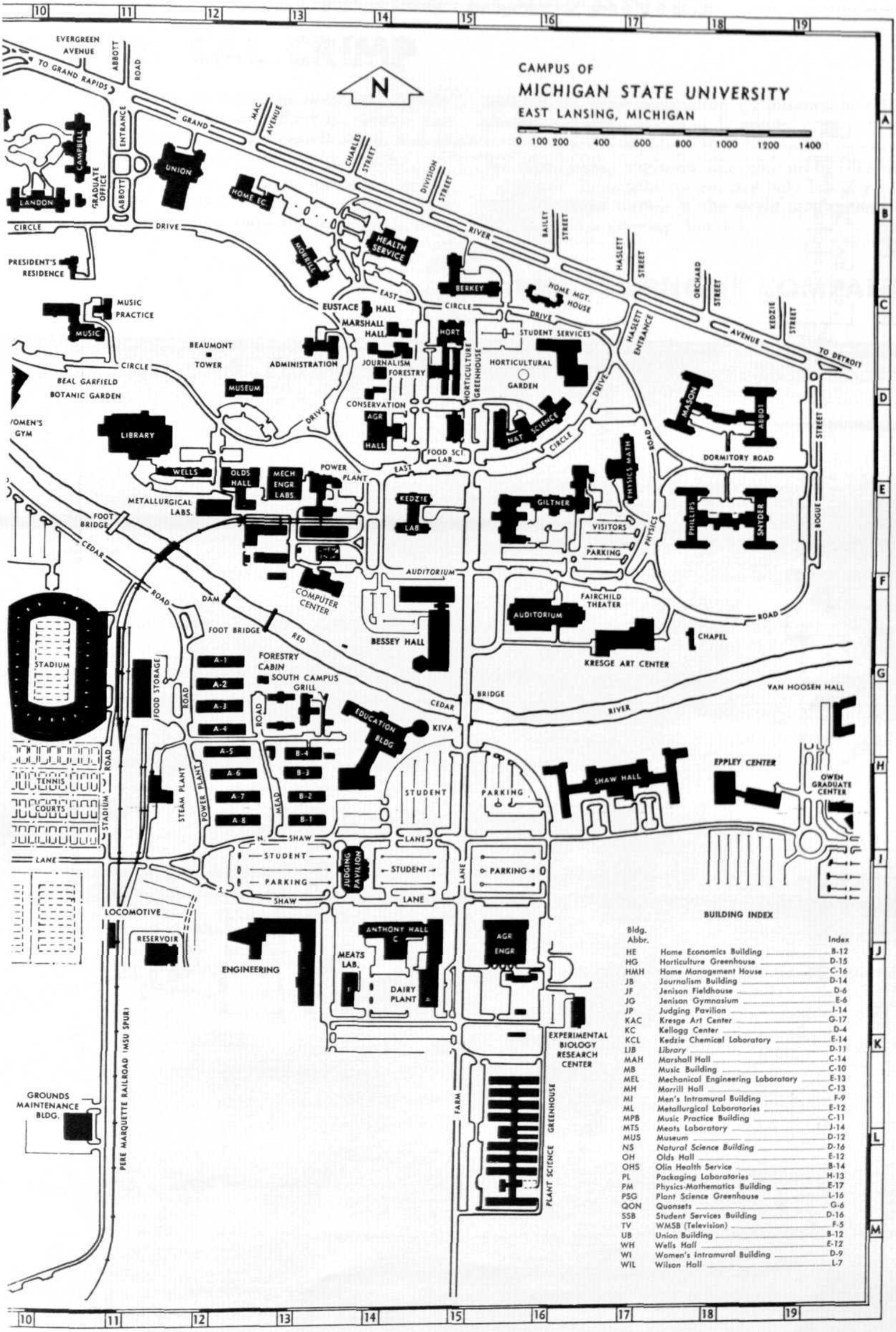
2:00-5:00
7:00-9:00 P.M. JETS Exhibits - Judging - Library

9:00 P.M. Exposition Closes

Saturday, May 4, 1963

9:00 A.M. Engineering Exposition reopens all engineering exhibits and information centers are open throughout the College of Engineering Bldg.

Industrial Exhibits Open - Lobby
Departmental Tours - Start every hour on the hour - Lobby
Individual Exhibits Open
JETS Exposition Open - Library
Films - Room 146 - continuous showing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EVERGREEN AVENUE
TO GRAND RAPIDS
ABBOTT ROAD
GRAND RIVER AVENUE
MAC AVENUE
CHARLES STREET
DIVISION STREET
BAILEY STREET
HASLETT STREET
ORCHARD STREET
KEDZIE STREET
TO DETROIT
CAMPBELL
LANDON
UNION
HOME EC.
GRADUATE OFFICE
ENTRANCE
CIRCLE DRIVE
PRESIDENT'S RESIDENCE
MORRILL
HEALTH SERVICE
BERKEY
HOME MGT. HOUSE
EAST CIRCLE DRIVE
EUSTACE HALL
MARSHALL HALL
MUSIC PRACTICE
MUSIC
BEAUMONT TOWER
ADMINISTRATION
JOURNALISM
FORESTRY
HORT
HORTICULTURE GREENHOUSE
STUDENT SERVICES
HORTICULTURAL GARDEN
HASLETT ENTRANCE
MASON
ABBOT
BEAL GARFIELD BOTANIC GARDEN
MUSEUM
CONSERVATION
AGR HALL
NAT. SCIENCE
DORMITORY ROAD
WOMEN'S GYM
LIBRARY
FOOD SCI. LAB
WELLS
OLDS HALL
MECH ENGR LABS.
POWER PLANT
METALLURGICAL LABS.
KEDZIE LAB
PHYSICS MATH
GILTNER
VISITORS PARKING
PHILLIPS
SNYDER
BOGUE STREET
FOOT BRIDGE
CEDAR ROAD
AUDITORIUM ROAD
COMPUTER CENTER
DAM
FAIRCHILD THEATER
AUDITORIUM
FOOT BRIDGE
RED CEDAR RIVER
BESSEY HALL
CHAPEL
KRESGE ART CENTER
STADIUM
FOOD STORAGE
FORESTRY CABIN
SOUTH CAMPUS GRILL
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A-2
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A-4
A-5
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B-1
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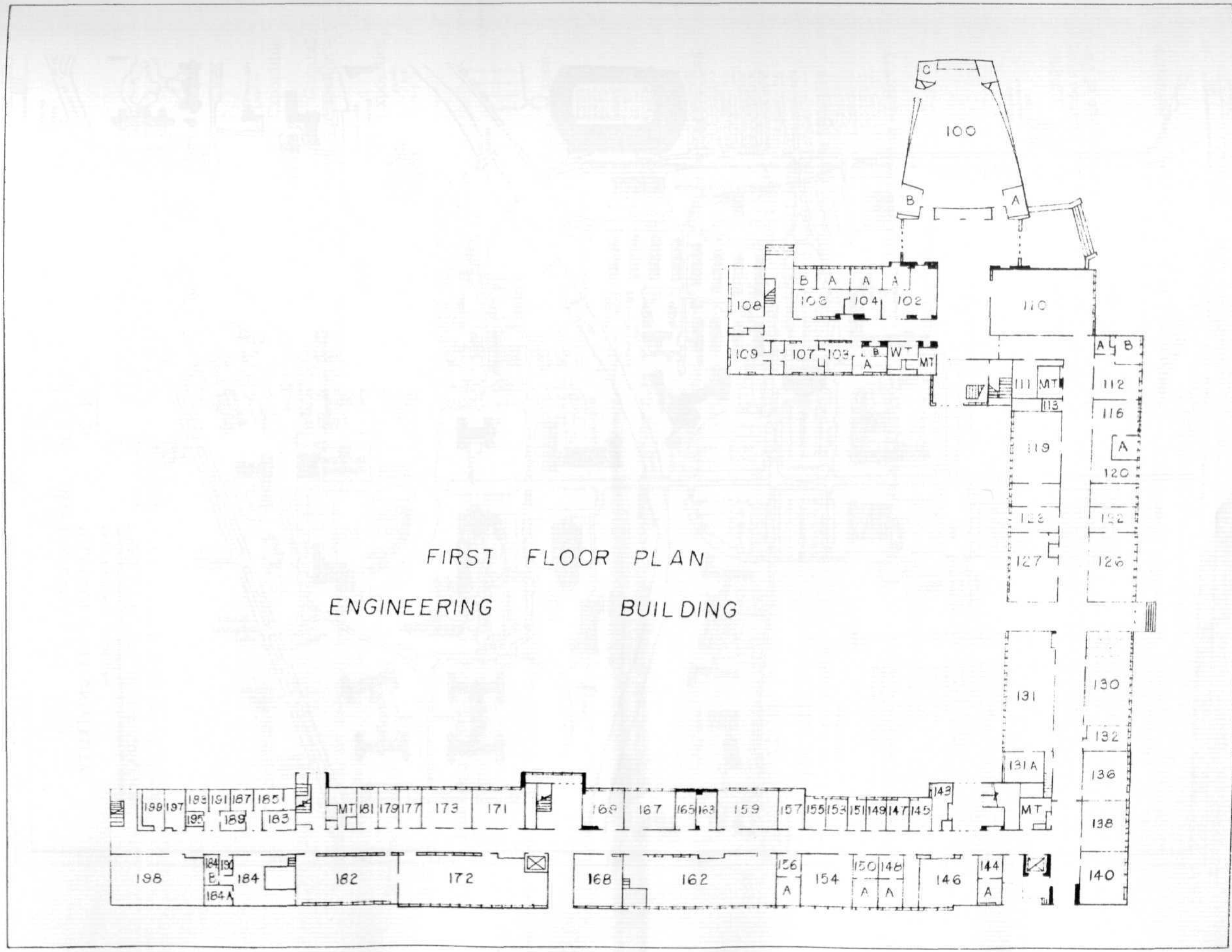
B-4
ROAD
EDUCATION BLDG
KIVA
BRIDGE
VAN HOOSEN HALL
TENNIS COURTS
STADIUM ROAD
STEAM PLANT
POWER PLANT
MEAD
STUDENT
PARKING
SHAW HALL
EPPLEY CENTER
OWEN GRADUATE CENTER
N. SHAW LANE
LANE
STUDENT PARKING
JUDGING PAVILION
S. SHAW
LOCOMOTIVE
RESERVOIR
ENGINEERING
ANTHONY HALL
MEATS LAB.
DAIRY PLANT
AGR ENGR
EXPERIMENTAL BIOLOGY RESEARCH CENTER
FARM LANE
PLANT SCIENCE GREENHOUSE
GROUNDS MAINTENANCE BLDG.
PERE MARQUETTE RAILROAD (MSU SPUR)
BUILDING INDEX
Bldg. Abbr. Index
HE Home Economics Building B-12
HG Horticulture Greenhouse D-15
HMH Home Management House C-16
JB Journalism Building D-14
JF Jenison Fieldhouse D-6
JG Jenison Gymnasium E-6
JP Judging Pavilion I-14
KAC Kresge Art Center G-17
KC Kellogg Center D-4
KCL Kedzie Chemical Laboratory E-14
LIB Library D-11
MAH Marshall Hall C-14
MB Music Building C-10
MEL Mechanical Engineering Laboratory E-13
MH Morrill Hall C-13
MI Men's Intramural Building F-9
ML Metallurgical Laboratories E-12
MPB Music Practice Building C-11
MTS Meats Laboratory J-14
MUS Museum D-12
NS Natural Science Building D-16
OH Olds Hall E-12
OHS Olin Health Service B-14
PL Packaging Laboratories H-13
PM Physics-Mathematics Building E-17
PSG Plant Science Greenhouse L-16
QON Quonsets G-6
SSB Student Services Building D-16
TV WMSB (Television) F-5
UB Union Building B-12
WH Wells Hall E-12
WI Women's Intramural Building D-9
WIL Wilson Hall L-7



