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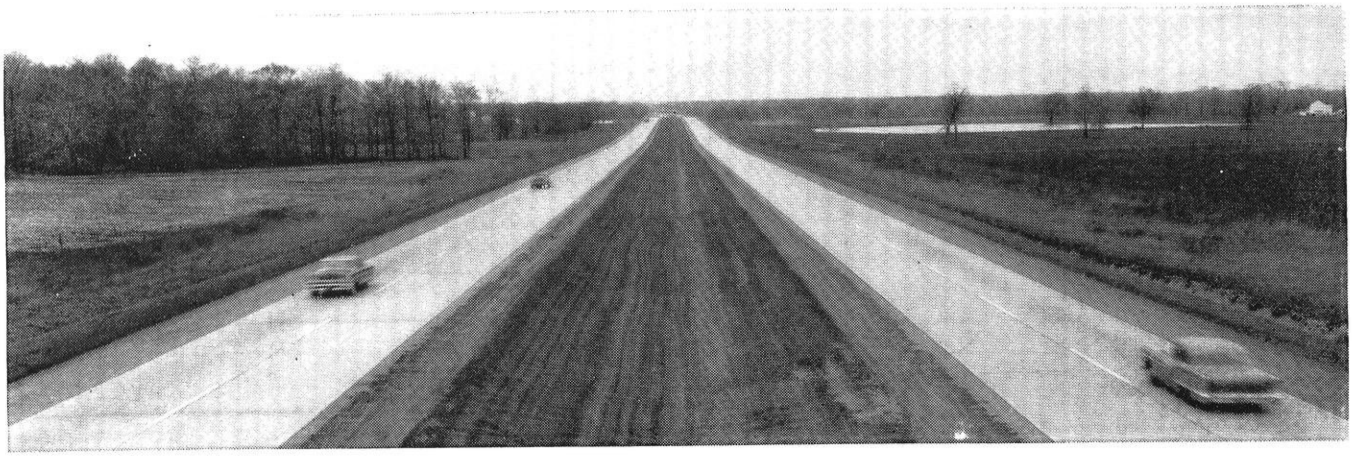
OCTOBER

1958

25¢



Design a 2-lane steel bridge to cross a modern highway—

$44,000 in cash awards!

American Bridge Division of United States Steel announces a $44,000 Steel Highway Bridge Design Competition dedicated to stimulating the engineering mind to a more imaginative, more effective use of steel in the construction of small bridges.

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Awards for College Engineering Students

	each
1st Award	$4,000.00
1st Honorable Mention	$2,000.00
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Problem: Get two lanes of traffic across a modern 4-lane highway in accordance with latest standards for today's highways.

Objectives: Originality of design, greater utilization of the inherent properties of steel, economy, and aesthetic appeal.

Requirements: Just one. The steel bridge must comply with the Geometric Standards for the National System of Interstate and Defense Highways using H-20-816-44 loading. The type of structure, the type of connections, span length and number of piers, if any, are completely up to you since you are designing with steel.

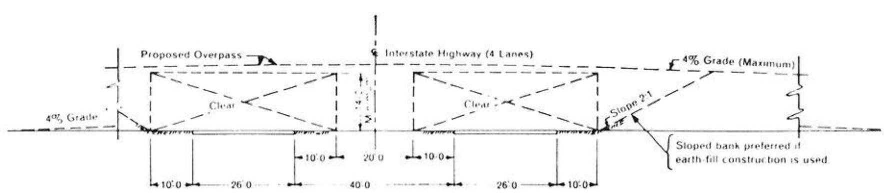
Eligibility: The competition is open to all professional and design engineers and college engineering students except employees and/or members, and their immediate families, of the following firms and groups:

United States Steel and its subsidiaries, divisions, agents and dealers
Structural steel fabricating firms
American Institute of Steel Construction
Rules Committee and Judges

See list of awards above.

Rules and Judging: The competition will be under the supervision of the American Institute of Steel Construction, which has appointed a Rules Committee and a panel of judges composed of prominent consulting engineers and architects.

Deadline: Entries must be postmarked or expressed to arrive not later than midnight, May 31, 1959. *USS is a registered trademark*



ELEVATION and CLEARANCE DIAGRAM

Send for your entry booklet now: Contains complete information on the Steel Highway Bridge Design Competition—everything you need to know to prepare your entry. Just fill in and mail the coupon and get started with your design without delay.

United States Steel

Competition Editor, Room 1831
American Bridge Division
525 William Penn Place
Pittsburgh, Pennsylvania

Please send me a copy of your $44,000 Steel Highway Bridge Design Competition entry booklet.

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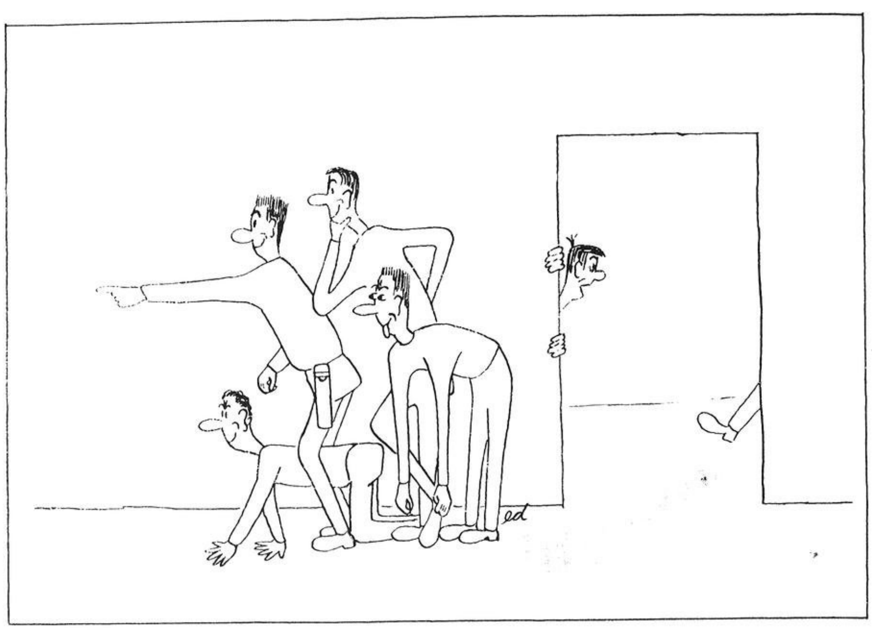
Engineering Student ☐ (Check one)

Street..

City.. **State**.......................

"Oh No! We've Got To Go Back! I Forgot My Freshman Lectures Notebook!"



"Hey Fellas—Guess What Just Went By"

Volume 63 | OCTOBER 1958 | Number 1

WISCONSIN ENGINEER

The Student Engineer's Magazine

FOUNDED 1896

Features

Departments

Cover

Some Toy! One of the River Queen's four crawler truck units. Each crawler weighs 217,700 pounds, is 13 feet 5 inches wide and 26 feet 9 inches long.

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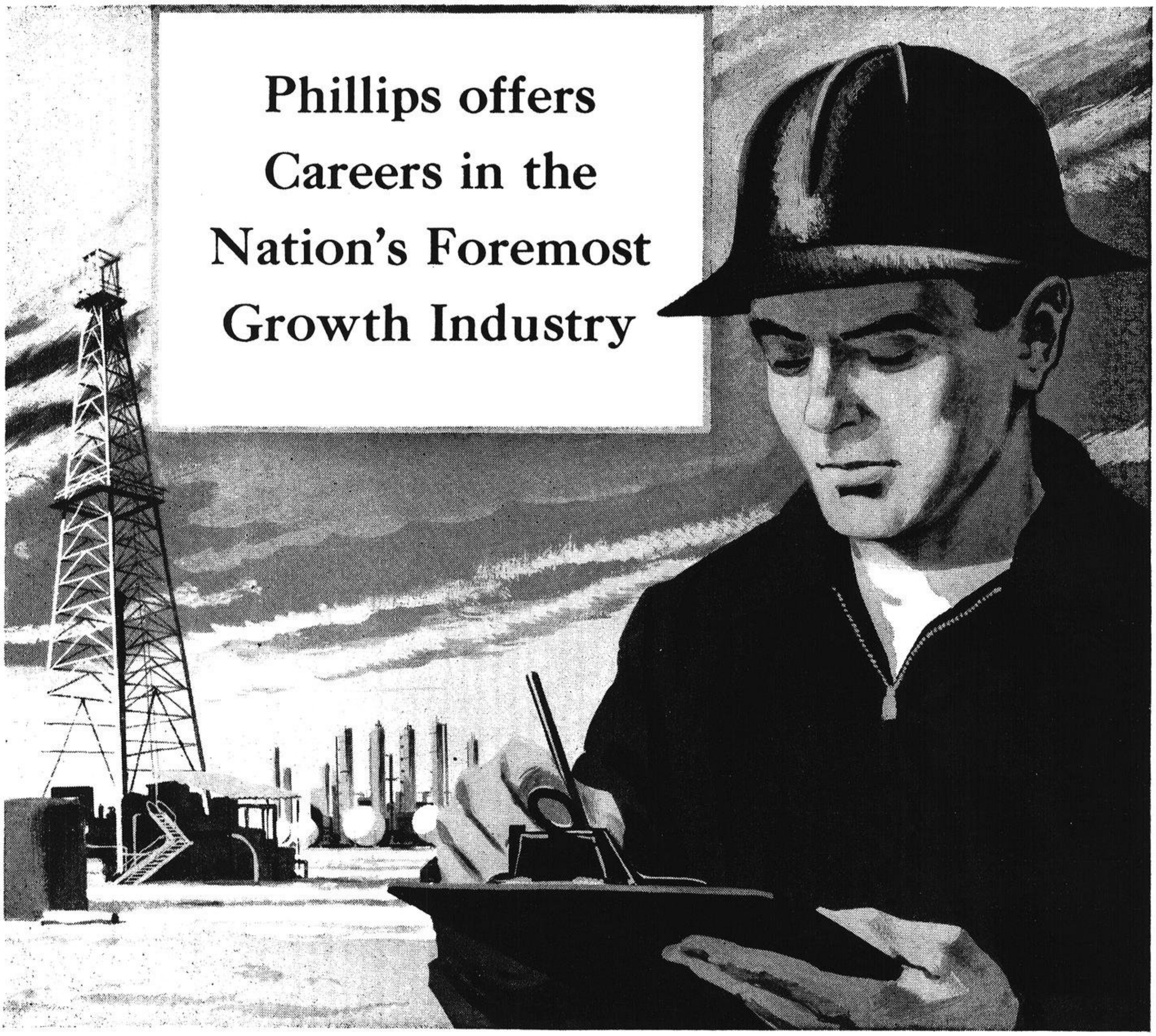

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FOR THE SPACE AGE

Systems in the Air

The march of electronics into the Space Age is being quickened as a result of Hughes work in airborne electronics systems.

One such development is the Hughes Electronic Armament System, which pilots high-speed jet interceptors to enemy targets, launching Hughes air-to-air guided missiles, and flies the plane home. Even more sophisticated Electronic Armament Systems completely outstrip those presently released for publication.

Working on space satellites, Hughes engineers are active in the preliminary design of guidance and control systems, communication and telemetry systems, sensing devices using infrared, optical and radar techniques.

Information resulting from Hughes study in the fields of air-to-air and ballistic guided missiles is presently paying dividends into the fund of space knowledge.

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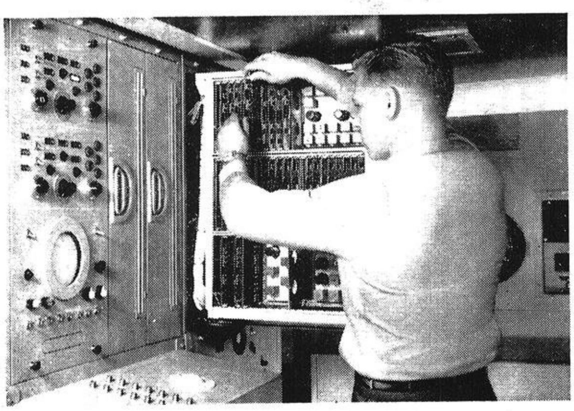
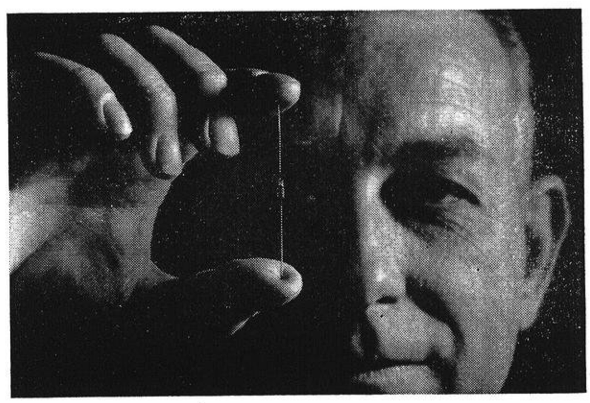
The advanced nature of Hughes electronic systems—in the air, on the ground, and for industry—provides an ideal growth environment for the graduating or experienced engineer interested in building rewarding, long-range professional stature.



Data Processors, which monitor hundreds of aircraft and store the information for high-speed assignment of defense weapons, comprise one part of an advanced Hughes ground defense system.



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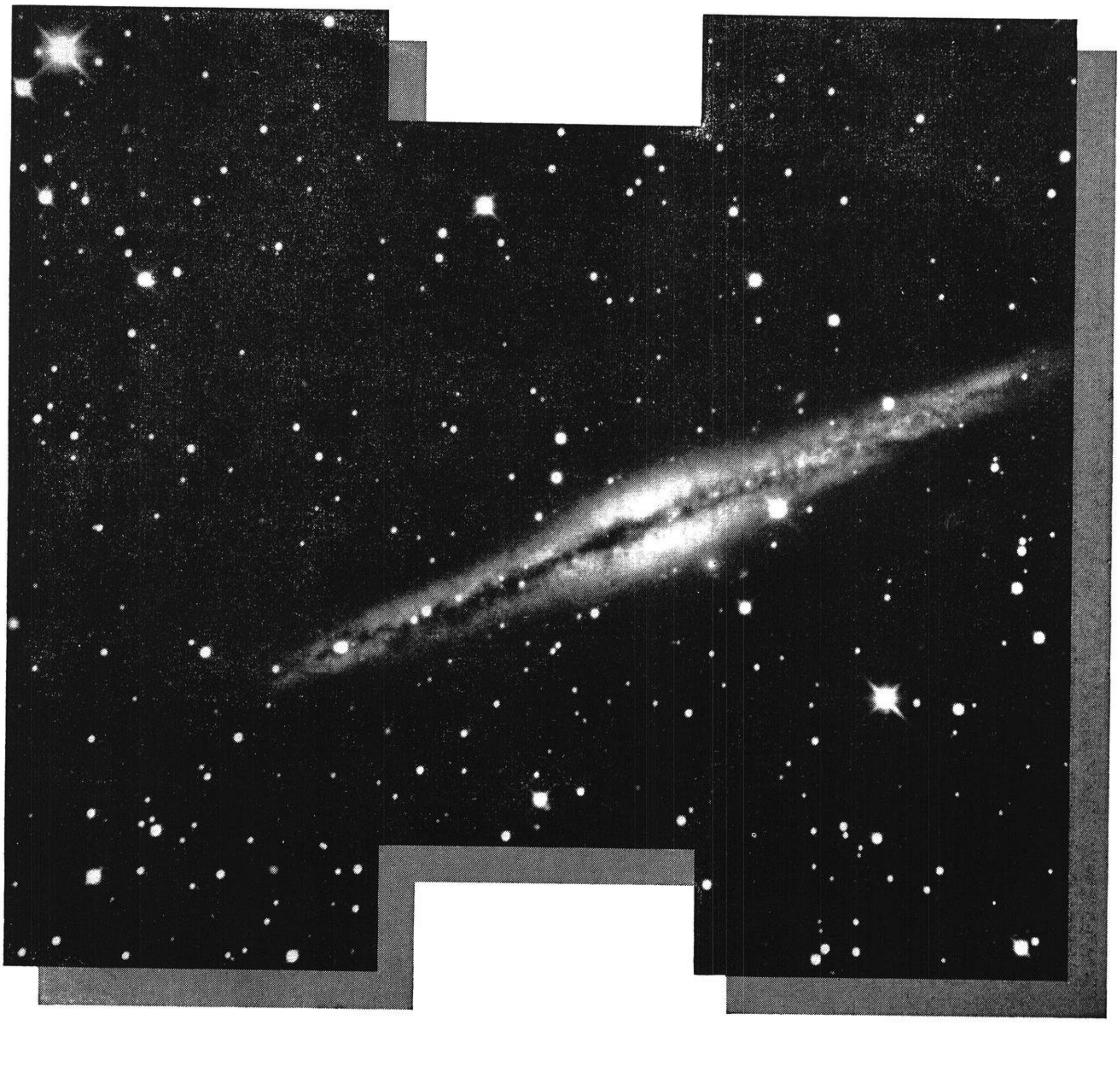

the beginning of a **million dollar** detective story

Men, vehicles and instruments bound for the middle east

The cast of this story may include a part for you. GSI is a leader in the worldwide search for new petroleum reserves. Emphasis is shifting to foreign areas and there is a world of opportunity awaiting those who can qualify for a career in geophysical exploration.

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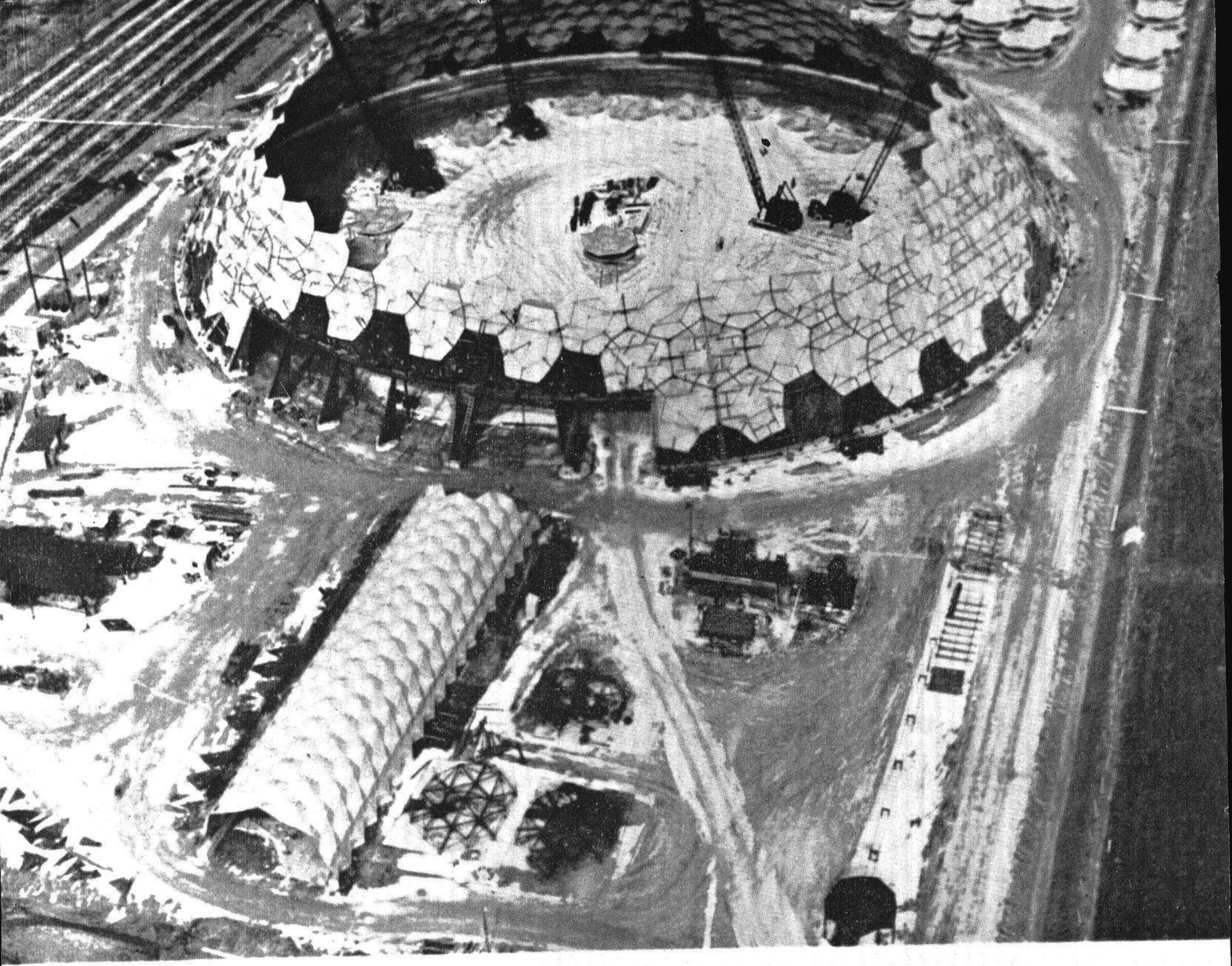
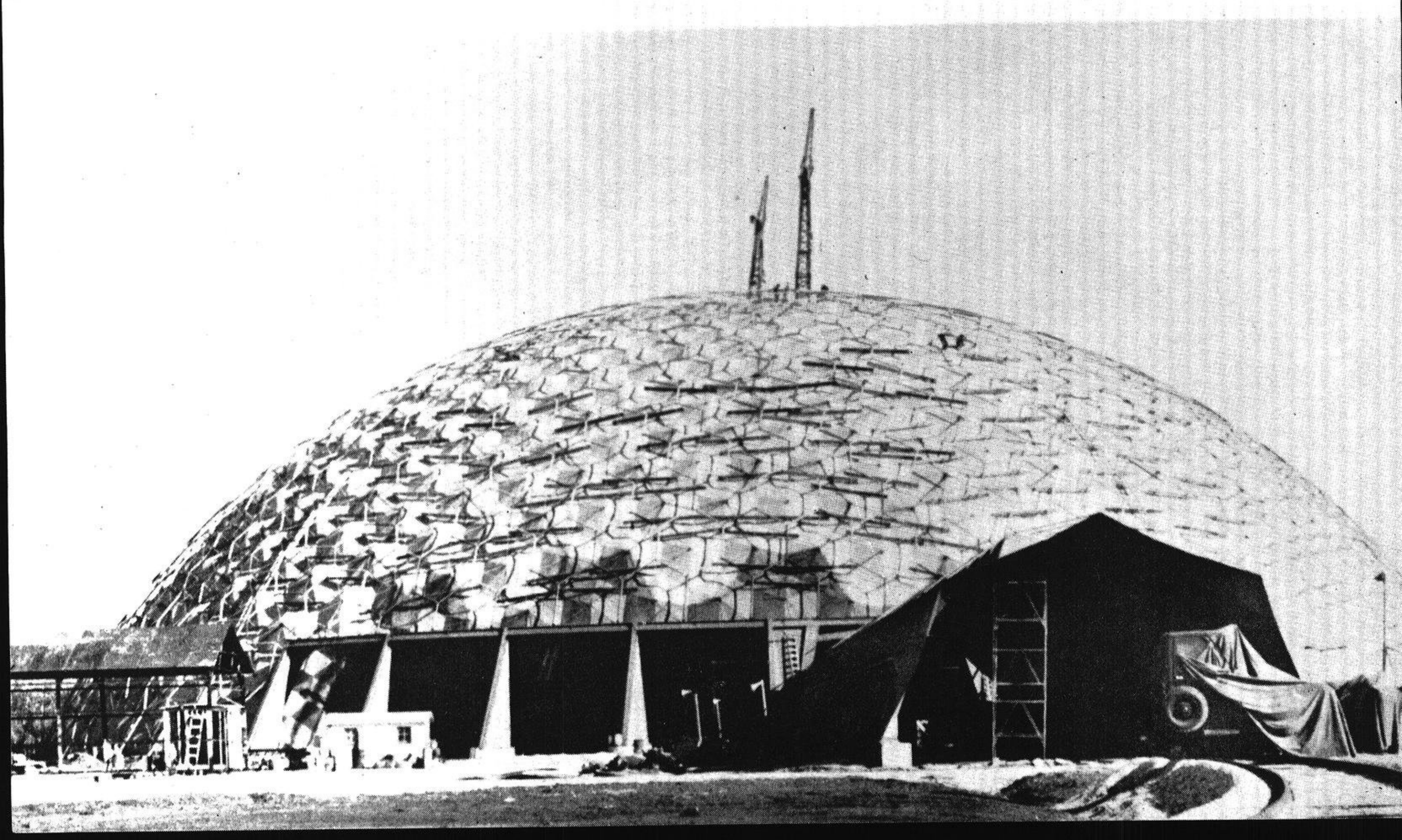




Rambling WITH THE EDITOR

In this first issue of *The Wisconsin Engineer* this year, we naturally think of getting back to the hustle and bustle of engineering curriculum and campus activities. After about six weeks of the usual "rat race" and readjustment, things around the "engine" school are molding into normality.

Summer activities of Wisconsin engineering students varied, of course, but the majority were found either attending summer classes or working in industries of some kind. Jobs for non-graduates were rather hard to find this summer; just about all companies who hire summer help either hired none at all or reduced the number they employed considerably.

Talking with graduate engineers that were aware of the employment situation revealed their concern, also, about the security of their own jobs. The machine-tool industry all over the nation was in one of the worst conditions it has been in, in many summers, hydraulic products were just holding their own if they were not slipping behind the usual, and the electrical industries were certainly not suffering any growing pains. The aviation industry in many places was about the only one that was making any headway, and then it was not an outstanding showing.

Some companies that are engaged in two or more of the operations mentioned above, including aviation products, transferred many engineers from their other plants to the aviation works in order to maintain them with the company. Even with this attempt to keep them, several had to be laid off as a result of the spring "budget cuts."

This industrial condition caused many students, unable to find summer employment, to remain on campus for the summer session. The other fortunate ones found jobs at whatever they could.

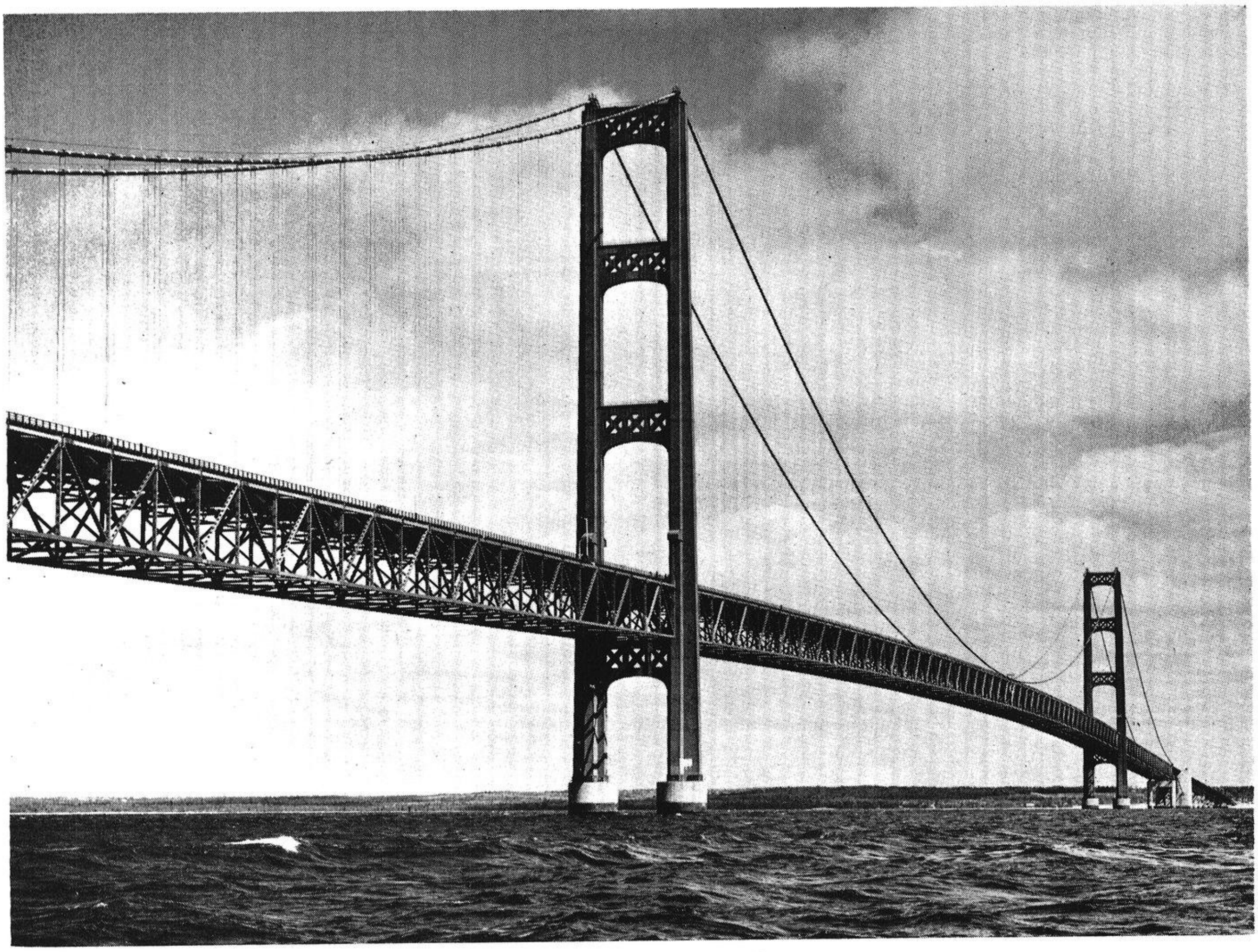
Something should be said, however, about the jobs made available to engineering students for summer employment. A great deal of praise and appreciation should be paid these companies by every undergraduate engineer who has been privileged to work as a technician, engineering aide, in the production shop, or on the drawing board. The experience gained here is invaluable to him as a future engineer. It is experience that can not be replaced with any class-room work in theory or by so-called laboratories where the student has only a chance to "observe" and seldom the chance to perform. Educators more and more, it seems, are failing to realize the importance of courses where the engineering undergraduate has a chance to work with his hands—to see how the machines that he solves problems about really works.