FIRST FLOOR PLAN

ENGINEERING BUILDING

NEW AUTOMOTIVE GAS TURBINE

by George Taylor

Can you imagine a car that will run on fuels ranging from diesel oil to jet fuel and still deliver top performance? Did you ever think you would drive a car that requires no oil change or tune-up? These are some of the characteristics of the gas turbine engine. The Chrysler Corporation has successfully applied this type of engine to the automobile, and such a car will someday be available to the public.

The Chrysler turbine-powered car was unveiled to the public in 1954. In March, 1956, Chrysler engineers drove a standard production Plymouth equipped with a turbine from New York to Los Angeles. This was an experiment to check the performance of the engine in a wide range of driving and climate conditions. They noted exceptionally good fuel economy in the city and on the highway. In 1958 a much improved model powered a Plymouth in a 576-mile test run from Detroit to New York, using diesel fuel. The car averaged 19.4 miles per gallon.

The results of these tests led to the development of a third model called the CR2A gas turbine engine. After George J. Heubner, director of the gas turbine research program at Chrysler, successfully drove a turbine-powered Dodge Dart from New York to Los Angeles, and other considerations were successfully resolved, Chrysler officials decided to consider seriously going into production of the turbo car. Tests indicate that this engine, rated at 140 horsepower, will outperform a 200 horsepower V-8.

The CR2A does not resemble a reciprocating engine in any respect. It has no reciprocating parts. There is no jerking up and down of pistons and valves which causes unnecessary friction and power loss. But the moving parts of the turbine engine rotate in one direction like a windmill. It is a much simpler engine than the reciprocating type. The components include a starter-generator, a gas generator consisting of an air compressor and a turbine wheel which drives the compressor; a second stage turbine which directs power to rear wheels of car, a can-like burner with one spark plug, and the regenerator. The CR2A has one fifth as many moving parts as a V-8 and weighs some 400 pounds less.

The components are housed in a drum-shaped steel casing. It is designed to be cooled by air, hence no radiator is needed. The gas generator is located in the front of the housing along with the starter-generator. When the key is turned to start the car, the starter - generator rotates the compressor 20,000 revolutions

This is the gas turbine engine which, sans la madamoiselle, powered a 1962 Dodge Turbo Dart on a test run from New York to Los Angeles.

per minute. After the engine begins to fire, the starting motor becomes a generator. The gas generator rotates at a maximum speed of 46,610 RPM. The second stage turbine is located directly behind the first, but it is not connected mechanically to it. Preceding this turbine is a set of variable nozzles which direct the flow of air on to the blades of the second stage turbine. This turbine is rated at 140 horsepower at 39,000 RPM and has a maximum permissible speed of 47,730 RPM. This, in turn, is connected to the transmission at an 8.53 to 1 gear ratio with a reduced output speed of 4570 RPM.

The regenerator is mounted horizontally in the top of the engine. It is made of rolled corrugated steel, and has many small passages to permit the flow of air. It has the appearance of a cigarette filter, only much larger, of course. At maximum engine speed the regenerator rotates at 17 RPM. The regenerator core is divided into two parts -- the front and rear halves -- by gaskets which are built into the housing.

Air enters the compressor at a rate of 2.2 pounds per second, and it is compressed at a 4 to 1 ratio. It travels up through a collector and down through the front half of the regenerator where it picks up heat from the metal matrix. The air then enters the burner where the burning fuel raises the temperature to 1700 degrees F. This extremely hot gas expands rapidly through both turbines and is exhausted up through the rear half of the regenerator. Much of the heat is captured in the matrix and the heated section rotates to the front of the regenerator housing to receive incoming air.

Hence, the regenerator serves two functions. It captures the heat from the exhaust and lowers the temperature below that of the exhaust from the reciprocating engine. It was necessary to lower the exhaust temperature before the turbine could be used for automotive purposes. If the regenerator were not used the exhaust temperature would exceed 1000 degrees F. The second function is to increase the fuel economy of the engine. Since the air is preheated before entering the burner, it does not require as much fuel to bring it up to the desired temperature.

The burner enables the engine to burn the fuel with 95 percent efficiency, which means that the exhaust is free of carbon monoxide.

What will this new engine mean to the consumer? In the first place, it will cost much less to drive a turbo car. The engine currently delivers the same fuel economy as a piston engine of comparable horsepower, but there is one important difference. The turbine will run on diesel fuel, kerosene, lighter fluid, alcohol, gasoline, and even Napoleon Brandy if you choose to be extravagant. In short, it will run on anything that will flow through a pipe and that will burn. Chrysler engineers have found, however, that the life of the engine will be shortened if leaded gasolines are used, because the lead will build up a fine coating on the turbine blades. The engine will deliver maximum fuel economy with diesel fuel.

Unlike a reciprocating engine, which requires an oil change every 2 or 3 thousand miles, the CR2A uses the same oil indefinitely. The bearings are sealed units and the oil is never exposed to the hot gases; hence, it cannot become dirty. It is therefore reasonable to assume that the factory lubrication will last the life of the engine.

Since the CR2A is air cooled, it has no radiator. This further lowers the cost of maintenance by eliminating the need to buy antifreeze in cold regions.

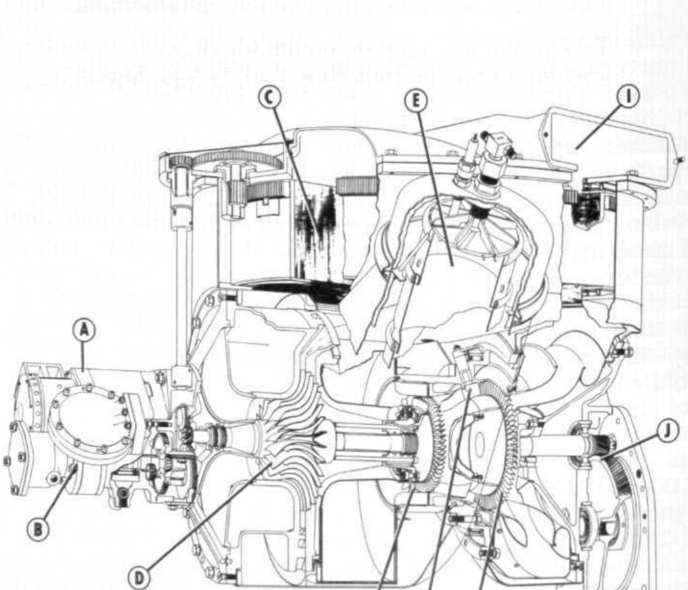
What is it like to drive a turbo car? You will have to change your driving habits to operate this car. If you are accustomed to driving with an automatic transmission, the operating procedure will be the same. Simply turn the key and stepon the gas. My first ride was almost unbelievable. The first thing I noticed was the absence of vibration which is so characteristic of reciprocating engines. When you step on the accelerator there is a split second pause. Then the car accelerates rapidly but with elastic smoothness. It seems as if the car is being pulled by a rope. Aside from the usual bumps on the road, I felt only the slight jerk of the transmission shifting through the gears. But the big surprise comes when you try to guess how fast the car is travelling without looking at the speedometer. At 35 miles an hour it seemed to me that the car had not exceeded twenty. It will accelerate from zero to 60 in 8.5 seconds, and the maximum speed is 115 MPH. This is phenomenal for a car which weighs 4000 pounds with only a 140-HP engine.

The turbine makes a high-pitched whine similar to that of a jet airliner preparing to leave the runway. Huebner said that a muffling devide can be installed that will eliminate the noise. He added, however, that no attempts are being made to silence the whine in the cars currently being tested in hopes that it will attract the attention of the public.

Will Chrysler's turbo car cost more to buy? Like anything else which is sold for the first time, the new turbo cars will cost several thousand dollars more than the current models. Chrysler engineers say, however, that because of the simplicity of the engine it will cost no more to produce than the reciprocating type once it has been adapted to mass production. This means that within a few years after their introduction, turbo cars will cost about the same as present models.

It is not known just how soon the cars will be available to the public, because there is further testing yet to be done. Chrysler is planning to build 50 to 75 turbo cars in 1963 to be delivered to selected users in all parts of the country. This will give the engineers a more accurate picture of what effects, if any, various climates and driving habits will have on the engine. Even if the results of these tests are favorable the date for full-scale production has not yet been decided.

Some 90 years ago man developed the internal combustion engine, and it has been applied to all modes of transportation. It has been regarded as a reliable power plant and went virtually unchallenged in the automotbile until recent years. All of the major auto firms considered the possibility of replacing the reciprocating engine with the gas turbine, but only Chrysler has decided that this totally new engine can be adapted for use in passenger cars. With its many advantages -- the ability to run on almost any fuel, low maintenance costs, and the simplicity of the engine, to mention just a few --the gas turbine engine appears certain to find a place in the automotive industry.



MAIN COMPONENTS OF THE CR2A gas turbine which powers the Dodge Turbo Dart are: (A) the starter-generator; (B) fuel pump; (C) regenerator; (D) compressor impeller; (E) combustion chamber; (F) first-stage turbine, which drives the compressor impeller and accessories; (G) variable second-stage nozzle; (H) second-stage turbine which supplies power to the driveshaft; (I) one of two exhaust outlets; (J) single stage helical reduction gear of 8.53-to-1 ratio which reduces power turbine rpm of 39,000 to 45,730, to a rated output speed of 4,570 to 5,360 rpm.

NEW MSU SCIENCE CENTER

SCIENCE COMPLEX RISING AT MSU -- This is how the southeastern part of the Michigan State University campus will look in 1964. All the buildings will be devoted to science education and research, except for the $1.4 million, 1,000 car-capacity parking ramp (1) to be completed this fall.

A "space-age" planetarium (2) is to be completed by this summer at a cost of $500,000. The 50-million volt cyclotron (3) will be operating in 1964. The building is costing $1.4 million and the cyclotron itself, another $1.4 million. The $3.5 million veterinary medicine building (4) is entering the final planning stage and will be completed by late 1964.

The chemistry bupldinq (5), now under construction, is to be ready by the fall of 1964 at a cost of $6 million. Contracts for construction of the $5.2 million biochemistry building (6) are to be awarded soon. It will be completed by late 1964. The Biology Research Center (7) was completed in 1960 at a cost of $620,000.

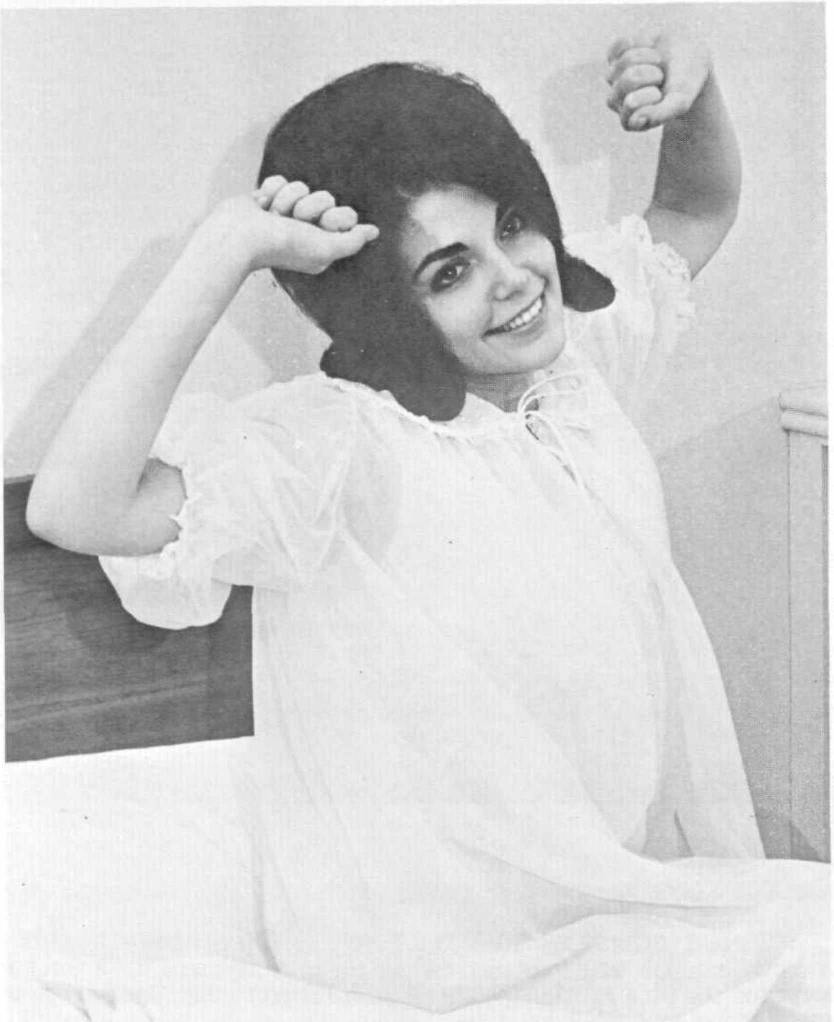
The chemistry building is the only structure which has an appropriation from the state.

The planetarium is being built through contributions to the MSU development fund, including $250,000 from Mr. and Mrs. Talbert Abrams of Lansing. The parking ramp will be paid for out of operating revenues. Other construction is being supported by grants from the National Science Foundation and the National Institutes of Health.

The perspective for this sketch is from the intersection of Shaw Lane and Farm Lane, looking southeast. A portion of the Agricultural Engineering Building is seen at lower right.

MISS ENGINEER

Maria Colucci



Fashions by: *The Scotch House*

Knapps

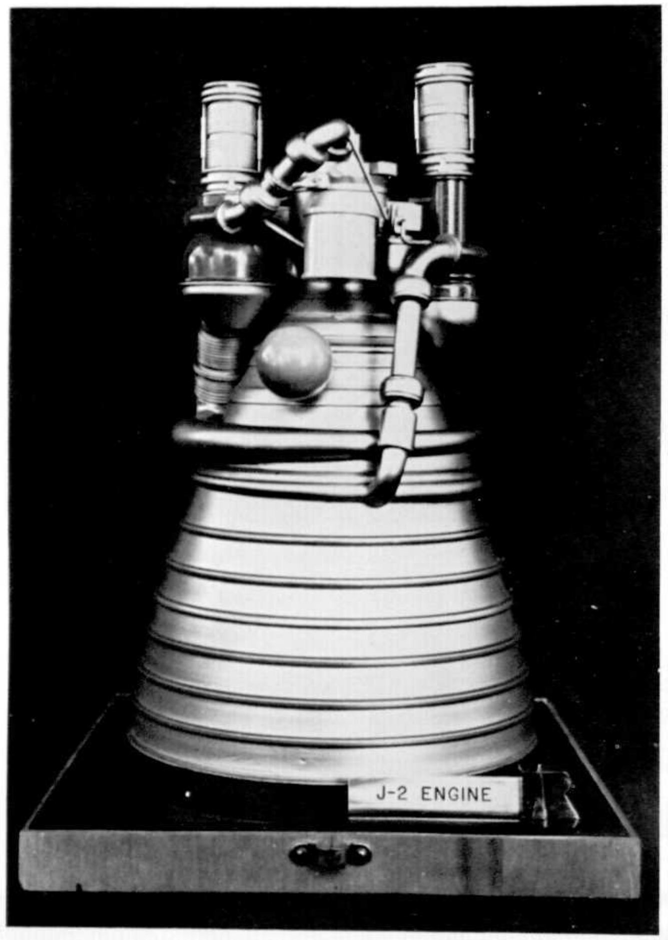
Photographed in the Presidential Suite of
The Jack Tar Hotel

by Lowell Kinney

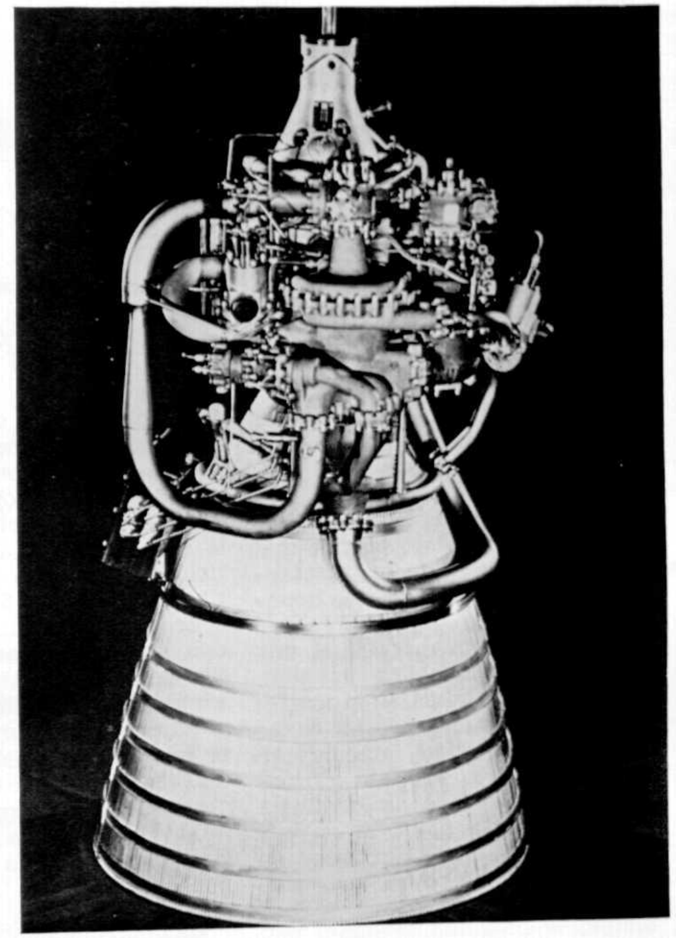
HYDROGEN POWER

edited by

John Callahan



The J-2 engine will utilize an oxygen-hydrogen fuel system to develop 200,000 pounds thrust.



The famous RL-10, pioneer oxygen-hydrogen rocket engine, develops a thrust of 15,000 pounds.

Space inevitably means rockets, because rockets are the only propulsion means available for driving into the hard vacuum of space where our familiar piston engines and turbojet engines fail. In turn, rockets historically connote solid propellants, dating back a few thousand years to the ancient Chinese. Liquid-fueled rockets (using alcohol and liquid oxygen for example) are a relatively very recent innovation, pioneered by such men as Robert Goddard in the 1920's and 30's in this country, and Herman Oberth and others in Europe. Liquid propellants received their big push from the engineering advances of the German teams during the last War.

Today, the U.S. rocket fraternity is divided into two camps, a solid fuel camp and a liquid propellant camp. Each includes brilliant scientists and engineers, and each camp can point to important successes and fantastic rates of progress, particularly in terms of size and power. Both solid and liquid rockets have been developed to produce over a million pounds of thrust, corresponding to many millions of horsepower at high speeds for short periods. Both solid and liquid rocket proponents are now aiming at rockets having ten million or more pounds of thrust.