Reading a news release recently, I noticed the comments of a leading industrial executive about the lack of preparation given to today's graduating engineers in this field of physical training. He pointed out that an engineer is about the only one of professional status that is not taught to be competent with his hands as well as his mind. He said we would not think of submitting to a surgeon that had stores of knowledge, even genius, and maybe a degree or degrees as a specialist and, yet, had hardly handled the instruments with which he was working. He made the point that, in today's highly technical and scientific age where the future of man's existence may depend upon engineering competence, this matter can not and should not be taken lightly.

Other companies are probably realizing this also, and it is almost certain that the experience they can provide for engineers yet in school will pay off in future rewards unable to be measured in terms of the few dollars they spend each summer that are listed in their accounting books as "Training Program."

In the above photo the world's largest circular building, Union Tank Car's Dome, is shown at the halfway point of construction. Three hundred twenty one hexagonal panels form the skin of the all-steel Dome.

The Union Dome in Baton Rouge, Louisiana (lower photo), the first major industrial use of a geodesic dome in this country, is expected to be in full operation this month.



The Mackinac Suspension Bridge.

Construction of the Mackinac Bridge

by James A. Haefner

THE construction of the Mackinac Bridge is similar to the construction of the Golden Gate Bridge, George Washington Bridge, and the original Tacoma Narrows Bridge. These bridges are suspension bridges. The reason for using the Mackinac Bridge as an example is that the newest and finest construction techniques were used and that the bridge is now one of the most famous in the world. The account of the construction of the bridge in this report will follow this step by step plan.

Piers are built to support a bridge, and anchorages are built to anchor the main suspension cables. These piers and anchorages are the first part of a bridge to be constructed. Once these are built, the steel work can begin.

Steel towers are erected to support the large suspension cables. The cables are then spun and suspender ropes are hung from them. Stiffening sections of steel, used to support the roadway and give the bridge stability, are attached to these suspender ropes. When all stiffening sections have been hung, the roadway is welded to them.

The information in this report is to inform the reader of how the suspended portion of the bridge

Roadway stringers are lifted from the barge to the roadway for the suspended span of the bridge. These are moved by temporary derricks such as the one set up at the right.

was erected and the amount of steel and concrete used in building.

Cable Anchorages

The construction of the cable anchorage piers, along with the main tower and cable support piers, is the first step in the building of a suspension bridge. The cable anchorages are the immovable anchors for the main suspension cables and are large rectangular masses of reinforced concrete.

These anchorages were built by driving sheetpile to bedrock (86 feet), then digging the mud or overburden from the cofferdam. Stone was dumped in the cofferdam and at Intrusion mortar was forced into the stone to make Prepakt concrete.

These blocks of concrete measure 135 by 115 feet and are as high, above water, as a ten-story building. The south anchorage contains 55,000 cubic yards and the north anchorgae contains 47,000 cubic yards of concrete. The anchorages are designed for an ice pressure of 115,000 lb. per linear ft. Figure 1 shows the size and shape of a cable anchorage.

Main Tower and Cable Support Piers

The four piers were constructed by driving steel sheetpile caissons to bedrock at a depth of 130 feet for the cable support piers and 206 feet for the main tower piers. The caissons were then filled with stone and an Intrusion mortar was forced into the stone to make Prepakt concrete.

The cable support piers contain 24,000 cubic yards of concrete and tower piers contain 85,000 cubic yards. Figures 2 and 3 show how the Mackinac Bridge tower and support piers look.

Main Tower Erection

The main towers are to support the heavy main suspension cables. The cables are fitted in a saddle at the top of the towers. The towers are composed of 27 cells and a maintenance elevator.

Construction

Sections of the tower were prefabricated on shore and then floated into position by barge. From the barge the sections were picked up by a floating derrick and lifted into position on top of the piers. When the floating derrick could no longer be used, a creeper derrick was attached to the already erected portion of the tower. The creeper derrick would climb the tower as it added additional sections to it.

Riveting and welding was done inside the dark confined cells of the tower. Workmen were provided with electric cap lamps powered by special batteries. Electric wiring was impractical to install in the remote recesses of the towers due to the safety hazard of the wires. Temporary elevators were put in to facilitate the movement of the riveters and their equipment.

The towers are constructed to a height of 552 feet above the water. The weight of the steel in the two main towers is approximately 13,000 tons. The two towers took five months to build.

Cable Spinning and Suspender Hanging

Before the cable spinning could be accomplished catwalks had to be hung in the same position as the main suspension cables. The first job was to hoist into place 2¼ inch wire rope to provide support for the catwalks. Ten of these ropes were needed; five wires for each catwalk.

The wire rope was unreeled into the water from a barge that was towed from pier to pier of the central span. Guy derricks, on top of the towers, lowered a line to water

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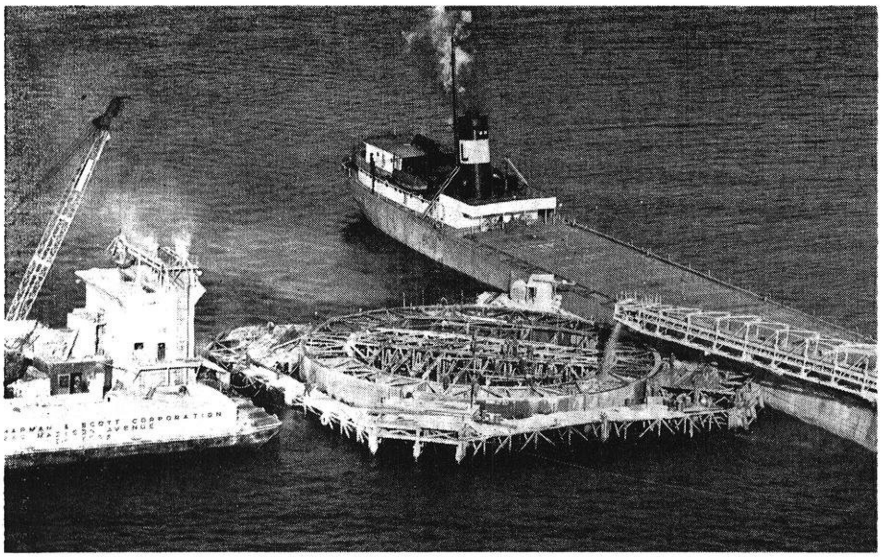


Here stone is being unloaded into a 130-foot deep caisson. Intrusion mortar was then forced into the stone to make Prepakt concrete.

level where it was fastened to the rope ends. The derricks then lifted the ends to the top of their towers where they were secured to a saddle.

The catwalk was made of chain link fencing, 9 by 100 feet; 6 by 8 inch wooden cross beams were attached every ten feet. After wooden posts were attached to the edges, later serving as hand rails, the decking was folded up accordian-wise and hoisted to the top of the towers. The decking was threaded on to the ropes and slid down to the sag by gravity. Near the bottom of the sag a "tugger hoist" was used to pull together the decking as it slid down from both the towers. Wooden cleats were attached on steeper slopes to insure footing. When both catwalks were in place, they were connected at intervals by cross-bracing, which served as an access from one catwalk to the other and stiffened the catwalks against waving motion. Wires were also connected diagonally between catwalks to serve the same purpose.

Construction

Tramway frames for supporting the endless rope that hauls the "spinning wheels" were erected on the towers, cable bents (piers), and ends of the anchorages. Other necessary wiring was installed, such as electrical cables for illumination, signals, power control, and telephone service.

Reels of cable wire were hoisted to the anchorages and set up in a bank of eight reels. This bank of reels serviced the cable spinning operations on the two catwalks. Wire was drawn off the reels by the spinning wheels which were hauled from anchorage to anchorage by the endless haulage rope. The proper tension was put on the wire, to avoid snarling, by and arrangement of floating pulleys, and counterweights in combination with brakes on the cable reels. A diesel engine was set on top of the anchorages to supply power for pulling the haulage rope.

Spinning Operations

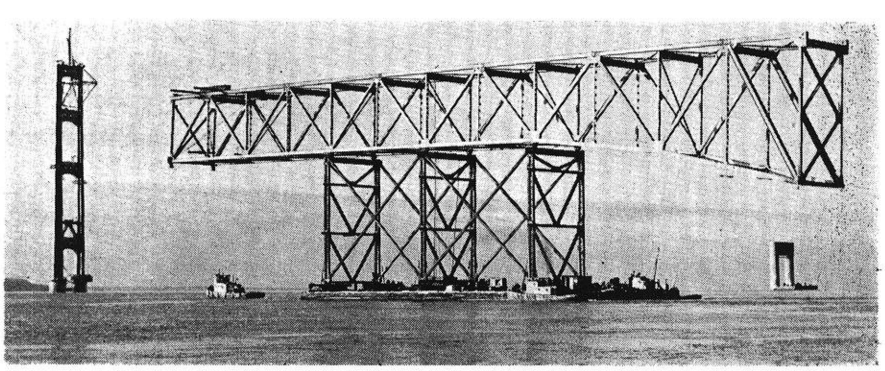
The cable is made up of 37 strands, each strand containing 340 wires. In starting the spinning of a strand, the beginning end of a wire was passed around a strand-shoe and clamped. Enough slack was left in the wire beyond the clamp to form a loop which was slipped on to the grooved rim of the spinning wheel.

The haulage rope was started, pulling wire from the reel (called the "live wire") over the top of the spinning wheel, while the bottom wire (dead wire) remained in fixed position at its end on the strand shoe. After the wheel has been hauled its entire distance to opposite anchorage, the haulage rope stopped and the loop was transferred from the spinning wheel to a strand shoe. The live wire was then wound around the strand shoe, and a second loop was formed and carried to the opposite anchorage.

In this way, the spinning wheel alternately carried wire first from one reel on one anchorage and then from a reel on the other. There were four wheels in operation at the same time, two for each cable. As a wheel left an anchorage on one cable a wheel also left the opposite anchorage on the other cable. Thus four wires were being spun at the same time on each cable.

As the spinning wheel moved toward the first tower, workmen stationed along the catwalk first pulled down the dead wires and placed them under hooks. Then the live wires were pulled down and placed under sheaves alongside the hooks. This prevented the wires from swinging and kept them sorted.

As soon as the wheel passed the first tower the dead wires were removed from the hooks and adjusted for sag. This adjustment was made at the center of the span by comparison with a "guide wire" extended between the anchorages. This guide wire was adjusted by surveying instruments until it had the exact sag desired for the cable. This sag is 350 feet, one-eleventh of the length of the center span.



A backstay span is towed to site by tugs. Much of the construction was prefabricated on land.

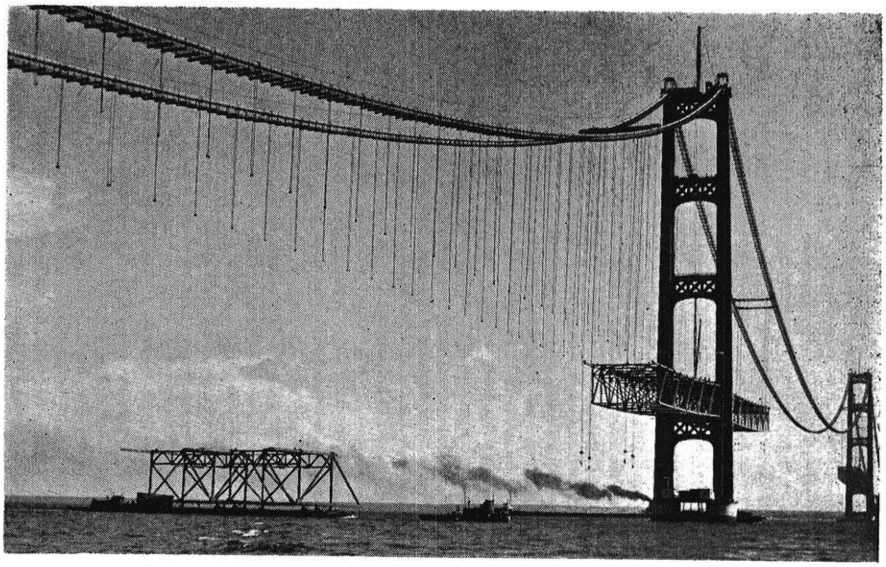
With the completion of each strand its wires were bound together at intervals with galvanized steel straps. Adjustments on the strands were made at night when temperatures were more uniform. When all strands had been completed, they were compressed to a hexagonal cross-section 24½ inches in diameter. Steel bands were put on the cable and the cable was ready for the attachment of suspender ropes.

Suspender Hanging

The suspender ropes are the 2¼ inch wire rope used to support the catwalk. The rope was prestressed, at a fabricating plant, under a tension of 115 tons. This removed all stretch and provided means of accurate measurement. The rope was then cut to its desired length and sockets installed on the ends.

The suspender ropes were hoisted to their position (39 foot intervals) on the main cable by a hoist which rode along the main cable. These suspenders were very straight and relatively stiff which kept them from becoming tangled even in a relatively high wind.

When all suspender ropes were hung in position the main cables were covered with a heavy red lead paste and wrapped with .162 inch galvanized wire. At the anchorages the main cables were enclosed in a "splay saddle", because from here the individual strands would diverge as they stretch to their separate anchorages in eyebars. Each main cable consists of 12,580 wires, which when stretched out would reach 41,000 miles. These wires make up 37 strands with a 38th stiffening strand between anchorage and cable support pier. The diameter of the cable is 24½ inches. Each wire is .196 inches, or about 13/64 inches, in diameter. The total weight of the cable, wire, and fittings is 12,500 tons. There is a total of 368 vertical hanging suspender ropes, spaced 39 feet apart. The suspender ropes are 2¼ inches in diameter. These ropes vary in length from a few feet to 720 feet. The longest ones weigh 7200 pounds each



Suspended truss sections were lifted into place and attached to 24.5 inch cables. The weight of the cable and wire alone is 12,500 tons.

Placing of Stiffening Truss Sections

The Mackinac Bridge is designed for H20–S16 truck and trailer loading, and for a wind pressure of 50 psf (120 mph) combined with dead load. The truss sections are used to support the roadway and help give the bridge its aerodynamic stability.

Construction

The truss sections were prefabricated on shore in 80 foot sections. These sections were then loaded on barges and towed to their position in the bridge.

The erection of the truss sections was accomplished by wheel mounted lifting struts operating on top of the main cables, two each way from the main towers. The struts frame-work was made up of a 30 foot boom section of a derrick and 19 foot extensions welded to each end.

The wheels of the struts were made up of 8 inch steel pipe cores surrounded by several thicknesses of ⅝ inch laminated plywood. The outer surface was turned by a lathe to match the 24½ inch diameter main cables.

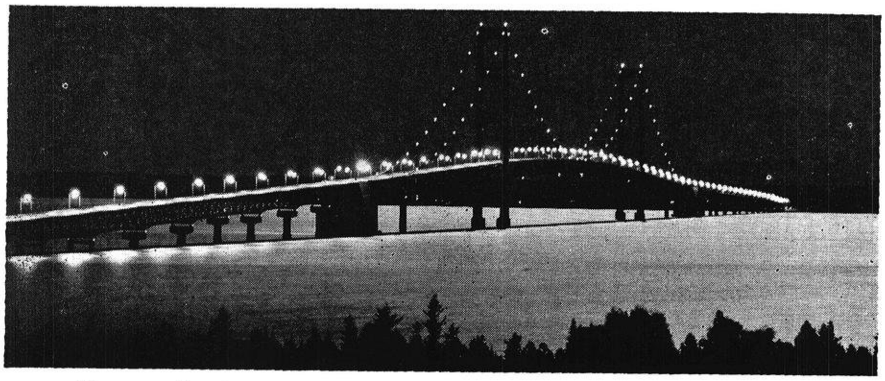
The lifting struts had four sets of lifting falls. This pickup-arrangement gave considerable freedom to maneuver in hoisting the truss sections into position for attachment to the wire rope suspenders.

Hoisting Operations

The hoisting was sychronized by telephone from the point of erection. To keep the sections level, in hoisting, two giant levels were made to permit leveling in four directions. These levels were 10 foot, white wooden boxes containing an 8 inch black ball. One level was located on the top chord of a truss member, the other on one of the cross trusses.

As each section was raised into position, it was loosely connected to the preceding section, since all the holes did not come into alignment until the full dead load of

(Continued on page 44)



The completed Mackinac under the lights as seen from the northwest.

Which of the following are practical applications of COPPER or COPPER ALLOYS?

- ☐ 1. Ship fittings.
- ☐ 2. Television antennae.
- ☐ 3. Heat sinks for missile nose cones.
- ☐ 4. Architectural extrusions.
- ☐ 5. Prefabricated plumbing lines.
- ☐ 6. Pipelines for sodium hydroxide.
- ☐ 7. Collector vanes for solar heating.
- ☐ 8. Resistance heating elements.
- ☐ 9. Resistance-welding electrodes.
- ☐ 10. Gold-plated jewelry.

Now try your hand at these True-False Selections:

- ☐ 11. Proved copper reserves have decreased in the last 20 years. ☐T, ☐F.
- ☐ 12. On the machinability rating scale, Free-Cutting Brass rates 100. ☐T, ☐F.
- ☐ 13. The green patina of copper can be developed artificially. ☐T, ☐F.
- ☐ 14. Copper and copper alloy parts should be joined only by riveting. ☐T, ☐F.
- ☐ 15. Nickel Silver is an alloy of nickel and silver. ☐T, ☐F.

1. **Yes.** Copper, and many of its alloys, have excellent resistance to salt water corrosion.

2. **No.** The important properties of copper are not needed and lighter, cheaper metals are usually used.

3. **Yes.** Copper's high heat conductivity protects the delicate instruments inside by quickly dissipating the surface heat of re-entry.

4. **Yes.** Architectural bronze extrudes readily and is used for a wide variety of architectural shapes.

5. **Yes.** Because copper tubing can be easily and firmly soldered, it lends itself well to prefabrication. The few unassembled joints are soldered on the site, eliminating the use of threaded fittings.

6. **Yes.** Copper-nickel alloys have good resistance to many alkalies and are often used in contact with them.

7. **Yes.** Large vanes of copper are blackened and mounted on a roof to collect the sun's rays. The high thermal conductivity of copper makes it very efficient for this use. The copper carries the heat to a circulating water system.

8. **No.** The conductivity of copper and its alloys is too high for this purpose.

9. **Yes.** Here the current is introduced through the electrodes to the parts to be welded. Several copper alloys are well suited for this use because of their high strength at elevated temperatures.

10. **Yes.** The low-zinc brasses are easily worked and are readily plated for high-quality costume jewelry. Most copper alloys lend themselves well to polishing and plating.

11. **False.** Reserves have increased. Published figures are no indication of long run availability or total mineral deposits. The industry lists only those reserves which have been "proved" for immediate development. Since the copper industry has grown in these years, so, too, have the proved reserves. Future copper supplies are vastly greater than any known "reserve" figures would indicate.

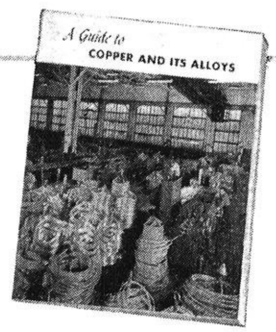
12. **True.** Free-Cutting Brass usually can be turned at maximum spindle speed and many other copper alloys at high speeds. A large number of copper alloys are available for easy machining.

13. **True.** The Copper & Brass Research Association has developed a spray process which has been successfully used to give architectural and ornamental parts an attractive green patina much faster than nature would do it.

14. **False.** Good joints between copper or copper alloy parts can be made by soldering, brazing or welding.

15. **False.** The Nickel Silvers are copper alloys. They derive their name from their silver-like color. A typical composition is 65% copper, 18% nickel, 17% zinc, and no silver at all.

The copper alloys, of which there are more than forty that are standard and many more that are special in current use, have many properties just as unique as this "silver" that isn't silver. If you'd like to learn more about them, or if you really flunked this quiz, send for your copy of "A Guide to Copper and its Alloys." The Copper & Brass Research Association, 420 Lexington Avenue, New York 17, N. Y., will be happy to supply it.



"A GUIDE TO COPPER AND ITS ALLOYS"

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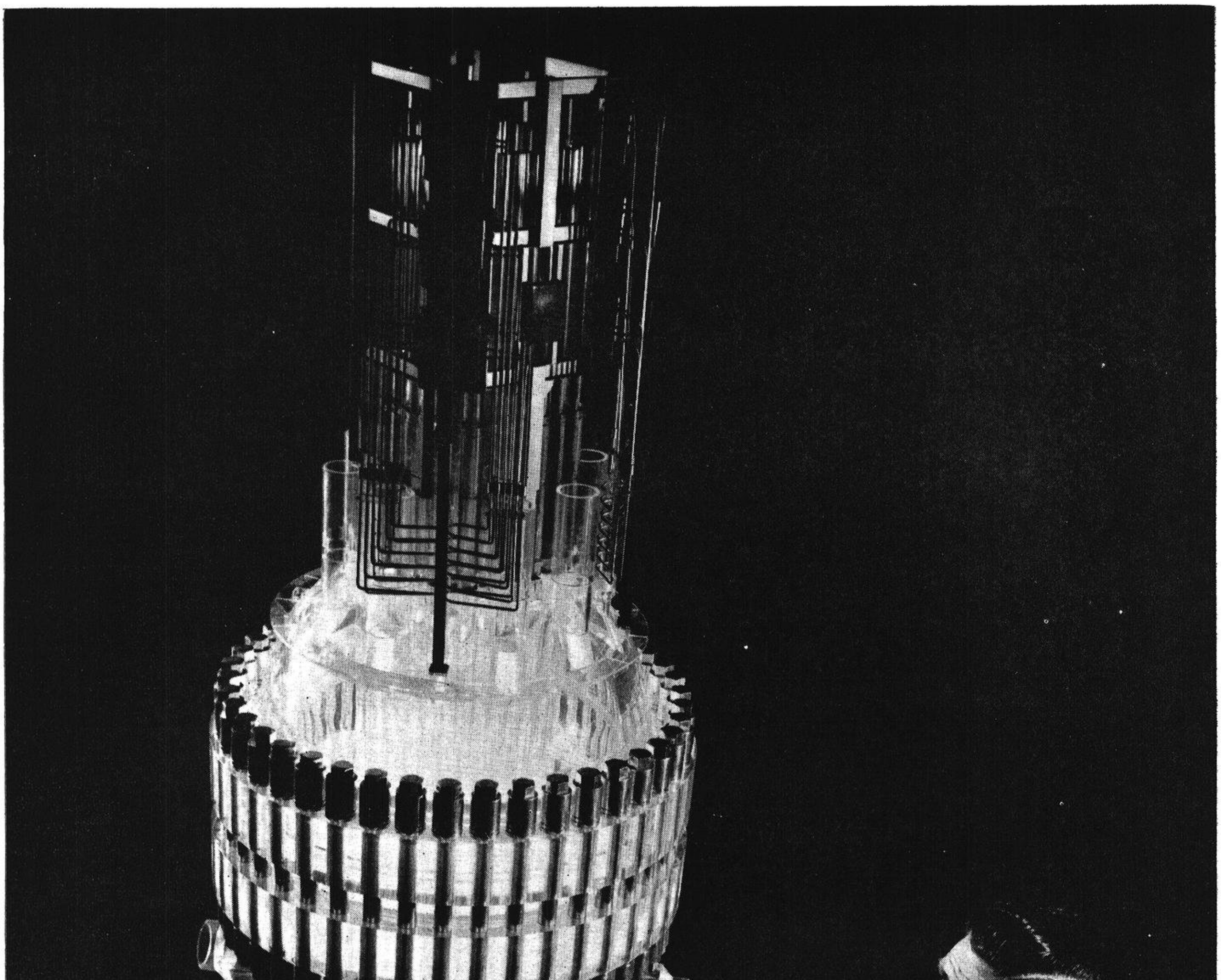

Westinghouse Electric Corporation engineer Paul Halpine makes a last minute check of this plastic and steel model of the nuclear reactor, or atomic furnace, which will be used in the nation's first full-scale atomic power plant for generating electricity at Shippingport, Pa. The model shows that the uranium core, or "heart" of the reactor, is located at the base of the reactor.

Reactors—Engineering Questions

by Rudolph F. Wirth

The problems of atomic power reactors deal with engineering feasibility and economics. Various types of reactors are here explained and illustrated.

THE unknown problems of atomic power reactors being investigated are mainly engineering questions: How practical is sodium as a coolant? How long can a high pressure radioactive water system be kept leakproof? Will the slightly radioactive turbine or the steam boiler be an important maintenance problem? The following descriptions will show that the reactors are intended primarily to answer such questions of engineering feasibility and economics.

Water Reactors

The first three types of reactors to be described are those using water as a coolant. The water will be either ordinary water or heavy water. Two reasons water will be used, in spite of its low thermal efficiency, are: (1) water is plentiful; (2) most important, it is the only common coolant which is also a moderator.

Pressurized Water Reactor (PWR)

The reactor shown in Fig. 2 was designed by the Westinghouse Electric Corporation. Its principle is that of the reactors used to power submarines. However, the fuel used in PWR will be slightly enriched natural uranium instead of highly enriched U–235. The core will generate approximately 300,000 kilowatts of heat, which will be transferred to a heat exchanger by circulating water at a pressure of 2000 pounds per square inch and a temperature of 525 degrees F. This will produce saturated steam at a pressure of 600 pounds per square inch. The steam will then go to a conventional turbine which should generate a net electrical output of more than 60,000 kilowatts.

The high pressure core will be contained in a carbon-steel vessel nine feet in diameter, coated with stainless steel. The uranium will be distributed in a tight cluster of metallic fuel elements.

The PWR will need few control rods because the expansion of the water as the temperature goes up allows neutrons to leak out more easily. Such a system is inherently self-stabilizing. Each high pressure component is enclosed in a gas-tight pressure vessel to prevent the possibility of a nuclear runaway. The whole reactor system will be underground.

The PWR is less experimental than the other reactors because the submarine reactor has already demonstrated the feasibility of the high-pressure water system and pioneered some of the necessary equipment. None of the estimates of cost suggest that PWR will be economical; in fact, the choice of water cooling and moderation was a result of the requirement for reliable nuclear power rather than cheap nuclear power.

Several paths lead toward more economical power than the PWR. As new techniques are developed, the cost of producing fuel elements for reactors will decrease.

Neutron economy can also be improved by using heavy water or by replacing uranium with thorium and U–233. Furthermore, a higher pressure will raise thermal efficiency and lower cost.

Experimental Boiling-Water Reactor (EBWR)

One obvious way to improve the performance of a water-cooled reactor is to eliminate one circulation loop and generate turbine steam directly in the core instead of a separate housing. The pressure of the system would be lowered because the highest pressure in the reactor would be that in the turbine. This type of reactor, as shown in Fig. 3, is the experimental boiling water reactor to be built by Argonne National Laboratory. It will use slightly enriched uranium like PWR, but thorium could be used as well. Thorium might make the reactor a breeder if heavy water were used as the coolant. However, ordinary water will be used instead because of the difficulty and expense of making a watertight turbine to use with heavy water.

Roughness of operation caused by the boiling is the main uncertainty about EBWR. The density of the moderator fluctuates as it boils and this density change affects the leakage of neutrons. Therefore the power level will fluctuate and the higher level causes greater fluctuation. This means that the direct boiler must operate at a lower power level per unit volume than the PWR circulator. The General Electric Company

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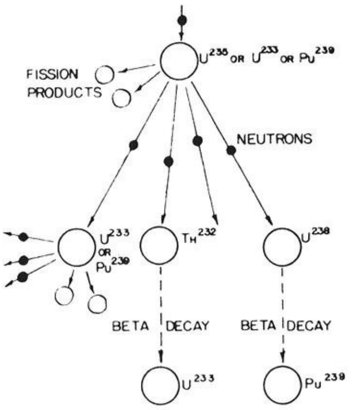

Fig. 1.—Fuel breeding cycle.

likes the mechanical simplicity of EBWR and thinks its power level is high enough to be of interest as a long-term possibility.