When solid and liquid rocket men meet together at an American Rocket Society seminar, the competitive spirit is terrific. Arguments rage into the wee hours and tempers soar. With this state of affairs prevailing among the nation's top engineers, one would be brash indeed to summarize or over-simplify the relative merits. However, while the arguments will probably remain unsettled for years to come in borderline or overlap areas, certain conclusions have emerged and can be simplified by the following:

When you want push-button firing, you use a solid propellant. When you need high specific impulse, you turn to oxygen-hydrogen. In choosing a propellant on this basis, keep in mind that the mission capability improves as an exponential rather than a linear function of the specific impulse. It should be noted that all upper-stage space missions are to be handled with liquid oxygen-hydrogen.

Now, let us take a look at the key merit factor which we call specific impulse. Specific impulse is defined as the pounds of thrust derived in a rocket engine, divided by the pounds per second of propellant flow, which is the sum of the oxidizer flow and the fuel flow. Picture A shows that the specific thrust is roughly proportional to the square root of the flame temperature in the reaction chamber, divided by the average molecular weight of the exhaust products.

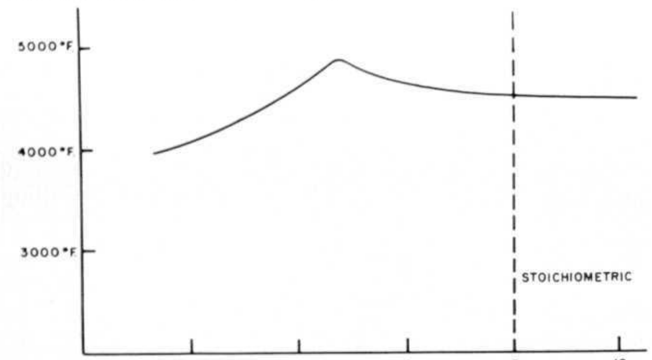
Specific impulse values may be achieved with a wide range of fuel and oxidizer combinations. We see that hydrocarbons burned with liquid oxygen yield a slightly higher specific impulse than the so-called storable, or non-cryogenic, propellant combination N_2H_4-N_2O_4. Specific impulse takes a big jump in going to liquid hydrogen-liquid oxygen, which has become the workhorse propellant for upper-stage engines. There is a smaller jump when we go to liquid hydrogen-liquid fluorine, which is usually stated to yield the highest specific impulse of any chemical propellant combination. This is not quite true under certain conditions, since beryllium hydride burned with liquid fluorine achieves a slightly higher specific impulse. This combination would certainly be useful if it were not for the extreme toxicity of the beryllium. For a comparison, we state the hydrogen nuclear rocket situation. Here, liquid hydrogen is considered to be the only practical working fluid, and the specific impulse is about double that which is achieved with chemical propellants.

It would be in order now to take a look at the methods of producing liquid hydrogen, and we might first consider the ways in which gaseous hydrogen is produced. There are four processes which are ordinarily considered (bearing in mind that liquid hydrogen plants almost always use rather large flows of gaseous hydrogen.) First, one naturally looks for sources where hydrogen is available as a by-product. Usually this means petroleum refining. By-product hydrogen is characterized by wide fluctuations in purity. Furthermore, by-product hydrogen from the petroleum industry is generally considered to be of decreasing availability. As the petroleum industry in future years prepares to process crudes which are higher in sulphur and asphalt content, the hydrogen by-product will have to be used internally in the refinery. In general, we understand that hydrogen as a by-product of petroleum refining will slowly disappear in the next decade, forcing us to turn to primary methods of producing hydrogen.

Two primary methods are dealt with here; the steam reforming of hydrocarbons, and the partial oxidation of hydrocarbons. The last source; coke oven gas (which contains 30 to 50% hydrogen) is an important one. It must always be considered when planning a liquid hydrogen installation at a specific location.

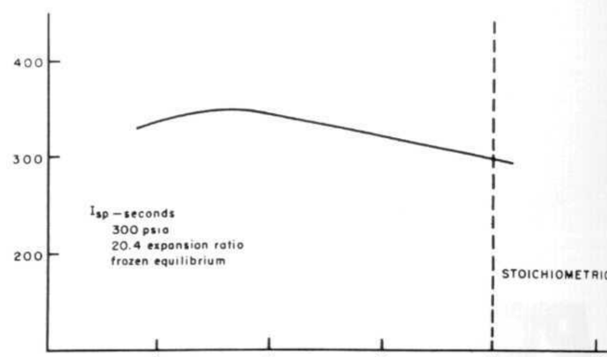
Picture B shows a generalized flow diagram for the liquefication of hydrogen after the hydrogen gas has been purified to the extent of something like 99.99% purity.

The diagram is self-explanatory, but two comments can be made: First, a tremendous amount of power is used. In producing 15,000 lbs. of liquid hydrogen per day, air must first be separated to produce oxygen for partial oxidation and liquid nitrogen for precooling the hydrogen. You will note that 1200 kilowatts of electric power are required to drive the air compressor. On the lower left side of the diagram, MEASURED FLAME TEMPERATURE vs O_2/H_2 RATIO



A

THEORETICAL SPECIFIC IMPULSE vs O_2/H_2 RATIO



C

you can see that another 6300 kilowatts of power are required to drive the hydrogen compressor. The total is about 7500 kilowatts and, dividing this total into 15,000 lbs. per day, we find that about 12 kilowatt hours of electric power are required to liquefy 1 lb. of hydrogen. The second thing to note is that all of this power finally appears as heat, which must be taken out in cooling water. The makeup cooling water for this size plant amounts to something like 900,000 gallons per day. Therefore, in locating a liquid hydrogen plant, it is very important to consider first, a source of cheap power and, second, a source of cheap cooling water.

We turn now to the combustion properties of gaseous hydrogen. The principal point to be observed is that hydrogen (as is well known) is inflammable over a wide range of concentrations in air and oxygen. The ignition temperature is about 1,000 degrees F. In designing hydrogen equipment, one always assumes that, sooner or later, any escaping hydrogen will catch fire. By designing accordingly, one can stay out of trouble. You will also note that the heat of combustion is 325 B.t.u. per standard cu. ft. Multiplying this by the density, we find that it equals about 60,000 B.t.u. per pound, which is three times the heat of combustion of any hydrocarbon. This accounts, in part, for the great desirability of hydrogen for space missions.

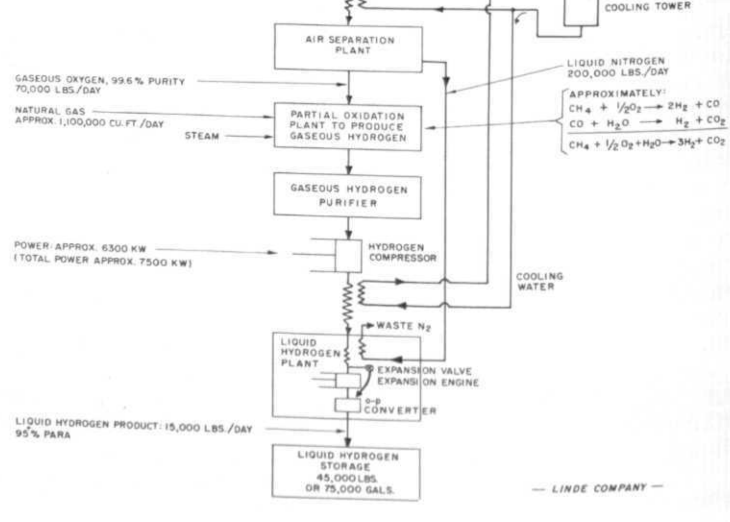
The curve (Picture C) of the specific impulse, plotted as a function of the oxygen/hydrogen ratio, is noteworthy in the following respect: You can see that the maximum specific impulse occurs at a ratio of about 3 parts oxygen to 1 part hydrogen by weight. You can see also, that as you increase the oxygen/hydrogen ratio, the specific impulse decreases, but not very rapidly. In actual rocket operations with upper-stage vehicles, advantage is taken of this fact. The practice is coming to be to fire at a ratio of about 5 to 1 oxygen/hydrogen by weight. You will see that this has reduced the specific impulse a little bit, but the advantage is that a higher proportion of the more dense propellant is increased. This means that the size of the tankage can be decreased, thus optimizing the mission from the standpoint of density as well as specific impulse.

Now we come to some of the end results of the oxygen-hydrogen rocket program. Picture D shows the famous RL-10 engine manufactured by Pratt & Whitney. This is the engine that is being used as a basis to be counted upon for the first oxygen-hydrogen vehicle flights. This engine produces a thrust of about 15,000 lbs. Two RL-10's will be used to propel the Centaur vehicle (atop an oxygen-kerosene Atlas). Centaur will be the first oxygen-hydrogen vehicle to fly in this country's space program.

Picture E shows the J-2 engine. This is the oxygen-hydrogen engine which, is being developed by the Rocketdyne Division of North American Aviation on a NASA contract. This engine will have a thrust of 200,000 lbs. It will burn oxygen-hydrogen at a ratio of about 5 to 1 by weight. A 1,200,000 lb. oxygen - hydrogen engine is being developed by Aerojet.

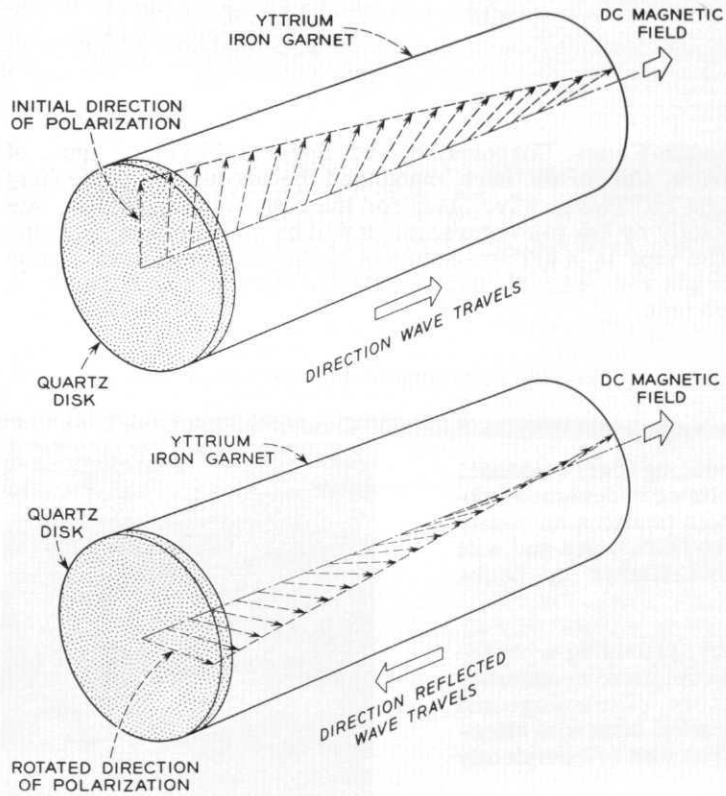
In closing, it is probably safe to say that when man jumps off to the moon in his Appollo capsule, it will be with the help of the simplest and most energetic of all chemicals, liquid hydrogen.