Homogeneous Reactor (HRE–2)

The circulating-water system and the direct boiler reactors have difficulties because the fuel, moderator, and coolant are separate. The homogeneous reactor, shown in Figure 4, was introduced to overcome these difficulties.

The fuel (uranium or thorium) in a homogeneous reactor is dissolved in water in the form of a salt. The solution is then circulated through pumps and heat exchangers to extract the heat produced by the fissioning atoms. The exchangers will generate high-pressure, nonradioactive steam. A direct-boiling homogeneous reactor would be unsatisfactory because the steam would be extremely radioactive.

Two homogeneous reactors are being built, the first of which will generate only 5000 kilowatts of heat. It will be called HRE–2 and its purpose will be to explore engineering problems. It will consist of a spherical vessel in which the fuel solution will circulate through a core shaped so the fluid will become critical and heat up. After leaving the core, it will travel through piping shaped to quench any chain reaction.

The most remarkable aspect of the homogeneous reactor is its simplicity. There are no mechanical control rods because the system is completely self-regulating. As cooler and more reactive fluid is pumped into the core, the power is increased by a factor of almost

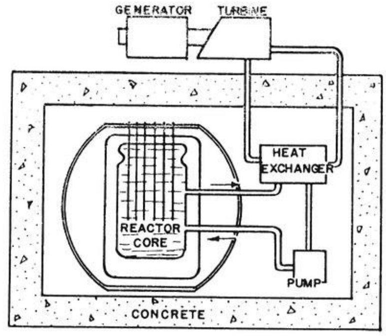

Fig. 2.—Pressurized water reactor.

one million in a few tenths of a second. However, as soon as the water is heated the reactor levels off to a steady output. The initial flow of cooler water causes a rise of reactivity at the rate of .8 percent per second. Such a rise in any heterogeneous reactor would almost certainly cause violent and dangerous pressure surges.

Nuclear stability of the homogeneous system is acquired only by handling billions of curies of radioactivity in solution under high pressure. Nuclear safety requires absolute leaktightness and material control. The HRE–2 is being built to establish the feasibility and reliability of such a system.

HRE–2 will be followed by a larger reactor called HTR with a heat output of at least 65,000 kilowatts. HTR will contain thorium in heavy water and manufacture

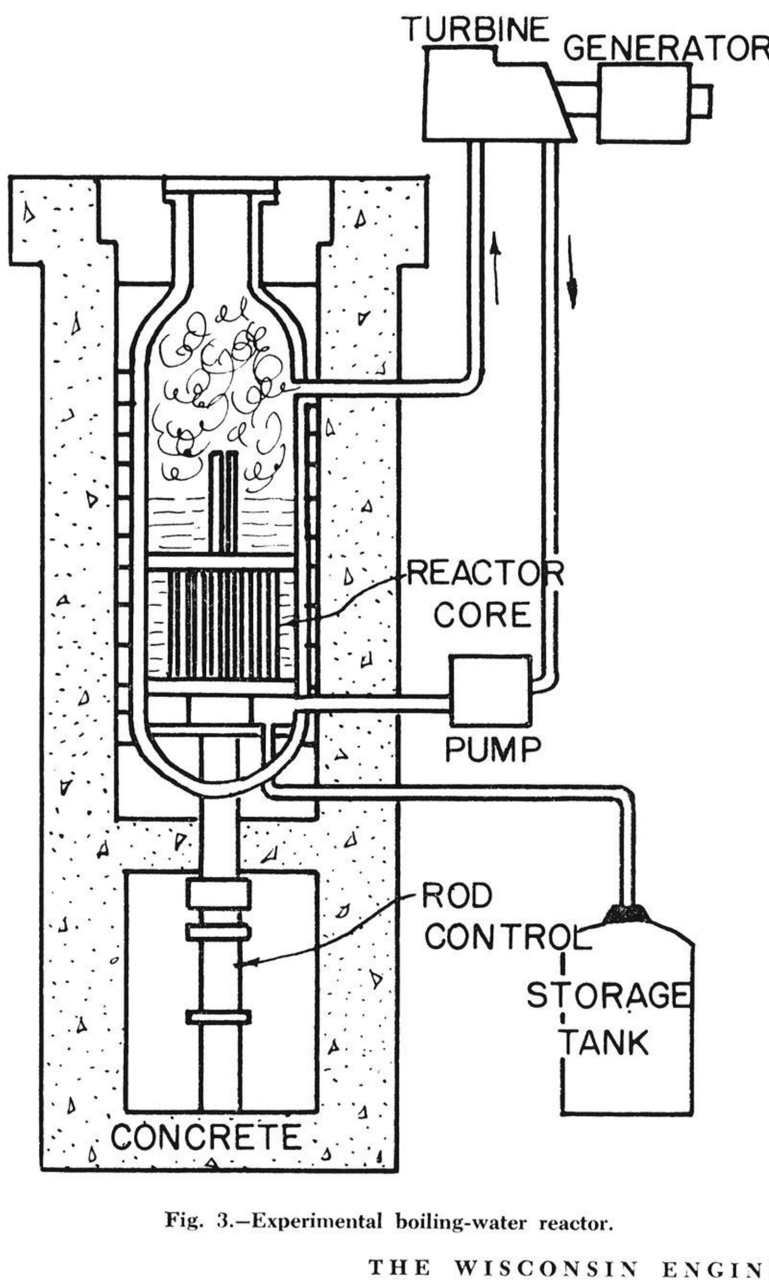

Fig. 3.—Experimental boiling-water reactor.

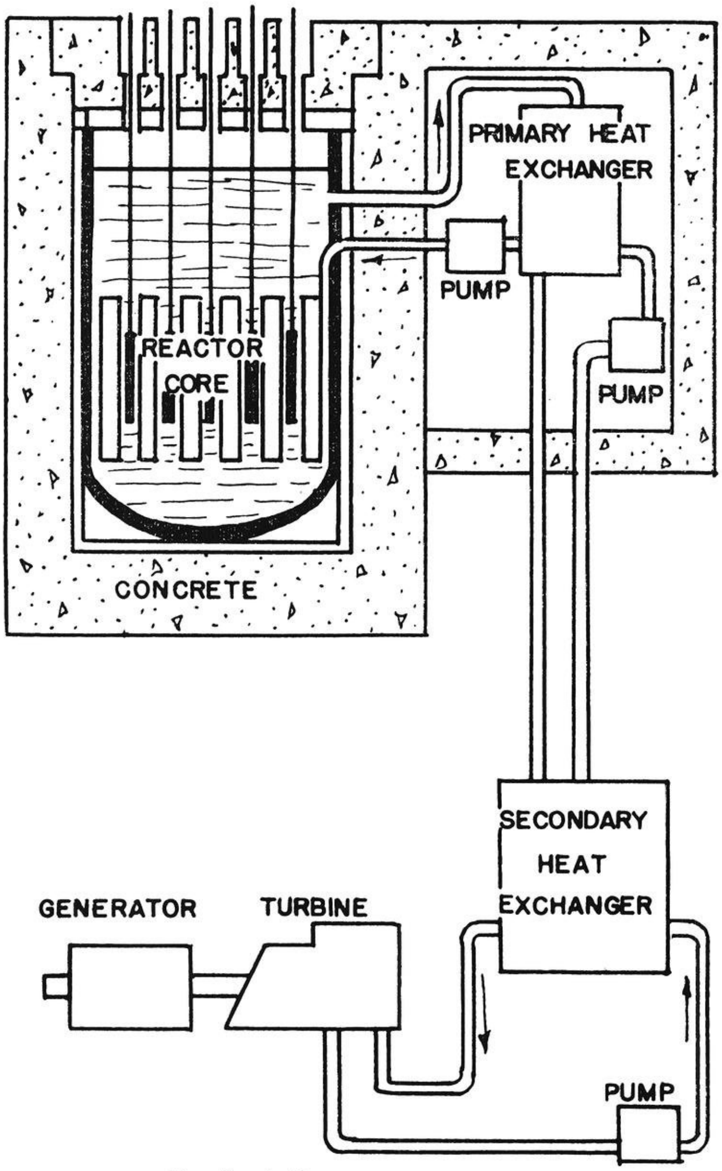

Fig. 5.—Sodium reactor experiment.

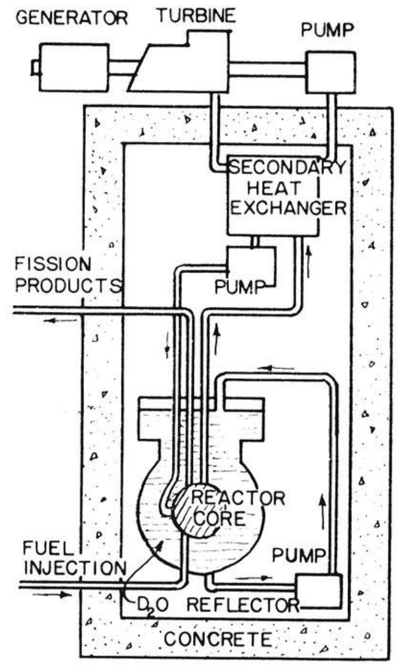

Fig. 4.—Homogeneous reactor.

U–233 in a thorium blanket. It is hoped that it will be the first thorium thermal breeder.

The inherent difficulties of a homogeneous reactor connected with radioactive and corrosive fluids under pressure make the probability of success less than in more conservative types. Yet the incentive is so great that a major effort has been launched to solve the difficulties.

Sodium Reactors

The remaining two reactors are grouped together because of similarity of coolants and external equipment. In both reactors, steam heated by hot sodium will operate turbogenerators. An intermediate fluid will be incorporated to carry heat from the reactor sodium to the steam generator to avoid contact between the steam and the radioactive sodium.

Sodium Reactor Experiment (SRE)

In the sodium reactor experiment, shown in Figure 5, which was designed by North American Aviation, Inc., sodium instead of water flows past and cools the fuel elements. The reactor has a graphite moderator with the fuel in tubes running through it.

From the nuclear standpoint, the 20,000 kilowatt reactor is conservative and should be successful. However, its power cost is estimated to be between 8 and 10 mills per kilowatt hour, which is somewhat high for competition in the U. S. There are several development possibilities which may lower the cost to 4 or 5 mills if they are successful. These are: (1) simplification of the expensive sodium plumbing; (2) operation as a breeder or near-breeder with thorium; (3) improvement in the fuel elements to allow a higher burn-up than the one percent suggested as the economic minimum.

A sodium reactor can be operated at very high temperatures which gives it a greater thermal efficiency than a water-cooled system. The best water system has the advantage of greater simplicity.

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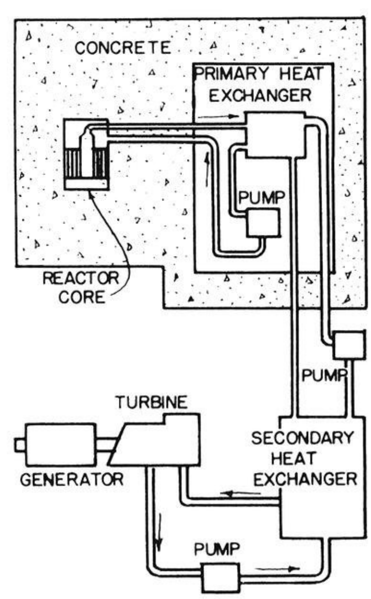


Fig. 6.—Experimental breeder reactor—II.

Prestressed for Strength

by Robert F. Frederick ce'59

In this article the author explains merits of prestressed concrete which provides higher tensile strength without disadvantages that occur in reinforced concrete.

CONCRETE has a compressive strength equal to many times its tensile strength. It is quite easy to make concrete with a crushing strength of more than 6000 pounds per square inch after 28 days, but it is more difficult to obtain tensile strengths higher than 350 lb. per sq. in. at the same age. This is why concrete is reinforced with steel bars placed in the direction in which the tensile forces act. The tensile strength of concrete is so small that it is often neglected. Under the working load the concrete on the tension side of a reinforced concrete beam is generally cracked since it is unable to conform to the normal strain in the steel.

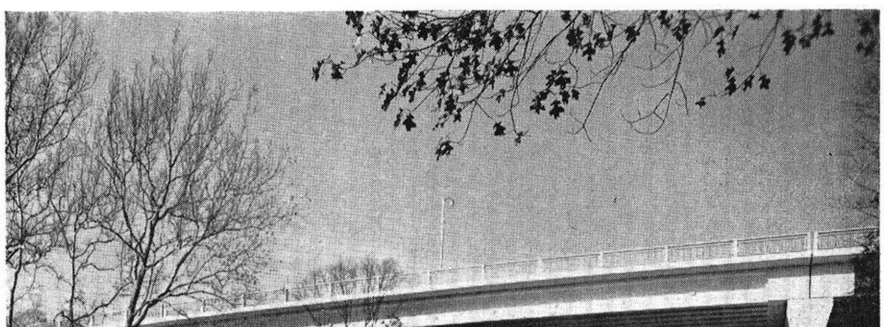
Another weakness of reinforced concrete is that the size of a beam is often determined by diagonal tension. If the shearing force is high a very large beam is needed and, in such a case, the dead load becomes too great for practical purposes.

Also, in reinforced concrete, full use cannot be made of high strength concrete; that is, if the size of a beam were reduced beyond a certain limit the amount of reinforcement required would make the beam uneconomical. It may be thought that it would be possible to substitute high strength steel in place of the mild steel, but this would not work since the strain of the high strength steel would be almost six times the strain of the mild steel, and this would cause wide cracks in a beam under a working load.

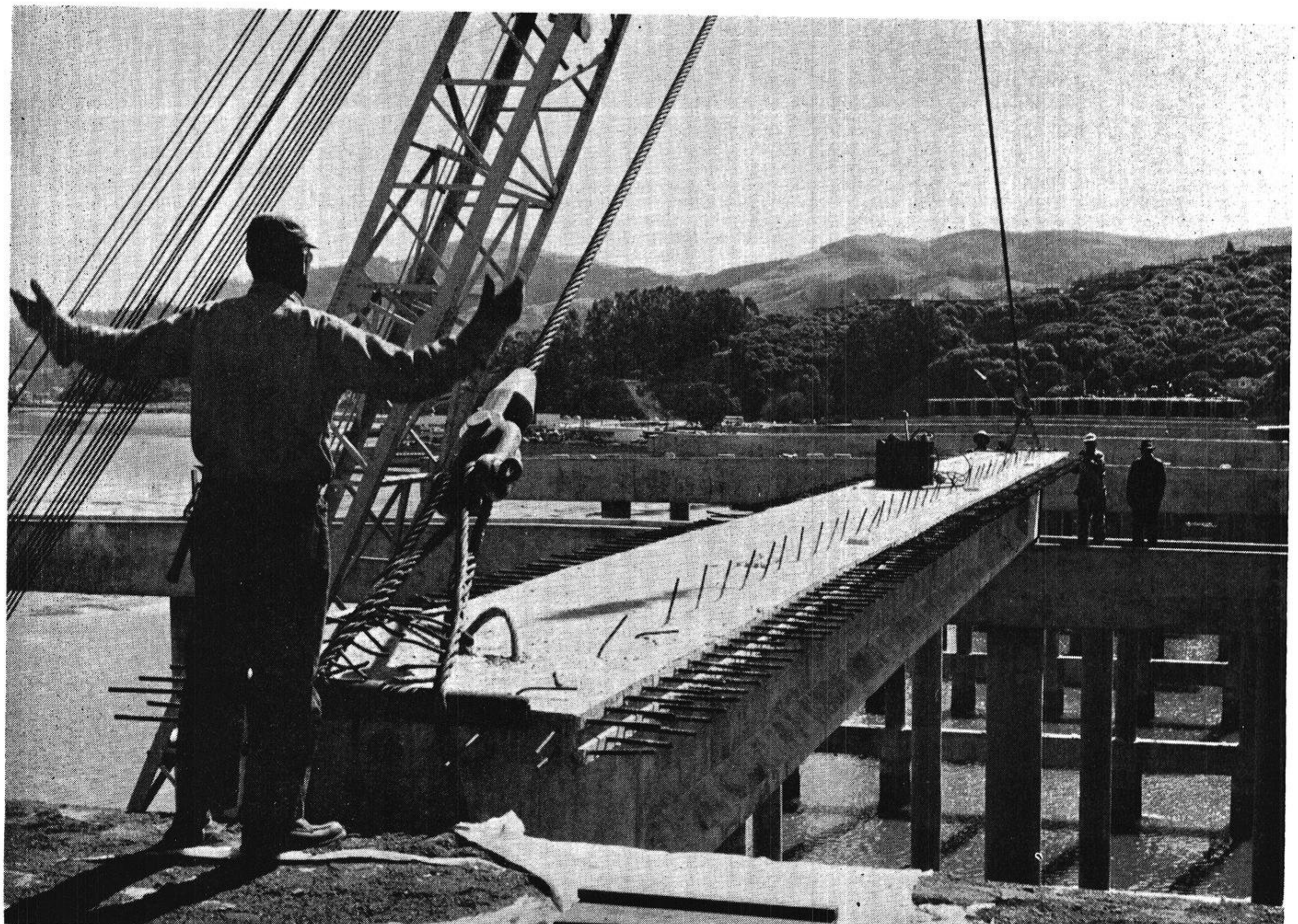
Prestressed concrete is the solution for these weaknesses. Suppose we apply a uniform pressure in all directions of 2000 lb. per sq. in. to a plain concrete beam. If this beam were placed on supports and forces caused to act on it, it would not crack so long as the load alone did not create tensile stresses higher than 2000 lb. per sq. in. plus the tensile strength of the concrete. This is the principle of prestressed concrete. The compression introduced by the external pressure applied to the beam is the "prestress".

Reinforced Concrete vs. Prestressed Concrete

For a comparison we will first design an ordinary reinforced con-



Walnut Lane Bridge in Philadelphia, the first major prestressed bridge to be built in this country (1949–50). The 160-ft. center beams still hold the U. S. span record for this type of construction, although a prestressed concrete bridge in Washington, D. C., will shortly better this length with a 216-ft. clear span.



—Photo courtesy of California Department of Highways and Public Works

Construction view of the Richardson Bay Bridge in Marin County, Calif. This prestressed concrete bridge is to carry traffic on scenic highway U. S. 101.

crete slab bridge, 66 ft. long, having to carry its own weight plus a superimposed load of 400 lb. per sq. ft. The slab shall have a thickness of three feet seven inches (dead load of 540 lb. per sq. ft.) and mild steel reinforcement of 11.4 sq. in per ft. of width placed three inches above the bottom of the concrete. Due to the total load of 940 lb. per sq. ft. we have the following stresses: compressive stress in the concrete, 1430 lb. per sq. in.; tensile stress in the steel, 16,600 lb. per sq. in.; diagonal tension, 80 lb. per sq. in. This is not a good design. The stress in the concrete is too high, and the amount of steel is nearly 2.4 per cent, which, if placed in one layer would require 1⅞ in. bars at 1⅞ in. center to center. This placement of steel is impracticable if not impossible.

Now assume that the bridge is to span a trench cut into rock and that the supports are rock. After the false work is erected a concrete slab 32 in. thick with no reinforcement is poured with the left-hand end against the rock and the right hand end a short distance from the rock. After the concrete has hardened, a hydraulic jack is placed in the gap between the concrete and the rock at the right-hand end and a force of 268,000 lb. per ft. is applied two inches above the bottom of the slab. The eccentricity of this force is 14 in. Because of this force the slab deflects upwards and leaves the false work. As soon as the slab leaves the falsework the deadload goes into action.

If the 268,000 lb. force alone had been applied, the stresses at mid-span would be:

$$\text{Top fiber: } \frac{268{,}000}{32(12)}\left(1 - \frac{6(14)}{32}\right) = 1120 \text{ lb. per sq. in. (tension).}$$

$$\text{Bottom fiber: } \frac{268{,}000}{32(12)}\left(1 + \frac{6(14)}{32}\right) = 2550 \text{ lb. per sq. in. (compression).}$$

The dead load would be 400 lb. per sq. ft. and the stresses due to the dead load would be 1275 lb. per sq. in. (compression) in the top fiber and 1275 lb. per sq. in. (tension) in the bottom fiber. These stresses occur at the same time; therefore, the combined stresses are:

Top fiber: $-1120 + 1275 = 155$ lb. per sq. in. (compression)
Bottom fiber: $2550 - 1275 = 1275$ lb. per sq. in. (compression)

When the stresses due to the superimposed load are now added the result is:

Top fiber: $155 + 1275 = 1430$ lb. per sq. in. (compression)
Bottom fiber: $1275 - 1275 = 0$

At mid-span there is no tensile stress.

The diagonal tension is calculated to be 15 lbs. per sq. in.

To sum up, a slab of ordinary reinforced concrete has a thickness

(Continued on next page)

of 3 ft. 7 in. and a high amount of steel. For the prestressed slab the thickness is 2 ft. 8 in. and no steel is required. The stress in the concrete has remained at 1430 lb. per sq. in. and the diagonal tension has been reduced from 80 lb. per sq. in. to 15 lb. per sq. in. This is the result of prestressing.

Instead of placing the slab in compression with the aid of a jack another method may be used. The false work is erected and on it at the required height, round steel bars are placed, each in a metal casing, to prevent bond between the concrete and steel. The bars extend beyond the end of the slab and are threaded at the ends. The concrete is then placed and allowed to harden. Nuts are then fitted on the end of the bars and tightened to produce a stress of about 16,000 lb. per sq. in. The bars now produce the same effect as did the jack. The steel used in this case would be a high tension steel in order to obtain the desired stress, and the concrete would consist of good cement, good grading, little water, and proper curing.

Methods of Prestressing

There are two principal methods of prestressing, postensioning and pretensioning. The first method is accomplished by stretching the cables after the concrete has hardened; the latter is done by stretching the cables or wires before the concrete is placed.

Postensioning

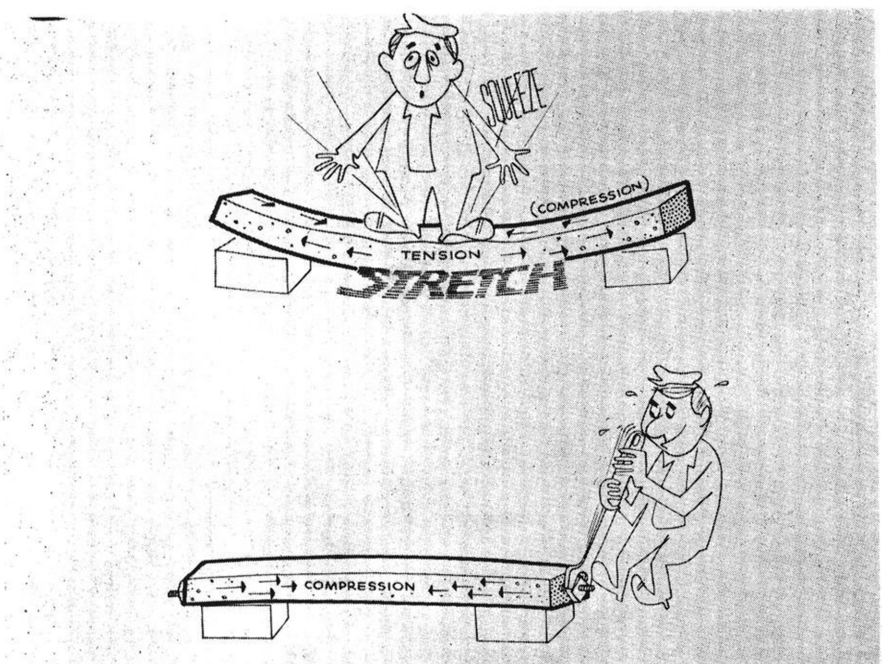
M. Freyssinet's Method. The M. Freyssinet method consists of using cables with wires of 0.2 in. or 0.276 in. in diameter. The usual number of wires per cable is 12. The wires are placed around a helical spring, and the resulting cable is inserted in a hole formed in the beam by a removable rubber core. Other possibilities would be to have the cable in a metal sheath or wrapped in bituminous paper and laid in place before the concrete is poured. The prestress is obtained by stretching at the same time all the wires of a cable by a hydraulic jack.

Advantages of this system are that the securing of the wires is not expensive and the stretching force is obtained quickly. Some disadvantages are that by stretching all the wires of a cable at once all the wires may not have the same stress, and to produce the required force, large and expensive jacks are needed.

The Belgian Sandwich Cable. The Belgian Sandwich method was devised by Gustave Magnel. He maintained that the wires must be placed in a definite order and that only two wires should be stretched at one time to obtain uniform stress. The wires would be held in spacers of four wires to a horizontal layer. The cable that was made up of these wires would be encased in a metal sheath or holes would be formed in the concrete to enable the cable to be passed through the beam after the concrete has hardened. The ends of the wires are attached to steel locking plates called "sandwich" plates. These plates are provided with wedgeshaped grooves in which the wires are placed, two in each groove, and held by a steel wedge. The stretching force is applied by means of a heavy hydraulic jack.

The main advantage of this method is that it permits the use of cables consisting of a large number of wires. Disadvantages are that this method is more expensive than the Freyssinet method, and it takes more time to apply the desired force.

Electrical Prestressing. In electrical prestressing the bars are threaded at their ends and coated with melted sulphur. The bars are then used as ordinary reinforcement but extend beyond the end of the concrete. After the concrete has hardened, the bars are electrically heated. The heat melts the



The principle of prestressed concrete is illustrated in simplified terms in these drawings. The conventional type of beam shown at the top can be given increased strength by stretching the steel wires reinforcing it (middle drawing). The concrete, which is then under compression, is able to withstand much heavier loads than before. This new type of beam has been called "concrete with muscles."

sulphur, which causes the bond between the steel and the concrete to be broken and elongates the bar. Nuts are tightened at the end of the bars so that after the bars have cooled the concrete is in compression. The sulphur solidifies again and re-establishes the bond allowing the removal of the nuts.

Disadvantages of this method are possible lack of uniform prestress and the possibility of chemical action of the sulphur damaging the steel and the concrete.

Pretensioning

Hoyer's System. The Hoyer System consists of stretching thin wires between two buttresses and pouring the concrete into the desired dimensions and allowing it to harden. Then the wires are cut and the concrete has been prestressed.

A disadvantage of this system is the need for strong buttresses which are not cheaply built.

Schorer's System. The Schorer System consists of wrapping thin wires around a high tensioned steel tube.

The tube is wrapped in paper or a thin sheet metal to keep it from bonding to the concrete. Half of the wires are wound in one direction and the other half in the opposite direction. The wires are kept away from the tube by means of small metal disks located on the tubes. The wires are then attached to a device which consists of two parts capable of sliding one along the other. One part rests upon the tube, and the other is the part which holds the wires. A hydraulic jack rests upon the former part and pulls upon the latter. When the required elongation is obtained, a nut is turned in order to fix the two parts relative to each other. The jack is then removed.

When the concrete has hardened, the device is removed and compression is induced in the concrete by bond. The tube is then pulled out and the hole is filled with grout.

Materials Used in Prestressing

In prestressed concrete construction, a uniform quality of concrete is important. To obtain this uniformity a concrete mix that has better than the average plasticity and stickiness is needed. This concrete, when vibrated, should flow readily into place without segregation and bleeding. Close control is required with respect to grading of materials, batching, mixing, transporting and placing.

Drying, shrinkage and creep of concrete are closely related to and caused by, the removal of absorbed water from the hardened cement paste. Drying shrinkage of concrete is almost proportional to the amount of mixing water used. Creep is proportional to the amount of hardened cement paste and the water-cement ratio.

In the construction of prestressed concrete it is important to keep drying shrinkage and creep at a minimum because of their effect on the magnitude of the final prestress. It is therefore advisable to keep the paste content at a minimum and water-cement ratio as low as possible and still get the desired strength in the concrete.

The grading and maximum size of aggregate have an important effect on shrinkage and creep. As the maximum size of the aggregate gets larger, the shrinkage decreases. It is also important to have a well graded aggregate.

Admixtures are sometimes used to improve early strength, reduce the required amount of mixing water, improve workability and plasticity, and to reduce bleeding. This is desirable provided that these admixtures do not increase drying shrinkage and creep.

The steel used in prestressing must be of high tensile strength.