A SCHEMATIC FOR PRODUCTION OF 15,000 LBS./DAY OF LIQUID HYDROGEN



B

FIELD WAVE ROTATION



Scientists at Bell Telephone Laboratories have rotated the direction of polarization of a transverse ultrasonic wave traveling in a crystal by causing the wave to interact with a magnetic field. Their work is significant because the rotation is non-reciprocal, that is, when the wave is reflected at the end of the crystal and travels back to the input it does not rotate back to its original direction of polarization.

A new family of ultrasonic devices, such as circulators and isolators, now appears possible. An ultrasonic isolator, for example, might be used in ultrasonic delay lines to suppress reflections which occur when a wave encounters a discontinuity in a system. The isolator would work this way: An ultrasonic wave leaves the input of a system and travels through the isolator, which rotates the direction of polarization of the wave 45 degrees. When the wave is reflected back to the isolator it is rotated an additional 45 degrees. A device in the isolator absorbs the energy of waves polarized at 90 degrees; thus the reflected wave is prevented from reaching the input of the system.

Herbert Matthews and R. Conway LeCraw of Bell Laboratories recently described their experiment in Physical Review Letters, a Journal of the American Physical Society.

They bonded a quartz disk to one end of a cylinder of single crystal yttrium iron garnet and applied a dc magnetic field parallel to the axis of the cylinder. The magnetic moments of the iron atoms in the garnet then lined up parallel to the field.

Next, they applied a pulsed radio frequency electrical field to the quartz disk generating (by the piezoelectric effect) an ultrasonic wave pulse. This 500 megacycles per second pulse was polarized parallel to the (100) quartz axis.

The ultrasonic pulse traveling down the garnet cylinder strained the cyrstal lattice so that the iron atoms were alternately pulled apart from each other and squeezed together in a direction perpendicular to the magnetic field.

Straining the atoms created a second magnetic field, called an rf field because it varied with the frequency of the pulse. The rf field was perpendicular to the applied (dc) magnetic field. A component of the rf field interacted with the lined-up iron atoms and changed the direction of their magnetization. (This process is the inverse of magnetostriction whereby ferromagnetic materials such as iron elongate in the direction of a dc magnetic field and contact in a direction perpendicular to the field.)

The change in the direction of the magnetic moments of the iron atoms affected the direction in which they moved as the pulse strained the UIG moved as the pulse strained the YIG lattice. (The motion of the iron atoms was linearly polarized in a plane perpendicular to the wave's direction of travel.) The initial group of iron atoms moved up and down in this plane. The next group of atoms moved at an angle to the previous group in the perpendicular plane. This rotation was caused by interaction of the rf field and the lined up iron atoms and is analogous to the Faraday rotation of electromagnetic waves in ferrites. Each group of atoms was strained at an angle to the previous atomic strain and thus the direction of motion was rotated continuously.

When the wave was reflected at the end of the YIC cylinder, rotation of the strain polarization continued in the original direction since the interaction between strain and the lined-up iron atoms was independent of the direction in which the wave traveled. The amount of rotation depended upon the distance the wave traveled and the strength of the dc field.

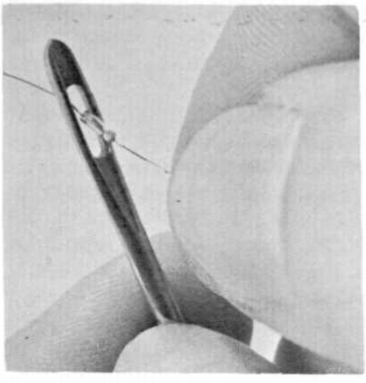
PRODUCTS FROM INDUSTRY

edited by Orville Barr

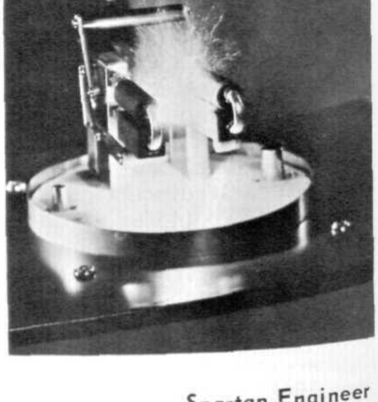
The Perkin-Elmer Corporation and Spectra-Physics, Inc., of Mountainview, California, have announced the production of the first visible-light continuous wave laser for the commercial market. Developed jointly by the two companies, it will be marketed by Perkin-Elmer. The unit is a helium-neon gas phase laser emitting a continuous bright red beam of coherent visible light at a wavelength of 6328 angstroms.

United Systems, Corp., Dayton, Ohio is introducing DigiTec-Model 200, a small, low cost, portable, digital DC voltmeter designed primarily for production use. The 7-lb. instrument features an easily read lighted display in 4 ranges from .000 to 1000. volts and will follow bi-directional voltage changes without flicker or backtracking.

DigiTec-Model 200 gives certified accuracy, providing a choice of 0.1% or 0.2% full scale accuracy, .05% resolution, readability and repeatability, 2 seconds' average reading time, over voltage and incorrect polarity protection. Floating or grounded input with effective filtering of AC ripple is also featured. The unit is completely transistorized.



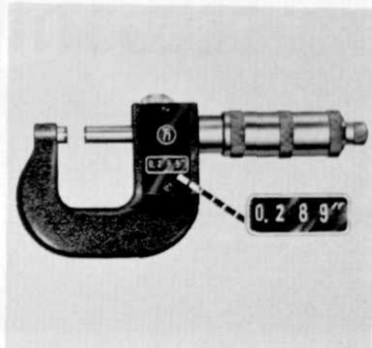
The smallest incandescent lamp ever produced on an assembly line has been placed into production by Sylvania Lighting Products, a division of Sylvania Electric Products Inc. The lamp is small enough to pass through the eye of a darning needle. Sylvania is a subsidiary of General Telephone & Electronics Corporation.



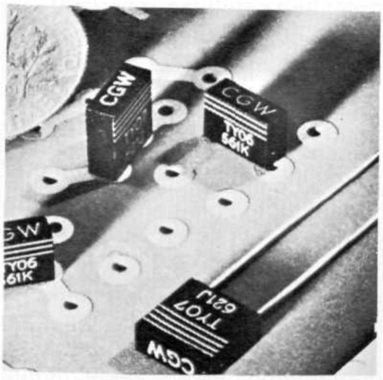
In a dramatic demonstration of carbon boil, sparks shoot from the vaporizing remains of a razor blade -- high-quality steel with a melting point of about 3000 degrees F. -- as it is heated well beyond that point in a Kopito Instant Furnace. Developed by Baird-Atomic, Inc., of Cambridge, Mass., the furnace produces a temperature of 5000 degrees F. -- approaching that of the sun's surface -- in but 3 seconds. Graphite cloth heating elements are supplied by National Carbon Company, Division of Union Carbide Corporation.

Three new high brightness cathode ray oscilloscopes in the high frequency 765 transistorized series are announced by the Du Mont Laboratories Divisions of Fairchild Camera and Instrument Corporation. All three instruments are electrically identical and feature the newly developed Du Mont frame grid 13 KV cathode ray tube.

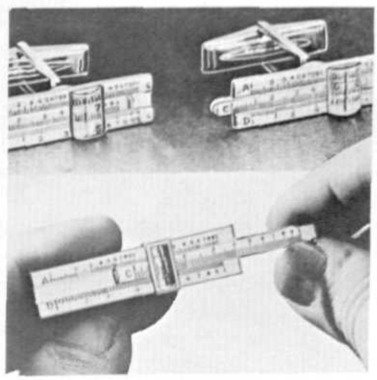
The instruments differ in mechanical configuration, however, with the new type 767-H constructed for rack mount use, the 766-H for bench and portable application, and the 765-H for true field portability.



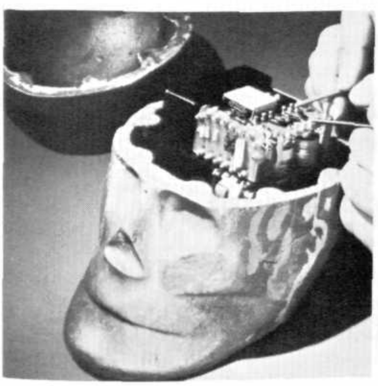
A new micrometer that dials visual readings automatically has just been introduced by Glass Laboratories, Inc., Brooklyn, N.Y. Called the D.R. (Direct Reading) Micrometer, it eliminates human error by providing automatic and exact dial readings from zero to 1". The D.R. Micrometer is a precision instrument fitted with a friction stop and lock screw. The measuring faces are made of tungsten and carbide. D.R. Micrometers come with a wooden case for safe storage when not in use. An accessory stand is available for desk or bench. Other models with extended ranges are available.



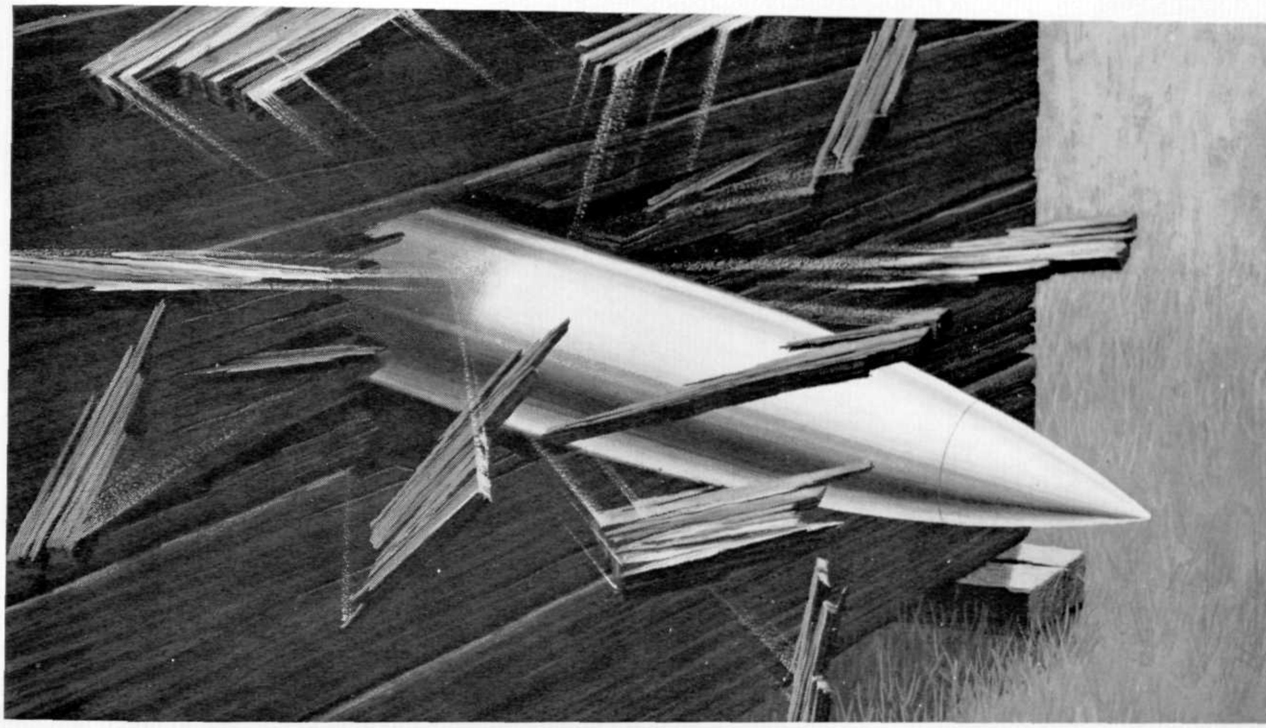
Corning Electronic Components is producing glass dielectric capacitors in insulating plastic shells to eliminate intercomponent shorting. Gold-flashed radial leads are 1 1/4-inch long and set .200-inch apart, convenient for connections between a set of printed circuit boards or for long spans between holes on top of a board. The new TV capacitors are ideal for circuitry requiring stability and high component density. Capacitive elements of the TV capacitors are made the same as all Corning capacitors: by stacking alternate layers of glass dielectric and conductor foil, then fusing the assembly into a monolithic unit.



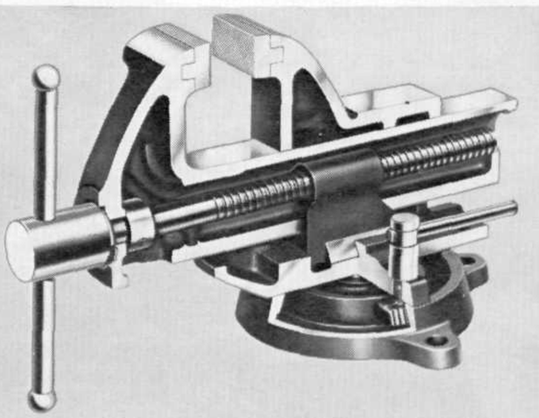
A real conversation starter! Fully calibrated with A, C, and D scales, this 2" miniature slide rule tie clasp really works! Tiny moving glass magnifies etched numbers. Completely accurate, it will solve all your problems the big ones do. Doubly useful, if you're in engineering, architecture, designing, accounting, electronics, or any of the fields where some quick-figuring comes in handy! An impressive business gift. Matching cuff links are non-operating, a pair. All in sterling silver. Leslie Creations, Lafayette Hill, Pa.



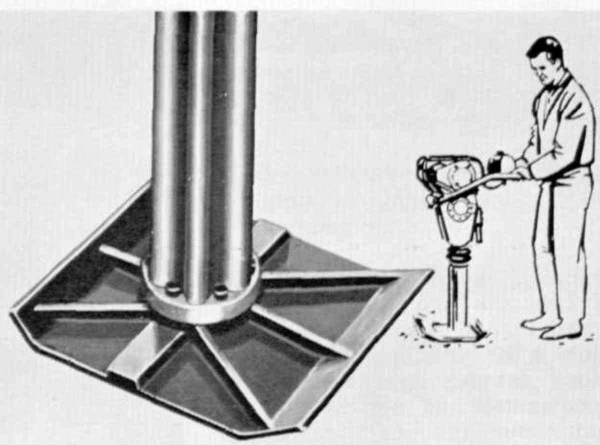
Probably the only steady head during the Institute of Electrical and Electronics Engineers annual symposium and exhibit will be displayed by Fairchild Controls. This head has to stay steady because it is fully instrumented with three subminiature rate gyros, three subminiature accelerometers, an inverter, six demodulators and room for three dynamic accelerometers more should the need arise. It is the mock-up of a head of the anthropomorphic dummy which is being developed for Project Apollo. Its purpose -- to provide data to scientists involved in the overall bioastronautics program designed to protect American astronauts from the hazardous environmental conditions to which they will be subjected during space flight.



Malleable artillery shell pierces 2 feet of solid oak at a velocity of 2,000 feet per second. In U. S. Army tests, pearlitic Malleable 105 millimeter shells were fired at 112% of rated maximum pressure. The new Malleable shells pierced the solid barricade, performing to the exacting requirements of the specification . . . proof of STAMINA.



"Guaranteed for Life" is the hallmark of confidence the manufacturer of this vise has had in its all-Malleable housing since first designed in 1917. These machinist's vises really earn their reputation as the most abused tool in the workshop, and about one million are now in use. All carry this unconditional guarantee . . . proof of STAMINA.



Pearlitic Malleable shoe for air-powered compactor delivers 900-pound blows at the rate of 350 per minute. Day after day, month after month, this rugged casting batters away on dirt, gravel, clay and rocks without significant wear or damage . . . proof of STAMINA.

Add Greater Stamina To Your Products With Malleable Castings

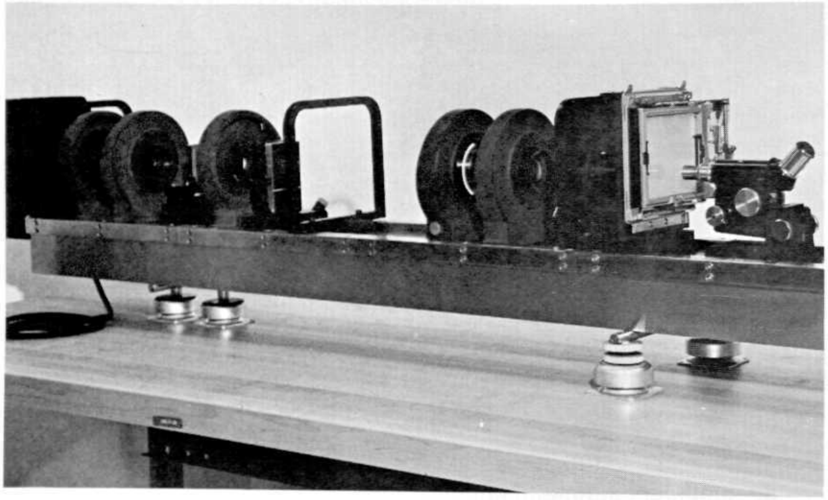
Your Free Copy of Malleable Engineering Data File is now available from any member of the Malleable Founders Society. Or write to Malleable Founders Society, Union Commerce Building, Cleveland 14, Ohio.

For more detailed information on how Malleable castings can improve your products, call any of the progressive companies that display this symbol —

MEMBER MALLEABLE FOUNDERS SOCIETY

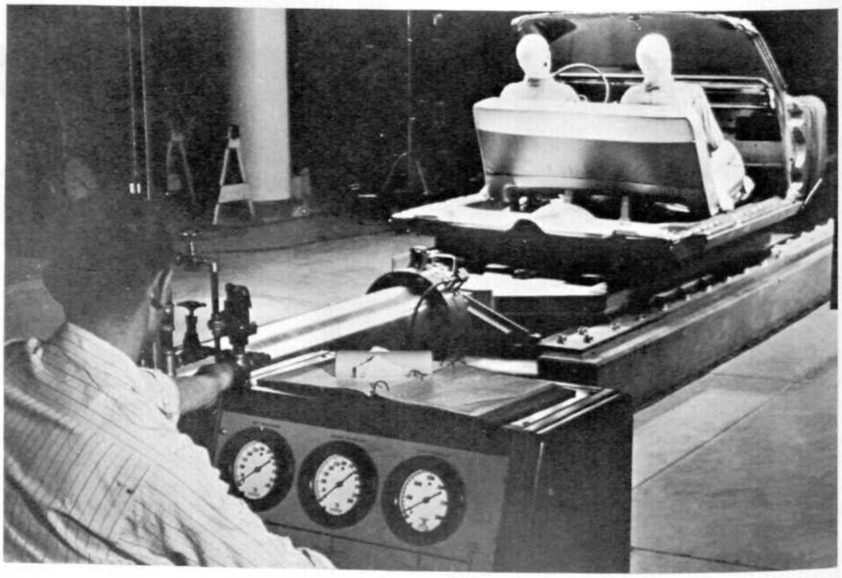
WHAT'S NEW IN MICHIGAN?

edited by Orville Barr



Shown here is a view of the interior of a $25,000 optical data processor, capable of performing millions of mathematical operations per second. This device, known as a correlator, can be placed on a table top and plugged into an ordinary electrical outlet. Produced by Conductron Corporation of Ann Arbor, it is capable of outperforming the largest digital computers in certain important types of computation. Furthermore, since its operation is based on the modification and manipulation of light rays by cleverly designed lenses, it has no electronic parts and is, therefore, inherently far more reliable than electronic digital computers.