Permissible Stresses In Prestressed Concrete

When a member is prestressed it still rests on its temporary supports and does not carry a superimposed load. To allow for this it is reasonable to adopt a working stress of one-third of the crushing strength at the time the prestress is established. Therefore, if the concrete has a crushing strength of 8800 lb. per sq. in. when the structure is placed in normal service, but only 5700 lb. per sq. in. when the member is prestressed, the adoption of a working stress of 2200 lb. per sq. in. is permissible

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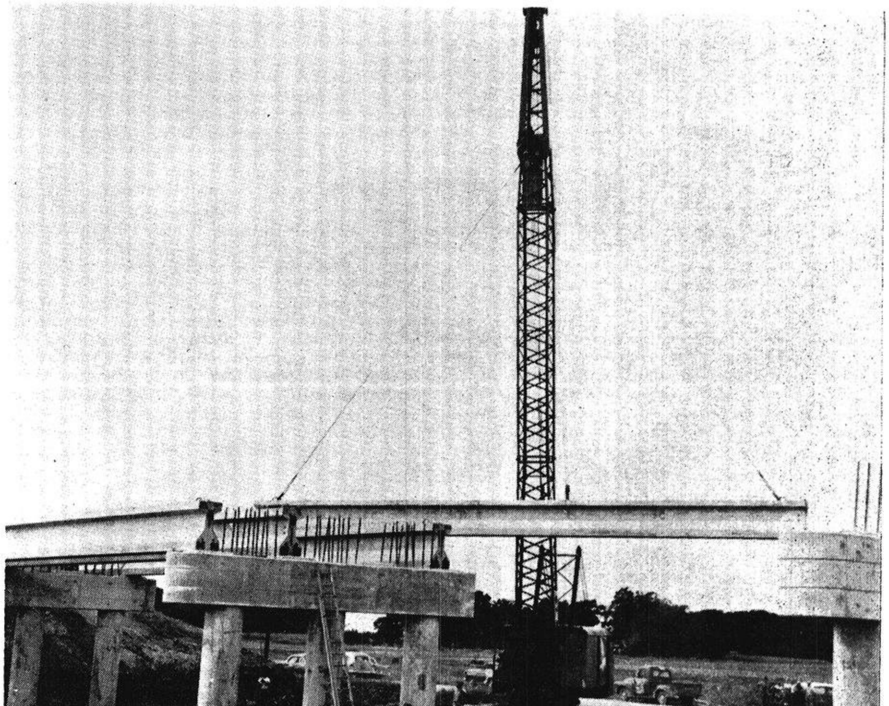
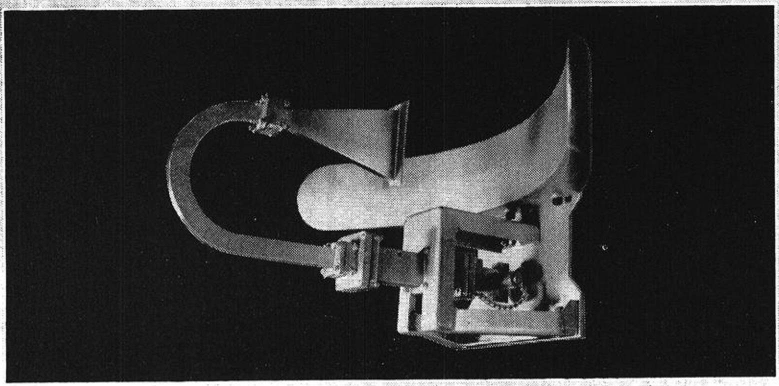
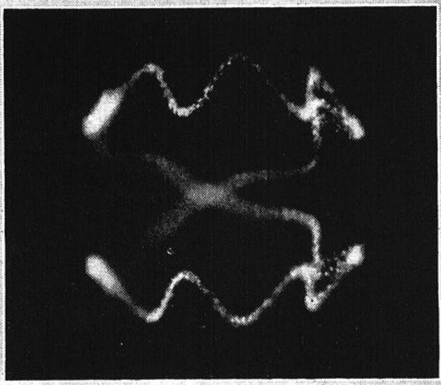


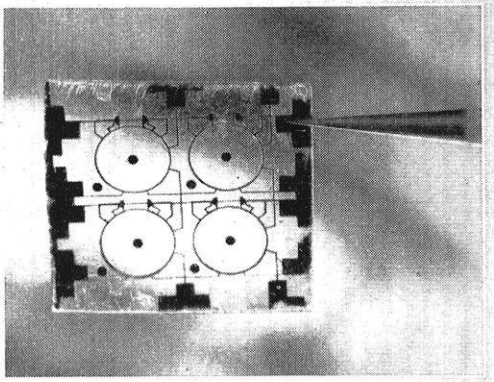
Scene taken during construction of a highway overpass on the Illinois Toll Road near Rockford. Beams were cast at a central casting yard and transported to the site. Prestressing the concrete permits longer beams of shallower arch than with conventional reinforcement.



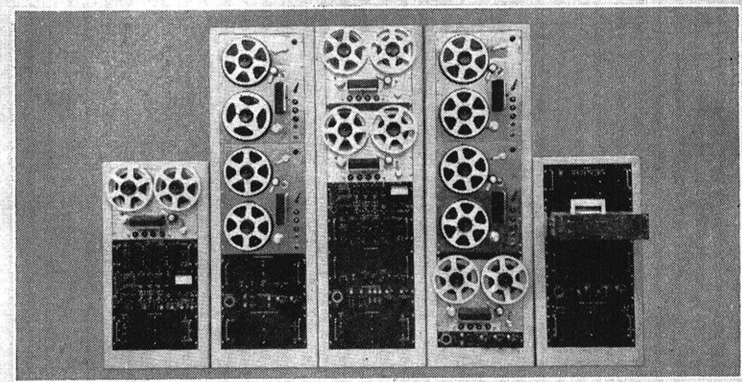
Horn fed parabolic reflector antenna for airborne applications.



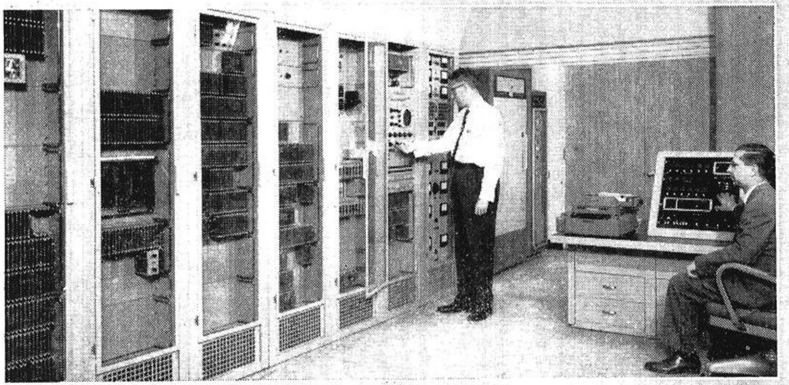
Charged aluminum particle suspended and controlled in a vacuum chamber by an oscillating electric field.



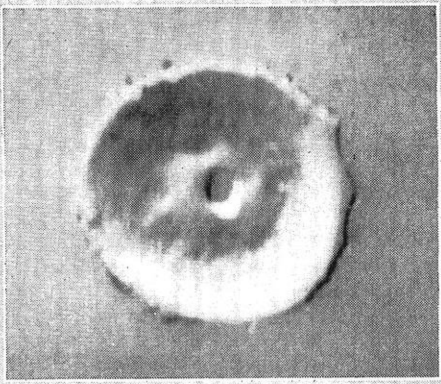
The Persistor gives promise of cryogenic computer memories with a capacity of 1,000,000 bits per cubic foot and access times of 1/30 microsecond.



Ground based data handling equipment for processing analog and digital reconnaissance information.



Data conversion system for digitizing and processing telemetered missile test data.



Electron micrograph of impact produced on aluminum coated glass by a 1 micron diameter particle traveling at 7,000 feet per second.

Pictorial **PROGRESS REPORT**

The photographs above illustrate some of the recent research, development, and manufacturing activities at Ramo-Wooldridge. Work is in progress on a wide variety of projects, and positions are available for scientists and engineers in the following fields:

- Digital Computers and Control Systems
- Communications and Navigation Systems
- Guided Missile Research and Development
- Infrared Systems
- Electronic Countermeasures
- Electronic Instrumentation and Test Equipment
- Basic Electronic and Aeronautical Research

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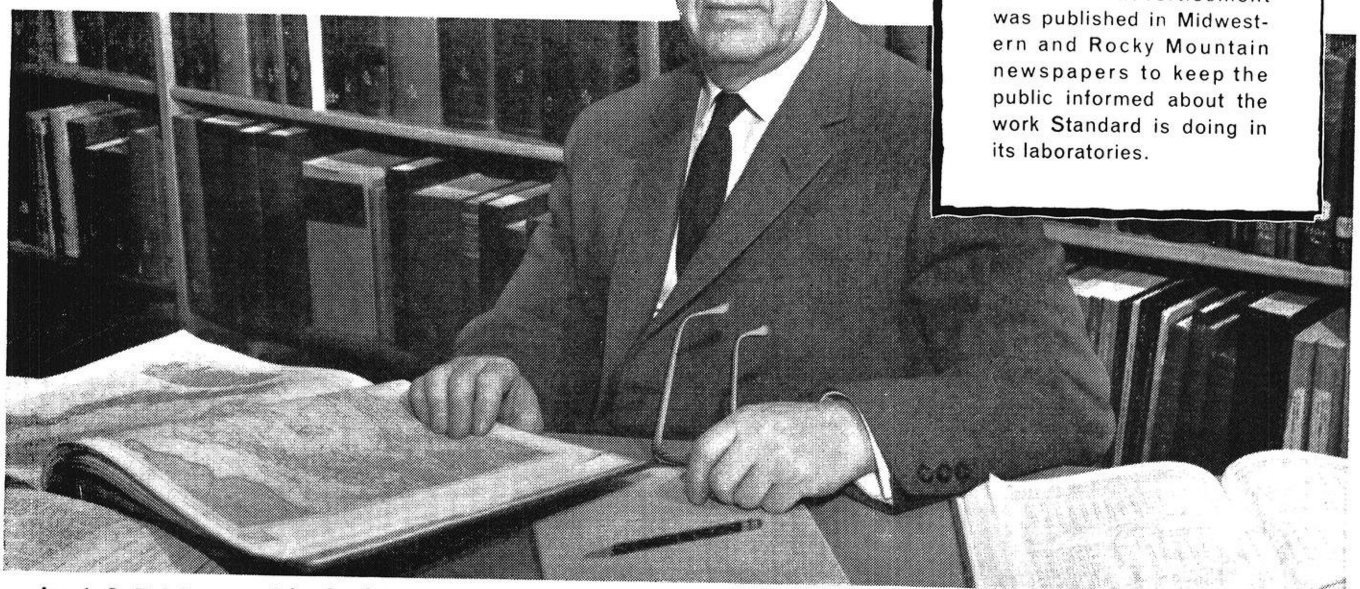

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Jacob G. Tolpin, expert in the field of foreign scientific developments, often is consulted by leaders in academic, government and industrial enterprises.

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It has been the daily job of Mr. Tolpin since 1937 to keep track of Russian scientific advances. He is a key man on the staff of specialists at Standard Oil who analyze foreign technical journals and patents.

The primary purpose of this work is to keep Standard Oil research scientists informed of developments throughout the world. But the work has broader significance. Standard Oil furnishes important foreign technical data to nationally important bodies and to libraries, such as the Library of Congress. The knowledge gained from the foreign periodicals thus is made available to all.

Even the Russians admit, says Mr. Tolpin, that American knowledge of petroleum technology is superior to their own. Standard's research at Whiting and other centers has resulted in many important discoveries which have helped to make America supreme in the field of petroleum and to strengthen its defenses. In the last few years alone, Standard scientists have made outstanding contributions that have advanced America's missile program and its jet air defense.

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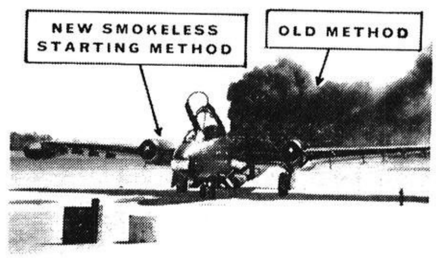
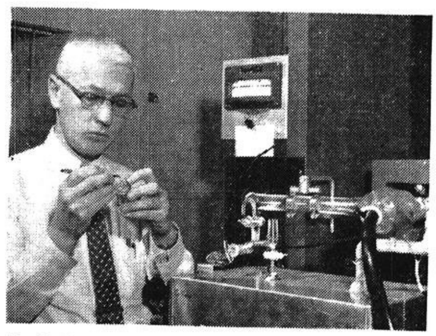
What makes a company a good citizen? One measure is the contribution a company makes to the economic and physical strength of its country. Through constant and intensive research, we at Standard have tried to make oil yield its maximum usefulness—both for civilian and military purposes. Steadily mounting efficiency also has helped to keep the price of oil and gasoline down.



America's jets now have a new, improved smokeless starter cartridge (being used in the engine above, left) as the result of a Standard Oil research development. The old method, on the right, was so smoky it made concealment impossible and also blocked fliers' views of the field.



Radiation-resistant lubricants for atomic power plants are under study in Standard's research laboratories. Seymour Meyerson, above, is engaged in pioneering work in this new field. He is an authority on the controlled shattering of molecules by electron bombardment.

STANDARD OIL COMPANY

STANDARD

THE SIGN OF PROGRESS... THROUGH RESEARCH

The Handy Computer

by P. A. Markstrom me'59

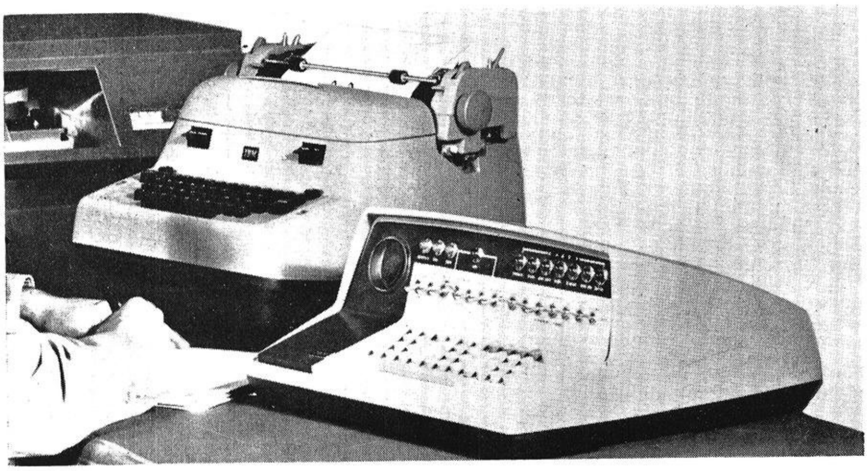
This article explains in simple terms the components, functional divisions, programming, and operation of an office size computer. An illuminating discussion of the binary system is also included.

THE type of machine considered in this report is the small, mobile, cabinet contained, externally programmed, electronic digital computer. This type of equipment is ideally suited as a tool for the engineer or scientist for exploring theory, simulating actual conditions, serving as an historical record of past problem solutions, as well as performing routine, everyday work. Although much of the material in this report applies to any small digital computer, the IBM 610 Automatic Decimal Point Computer is used for illustrative purposes.

The small computer has the distinct advantage of being operated directly by the user, eliminating the need for, and the difficulties arising from, the employment of an intermediate programming specialist as required by large machines. This direct operation allows decisions to be made during operation if it becomes apparent that a given method is not progressing satisfactorily.

A complete understanding of the problem by the operator allows many advantages to be realized that only become obvious during problem solution. Operation by the engineer often will prevent senseless answers or occurrence of blind alley stops. A hidden asset lies in the necessity of the engineer–operator to clarify and organize his problem in his own mind prior to and during programming. All of these factors, of course, cause executives and engineers alike to look with favor on the use of the small computer.

As the name implies, the digital computer operates numerically. Three number systems in common use today are the Arabic decimal, octal and binary systems, based on ten, eight and two digits respectively. These number systems are similar in their operation; the binary system, however, is most attractive to computer design men because of the simplicity of physical representation of its digits (0 and 1), and the resulting speed of machine calculation. Physically, a digit in the binary system may be represented as a switch position on or off, a hole punched or not, or any element in one of two possible stable states. This reduces machine multiplication to repeated addition, and division to repeated subtraction. These operations are easily carried out by the computer at high speeds without the necessity of a built-in multiplication table.



The IBM 610 Automatic Decimal Point Computer.

Another advantage of using the binary system is in the transfer of information within the computer. Internal digit transfer in a machine using a binary number system is quite easily accomplished by either sending or not sending a pulse to represent either of the two binary digits. In machines using other number systems a code consisting of combinations of binary elements to represent digits is used. For example, a simple machine code could be constructed using a pattern of four elements having one of two possible states.

Digit	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
	0	0	0	0	0	0	0	0	X	X
	0	0	0	0	X	X	X	X	0	0
Code	0	0	X	X	0	0	X	X	0	0
	0	X	0	X	0	X	0	X	0	X

In this code a pattern of four binary elements or "bits" represents each digit. The machine recognizes the digit 1 as the pattern (000X), the digit 2 as the pattern (00X0), etc. The digit three is represented as 2 (00X0) plus 1 (000X) or (00XX) and in the same manner 5 is represented as the coded 4 plus 1. The digits or characters are then combined to form groups of characters or a "word". For example, if the machine had a word length of 4 characters the number 1632 could be expressed in code as the word

0	0	0	0
0	X	0	0
0	X	X	X
X	0	X	0.

In all Arabic number systems a digit can have various values depending on its position in the number. That is, the number 165.54 is the sum of the number 100, 60, 5, .5, and .04; or the sum of the digits time powers of ten:

$$1 \times 10^2 + 6 \times 10^1 + 5 \times 10^0 + 5 \times 10^{-1} + 4 \times 10^{-2}.$$

This use of powers of ten is characteristic of the decimal Arabic number system. No reason exists for the use of only ten distinct digits (ten different values or ten individual states), so it is logical to develop other number systems which may have advantages under certain conditions.

One clear display of the three systems referred to previously is made by a table of equivalents or simply a counting table:

Decimal	*Octal*	*Binary*
0	0	0
1	1	1
2	2	10
3	3	11
4	4	100
5	5	101
6	6	110
7	7	111
8	10	1000
9	11	1001
10	12	1010

Another exhibit of the characteristics of the three systems is found in examination of several basic arithmetic operations in each of the systems:

	Decimal		*Octal*		*Binary*	
Addition:	6	5	6	5	1	110
	+7	+4	+7	+4	+1	+10
	13	9	16	11	10	1000
Subtraction:	10	9	10	14	10	1001
	−5	−3	−5	−7	−1	−10
	5	6	3	4	1	111

Multiplication and division can be performed in octal or binary arithmetic in the same manner as in decimal mode. To be noted is the fact that multiplication tables in the decimal and octal systems aid in performing multiplication and division, but these two processes are reduced to their simplest form of repetitive addition or subtraction in the binary system. The latter are lengthy procedures to carry out manually but are of no consequence to a machine. At any rate, there is no necessity in either manual or machine operations to refer to multiplication tables in the binary system.

Returning once again to number representation: the familiar decimal method of representing numbers by the sum of their individual digits times a specific power of the number base 10 is easily extended to the octal and binary systems using number bases 8 and 2:

The decimal number $(392)_{10} = 3 \times 10^2 + 9 \times 10^1 + 2 \times 10^0$

The octal number $(463)_8 = 4 \times 8^2 + 6 \times 8^1 + 3 \times 8^0$

The binary number $(101)_2 = 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

The entire computer is within easy reach.

A possible conversion from octal to binary and conversely is immediately apparent:

$$\begin{aligned}(100101)_2 &= 1 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 \\ &= 4 \times 2^3 + 0 \times 2 \times 2^3 + 0 \times 2^3 + 4 \times 2^0 + 0 \times 2 \times 2^0 + 1 \times 2^0 \\ &= 4 \times 8^1 + 0 \times 8^1 + 0 \times 8^1 + 4 \times 8^0 + 0 \times 8^0 + 1 \times 8^0 \\ &= 4 \times 8^1 + 5 \times 8^0 \\ &= (45)_8\end{aligned}$$

The conversion from binary to octal can be made mentally, then, by grouping the binary digits in sets of three and replacing the group by the equivalent in octal:

$$(100/111/010/110/101)_2 = (47265)_8$$
$$(\ 4\ \ /\ 7\ \ /\ 2\ \ /\ 6\ \ /\ 5\ )_8$$

and conversely:

$$(4\ 3\ 1\ 6\ 7)_8 = (100\ 011\ 001\ 110\ 111)_2$$

Manual conversion from decimal to binary and octal and the reverse is a more tedious task, but these conversions generally can be performed by the machine.

In situations where great speed is not a requirement, operation in decimal mode is of advantage in that input and output, as well as any check on intermediate results, are in the form most usable to the engineer. In large machines where speed is of the utmost importance the binary system is most advantageous. To bridge the gap between the two, the small computer is equipped with an octal system. This system, inherently the same as binary, allows easy number conversion and needs only one-third as many digits for number representation. Thus a small computer can be used to advantage in conjunction with a large computer for testing logic, scaling, and debugging parts of programs which are to be run on the large computer.

Since the small computer operates in decimal or octal arithmetic and utilizes a keyboard allowing the direct entry of the digits, operation is straightforward. Basic commands are presented in their commonly recognized form on the keys: $+$, $-$, $\times$, $\div$, $\surd$, $\div\times$, keeping the machine operation comfortably close to the engineers' way of thinking. Continuous command control allows the operator to advance the solution of his problem at his own pace, including planned stop sets, continuation, reading out intermediate results at predetermined or critical places, and automatic testing of magnitudes for further decisions.

Quite naturally there is a tendency to compare characteristics of the large and small computers, and indeed some similarity does exist. It is important to recognize, however, that the small computer is a distinct machine with individual characteristics and specific abilities different from those of a large computer. The small computer is not a "scaled down" large computer. It is designed to fulfill specific needs of scientists and engineers requiring a relatively inexpensive machine with capabilities above those of the desk calculator but not as complex as a large machine. In fulfilling these needs, speed has been balanced with simplicity and economy. Size and weight have been reduced without impairing ease of operation. An externally stored program and the ability of storage registers to add and subtract directly have allowed the reduction of the memory unit capacity, reducing cost accordingly.

A typical large digital computer may have a high speed magnetic core type memory with a slower drum type auxiliary memory, giving a total capacity of over 40,000 words. Operating speeds may reach 40,000 operations per second for simple operations (additions, subtractions, shifts, etc.). A control unit is placed internally, instructions are loaded into memory (an internally stored program) and, under internal control, the large machine is capable of executing thousands of instructions per second. This is opposed to the magnetic drum type memory of a small computer, which has a capacity of approximately 100 words for data storage only. Operating speeds of these small machines are in the order of .28 seconds per operation for simple operations. No internal storage of instructions is possible with the small computer. Instructions are dispatched manually or from external input units. This slows down manual operation time but reduces programming complexity. Cost of the small computer is therefore considerably less than that of the large computer. While large machines may sell at $3,000,000 a small computer may be purchased for as little as $20,000.

Machine Components

The computer system is readily divided into two major divisions. The first and most obvious grouping of elements is that of the physical units: keyboard, cabinet, and typewriter. A second broad grouping is that of the functional components: input, output, control, memory, and arithmetic.

Physical Components

Keyboard. The keyboard serves as an information input device and machine monitor. The keys representing the decimal or octal digits as well as all manual commands are located here. A small cathode-ray-tube for visual inspection of storage register content is located in the upper left corner of the panel, and monitor lights for checking operation status are above the keys.

Cabinet. The cabinet is mounted on wheels to provide mobility and houses the computer proper. It contains the principal circuitry of the computer, the storage and arithmetic units, control circuitry, control panel and programming and data tape equipment.

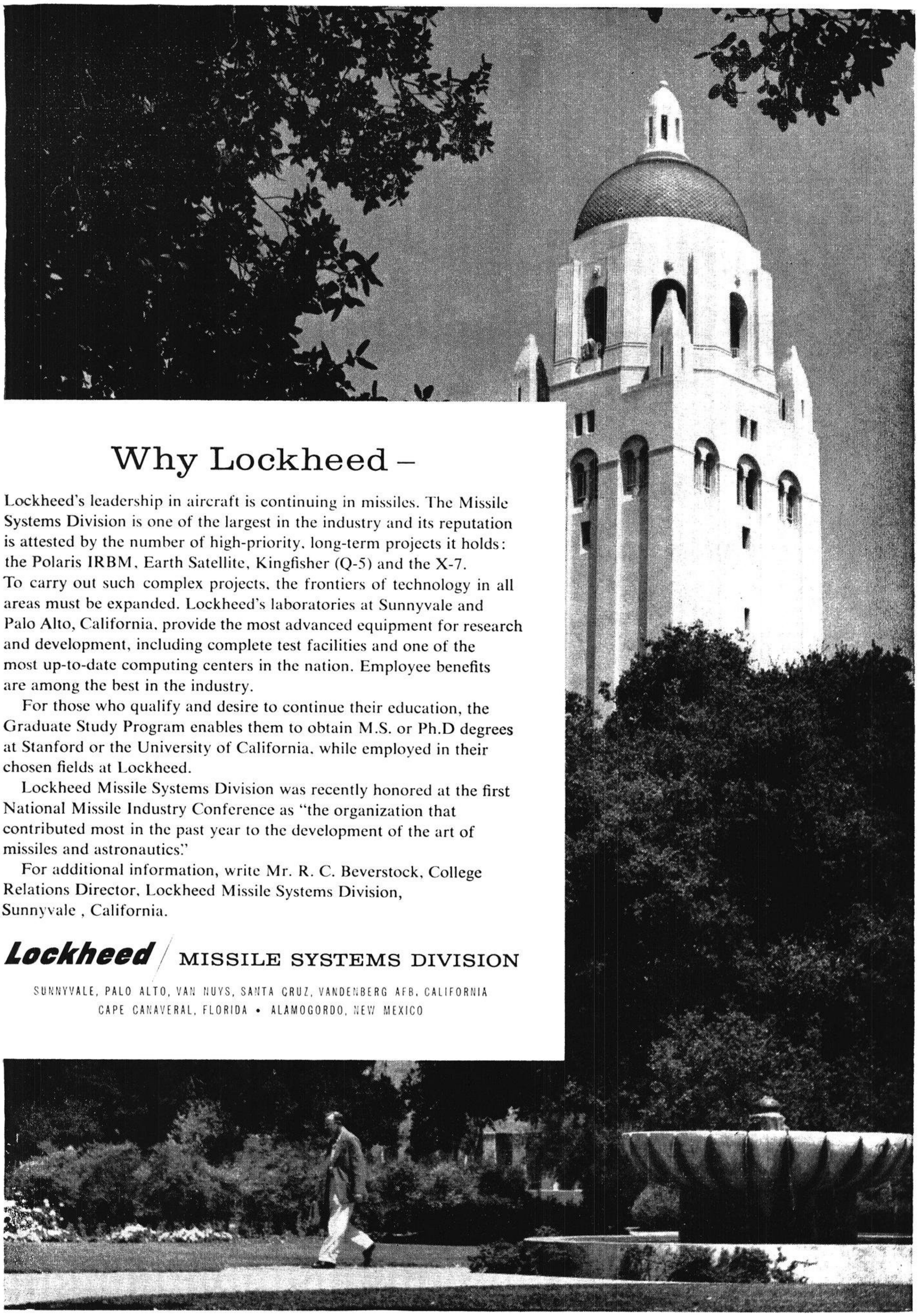
Typewriter. One mean of automatic output printing is the electric typewriter. In addition to automatic control of the typewriter by the computer, control may be assumed by the operator to allow manual typing.

Functional Divisions

Input. The input devices—punched cards, punched tape, keyboard or control panel—are the operator's means of communication with the machine. Input may be manual (keyboard) or automatic (all other devices). The operator is in command of the input center at all times, although he may delegate his command if he desires.

One effective means of relieving the operator of manually executing information input is to prepare a control panel to function automatically in a prearranged order according to appropriately plugged-in wire connections. The panel has all the abilities of the keyboard with the additional advantage of automatic step progression or modification. If necessary, data may be inserted in the correct places by causing the panel

(Continued on page 60)



Why Lockheed –

Lockheed's leadership in aircraft is continuing in missiles. The Missile Systems Division is one of the largest in the industry and its reputation is attested by the number of high-priority, long-term projects it holds: the Polaris IRBM, Earth Satellite, Kingfisher (Q-5) and the X-7.
To carry out such complex projects, the frontiers of technology in all areas must be expanded. Lockheed's laboratories at Sunnyvale and Palo Alto, California, provide the most advanced equipment for research and development, including complete test facilities and one of the most up-to-date computing centers in the nation. Employee benefits are among the best in the industry.

For those who qualify and desire to continue their education, the Graduate Study Program enables them to obtain M.S. or Ph.D degrees at Stanford or the University of California, while employed in their chosen fields at Lockheed.

Lockheed Missile Systems Division was recently honored at the first National Missile Industry Conference as "the organization that contributed most in the past year to the development of the art of missiles and astronautics."

For additional information, write Mr. R. C. Beverstock, College Relations Director, Lockheed Missile Systems Division, Sunnyvale , California.

Lockheed / MISSILE SYSTEMS DIVISION

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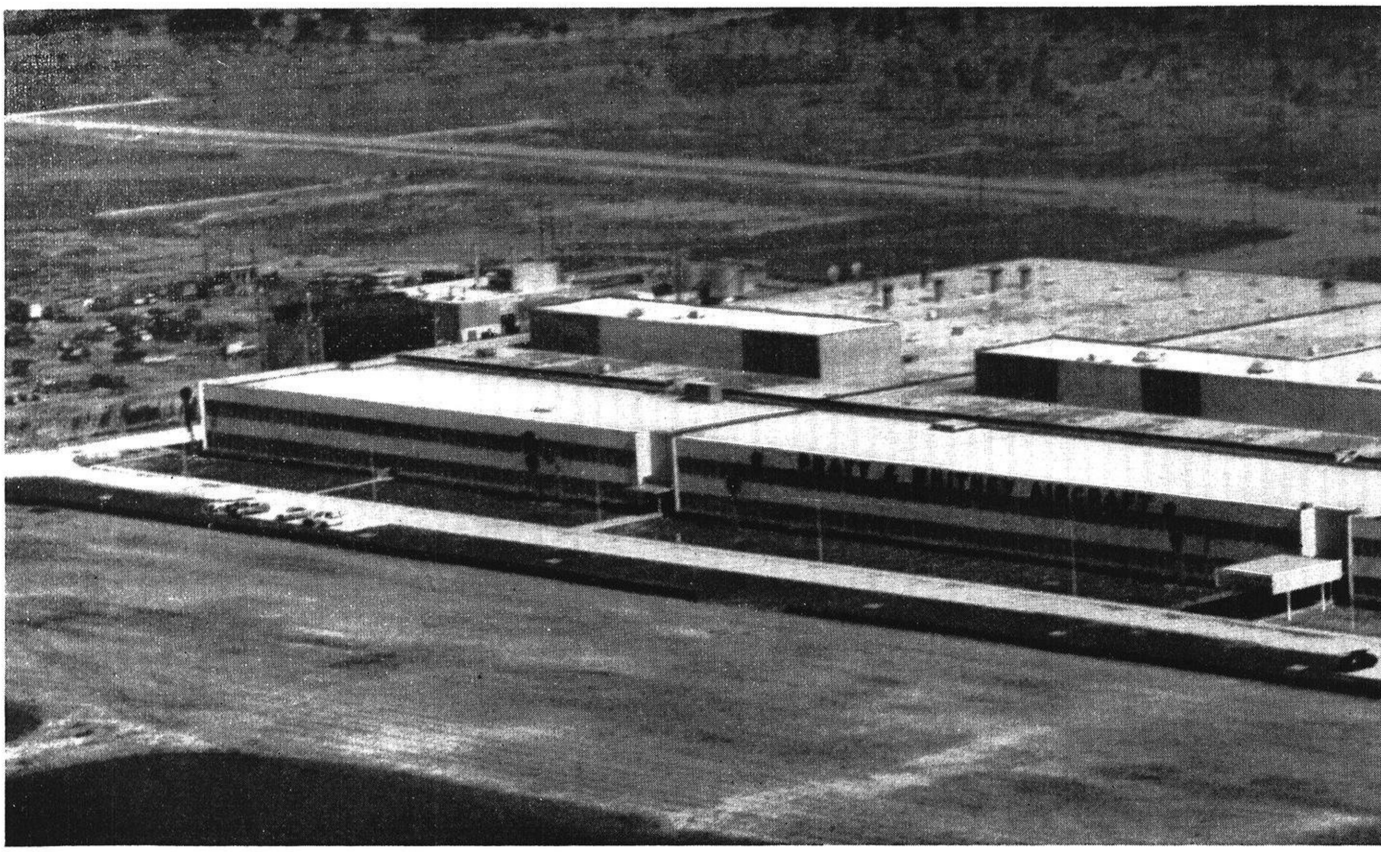
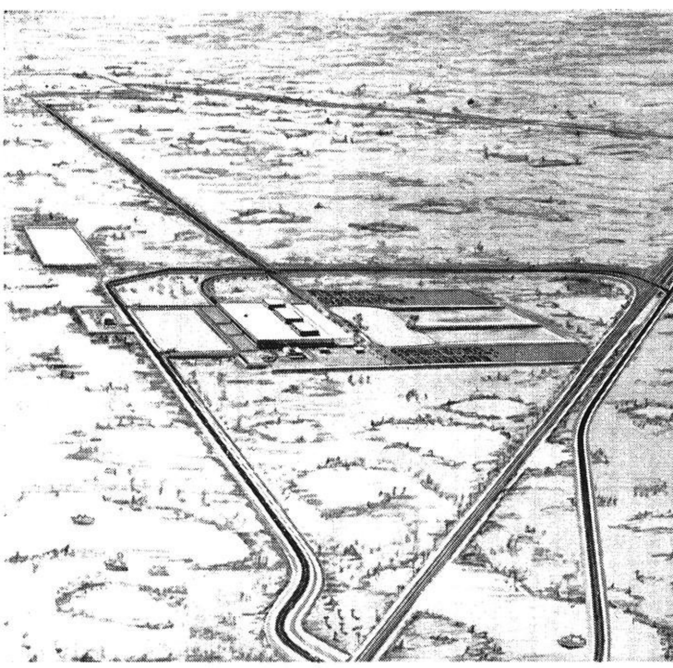
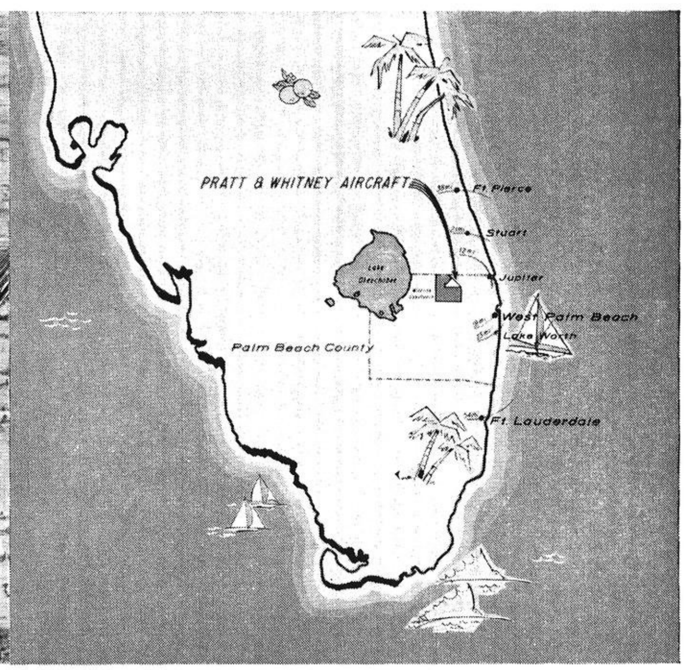


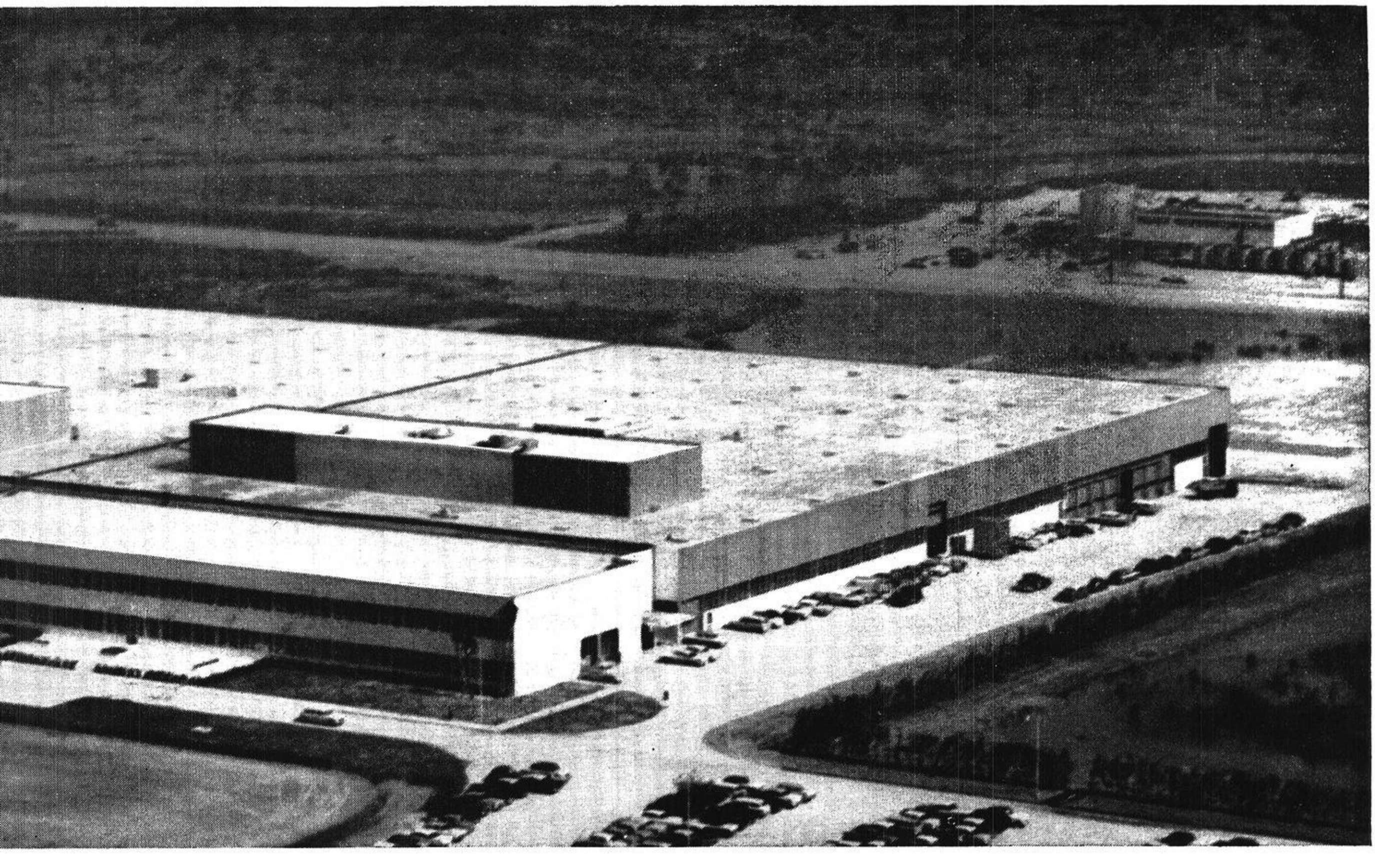
FLORIDA RESEARCH AND



ISOLATION—Ten square miles comprise the site of Pratt & Whitney Aircraft's new Florida Research and Development Center. Experimental shops and offices covering some 17 acres are in the foreground, while the tests areas, barely visible in upper left, lie four miles in the background.



LOCATION—The new Center is located at United, Florida, midway between West Palm Beach and Lake Okeechobee, in the upper Everglades area. It is almost surrounded by a wildlife sanctuary. Most employees live in the cities and towns along the east coast of Florida, driving to the Center on excellent new highways.



DEVELOPMENT CENTER...

Another Unmatched Engineering Facility to Advance Propulsion Systems of the Future

Future aircraft and missiles may require propulsion systems far different from those in wide use today — different in size, power output, appearance, and perhaps even in the basic method of utilizing energy.

To probe the propulsion future . . . and to build and test greatly advanced propulsion systems for coming generations of flight vehicles, Pratt & Whitney Aircraft is now operating its new Florida Research and Development Center. This facility supplements Pratt & Whitney's main research and development installations in Connecticut.

The new Florida Center, financed and built by Pratt & Whitney Aircraft, is unique in America's air industry. Here a completely air-conditioned plant with 17 acres under roof is specially designed and equipped for the development of new power plants of virtually any type. Testing is handled in special isolated areas; the nearest is four miles from the plant and many miles from any inhabited area. The new Center can be greatly expanded on its 10-square-mile site. Continued isolation is insured by a vast wildlife sanctuary in which the Center is located.

Of the many people employed at the Center today, about half are scientists, engineers and highly trained technicians. By late next year, the total number is expected to be almost doubled.

The new Florida Research and Development Center is one more reason why Pratt & Whitney Aircraft is able to continue producing the world's best aircraft propulsion systems . . . in whatever form they take.

For further information regarding an engineering career at Pratt & Whitney Aircraft, contact your college placement officer.

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FLORIDA RESEARCH AND DEVELOPMENT CENTER — United, Florida

SCIENCE HIGHLIGHTS

by Pete DeWitt che'60

ATLAS PROPULSION SYSTEM

The propulsion system for the 15,000 m.p.h. Air Force–Convair Atlas intercontinental ballistic missile is the most powerful system in the free world to enter flight test and production.

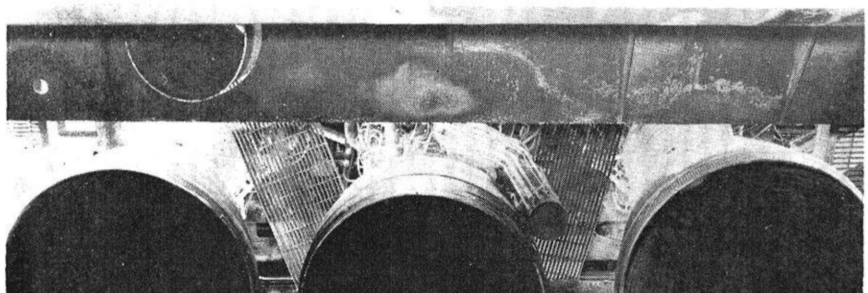
It is a cluster of liquid-propellant rocket engines. It consists of a twin-chambered booster engine, a sustainer engine for high-altitude efficiency, and two small stabilizing engines.

Operation: Each rocket engine in the Atlas propulsion system is designed to perform a specific job. The twin-chambered booster engine provides high thrust to lift the heavy missile from its launching site. It is jettisoned after operating for its programmed duration, when it has boosted the Atlas to high speed and high altitude.

The single-chambered sustainer, designed for efficient high-altitude performance, supplies the slightly lower thrust necessary to sustain powered flight and to keep the Atlas on course in the thinner air of the fringes of space.

Directional stability of the missile is maintained by swiveling the large engines of the propulsion system on gimbals—a part of their assembly—and moved by struts actuated by the guidance equipment of the missile.

Roll control is provided by the propulsion system's vernier or stabilizing rocket engines, small auxiliary units for precise thrust adjustments. They are mounted on the side of the missile and are also gimbaled for movement.



This is the first photograph of the free world's most powerful cluster of rocket engines, released by permission of the U. S. Air Force following initiation of long-range flight tests of Atlas ICBM's at Cape Canaveral. Made by Rocketdyne, a division of North American Aviation, Inc., the primary units are composed of a twin-chambered booster at left and right and a sustainer in the center.

All engines of the Atlas propulsion system develop thrust from the propulsive gases created by the combustion of liquid oxygen and RP–1, a hydro-carbon fuel similar to that used in turbojet engines. Combustion occurs at temperatures above 5,000 degrees F. Thrust chambers of the engines are cooled to withstand the heat by RP–1 fuel streaming through their hollow walls. The fuel is forced at high speed through the walls and into the combustion area by the engine's high-flow, lightweight turbopump.

HELIUM DIFFUSION CELL DEVELOPED BY BELL

A diffusion technique which promises to facilitate greatly the large-scale separation of helium from gaseous mixtures such as natural gas has been developed by K. B. McAfee of Bell Telephone Laboratories. Helium with no detectable impurities may also be obtained by using this technique as a purification process.

In the newly developed diffusion process, helium is separated from a gaseous mixture, such as natural gas, by passing the mixture over the surface of glass which has a high permeability to helium and low permeability to other gases. Silica glass has been found to be particularly advantageous in this respect, having a permeability to helium as much as one thousand times greater than for hydrogen, the next most diffusible material. The permeability is high enough to permit relatively large quantities of helium to diffuse through the glass under proper conditions.

K. B. McAfee (left) and H. Kraft of Bell Telephone Laboratories are examining a cell which was built to study the separation of helium from gaseous mixtures. This cell contains roughly 1½ miles of 15-mil diameter glass tubing.

To obtain appreciable quantities of helium, a large surface of glass must be exposed to the mixture, the glass must be very thin, and a high pressure differential should be maintained between the two sides of the glass. An excellent configuration for providing such conditions consists of a bundle of fine capillary glass tubing so arranged that the gas mixture flows around the outside of the tubing under high pressure and the helium is recovered from the inside of the capillaries. Appropriate seals have been developed to facilitate such an arrangement.

Silica or pyrex tubing can be drawn having an external diameter of two mils and a wall thickness of two-tenths of a mil. Such tubing can withstand a compressive stress in excess of one thousand atmospheres, and is ideally suited for the separation or purification of helium. Diffusion through the glass increases rapidly with temperature, and the tubing will withstand temperatures of 400°C and higher over long periods of time without deteriorating.

Tests on an experimental thin wall capillary diffusion cell made up of a bundle of capillaries indicate that a similar cell containing enough capillaries to occupy about two cubic yards would pass nearly 1,000 cubic feet per day of helium at room temperature with a pressure differential of 1,000 atmospheres, assuming a concentration of 1 per cent helium in the gas mixture can be maintained. Increasing the temperature to 400°C would permit the recovery of 100,000 cubic feet of helium per day. A cell of this type will not deteriorate with time, and might be placed directly in a gas pipeline. Thus it appears that this process may have a truly large scale potential.

Exceptionally pure helium results from a single diffusion step, even though the initial mixture contains as much as 90 per cent hydrogen and only 10 per cent helium. A careful analysis indicates that there is less than 0.0009 per cent hydrogen in the helium purified by such a step. Helium purified by diffusion through glass by this process is among the purest gases which it is possible to produce.

INTERCHANGEABLE GUIDANCE SYSTEMS FOR MACE

The United States Air Force TM–76 Mace is being test flown at Holloman Air Force Base, New Mexico, to check out its Inertial and ATRAN guidance systems. The systems are fundamentally interchangeable with only minor production changes to the missile. The ATRAN-guided Mace is designated the TM–76A, while the Inertial MACE is known as the TM–76B. Results of "on-range" flights and long range flights from Holloman to Wendover Air Force Base, Utah, have been termed highly successful by Tactical Air Command and Martin Company representatives.

(Continued on next page)

A United States Air Force TM–76 Martin Mace is launched at the Holloman Air Force Base Missile Development Center. The Mace uses either ATRAN or Inertial guidance, both of which are completely self-contained and require no ground control.

ATRAN permits the Mace to fly at extremely low altitudes, thus complicating enemy radar defenses. The effective range of the best radar under development is extremely small when used to detect low-flying targets. The number of installations needed to present a solid radar "fence" around an enemy country would be enormous. Further, a Mace must be traced, not just "detected," before any defensive steps can be taken. In addition, the Mace can be programmed to vary its altitude during a given flight.

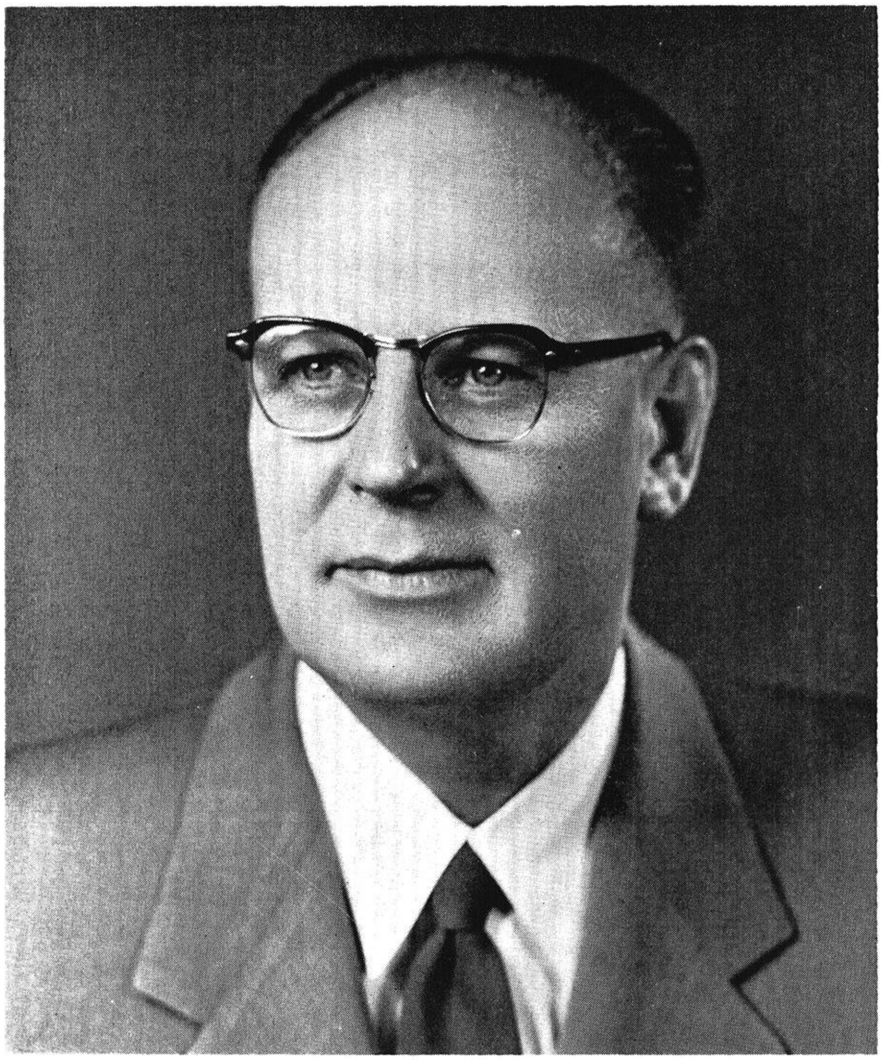
The Inertial guidance system gives the Mace complete invulnerability to enemy jamming. Not only does it eliminate the need for ground control facilities, but the system emits no radiation of any type, preventing enemy electronic detection. Highly accurate, Inertial guidance permits the Mace to be flown over any course including wide expanses of water. No terrain check points are necessary. The system compensates for changes in wind, temperature and barometric pressures, is not limited by foul weather or unusual climatic conditions.

The Mace Inertial guidance system is a form of "memory-navigation." This means that the geographic position of both launch point and target point must be known and set into the system prior to launch. The missile then "knows" the exact distance to be travelled. Once launched and streaking towards target, the system is aware at any given instant exactly how far it has travelled. It then subtracts this distance from the "remembered" total distance and knows precisely how far it is to target. This process is constantly repeated until distance to target becomes zero, and the Mace explodes in an air burst or impacts. The Inertial system is gyroscopically stabilized so that it maintains its reference to launch point at all times, regardless of the missile's altitude. The system also senses any off-course motion and immediately provides the autopilot with the necessary data to position the controls for a return to course. The Mace's Inertial guidance system was de-

(Continued on page 48)

Using exhaust gases traveling at five times the speed of sound from an oxygen-kerosene flame, National Carbon Company is developing graphite-base materials to withstand the high temperatures of rocket engine components.

Meet the President



Clifford J. Nelson.

CLIFFORD J. NELSON, President of the Wisconsin Society of Professional Engineers was born at Milwaukee, Wisconsin in 1910. He attended grammar and high schools in Milwaukee and St. Olaf College in Northfield, Minnesota and graduated from Marquette University with a B.S. in Civil Engineering in 1933.

Mr. Nelson was employed by the Wisconsin Highway Commission from 1930 to 1938. In 1938 he became President of the Nelson Construction Company of Black River Falls, a position which he has held to the present time. He served in the U. S. Army in World War II from 1942–1946. At present Cliff holds the rank of Lt. Colonel, Engineers, U. S. Army Organized Reserves. In 1950 Mr. Nelson became President of the Western Chapter of W. S. P. E. Prior to becoming State Society President he had served as 2nd and 1st Vice President in 1955 and 1956.

Mr. Nelson is a Past Director of the Wisconsin Road Builders Association and a member of the Lions Club and Masonic Lodge.

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The report of the Civil Defense Committee of W. S. P. E. submitted by its chairman, Albert R. Striegl, at the Board of Directors Meeting on August 23, 1958 should be of vital interest to all engineers. Presented here is a brief summary of that report.

THE State of Wisconsin Civil Defense Survival Plan has been completed in draft form and is now being reviewed at State and Federal levels before being issued in final form. I have seen the plan and have reviewed most of Annex H on Engineering Services. The plan sets up a Co-Director of Engineering Services under the State C–D Director. The chairman of the State Highway Commission is assigned as Co-Director. The five main divisions of engineering services under this Co-Director, are Utilities, Transportation Maintenance, Structures, and Resources, each headed by a Chief of Division and each having four or five main subgroups. The Co-Director is given a technical advisory staff to be provided by such groups as WSPE and Wis. Architects Assn. The main criticism of the plan seems to be that the chain-of-command is too circuitous for an emergency situation. Operational orders are to pass through regional directors where appointed, county directors, city or village directors, and finally to the operating level. This would result in too slow action for an emergency situation. The plan should be made public as soon as possible so that experience can be gained, since any emergency plan known only to a few is of little value in a situation involving a large part of the population.

The administration of Federal civil defense has changed in recent months under public law 7576 which merges the Office of Defense Mobilization and the Fed-

(Continued on next page)

eral Civil Defense Administration into the Office of Defense and Civilian Mobilization. It appears that Congress has become more aware of civil defense problems. The ODCM director speaks for the President as a staff member and has the responsibility for planning to meet whatever emergency might come up—either war or natural disaster. The OCDM has the responsibility for the planning, direction and implementation of the planning for the emergency use of the resources of this nation that are not definitely assigned to the military. Gov. Leo A. Hoegh, former civil defense director, has been made director of the combined agency, possibly implying more attention to C–D matters.

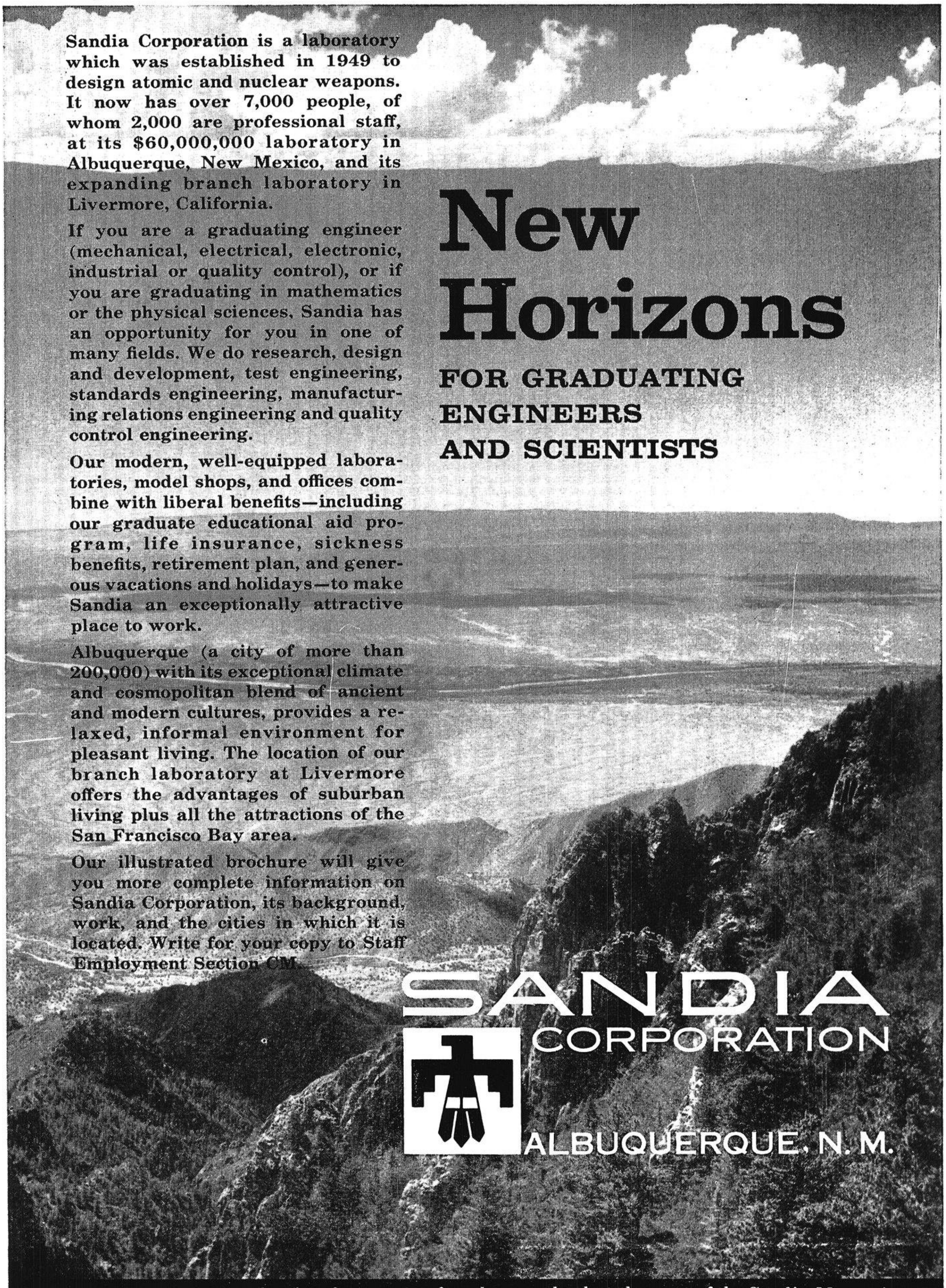
Bill 7576 makes civil defense a joint responsibility between the Federal Government and state and local areas. The Federal Government will supply matching funds for administrative costs to state and local governments in order to build up the stature and capabilities of civil defense. Wisconsin has been allocated $230,000 of the total of $25 million appropriated for matching administrative costs for C–D in 1959. State and local governments have proviously had to bear all administrative costs as Federal matching funds were limited to certain categories of C–D equipment and supplies. This change recognizes joint Federal responsibility and should expedite C–D planning.