This unique Impact Sled is now in use at General Motors Proving Grounds. it is used to test the performance, under high speed crash conditions, of automotive safety devices ranging from door latch assemblies to complete body assemblies (see photo). The device uses a compressed air-cylinder imbedded in 91 tons of concrete and with a 300,000 pound thrust to give the test vehicle a 40 G acceleration. Previous devices have used rapid deceleration to simulate crash situations. The shock can be directed from any direction, giving engineers unlimited possibilities for creating the best test situation.



This experimental Ground Effect Machine (GEM), tested by General Motors Research Laboratories Engineering Development Department, skims over land and water at a 4-inch altitude with driver. Fore and aft fans driven by 15-horsepower engines produce a continuous sheet of air from an annular jet around the bottom of the vehicle. This sheet seals a supporting low pressure air bubble under the vehicle.

MSU NEWS NOTES

edited by Orville Barr

An unprecedented "academic common market" will allow graduate students at Michigan State University, University of Michigan and nine other major midwestern universities to move freely from one institution to another.

A "traveling scholar" from any of the participating universities will be able to take specialized courses at another university for one semester, or two quarters, while remaining registered at his own school.

The plan was announced Feb. 16 by the Committee on Institutional Cooperation, a group formed several years ago by the Big Ten universities and the University of Chicago to stimulate cooperative projects.

The chief goal of the innovation is to make it possible for a graduate student at a CIC university to have the advantage on a short-term basis of a special opportunity available at another.

It might take the form of a special laboratory, a library collection, or a faculty member highly qualified in a particular area.

The program will begin in September 1963 and run initially for a two-year trial period.

Michigan State University's growing space program has received recognition from the National Aeronautics and Space Administration in the form of training grants for eight graduate students.

Grants for from 2 to 15 students were made to each of 88 colleges and universities, NASA announced.

The federal agency pointed out that the grants are designed to help meet future needs for scientists and engineers and that:

"The institutions were selected not only because they have doctoral programs in space-related science and engineering but also because of their willingness to undertake a strengthening of their programs in these areas."

A recent survey of the MSU College of Natural Science and College of Engineering showed that 32 staff members were active in space-related research.

Their interests covered a wide range. They included such areas as germ-free animal research and relativistic aspects of space vehicles.

For the third straight year a Michigan State University mathematics team is among the top 10 in the United States and Canada.

The MSU team placed 10th among teams from 157 U.S. and Canadian colleges and universities competing in this year's William Lowell Putnam Mathematical Competition.

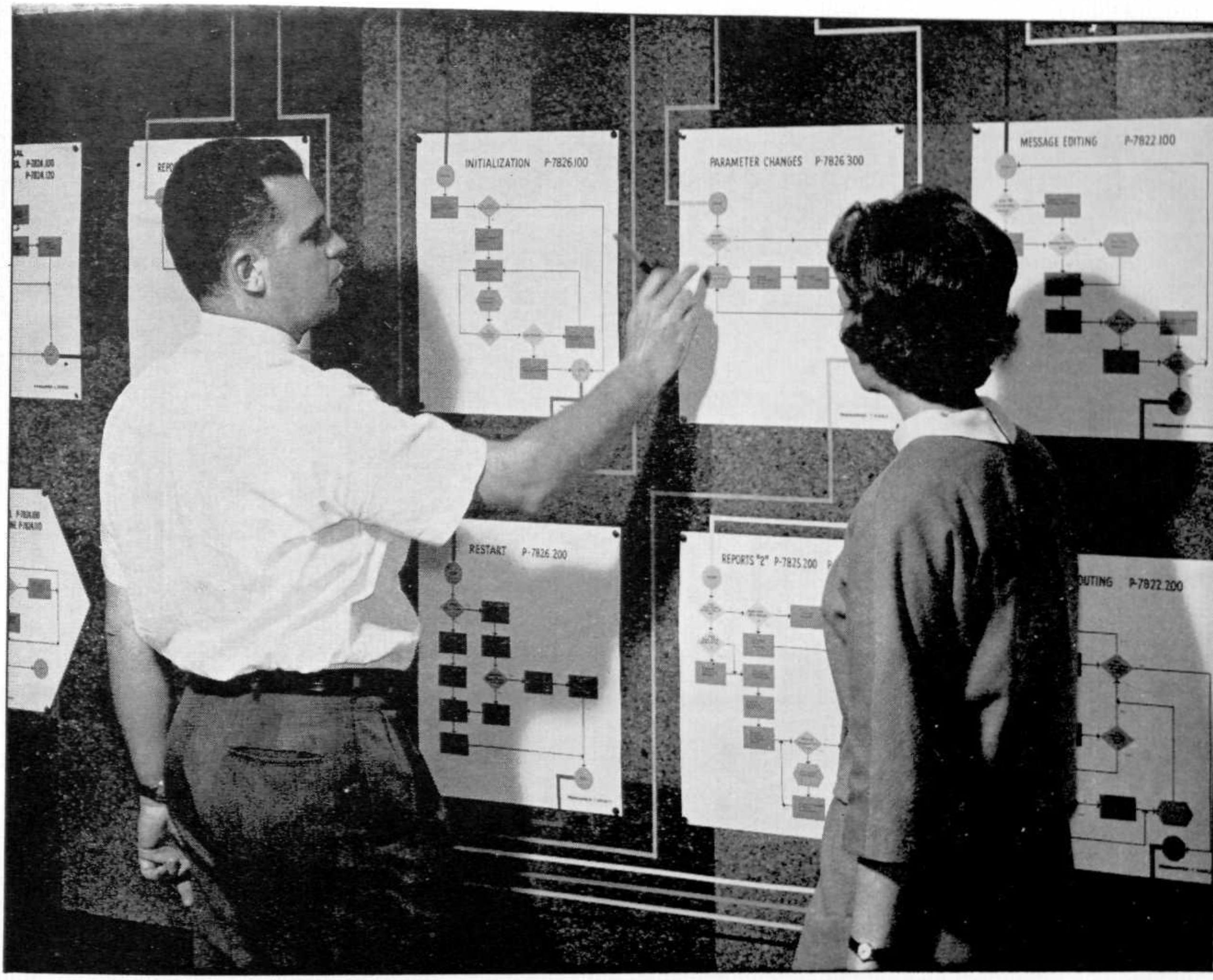
Although it lost the number one national position it gained last year, MSU still led all other Midwestern schools.

Members of the team were Robert Bartholomew, Grand Rapids senior; Robert E. Greene, Knoxville, Tenn., junior; and Stephen E. Crick, Jr., Livonia freshman. Greene also served on last year's team.

They were coached by Dr. Leroy M. Kelly, with the aid of Dr. Fritz Herzog. Both men are professors of mathematics at MSU.

The first five teams, announced by the Mathematical Association of America, came from, in order: California Institute of Technology, Dartmouth College, Harvard University, Queens University (Ontario, Canada), and the University of California at Los Angeles.

Winning honorable mention were: Michigan State, Massachusetts Institute of Technology, New York University, University of California, Berkely, University of Toronto, and the University of Manitoba.



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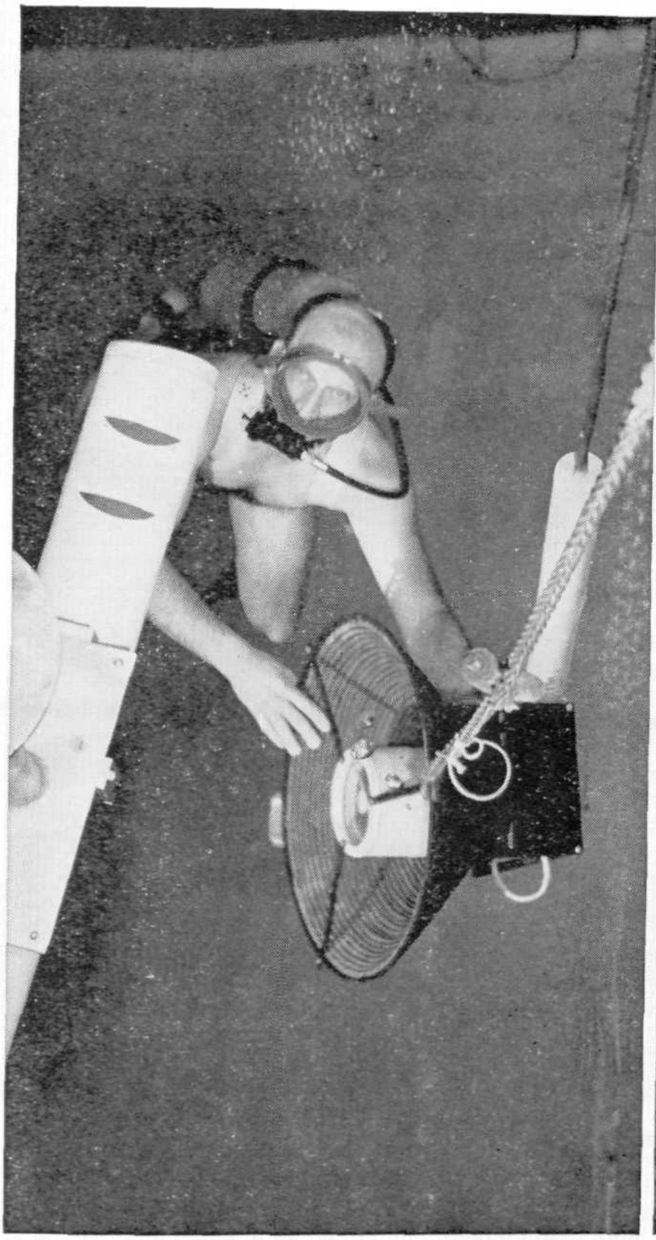
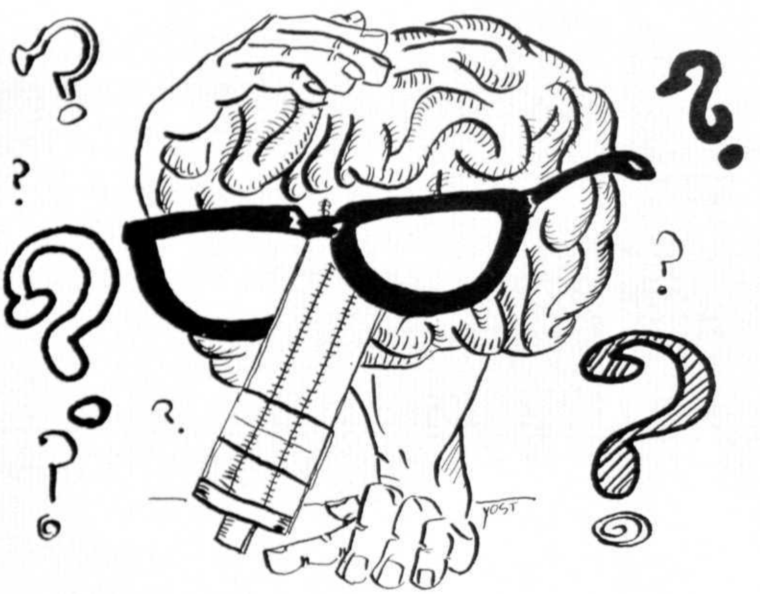


BRAIN TEASERS



(1) It was the daily practice of a milkman to fill his two sixteen-gallon cans with pure milk before he started out to serve customers on four different streets, the same number of quarts being delivered on each street.