Mr. Chas. Nagel has represented WSPE at meetings of the Milwaukee area advisory committee on protective construction. The writer also has attended meetings of this group which is at present considering primarily shelters that might be built for protection against radio-active fallout rather than as protection from direct hits. The national policy has changed somewhat, due to the shortening time of probable warning, from stress on evacuation of the non-essential population in times of emergency and fallout protection for essential workers. An article in *"Time"* magazine issue of August 25, 1958, states the large savings of people possible in the larger cities anticipated from adequate fallout shelters, cutting the loss from possibly

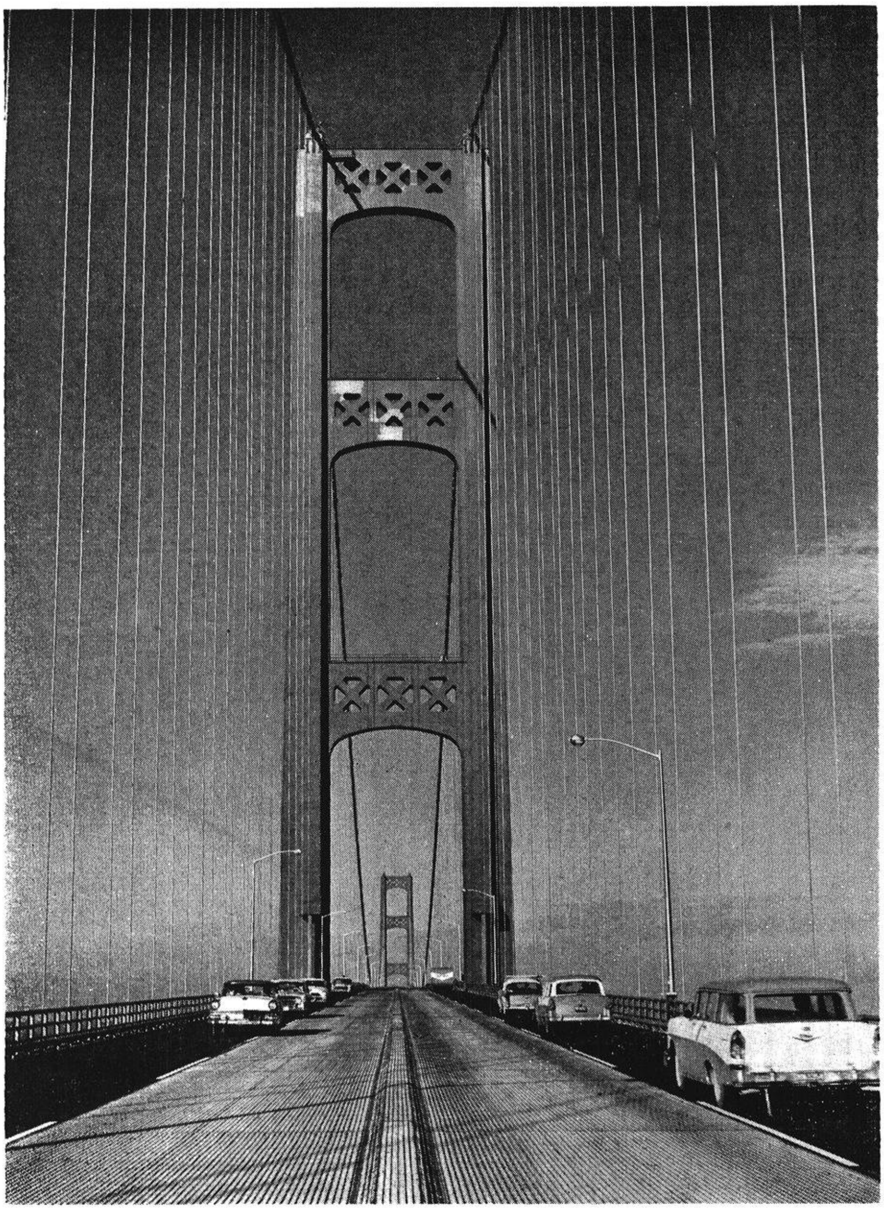
(Continued on page 56)

APPLICATIONS FOR MEMBER AND AFFILIATE MEMBER—JUNE 21, 1958 & AUGUST 23, 1958

Name and Position	Address	Reg. No.	Sponsor
MILWAUKEE			
Ralph Wiken, PE Ass't to Vice Pres.-Chief Engr. The Falk Corp.	3001 W. Canal St. Milwaukee 1, Wis.	E-1962	F. C. Koehn, PE
Gerald W. Bard, EIT Chemical Engr. Chain Belt Co.	4701 W. Greenfield Ave. Milwaukee 1, Wis.	ET-1501	Weld Conley, PE
SOUTHWEST			
Robert Phillips, EIT Engineer General Engineering Co.	630 W. Pleasant St. Portage, Wis.	ET-1691	Vernon Coffey, EIT
Richard N. White, EIT Structural Engineer John Strand Engineers	2020 University Ave. Madison, Wis.	ET-1447	Lyle Hird, EIT
Adolph J. Ackerman, PE Consulting Engineer (Hydroelectric)	1250 Sherman Ave. Madison 3, Wis.	E-5208	F. T. Agthe, PE
Donald F. Wendel, EIT Highway Engineer Mead & Hunt, Inc.	4326 Mohawk Dr. Madison 5, Wis.	ET-1813	H. H. Buer, PE R. L. Sterna, PE
FOX RIVER VALLEY			
Fred A. Haselow, PE Chief Engineer Charmin Paper Products Co.	328 Greene Ave. Green Bay, Wis.	E-6607	M. J. Auchter, PE
Thomas E. Orbison, Jr., PE Partner Orbison & Orbison, Consulting Engineers	123 E. Harrison St. Appleton, Wis.	E-6661	T. E. Orbison, PE
O. Harold Arndt, EIT Design Engineer Cleereman Machine Tool Corp.	718 Lincoln Ave. Kaukauna, Wis.	ET-1819	John Stauss, PE
NORTHWEST			
Harold J. Cleary, PE Manager Jump River Electric Co-op, Inc.	1102 W. 9th St., No. Ladysmith, Wis.	E-6625	V. M. Dufeck, PE
WISCONSIN VALLEY			
Jayme B. Olson, EIT Wm. T. Collings, PE		ET-1864 E-4361	Ralph G. Laumer, PE Emil C. Uranich, PE



This photograph depicts the view from 10,800 feet above sea level at the crest of the Sandia Mountains, looking westward across the Rio Grande Valley and the northern limits of the city of Albuquerque.



Today the bridge stands completed, carrying streams of traffic daily across its span connecting the peninsulas of Michigan. It stands a superb job of construction and stability.

Mackinac Bridge

(Continued from page 15)

the floor system was erected. There was no danger of these sections breaking loose.

There were 89 stiffening trusses lifted from barges into position by the two hoists. These truss sections were heavy, ranging up to 130 tons for one panel of two side trusses with cross-bracing. They had to be hoisted a maximum of 155 feet above water level. These truss sections were erected in the 3800 foot center span, the two 1800 foot side spans, and the two 472 foot backstay spans.

Placing of the Roadway

The roadway is composed of I-beam Lok grating set on top of the stiffening trusses. The roadway width is 48 feet, of which two feet is a center mall. There is three feet added to each side of the roadway as sidewalk. This is a total width of 54 feet.

Aerodynamic Stability

The high degree of aerodynamic stability is due to the provision of wide open spaces between truss sections. The trusses are spaced 68 feet apart and the roadway is 48 feet wide, leaving open spaces 10 feet wide the full length of the suspension bridge. Further stability is provided by the longitudinal opening in the middle of the roadwayfl The two outer lanes each 12 feet wide, are solid, while the two inner lanes, each 11 feet wide, and the 2 foot wide center mall are made of open-grid construction.

Wind tunnel tests show conclusively that the bridge has complete and absolute aerodynamic stability against coupled oscillations (combined vertical and torsional) at all wind velocities and angles of attack.

Construction

Construction of the roadway was made by first setting I-beam stringers longitudinally along the top of the truss sections. Grating was laid over the stringers and tack welded. By working each way from the towers mobile cranes were permitted to work over previously laid grid. The outer two lanes were concrete-filled steel grid, utilizing light weight portland cement concrete 4½ inches deep. The concrete was delivered by truck, deposited in place, and vibrated.

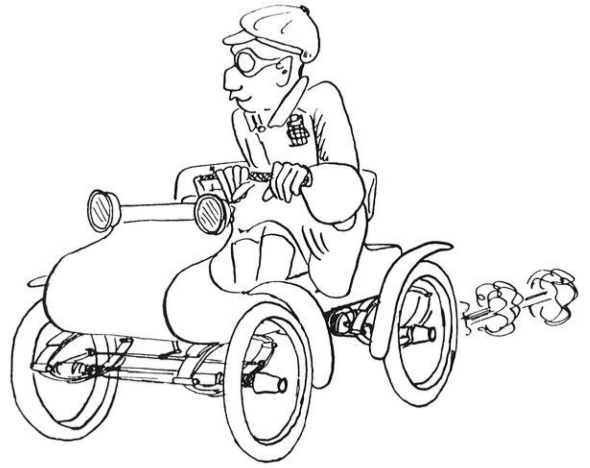
The concrete mixture contained 6½ bags of cement, 450 lbs. of lightweight expanded shale coarse aggregate, 1570 lbs. of lightweight fine aggregate, and 29 gal. of water per cubic yard.

The asphaltic concrete surfacing on the outer two lanes was ¾ inches thick at the edges and 1¾ inches at the center line of the lane. This asphalt was mixed in a plant three miles from the bridge and transported to the job in a fleet of 10 trucks.

A problem that was encountered was the laying of the asphaltic concrete over the 80 expansion and fixed joints. The joints were designed to be set flush with the finished pavement and therefore were protruding 1¾ inches. Masking tape was laid over the opening in the joint to prevent falling asphalt. A crawler type paver had to be used. The tape was scraped off before the asphalt was rolled to its final crown. The hot asphalt was first laid at an average of 22 fpm which later increased to 32 fpm.

A total of 1800 tons of asphaltic concrete surfacing was used on the suspension spans.

THE END



THE ENGINEER OF YESTERYEAR

by John Nichols

June 1896

PROFESSORS Snow and Austin of the physics department have been doing much successful work with the "X-rays." Since the early experiments in the general line now so familiar to all, in which many fine negatives of special value were obtained, they have been investigating along the line of the reflection of the rays. Besides the reflection through tubes and from pieces of metal placed behind photographic plates, experiments have been tried with the Crookes' tube placed in the focus of a parabolic reflector from a locomotive head-light. The fluorescent screen glowed faintly but certainly, when placed in front of the reflector when the direct radiation of the tube was entirely cut off. With a plain metal mirror behind the tube instead of the parabolic, no evidence of reflection great enough to excite the screen was found. This may perhaps be taken as an indication that the reflection is at least in part regular. Unsuccessful attempts have been made to repeat the experiments described by Becquere; (Comptes rendus, March 2, 1896) on some invisible radiations given out by fluorescent substances, which are capable of traversing bodies opaque to ordinary light. Though these experiments have been amply verified elsewhere, the results here have been negative. The salt used was uranium-nitrate. A photographic plate was exposed to its influence for twelve hours, the salt being a part of the time in the direct sun light. A new Edison screen of calcium-tungstate has been obtained with which better results in reflection are expected. They are now engaged on the diffraction of the rays.

A comparative test of a compound and a single expansion locomotive was made on two engines belonging to the C. & N. W. R. R. Co. on through freight service between Milwaukee and Sheboygan. Six round trips of 104 miles each were made with each engine. The engines were ten-wheelers of Schenectady make, one a single expansion 19″x24″, the other a two-cylinder compound 20″ and 30″x24″. All other dimensions were the same on both.

The average per centage of coal saved by the compound engine was 7.74 per cent; water per I.H.P. hour, actual 17.12 per cent. Water per I.H.P. per hour for dry steam at 160 lbs. gauge, 20.32 per cent; water per ton mile, actual 9.15 per cent; and water per mile ton of train resistance for dry steam at 160 lbs. gauge 14.27 per cent.

October 1897

Each day sees some new field opening wherein gas and gasoline engines may be used to great advantage. Among the latest may be mentioned their appliance to hoisting and mine hauling. For hoisting work in small mines where horse-power machinery will no longer give satisfaction, the gas engine offers a number of advantages that are worthy of consideration. Already the economy of gas and

Dean John B. Johnson, dean when Education Building was first built as the Engineering Building. Photo appeared in the April, 1904, Engineer.

gasoline engines is much greater than that of the steam engine. Of the energy contained in gas, from 20 to 23 per cent is converted into effective form, the remainder being carried off with cooling water or rejected with the discharged gases or in radiation. Recent investigations have shown an effective conversion of energy much higher than the above, the gain being obtained by a reduction in the amount of heat rejected with the cooling water. It is evident that the economy can be made still greater if mechanical difficulties, such as cylinder wear, lubrication, etc., did not forbid the use at present of higher temperatures. It is thought however, by improved methods of lubrication and by modifications in construction, much higher temperatures than at present can be used.

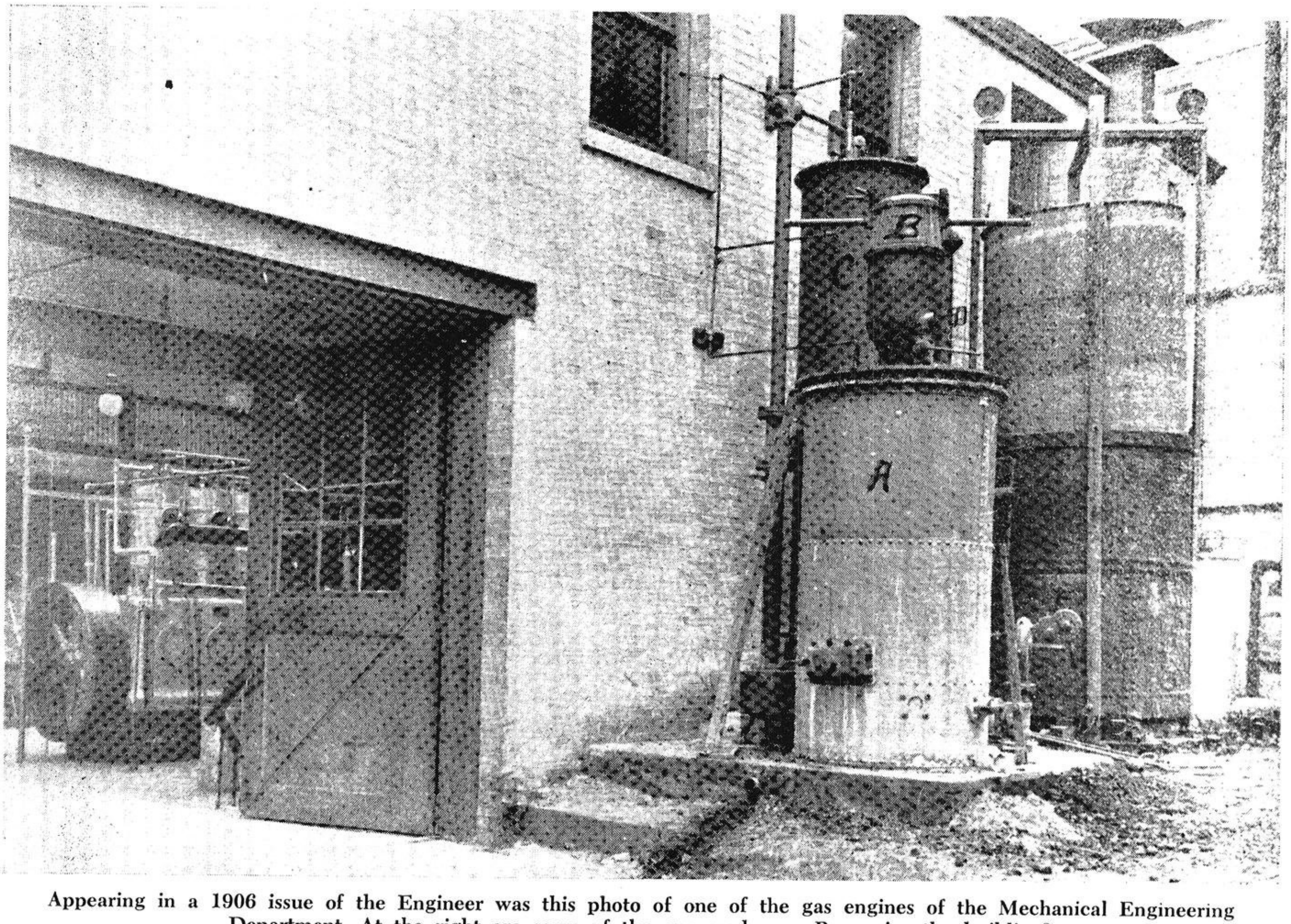
January 1898

The already extensive facilities of the physics department of the University have been increased by the acquisition of a Winshurst Influence machine made by Newton and Company, London, England. This machine is probably the largest and most powerful of its kind in this country. The case is six feet long, three feet wide and five feet high, while the two large brass conductors extend a foot above the top. There are fourteen revolving plates, each thirty-six inches in diameter. When running at full capacity, two hundred revolutions per minute, a spark eighteen inches in length is obtained. The principal object in getting the machine was to investigate the effect of a long spark, it being too powerful for ordinary work in the classroom. The principle trouble encountered so far in working with the machine is to get a Leyden jar strong enough to hold the charge. Several have already been broken, but Professor Snow has succeeded in fixing two so as to hold light charges, by scraping the foil down to two inches inside the jar and one inch outside. At present the machine is driven by hand and has shown great power, having given an eight inch spark, and penetrated ⅝ inch of glass.

April 1898

The College of Engineering of the University of Wisconsin enjoys the distinction of possessing the most modern and complete refrigerating plant for scientific and testing purposes. Refrigeration may be obtained in a number of different processes and again these processes may use different liquids of gases to accomplish the cooling. By far the larger number of plants in use are of the compression process and use ammonia or carbon dioxide as the working fluid. The one just installed is an ammonia machine of the compression process. This plant was built by Wm. Challoner and Sons of Oshkosh, Wisconsin, and consists of a three cylinder, single acting compressor, a condensing tank, cooling tank, ammonia storage and oil separating tanks. If used for making ice, its capacity would be about five tons every twenty-four hours.

THE END



Appearing in a 1906 issue of the Engineer was this photo of one of the gas engines of the Mechanical Engineering Department. At the right are some of the gas producers. Recognize the building?

Science Highlights

(Continued from page 38)

veloped by the AC Spark Plug Division of General Motors.

The Mace, designed and developed by The Martin Company, is a ground-to-ground, jet-powered, 650 mph tactical missile, 44 feet long with a 23 foot wing span. Travelling at altitudes over 40,000 feet or at extremely low level, according to the tactical situation, the missile dives on target at supersonic speeds. Capable of carrying a nuclear warhead, the Mace's instant retaliation capability will be an effective deterrent to enemy aggression.

MACHINES TALK BACK

Production machines that "talk back" to man—and in his own language, too—are making themselves heard in the expanding age of automation, according to a young Lockheed scientist.

Henry M. "Hank" Lakin, 32, a senior scientist at Lockheed's Van Nuys, Calif., missile plant, told of his work in the development of man-machine "common languages" at the second International Congress of Cybernetics recently in Namur, Belgium.

Cybernetics is the comparative study of the control system (brain and nervous system) of animals and of mechanical-electrical communication systems such as computers. It touches upon most areas of natural and physical sciences.

Through high speed electronic computers (acting as interpreters) and a typewriter device (Flexowriter), Lakin explained, automatically controlled production machines will "discuss" with the operator the progress of the work being performed.

Any number of statements, reflecting almost any situation the machine might encounter, can be built into the computer's brain.

Choice of the proper statement would depend on the situation the machine meets. This is signalled to the computer which electronically selects and triggers the phrase.

"And we aren't limited to polite conversation, either," Lakin said. The machine's back-talk could range from strictly-business phrases like "Have revised your last instruction" or "Recheck command 103" to "You sure got us into a jam this time, wise guy," "Let's not botch it up again, bud," or "I hope you know what you're doing."

Lakin received his bachelor's and master's degrees from the University of Michigan and did post-graduate work at Michigan and M.I.T. He came to Lockheed Missile Systems division three years ago.

SPACE AGE SPAWNS NEW TECHNOLOGY

With yesterday's "high-temperature" materials all but melting away under the intense heats of today's rocket engines, scientists are looking to new technology to produce the materials of tomorrow. Development engineers at National Carbon Company, Division of Union Carbide Corporation, find the company's 75-year experience in producing carbon and graphite for industry gives them a valuable start in attacking the temperature problems created by the space age. Here at one of the company's development laboratories, a technician watches through an observation port in a flame-test chamber as a new graphite-base material is put through its paces. (See picture) Positioned in a jet of exhaust gases traveling at five times the speed of sound from an oxygen-kerosene flame (note characteristic diamond-shaped supersonic nodes), the conical specimen reaches a white heat of approximately 5,000 degrees Fahrenheit in a matter of seconds. Conventional graphite erodes beyond tolerable limits in about eight seconds, but National Carbon has already produced materials that hold dimensions ten times longer, and has its sights on even longer cycles—well beyond the normal operating requirements of rocket engine components. The new knowledge being gained is expected to exceed everything previously learned of the behavior of materials at temperatures approaching that of the sun's surface, and gives promise of resulting in a whole new "family" of high-temperature materials for both industrial and military equipment of the future.

THE END

WE WANT MEN TO CREATE TOMORROW'S HEADLINES!

The new, dynamic and diversified Northrop Aircraft, Inc., creates an ideal work climate for forward-thinking scientists and engineers. Our three autonomous divisions are all in Southern California – are all headed by progressive management eager to examine and try new ideas.

Let's assume that *you* are a man who can qualify for one of our engineering teams – a man who can create history!

You'll earn what you're worth, get increases as often as you earn them – based on your own individual achievements. Our salary structure is unique in the industry; our vacation policy extra-liberal, as are all of our other fringe benefits.

You'll learn while you earn, with no-cost and low-cost education opportunities at leading Southern California institutions – earn advanced degrees and keep abreast of the latest technological advances in your own chosen field.

You'll work with men who are acknowledged leaders in their fields – men chosen for their own capabilities *and* for skills in guiding and developing the creative talents of younger men. And, these are men who delegate authority, assuring your fair share of credit for engineering triumphs.

You'll be flexible – able to apply your talents to the work you enjoy, in the field best suited to your own inclination and ability. Northrop Aircraft and its divisions offer wide diversity, with over 30 operational fields to choose from. All offer challenge aplenty – opportunity unlimited!

Now choose! See what each division of Northrop Aircraft has done and is doing. Then choose the division that offers *you* the most challenge. Write today to reserve your spot where news is *happening* – for your *own* chance to create tomorrow's headlines!

NORTRONICS DIVISION

Pioneers in celestial and inertial guidance. At Hawthorne: exploring infrared applications, airborne digital computers and interplanetary navigation. At Anaheim: developing ground support, optical and electro-mechanical equipment, and data processing devices.

Write: Engineering Personnel Mgr., Nortronics Division, 222 North Prairie Ave., Hawthorne, California
or: 500 East Orangethorpe Ave., Anaheim, Calif.

NORTHROP DIVISION

Creators of the USAF Snark SM-62, now operational with SAC. Currently active in programs for the ballistic recovery of orbiting man; readying the USAF-Northrop T-38 supersonic twin-jet trainer and the Northrop N-156F counterair fighter for flight tests.

Write: Engineering Personnel Mgr., Northrop Division, 1001 East Broadway, Hawthorne, California

RADIOPLANE DIVISION

Creator of the world's first drone family; has produced and delivered tens of thousands of drones for all the U.S. Armed Forces. Now developing ultra-advanced target drone systems for weapon evaluation, surveillance drone systems, and guided missile systems.

Write: Engineering Personnel Mgr., Radioplane Division, 8000 Woodley Avenue, Van Nuys, California

...NEWS IS HAPPENING AT NORTHROP

NORTHROP AIRCRAFT, INC., Beverly Hills, California

Prestressed

(*Continued from page 25*)

under the superimposed load, but only $\frac{5700}{3} = 1900$ lb. per sq. in. at the time the prestress is established.

Tensile stresses due to bending moments do not exist in theory, but there may be some tension in the top fiber during prestressing and in the lower fiber under the greatest possible load. The allowable amount of tensile stress in concrete is one-tenth of the compressive stress if no ordinary reinforcement is provided and one-fifth if reinforcement is used to resist all of the tensile forces.

The above mentioned working stresses provide an ample margin of safety. They allow for unexpected difficulties on the job.

The stress in the steel should not exceed 0.8 of the equivalent yield stress, or 0.6 of the tensile strength, whichever is smaller. The factor of safety in the steel is much smaller than in the concrete; so these permissible stresses in the steel should never be exceeded. When the steel is tested during prestressing it is stressed 10 per cent more than its greatest working stress and should never reach that stress again.

This photograph shows how the reinforcing steel is tensioned by a hydraulic jack to produce prestressed concrete beams.

Applications

The only methods of prestressing used on a large scale are:

(1) Cables stretched after the hardening of the concrete

(2) Wires stretched before the hardening of the concrete

The first method is more suitable for large structural members made on the job and is uneconomical for anything less than about 30 feet.

The second method is economically done in mass production in factories of concrete products of smaller size, since the handling and transportation of large members is expensive.

Prestressed concrete has been successfully used in the construction of railway bridges. One of the first railway bridges to be built of prestressed concrete was the Mi-?eir Bridge in Brussels. A comparison of estimates of materials for this job is as follows:

Slab in Ordinary Reinforced Concrete. The working stresses adopted were 1000 lb. per sq. in. in the concrete and 14,000 lb. per sq. in. in the reinforcement. The thickness is six feet at mid-span and five feet six inches at the supports. The quantities of material include 191 cubic yards of concrete and 25 tons of mild steel.

Slab in Prestressed Concrete. The working stresses were 2150 lb. per sq. in. in the concrete and 120,000 lb. per sq. in. in the steel wires. The thickness is three feet nine inches at mid-span and three feet seven inches at the support. Materials used consist of 110 cubic yards of concrete, 5⅓ tons of steel wire, 2.55 tons of steel in the end plates, and ⅔ ton of mild steel bars.

The cost of the prestressed slab was 85 per cent of the cost of the slab in ordinary reinforced concrete, although the thickness was much less.

Road bridges have also been successfully constructed with prestressed concrete slabs. The first prestressed road bridge built in Belgium was constructed with a span of 43 feet and a width of 39 feet. The materials included 120 cu. yd. of concrete 5½ tons of wire, and about 3½ tons of steel in the end plates. In ordinary reinforced concrete there would have been required about 150 cu. yd. of concrete and about 18 tons of mild steel. The amount of steel used is seen to be about one-third of that required for ordinary reinforced concrete. It could have been less; however, it was thought best to have a large margin of safety because of the lack of experience in this type of construction. Footbridges, bridges for pipe lines and beams for building are also constructed of prestressed concrete.

Conclusions

Prestressed concrete has been successfully used in place of reinforced concrete and possess the following advantages:

(1) The thickness of a slab is considerably reduced, resulting in a saving of concrete.

(2) The slabs do not crack if the working load is not exceeded by more than 50 per cent.

(3) Overall costs are reduced considerably.

(4) The amount of steel required is small.

THE END

DU PONT PLANTS AND LABORATORIES IN 26 STATES OFFER VARIED JOB LOCATIONS TO TECHNICAL STUDENTS

BENEFIT PROGRAM MEANS ADDED INCOME

by C. M. Forbes
Du Pont personnel representative

Don't forget the "extras" of an employee benefit program when you compare the job offers and salaries of different companies. At Du Pont, these extras mean added income that doesn't always meet the eye. They include life insurance, group hospitalization and surgical coverage, accident and health insurance, pension plan and paid vacation.

In addition, the Company sponsors a thrift plan. After two years of service, for every dollar you invest in U. S. Savings Bonds the Company sets aside 25 cents for the purchase of common stock in your name. Roughly, 60,000 of our employees are now participating in this plan.

If you have specific questions on Du Pont benefits, just send them to me. I'll be happy to try to answer them. E. I. du Pont de Nemours & Co. (Inc.), Room 12421 Nemours Building, Wilmington 98, Delaware.

EXPANSION PROGRAM OPENS UP MANY NEW CAREER OPPORTUNITIES

The location of your first assignment with Du Pont depends on your qualifications and on the openings in your field, but every effort is made to match the job and the location with your preference. The chances for a successful match are good.

Today there are men and women carving out careers with Du Pont at more than 75 plants and nearly 100 laboratories spread throughout 26 states. Last year the Company spent $220 million for new plants and for increased capacities at existing installations. This year new plants have already been put into operation in Virginia and Michigan. Six more are under construction. Others are planned for the near future.

Most Du Pont units, it is true, are located east of the Mississippi. Company headquarters, for example, along with many labs and plants, are located in and around Wilmington, Delaware, which is a pleasant residential area within easy reach of Washington, Philadelphia and New York. But there are also plants and laboratories in California, Iowa, Kansas and Texas, and plants in Colorado, Missouri and Washington.

Wherever you're assigned, you'll be proud of the Du Pont Company both on and off the job. You'll find the people you work with friendly, stimulating, and active in the life of the community.

MECHANICAL ENGINEERING MOVIE AVAILABLE FOR A.S.M.E. MEETINGS

There's a great demand for mechanical engineers at Du Pont. In fact, the ratio of mechanical to chemical engineers is just under 1:2. Whether your chosen field is research, development, plant engineering, production supervision or sales engineering, you'll find a good future at Du Pont.

If you would like to learn in detail what mechanical engineers do in the chemical industry, arrange to see the Du Pont film, *Mechanical Engineering at Du Pont.* It is available at no cost for A.S.M.E. chapter meetings, fraternity house and dormitory showings. Write to Room 12421 Nemours Building, E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Delaware.

SEND FOR INFORMATION BOOKLET

Informational booklets about Du Pont are yours for the asking. Subjects include: mechanical, civil, metallurgical, chemical, electrical and industrial engineers at Du Pont; technical sales, research and development. Just name the subject that interests you and send your name and school address to E. I. du Pont de Nemours & Co. (Inc.), Room 12421 Nemours Building, Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

ENGINE EARS

by Don Roeber (ee'60)

COMPANIES INTERVIEWING ON CAMPUS FIRST SEMESTER 1958–1959

(Interviews held on 4th floor of M. E. Bldg. unless otherwise noted.)

MONDAY, OCTOBER 20
Douglas Aircraft
Graver Tank & Mfg.
Los Alamos Scientific Labs
Pillsbury Mills
Standard Oil of California
U. S. Steel (all divisions)
U. S. Army Research and Development

TUESDAY, OCTOBER 21
Battelle Memorial
Colgate Palmolive
Fansteel Metallurgical
General Tire & Rubber
Inland Steel Products
Westinghouse
Zenith Radio Corp.
Corps of Engineers

WEDNESDAY, OCTOBER 22
Allen Bradley
Federal Reserve Bank of Chicago
Goodyear Tire & Rubber
Standard Oil of Ind. (all divisions)
State Highway Dept. of Indiana

THURSDAY, OCTOBER 23
Burroughs
General Telephone (Wis.)
Johnson Service
United Aircraft Research
Vanadium Corp.
Esso Standard of La.
Standard Oil of Indiana

FRIDAY, OCTOBER 24
H. D. Conkey & Co.
Cornell Aeronautical Labs
Esso Research & Engr. & Esso Std. Oil of La. & Jersey Production Res. (Latter two subject to change)
Humble Oil and Refining
P. R. Mallory & Co.
Midland Industrial Finishes
Pet Milk
Remington Rand Univac
Civil Aeronautics

MONDAY, OCTOBER 27
California Institute Tech. (Jet Propulsion)
Gulf Oil
Line Material Industries
Shell Oil & Affiliates (all divisions)

TUESDAY, OCTOBER 28
American Oil
Babcock and Wilcox
Consumers Power
Corning Glass Works
General Foods
Shell Oil and Affiliates

WEDNESDAY, OCTOBER 29
Bell System (all divisions)
Union Carbide Nuclear
U. S. Rubber
West Virginia Pulp & Paper

THURSDAY, OCTOBER 30
Louis Allis Co.
Avco Mfg. (Crosley Div.)
Bell System
Northern Illinois Gas
Trane

FRIDAY, OCTOBER 31
Air Reduction
Archer Daniels
Elgin National Watch
Falk Corp.
Harnischfeger
LeTourneau Westinghouse
Snap-on-Tools
Socony Mobil Oil (Overseas)
Trane
Upjohn

MONDAY, NOVEMBER 3
Air Preheater
General Electric
Institute Paper Chem.
Kimberly Clark
Phillips Petroleum Co.
A. O. Smith
Victor Chemical Works
Youngstown Sheet & Tube Co.

TUESDAY, NOVEMBER 4
Firestone Tire & Rubber*
B. F. Goodrich Chemical
Hamilton Standard
Haynes Stellite
McDonnell Aircraft
General Electric
General Electric-Research

WEDNESDAY, NOVEMBER 5
J. I. Case
Chevrolet Saginaw
Continental Oil
Factory Insurance
Kalamazoo Vegetable Parchment
Parke Davis & Co.
Sangamo Electric
Coast & Geodetic Sur.
General Electric Res.
Hamilton Standard

THURSDAY, NOVEMBER 6
Chemstrand Corp.
Collins Radio
Diamond Alkali
Firestone Tire & Rubber
Food Machinery
Radio Corporation of Am.
West Bend Aluminum

FRIDAY, NOVEMBER 7
Allied Chemical & Dye (all divisions)
Dayton Power & Light
Collins
Merck & Co.
R. C. A.

MONDAY, NOVEMBER 10
Argonne National Labs
Barber Colman
General Mills Central Research
General Mills Mechanical Div.
General Motors
Owens Illinois
Pure Oil
Republic Steel
Sperry Gyroscope

TUESDAY, NOVEMBER 11
Caterpillar Tractor
Inland Steel
Int. Business Machines (Ba)
Int. Harvester
Libbey Owens Ford Glass
Swift Research
Union Carbide
Whirlpool
Wis. State Bur. Pers.
General Motors

WEDNESDAY, NOVEMBER 12
Corn Products
Union Bag Camp Paper
General Motors (all divisions)
Caterpillar

THURSDAY, NOVEMBER 13
- American Cyanamid
- Bendix (all divisions)
- Chrysler
- I. B. M.
- Pratt & Whitney
- Wyandotte Chemicals

FRIDAY, NOVEMBER 14
- Askania Regulator
- Bakelite
- Koppers
- Linde Co.
- Martin Co.
- Wis. State Highway
- I. B. M.

MONDAY, NOVEMBER 17
- Commonwealth Edison
- Ethyl
- Procter & Gamble
- Standard Vacuum Oil.
- Texas Co.

TUESDAY, NOVEMBER 18
- Interstate Power
- Liberty Mutual Insurance
- Lubrizol
- National Malleable
- Peoples Gas Light & Coke
- Swift
- Ethyl
- Procter & Gamble

WEDNESDAY, NOVEMBER 19
- Aluminum Co. of America
- Chicago Bridge & Iron
- Columbia Southern
- Raytheon Mfg.
- Square D
- Standard Oil of Ohio
- Sun Oil Co.

THURSDAY, NOVEMBER 20
- AiResearch Mfg.
- Cargill
- City of Milwaukee
- Link Belt
- Mead Corp.
- Minneapolis Honeywell, Micro Switch & Morton Grove divisions
- Wisconsin Electric Power

PROFESSIONAL ENGINEERING FRATERNITIES

Triangle

Triangle Fraternity, 438 North Frances, is a social-professional fraternity of engineers and architects. The twenty chapters of Triangle are centered at midwestern colleges yet range from U.C.L.A. on the west to Cornell in the east. The Wisconsin Chapter has twenty-two members who are active in all campus activities.

Last spring Triangle sponsored tours through the engineering buildings as a part of Parent's Weekend. Although primarily a professional fraternity, Triangle has a social program adapted to engineering students. Football parties, a Christmas party, exchange dinners, St. Pat's Weekend, and the Spring Formal are the highlights of the social schedule.

Kappa Eta Kappa

Kappa Eta Kappa is a professional electrical engineering fraternity, with their house located at 204 North Murray. The forty-six members participate in various activities which were highlighted by the election of their candidate for Campus Clown at last year's Campus Carnival. Each month Kappa Eta Kappa puts up exhibits of interest to electrical engineers in the Electrical Engineering building.

KHK has chapters at Wisconsin, Minnesota, Kansas and the Milwaukee School of Engineering. They have a social program which meets the needs of electrical engineering students and includes informal parties, exchange dinners and an annual formal dance.

Alpha Chi Sigma

Alpha Chi Sigma is a professional and social fraternity in the fields of chemistry and chemical engineering. The "Ax" House as their chapter house is commonly referred to is at 621 North Lake. AXE has 63 collegiate chapters and 34 professional chapters. Their social activities include weekend parties, spring formal, exchange dinners and an annual picnic.

Alpha Chi Sigma's professional program is both extensive and varied. Several prominent local citizens are guest speakers throughout the year. As a service to local high schools, chemistry programs designed to stimulate interest in science are promoted by the fraternity.

NEW COURSE ESTABLISHED

The University Faculty has established a new "Course in Applied Mathematics and Engineering Physics". It replaces the old "Course in Applied Mathematics and Mechanics" which was somewhat too rigid for today's needs and no longer very popular with the students.

The course represents a joint program of the College of Letters and Science and the College of Engineering. It will provide basic training in related areas of applied mathematics, physics and engineering science, with emphasis on theoretical aspects in the engineering courses.

A number of options are available for the engineering science courses. There is one in Engineering Mechanics, one in Electrical Engineering, and then there is a more theoretical option designed for students whose main interest is in mathematics and physics.

The program will also be offered on the Milwaukee Campus of the University.

FORMER STUDENT WINS FELLOWSHIP

John B. Picchiottino, a 1958 bachelor of science graduate of the University of Wisconsin, has won a Hughes Master of Science Fellowship Award enabling him to continue his education while working part-time for Hughes Aircraft Company.

Picchiottino, of 300 W. Warnimont Ave., Milwaukee, Wis., is one of 136 graduates of 73 colleges and universities across the nation to receive Hughes M.S. Fellowship Awards for 1958. The group represents 37 states and Hawaii.

Picchiottino has enrolled this fall at the University of Southern California for graduate study leading to a master's degree. He worked full-time during the summer months and will work part-time during the regular academic year in a salaried job closely related to his studies at Hughes research and development laboratories. He will be a member of the Hughes technical staff. His tuition, fees and cost of textbooks will be borne by the company.

At Wisconsin, Picchiottino specialized in electrical engineering. He is a member of the Society of Student Engineers and Tau Beta Pi and received sophomore and a Unico National Scholarship. His activities included vice-presidency of the Radio Club.

PROF. LENZ TO HEAD CE DEPARTMENT

Prof. Arno T. Lenz, of the University of Wisconsin College of Engineering's department of civil engineering, has been chosen chairman of the UW civil engineering department.

Lenz succeeds Prof. James G. Woodburn, who served as chairman of the department for nine

(Continued on next page)

years in addition to teaching and research duties. Woodburn will be able to devote fulltime to these duties now.

Lenz has been connected with Wisconsin engineering for 30 years. He was graduated from the UW College of Engineering in 1928, earned a master of science degree in 1930 and a Ph.D. in 1940, all in civil engineering with his major field in hydraulic and sanitary engineering. He began his long career on the UW staff in 1929.

He is a member of a half dozen national engineering and educational organizations, and has done considerable research in the UW hydraulics and sanitary engineering laboratory in dam construction and hydrology, and water resources investigations.

TWO FACULTY MEMBERS WIN TEACHING AWARDS

A man who was transplanted from Holland to Wisconsin to become an inspiring teacher of mathematics for University of Wisconsin engineering students was awarded the annual Benjamin Smith Reynolds Award of $1,000 for excellence in the teaching of engineers.

The man is Prof. Jacob Korevaar, the UW department of mathematics, who, since 1952, has been specializing in the teaching of "engineering" or applied mathematics to UW engineering students. Before he came to the United States in 1949, the youthful Prof. Korevaar, now only 35, was referred to as "the best teacher of mathematics in Holland."

The presentation was made by Wilbur N. Renk, Sun Prairie, president of the UW Board of Regents, who said that Prof. Korevaar "has served his department far beyond the call of duty in building up its courses of study for engineering students. He has been teaching these courses in over-sized sections in order to provide for all students who have need of them in their major field of study. And outside the classroom he has been very helpful to students on an individual basis.

"He is highly regarded as a teacher and researcher by his departmental colleagues here at our University as well as nationally and internationally," Renk said. "He has shown a constant concern with the problems of the engineering student, and has vigorously advanced teaching in the area of engineering and applied mathematics. He is patient in considering the problems of students, yet he is stimulating to them.

"Prof. Korevaar has devoted so much of his time and energy to teaching and administration in connection with engineering students that it has been at the cost of advancing his professional standing in his own field through both fundamental and applied research. An excellent young mathematician, he has devoted himself wholeheartedly to the teaching of applied mathematics to his students, among whom is a very large percentage of engineers."

A 30 year-old assistant professor of electrical engineering at the University of Wisconsin who received his Ph.D. degree just three years ago, Wayne B. Swift, Monday received the coveted Kiekhofer Memorial Teaching Award.

The $1,000 check which goes with the award was presented before a meeting of the University of Wisconsin faculty by UW Regent George Watson.

Given annually to outstanding young Wisconsin faculty members for "excellence in teaching," the award is a "living memorial" honoring the beloved UW economics teacher, Prof. William H. Kiekhofer, whose classes in elementary economics enrolled more than 70,000 students during the long years of his teaching prior to his death in 1951.

Prof. Swift has taught a variety of undergraduate courses and is collaborating this year in teaching a graduate course and in research associated with Wisconsin's Vanguard Satellite.

In their citation for the award, the Kiekhofer Award Committee said he has "those characteristics which constitute the excellence in teaching symbolized by the late Prof. William Henry Kiekhofer."

"According to the testimony of his colleagues," the citation said, "Dr. Swift is generous, enthusiastic, never caustic, commands respect by reason of his very apparent intelligence and knowledge of his chosen subject. He likes to teach, to explain, and is unusually able in technical exposition. His unusual gift for words is seldom found in one with so much technical ability . . ."

SALARIES HOLD STEADY

Average starting salaries for 1958 engineering graduates are matching last year's all-time high.

Average starting pay for January and June engineering graduates at Illinois Institute of Technology, Chicago, was $470 a month—the same as last year, according to Earl C. Kubicek, director of placement.

The 1957 electronics boom brought electrical engineering starting salaries to $515 a month last year, he said. This year's electrical engineering average was $470 a month.

"However, mechanical-engineers, who are more basic in industrial application, commanded an average monthly salary of $483 compared to last year's average of $465," Kubicek added.

The over-all average, he pointed out, also included starting salaries for chemical, civil, fire protection and safety, food, industrial, and metallurgical engineering, and mechanics graduates.

"In spite of talk of recession, depression, and layoffs, there has been no material change in industry's demand for qualified engineers holding a bachelor's degree," he said.

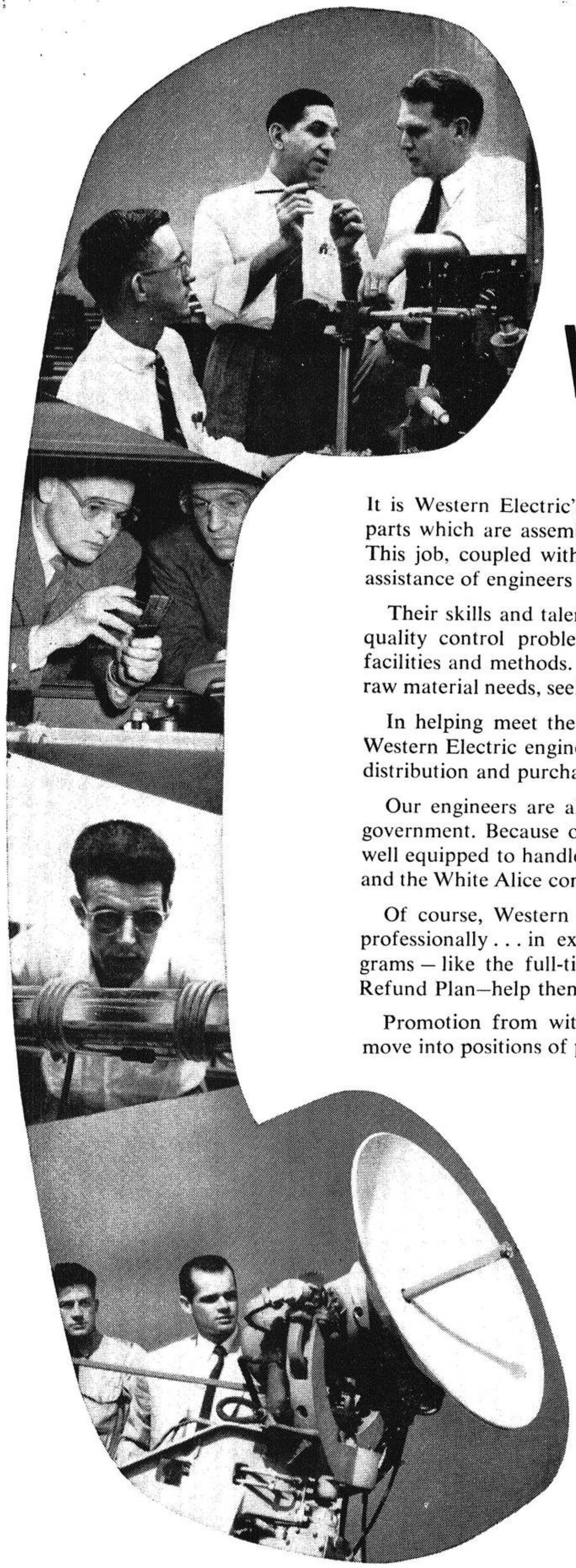
"Companies are becoming more and more selective," he added. "They want engineers who suit their needs—whether or not the graduates are draft exempt or in the top quarter of their class."

The market for engineers still is greater than the number of graduates, Kubicek added. He quoted a 1957 national survey made by industry which showed that a company was successful in recruiting when it secured 52% of the engineering graduates it needed through college recruitment.

"However, college recruiting still remains the most effective way for American industry to secure much-needed engineering personnel," Kubicek said.

THE END

It takes all kinds of engineers to do Western Electric's job



It is Western Electric's job in the Bell System to manufacture some 65,000 different parts which are assembled into a vast variety of telephone apparatus and equipment. This job, coupled with our other responsibilities as part of the System, requires the assistance of engineers in every field.

Their skills and talents are needed to develop new manufacturing techniques, solve quality control problems, determine machine and tool requirements, devise testing facilities and methods. They work on new applications for metals and alloys, calculate raw material needs, seek manufacturing cost reductions.

In helping meet the Bell System's need for more and better telephone equipment, Western Electric engineers have assignments in the other areas of our job—installation, distribution and purchasing.

Our engineers are also deeply involved in defense projects entrusted to us by the government. Because of our specialized experience as part of the Bell System we are well equipped to handle the job. Among these projects: the Nike guided missile system and the White Alice communications network in Alaska.

Of course, Western Electric engineers are encouraged and assisted in developing professionally . . . in expanding their technical know-how. Company-sponsored programs – like the full-time Graduate Engineering Training Program and the Tuition Refund Plan—help them along.

Promotion from within—a Western Electric policy—helps many of our engineers move into positions of prime responsibility. Today, 55% of the college graduates in our upper levels of management have engineering degrees. In the next ten years, 7,000 key jobs must be filled by newly promoted people—engineers included.

Western Electric technical fields include mechanical, electrical, chemical and civil engineering, plus the physical sciences. For more information pick up a copy of "Consider a Career at Western Electric" from your Placement Officer. Or write College Relations, Room 1111D, Western Electric Company, 195 Broadway, New York 7, N. Y. And sign up for a Western Electric interview when the Bell System Interviewing Team visits your campus.

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Reactors

(*Continued from page 21*)

The Argonne National Laboratory's Experimental Breeder Reactor No. 2, which is shown in Figure 6, is in many ways the most advanced, and most difficult, of all the reactors in the present program. The reactor will have a small core containing plutonium surrounded by a breeder blanket of natural U–238. The core will contain no moderating material, for it is important to keep the neutrons as energetic as possible to achieve the highest breeding gain. Such a concentration of fuel in a fast-neutron breeder is hard to cool and is susceptible to severe radiation damage. Therefore the big problem of the fast breeder is to acquire a delicate balance between unusable compactness and unworkable diffuseness.

EBR–2 will have a heat output of about 60,000 kilowatts and an electrical output of about 15,000 kilowatts. It is hoped that, while the specific power (material efficiency) is less than in thermal reactors, the breeding gain and high thermal efficiency of the fast-breeder system will make it an economic success.

The homogeneous reactor and the fast breeder represent the boldest and most difficult designs in the program. They also offer the greater potential return. Common sense forbids putting all the effort into the most advanced systems. Too much is at stake in designing a workable power plant to omit the more certain but less glamorous possibilities, in favor of more glamorous but less certain reactors.

Other reactors under study outside the AEC's program are: (1) the gas-cooled graphite reactor of the British; (2) the uranium–bismuth circulating fuel system at Brookshaven National Laboratory; (3) the large program of military reactors. It is expected that within five years the best types of nuclear power reactor design will be well known. THE END

W.S.P.E.

(*Continued from page 42*)

90% to about 3%. The article also notes the little the nation is doing to avert possible catastrophe. Reports from Russia are that the value of adequate shelters is realized there and that excellent shelters in the nature of deep subways with many branch rooms or tunnels have been constructed in major cities and probably at important military posts.

W. S. P. E. OFFICE

The Wisconsin Society of Professional Engineers has recently opened an office at 2550 University Avenue in Madison.

This is the first time that the State Society has had office facilities other than in the home or office of the Secretary–Treasurer. The office is now staffed with a regularly employed stenographer who will help to process much of the State Society's correspondence and publication material.

PUBLIC MEETINGS FOR THE ISSUANCE OF CERTIFICATES FOR P.E.'S AND EIT'S

Again this fall several of the State Chapters will sponsor public meetings at which Certificates of Registration as a Professional Engineer and Certification as an Engineer-in-Training will be presented. A member of the Engineering Section of the Wisconsin Registration Board of Architects and Professional Engineers will make the presentation to those engineers who have recently been successful in meeting the requirements.

It is anticipated that dinner meetings of the respective chapters will be held preceding the public meetings and that honored recipients of certificates along with their families and friends will be invited to attend. The Southwest, Northwest, Milwaukee, Lake Superior, Waukesha, and Southeast chapters have set dates in November and December.

SUMMER CONFERENCE

W.S.P.E. members from throughout the State met in Milwaukee at the Plankinton House on August 22–23, 1958 for the Eleventh Annual Summer Conference.

The annual summer meeting was held on the morning of August 23 at which time reports of the various State Committees were presented. (See Report of the Civil Defense Committee in this issue)

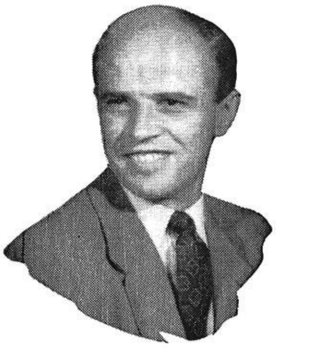
The Conference on Utilization of Scientists and Engineers and the National conventions of State Registration Boards of Architects, Engineers, and Land surveyors, were held this same week in Milwaukee and W.S.P.E. members were in attendance at some of the sessions. THE END

STUDENT ENGINEERING ORGANIZATION MEETING SCHEDULE FOR ACADEMIC YEAR, 1958–59

MONTH	DATE		
	Tuesday	Wednesday	Thursday
SEPTEMBER	23 Grp. 1, XE 30 Grp. 2, ASAE	24 Grp. 3	25 Polygon
OCTOBER	7 XE 14 Grp. 2 21 Grp. 1, XE 28 Grp. 2, ASAE	1 Grp. 4, ASCE 8 Grp. 3 15 ASCE, SAE 22 Grp. 3 29 Grp. 4, ASCE	2 $\gamma^{\beta}\pi$ 9 Polygon 16 None 23 Polygon 30 $\gamma^{\beta}\pi$
NOVEMBER	4 XE 11 Grp. 2 18 Grp. 1, XE 25 Grp. 2, ASAE	5 Grp. 3 12 ASCE, SAE 19 Grp. 3 26 Grp. 4, ASCE	6 Polygon 13 None 20 Polygon 27 None
DECEMBER	2 XE 9 Grp. 2 16 Grp. 1, XE	3 Grp. 3 10 ASCE, SAE 17 Grp. 3	4 Polygon 11 $\gamma^{\beta}\pi$ 18 Polygon
FEBRUARY	3 XE 10 Grp. 2, ASAE 17 Grp. 1, XE 24 Grp. 2	4 Grp. 3 11 Grp. 4, ASCE 18 Grp. 3 25 ASCE, SAE	5 Polygon 12 None 19 Polygon 26 $\gamma^{\beta}\pi$
MARCH	3 XE 10 Grp. 2, ASAE 17 Grp. 1, XE 24 Grp. 2	4 Grp. 3 11 Grp. 4, ASCE 18 Grp. 3 25 ASCE, SAE	5 Polygon 12 None 19 Polygon 26 $\gamma^{\beta}\pi$
APRIL	7 XE 14 Grp. 2, ASAE 21 Grp. 1, XE 28 Grp. 2	8 Grp. 3 15 Grp. 4, ASCE 22 Grp. 3 29 ASCE, SAE	9 Polygon 16 None 23 Polygon 30 $\gamma^{\beta}\pi$
MAY	5 XE 12 Grp. 2, ASAE 19 Grp. 1, XE	6 Grp. 3 13 Grp. 4, ASCE 20 Grp. 3	7 Polygon 14 None 21 Polygon

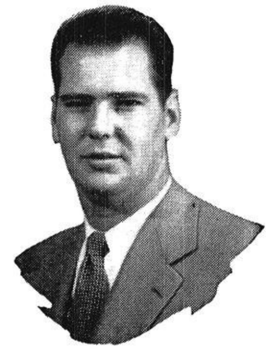
Group 1—$\pi\gamma\Sigma$ HKN
Group 3—$\theta\gamma$ Mu-SAN
Group 2—AFS BARS
Group 4—ASME AIEE AIChE AIME

Allis-Chalmers offers training course

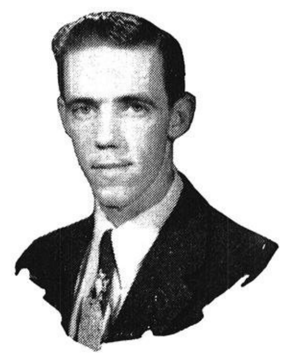


In nucleonics, Andrew Selep, Brooklyn Polytechnic Institute, BME '53, is working on the problem of reactor safeguards.

Special engineering by Paul W. Clark, Iowa State College, EE '49, is of large job involving combined electrical equipment.



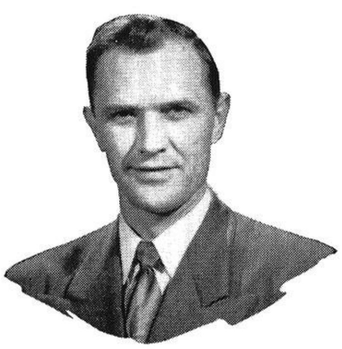
Sales manager, Robert Horn, Marquette University, EE '51, heads sales of voltage regulators used on power lines.



Electronics man, William E. Martin, Alabama Polytechnic Institute, BSEE '53, engineers applications of induction heaters.

plus wide choice of type and fields of

Design of generators for steam turbines is directed by G. W. Staats, Illinois Institute of Technology, Ph. D. '56.



Field sales of America's widest range of industrial equipment is career of Carl E. Hellerich, U. of Nebraska, ME '49.

Promotion man, Robert I. Carlson, Worcester Polytechnic Institute, ME '50, directs promotion of switchgear, and substations.

Application and sales of steam condensers for power plants are handled by William E. Ellingen, U. of Wisconsin, ChE '49.