After serving the first street, he connected with the city water supply and, lo, his cans were again filled to the brim! Then he served street number two and again backed up to the fount to replenish his cans as before.

He proceeded in this way to serve each street, flling his cans with water after each street had been delivered, until all of his customers were served.

If forty quarts and one pint of pure milk remained in the cans after all his customers were attended to, how much pure milk must have been delivered on each of the four streets?

(2) Five newsboys formed a partnership and disposed of their papers in the following manner. Joe Doe sold one paper more than one quarter of the whole lot, Melvin Brusher disposed of one paper more than a quarter of the remainder, Frank Doe sold one paper more than a quarter of what was left, and Tom Brusher disposed of one paper more than a quarter of the remainder. At this stage, the Doe boys had together sold just one hundred papers more than the Brusher boys had sold. Charlie Brusher now sold all the papers that were left.

The three Brusher boys sold more papers than the two Smith boys, but how many more?

(3) You have a piece of wire 0.01" in diameter and wind it into a ball such that the ball is spherical and two feet in diameter. If the ball contains no air space, compute the length of the wire without using the factor pi in your calculations.

(4) Two ferry boats start moving at the same instant from opposite sides of the Red Cedar River. One boat is faster than the other, so they meet at a point 720 yards from the nearest shore.

After arriving at the slip to change passengers, each boat departs exactly 10 minutes after it arrived. The boats meet a second time at a point 400 yards from the other shore. What is the width of the river at this point?

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(1) The milkman delivered 32 quarts of pure milk on the first street, 24 on the second, 18 on the third, and 13 and 1/2 of the fourth, making 87 and 1/2 altogether.

(2) The Brusher boys sold 220 more papers than the Doe boys. The total number sold was 1020.

(3) To solve this problem without making use of pi, it is necessary to recall Archimedes' discovery that the volume of a sphere is two thirds the volume of a cylindrical box into which the sphere exactly fits. The ball of wire has a diameter of 24 inches, so its volume is the same as that of a cylinder with a height of 16 inches and a base diameter of 24 inches.

Now wire is simply an extended cylinder. How many pieces of wire, each 16 inches long and 0.01 inches in diameter, are equal in volume to the 16 inch high cylinder with a base diameter of 24 inches? Areas of circles are in the same proportion to each other as the squares of their diameters. The square of 0.01 is 0.0001 and the square of 24 is 576. Thus, 5,760,000 wires have the same volume as one cylinder. The ball thus contains the equivilent of 5,760,000 wires, each 16 inches long. This is equal to 92,160,000 inches or 1,484 miles and 2,880 feet.

(4) When the ferry boats meet the first time, the slow one has gone 720 yards and their total distance is equal to the width of the river. After they both reach shore, each has traveled the width of the river so their total is twice the width of the river. Upon their second meeting, they have traveled a total distance equal to three times the width of the river. Since the total distance at the second meeting is three times the total at the first meeting, the distance traveled by the slower boat at the second meeting is three times the distance was 720 yards so at the at the second meeting is three times the distance it had traveled to the first meeting. The first distance was 720 yards so at the second meeting it had gone a total of 2160 yards. We also know it traveled once across the river and then returned 400 yards on its second crossing before the second meeting. Therefore, the river is 2160-400 or 1760 yards wide.

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Annual Financial Report of the Spartan Engineer

The Spartan Engineer is operated by the undergraduates of Michigan State University and is published every once in a while by those engineers that have nothing better to do. It is a non-profit (to say the least) organization and exists for the sole purpose of keeping the Dean of Engineering, the Dean of Students, the advisors and other campus censors employed.

It is only right that we should offer to our subscriber and other enemies a full account of our financial dealings.

Expenses:

Rent on rain machine for ROTC parades	$ 716.19
Editor's private secretary	3.91
Printing costs	32,190.00
Popcorn for campus ducks	201.19
National convention trip	1,819.10
Coral Gables for staff meetings	716.19
Bail for staff during fiscal year	12,181.70
Engraving of Dean's signature	4.75
Advertising commissions	00.00
Bribes to faculty	5,985.39
Paid to M.S.U. for wrecked police car	2,314.19
Expenses for clean up after staff meeting	78.62
Typing paper	.19
Staff salaries	39,171.18
Payment for parking tickets	45.00
Picnic for staff	
Bug spray	514.19
Food	.65
Fee to re-enter school (joke editor)	250.00
New T-Bird for business manager	2,800.00
Used tire for editor's bike	.26
Unsuccessful bribe to draft board to keep editor from being drafted	15,198.00
Unaccounted for	6,732.06

Income:

Advertising	3,714.16
Sale of 19 stolen books	1.98
Found under a table at the Gables	.17
Bets of Michigan game	18.32
Sale of old pin-ups to Playboy	.14
Deposit refund on editor's empty joy bottles	2,917.16
Sale of ME 101 tests to sophomores	605.37
Sale of staff's photo	.11
Sale of three hijacked airplanes	98,625.19
Offering collected by circulation staff posing as church Deacons	392.19
Sale of Morrill Hall	13.16
Sale of old Nixon buttons and stickers	28.15
Income from editor winning the writing contest	5.00
Subscription drive	.08
Paid on blackmail operations	
from faculty	8,171.18
from students	53.21
Income from fake ID cards	142.10
Renting of University cars	171.18

Swiped from the Wisconsin Engineer

Two first-graders stood talking in the school playground during recess when a plane flew over. "Look at that," said one. "It's a XB-50."

"No, a XB-51," commented the other. "You can tell by its wing sweep."

"You're right," conceded the first youngster, "But it's not going more than 760 miles per hour because it did not break the sound barrier."

The second lad agreed on this and remarked, "It's amazing the pressure developed on those planes when they go into a dive -- almost 12000 pounds per sq. in."

Then the school bell rang, indicating the end of recess and the first boy sighed, "Let's go back in and finish stringing those darn beads."

Psychiatrist to patient: "Your problem is that you had a happy childhood and you've got a guilt complex about it."

An optimist is a man who returns to the marriage bureau to see if his liscense has expired.

E.E.: "I thought you were going to visit the blonde in her apartment."

C.E.: "I did."

E.E.: "Why are you home so early?"

C.E.: "Well, we sat and chatted a while. Then suddenly she turned out the lights. I can take a hint."

A person who claims that an absolute zero is impossible, hasn't taken a quiz in thermodynamics yet.

M.E.: "What's worse than being a bachelor?"

C.E.: "Being a bachelor's son."

I serve one purpose in this school,
On which no man can frown.
I quietly sit in every class,
And keep the average down.

"It's quite simple," explained one of the seniors in E.E., "to hook up an electric power circuit. We merely fasten leads to the terminals and pull the switch. If the motor runs, we take our readings. If it smokes, we sneak it back and get another one."

The bee is such a busy soul,
It has no time for birth control,
And that is why in times like these
There are so many sons of bees.

Guests in a London hotel, hearing a scream in the corridor, discovered a damsel in a negligee being pursued by a gentleman who was, to put it bluntly, nude. Later it developed that the impetuous Romeo was an English army officer, who was promptly court-martialed. His lawyer won him an acquital, however, by virtue of the following paragraph in the army manual: "It is not compulsory for an officer to wear an uniform at all times, as long as he is, suitably garbed for the sport in which he is engaged."

Teacher: "What are the people of New York noted for?"

Boy: "For their stupidity."

Teacher: "What ever gave you that idea?"

Boy: "The book says that the population is very dense."

The wife was always antagonized by her husband's going out at night. His departing words, which especially angered her, were always: "Good night, mother of three."

But one night, she could stand it no longer, and when he took his hat, started out the door, and called cheerily, "Good night, mother of three" she answered quite as cheerily, "Good night, father of one."

Now he stays home.

The hen is the only animal that can lay around and make money.

M.E.: "Why is it that you always sit in the rear of the room when we are taking an examination?"

Classmate: "I don't wish to disturb the professor while I am making my consultations."

"Is there anyone here who is unfamiliar with the objectives of Engineering 160?"

THE ADVERTISER'S INDEX

This kind of engineer designs jobs instead of things

Once upon a time there was a creature known to jokesmiths as "the efficiency expert." When he wasn't being laughed at, he was being hated. Kodak felt sorry for the poor guy and hoped that in time he could be developed into an honored, weight-pulling professional. That was long ago.

We were then and are much more today a very highly diversified manufacturer. We need mechanical, electrical, chemical, electronic, optical, etc., etc. engineers to design equipment and processes and products for our many kinds of plants, and make it all work. But all the inanimate objects they mastermind eventually have to link up with *people* in some fashion or other—the people who work in the plants, the people who manage the plants, and the people who buy the products. That's why we need "industrial engineers."

A Kodak industrial engineer learns mathematical model-building and Monte Carlo computer techniques. He uses the photographic techniques that we urge upon other manufacturing companies. He collaborates with medicos in physiological measurements, with architects, with sales executives, with manufacturing executives, with his boss (G. H. Gustat, behind the desk above, one of the Fellows of the American Institute of Industrial Engineers). He starts fast. Don Wagner (M.S.I.E., Northwestern '61) had 4 dissimilar projects going the day the above picture was sneaked. He is not atypical. *Want to be one?*

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