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Plumbing Contractors:
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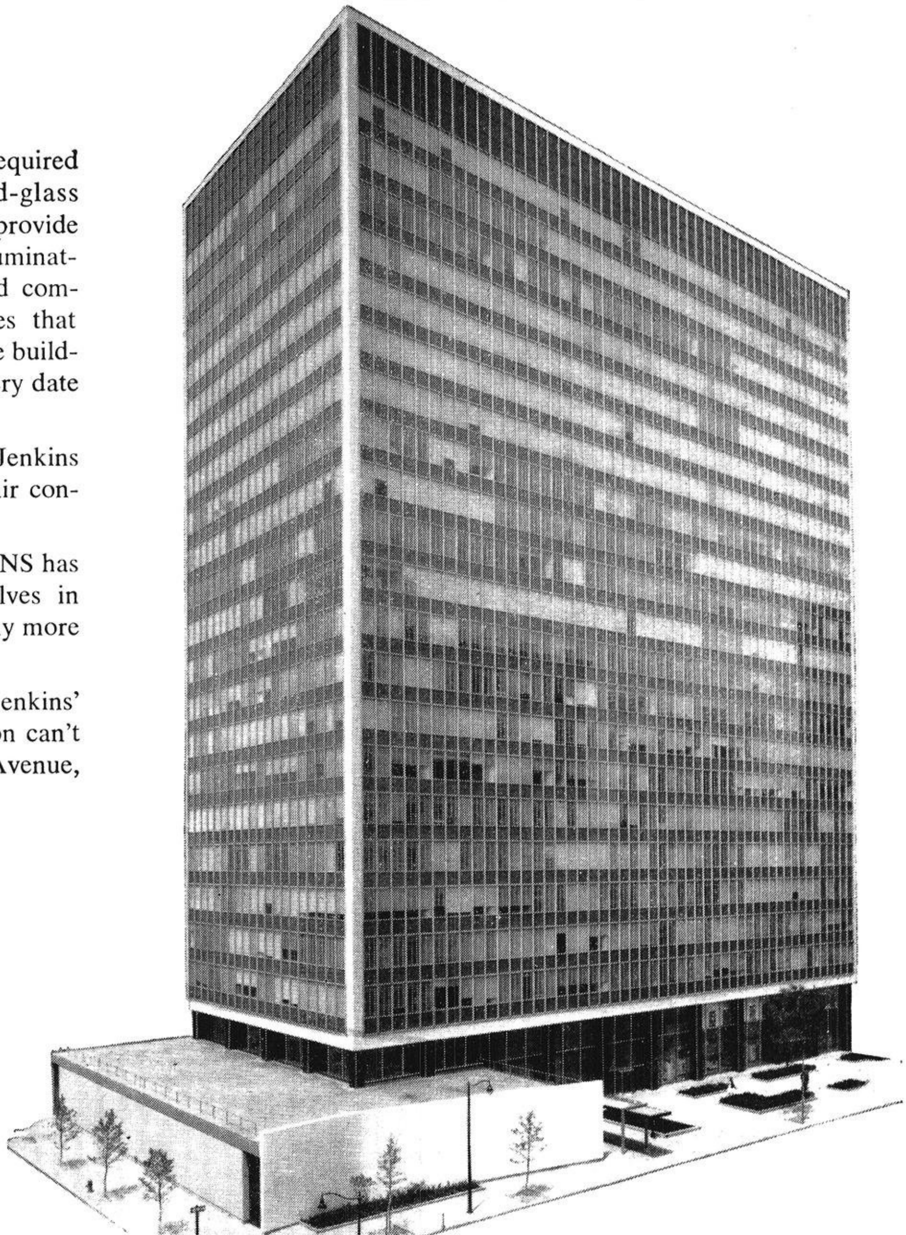
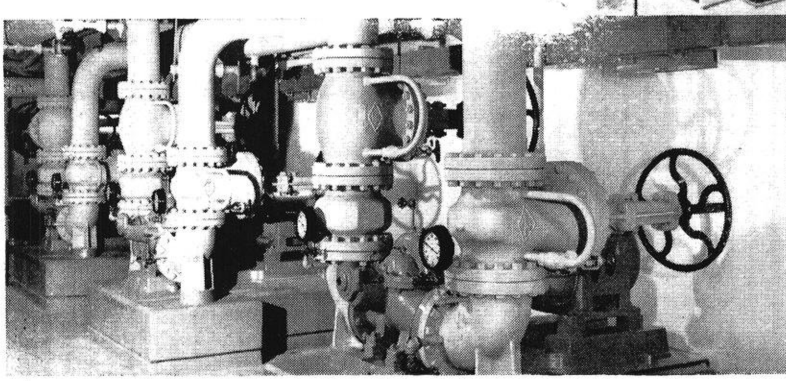
Managing Agents:
Ostendorf-Morris Company, Cleveland

THE ILLUMINATING BUILDING





Typical of more than 4,000 Jenkins Valves of bronze, iron and cast steel serving this building owned by the 55 Public Square Corp., Cleveland.

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VALVES
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Computer

(*Continued from page 30*)

to transfer command to the keyboard for operator control and subsequent manual entry of data. This is often the case in routines used repeatedly as, for example, transcendental functions.

Another means of automatic control is by use of program and data tapes. The program tape may be cut simultaneously with the original manual operation and used later in conjunction with a data tape. This is advantageous in loops or reproduction of program parts for reuse.

These methods of storing instructions or automatic programming are not to be confused with the internally stored programs of the large computer. This type of programming is still essentially external, the control panel and tape input devices not being part of the computer memory.

Output. Output is similar to input and utilizes the same physical components; however, it receives its information from internal sources and acts as a communication device to submit information from the machine to the operator. A special output device used on the IBM 610 is the cathode-ray-tube, which affords visual display of information stored in the register being addressed. On the sensitive surface of the tube a configuration of the magnetic spots in storage is simulated in a form visible to the operator. Knowing the code for the spot configuration, the operator can identify the content of the register in question.

Control. A control unit in the computer cabinet governs reciprocal flow of information between storage and the arithmetic unit. This unit governs the transfer of all numerical and command information received from external input devices and controls all information flow from the computer to the external output units.

Memory. The memory unit of most small computers is a magnetic drum capable of storing digits in the form of magnetic spot configurations in addressable locations. The IBM 610 uses an 8″ magnetic drum which has 80 working registers of locations each capable of storing a word of 31 digits and sign. These registers are able to regain information and perform addition or subtraction operations. Four additional registers have the same characteristics but are also able to participate in multiplication, division, square root extractions, and combined operations. All registers are designed to receive and store only one word or unit or numerical information, consisting of digits, decimal point and sign. Each register has a specific address, assuring recall of the number stored in that location and no other number. Submission of another number to a storage location already storing a number will eliminate that previously stored information. Some planning is needed to assure that the register addressed is the proper one, containing the number that the operator wants to work with.

Arithmetic. The arithmetic unit performs arithmetic and logical operations. Decimal point control can occur if the machine is operating under auto point (IBM 610) or in floating point mode (used on many computers). Simple choices may be made by the machine in this unit such as testing for plus–minus, or zero significance, if the operator has prepared the machine for such activities.

Basic Operational Techniques

Entry

The first step in machine operation is obviously the entry of data into storage. This involves at least one of the input units, the control unit and the memory unit. In the following descriptions manual operation, i.e., operation directly from the keyboard, will be assumed. Entry of data or any other operation may take place by any of the methods listed in the description of the input units, and action subsequent to information submission will be similar to that taken following manual submission.

The first action in an entry operation is the selection of a storage register which is to receive the information. This is done by depressing appropriate keys in the order representing the storage register's address. After the register has been selected, the operator gives the entry command by depressing the entry key. This clears the storage location addressed of any previously stored information and prepares the location for receipt of new information. The number is submitted by depressing the keys representing the specific digits in order of their occurrence in the number. Following this, the sign is given the number by depressing the plus or minus key. This will fix the number in storage.

Control of the decimal point may be made automatically if the machine is operating in auto point mode. In this method of decimal point control the decimal point is stored in the position as entered by the operator. This stored point will control shifting operations necessary to maintain decimal point significance during subsequent operations.

A diagrammatic interpretation of the activity during an auto point entry operation may be made from the following:

Program: Address register 01, command entry, enter number.

Program Execution:

Register 01 addressed
(Previous number still in storage)
+ 000000041 . 4200000000

Entry command given.
(Register's content cleared to zero)
000000000 0000000000

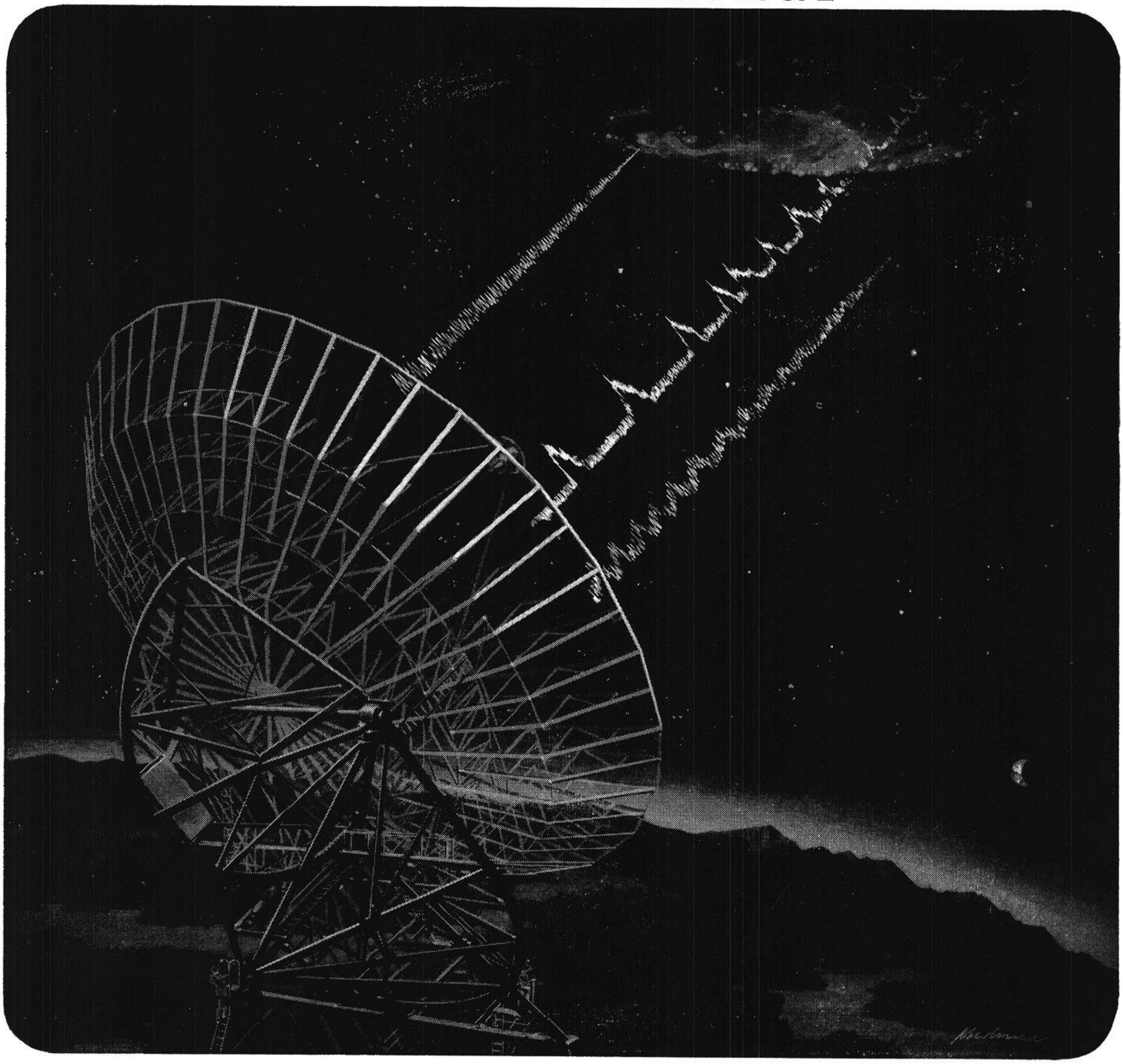
Number entered.
(Decimal point in its normal position)
57,68000000000000000

Sign given number.
(Number automatically shifted to center decimal point)
+ 0000000057 . 6800000000

The floating point method of decimal point control is based on a number representation consisting of two parts, the number itself (without decimal point) or the mantissa, and the power of ten which will give the mantissa its correct value. The machine must then keep track of the powers to correctly perform operations. By noting the power of ten associated with a particular number, the machine will automatically

(*Continued on page 65*)

IMPORTANT DEVELOPMENTS AT JPL



PIONEERS IN EARTH-SPACE COMMUNICATIONS

The exploration of outer space will take a new step forward with the completion of the new giant radio antenna being installed by JPL near Barstow, California. This huge "dish," 85 ft. in diameter, will enable the Laboratory scientists to probe still farther into space problems.

Information thus obtained and combined with lessons still being learned from the successful Army "Explorer" satellites, will provide invaluable basic data for the development of communication systems to serve space exploration programs. Long range communication will begin as a one-way link from space to earth, developing later into tracking and communicating with lunar vehicles at far greater ranges.

This activity will be part of a great research and development program to be operated jointly by JPL and the United States Army Missile Command.

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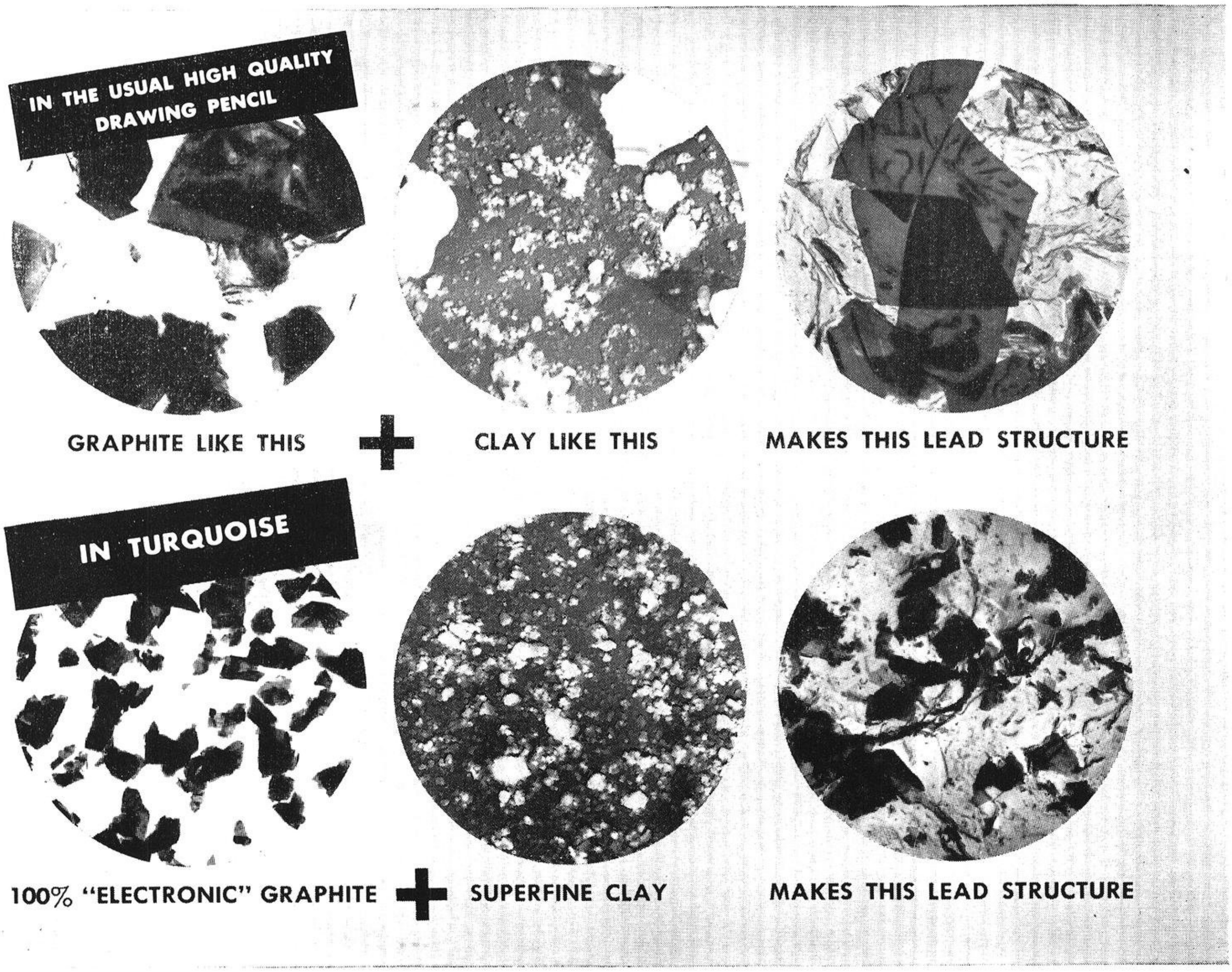

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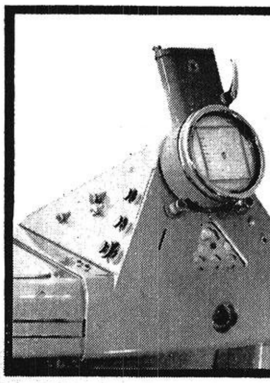
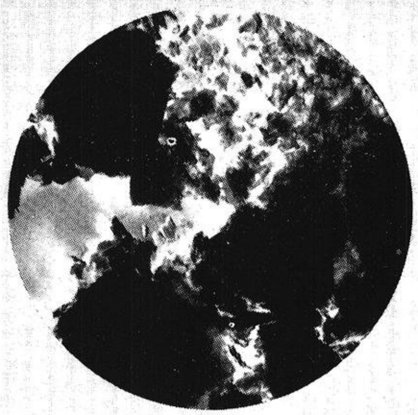


This Electron Microscope takes perfect pictures 7,500 times actual size—lets you **see** the startling difference between Eagle's "Electronic" Turquoise Lead and the lead in the usual quality drafting pencil.

Photographs courtesy of Ladd Research Industries, Inc.



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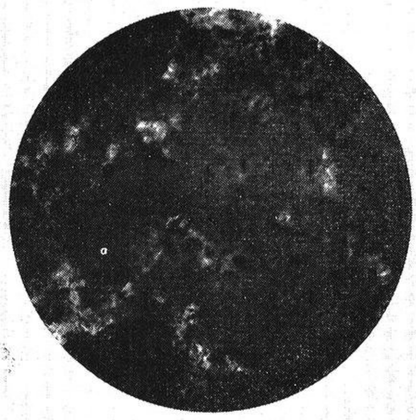

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(including Turquoise wood pencil, Turquoise lead, and Turquoise "skeleton" lead) naming this magazine. Eagle Pencil Company, 703 East 13th Street, New York, N. Y.

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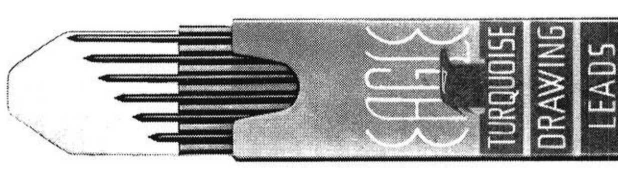
• **TURQUOIS CLEANTEX ERASER:** Super-soft, non-abrasive rubber.



• **TURQUOISE DRAWING LEADS:** Fit any standard lead holder. Grades 5B through 9H.

• **TURQUOISE LEAD HOLDERS:** Hold any grade of Turquoise lead.

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PENCILS AND LEADS

are the largest-selling in the United States!

Computer

(Continued from page 60)

shift the mantissa to the proper position to complete meaningful subtraction or addition. In the case of multiplication or division the computer simply adds or subtracts exponents to retain decimal point significance.

The IMB 610's storage registers differ from the registers used by most large computers in that they may act as accumulators (aid in addition and subtraction) as well storage registers. The operator selects the register containing the number he wishes to add to, or subtract from, and gives the command to add or subtract by depressing the plus or minus key on the keyboard. The equivalent of the content of the next addressed register will then be transferred to the selected register where the operation will be performed. The selected register acts as an accumulator. The result is developed in this selected register and the previous content of that register is lost. The second addressed register remains unchanged, however, as only the equivalent of its content was transferred to the first addressed register. The result remains in the selected or second addressed register, and the next command will be automatically addressed to it unless the operator specifically directs otherwise.

The following example will help clarify the procedure described above:

Problem: (+36.20) + (+49.09)

Program:

Memory allocation
- +36.20 to register 01
- +49.08 to register 02

Entry of data
- Address register 01
- Command entry of +36.20
- Address register 02
- Command entry of +49.08

In memory now, the storage registers which prior to the entry of the numbers + 36.20 and + 49.08 contained all zeros (having been cleared of any previous information by the entry command), now contain + 36.20 and + 49.08. To perform the required operations the operator selects register 01, gives the command to add, and addresses register 02. Register 01 acts as an accumulator, adding the equivalent of register 02 to itself. This action necessarily destroys the number + 36.20 in register 01 and the sum is the new content of register 01. The next command given will automatically be addressed to register 01 unless the command is preceded by a register selection.

The processes of multiplication or division require additional registers. These are the special registers of the IBM 610. To multiply, divide, extract square roots or to perform multiple operations, the operator selects the register containing the first operand, gives the command to perform the operation and addresses the register containing the second operand. The answer is developed in an answer register, leaving the previously selected and addressed registers unchanged. The answer register now becomes the selected register and the next command will be addressed to it automatically unless otherwise directed.

Now that some familiarity with the computer's physical elements and its operational abilities have been achieved, some concern must be given to actual problem solution. The work prior to the submission to the computer of the problem is no small matter. The greatest savings in time and money lie in this field. Figure 3 illustrates the logical steps in a typical problem solution from the time the problem is first recognized to its final solution on a computer.

Analysis

Following recognition of problem existence, work must be done to carefully define the problem and to state it mathematically. This is generally considered to be preliminary analysis and all steps following it compose what is known as programming.

Programming

Programming may be defined as all activities necessary to put the problem into a form acceptable to the computer. The computer functions only on simple arithmetic operations and elementary choices; therefore information and instructions must be given in the form of the computer vocabulary. The sequence of operation must be well planned for efficient machine use and for meaningful answers. The problem must be kept within the limits of the particular machine used, and a series of machine instructions must be formulated to assure this result. The product of this work is a written program or listing of events to be followed by the operator during submission of the problem to the computer. If the program is given to the machine from external sources, as it is in small computers, it is known as external programming. In the larger computers the program itself is given to memory and during operation the machine is controlled entirely from internal sources. The method of programming is one very distinctive feature differentiating the large from the small computer. Many of the small computer characteristics such as size, speed, and simplicity of operation may be traced directly to the fact that it is an externally programmed machine.

Logic of Notation

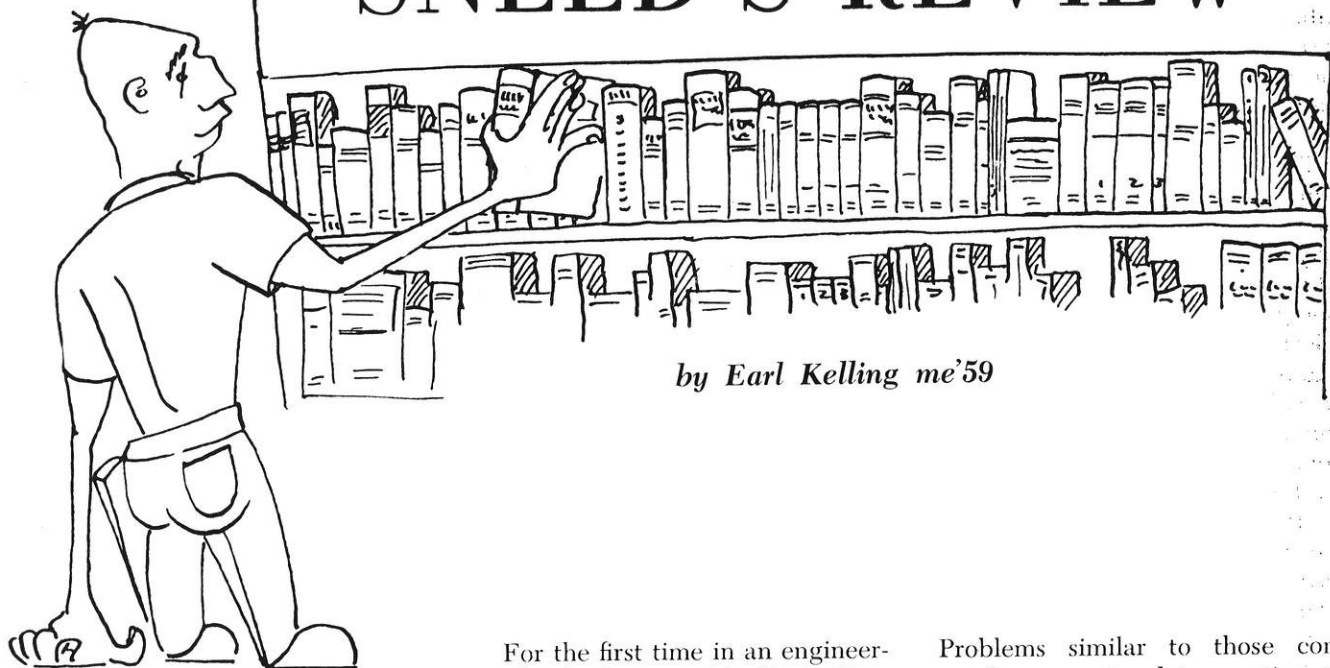
After a tentative program has been set up it is essential to inspect the entire sequence of operations to determine the logic of the notations given the various steps of the problem. This stage is one of determining if the program will work. Diagrams and flow charts are often used to follow the activities of production, and many times these diagrams will disclose logical errors not otherwise apparent.

Memory Allocation

Some time should be devoted to memory allocation, especially in more complex operations or those which will subsequently be assigned to large computers. Different blocks of memory should be assigned to different functions with the goal of maintaining maximum notation significance. Often it is useful to record all locations in tables or charts which may be used to indicate what is stored and its location.

(Continued on page 69)

SNEED'S REVIEW



by Earl Kelling me'59

GRAPHIC SCIENCE

By Thomas E. French and Charles J. Vierck
McGraw–Hill, 758 pages, $8.50

This outstanding new book is aimed at a complete understanding of graphical methods as they relate to the problems of the engineer, not to the problems of the draftsman. In this way the engineer becomes more competent to specify the graphical procedures used in accomplishing engineering work of a wide variety.

The three core subjects in drawing have been successfully combined for the first time in one volume. The focus throughout is on drawing as a tool for the engineer. In emphasizing the science of graphics the practical trade aspects, or art of graphics are minimized. This means that subjects such as jigs and fixtures, gears and cams, architectural and structural drawings, etc. have been omitted, and in their stead is a complete coverage of descriptive geometry—points, lines, planes, intersections, curved lines and curved and warped surfaces. Also covered are vector geometry, graphical solutions, functional scales, nomography, empirical equations, and calculus.

For the first time in an engineering book photographic illustrations are used extensively not only to dress up the book but to help in explaining fundamentals, especially in descriptive geometry. Each chapter has a photomural which is intended to intrigue the reader with the interesting possibilities of the discussion to follow. Also, photographs, pictorial drawings, and orthographic drawings are mixed in the presentation of theory and practice.

NONLINEAR CONTROL SYSTEMS

By Robert Lien Cosgriff
McGraw–Hill, 328 pages, $9.00

The McGraw–Hill Book Company announces an important addition to its Series in Control System Engineering—*Nonlinear Control Systems.*

It is the aim of this book to provide the control engineer with those methods of nonlinear systems which are practical in the control field. The selection of material is such that an extensive background is not required. Only those methods and techniques which are practical from an engineering standpoint have been included, and all mathematics beyond calculus is developed in the book.

Emphasis is placed on nonlinear theory and nonlinear equations. Problems similar to those commonly encountered in practice, together with their answers are included at the end of each chapter.

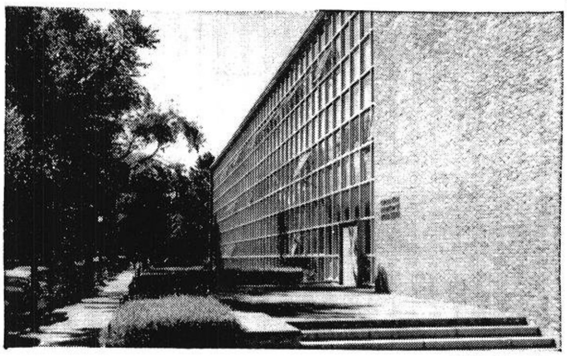
NUCLEAR ENGINEERING

The latest nuclear research in the application of atomic energy to the engineering industry was presented at the 1958 International Conference on the Peaceful Uses of Atomic Energy held in Geneva, September 1st to the 13th.

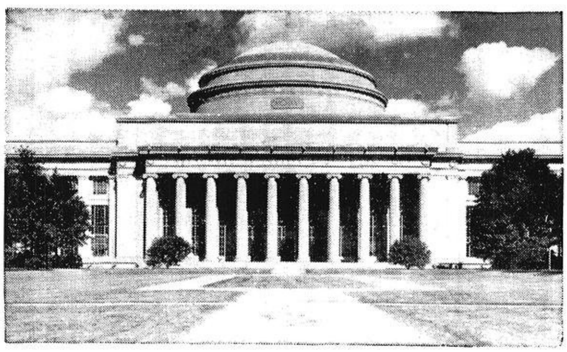
The Document Service of The Chronicle of United Nations Activities has inaugurated a complete service to supply the engineering industry with materials on the conference. Available immediately are the lists of papers to be presented, including several hundred dealing with engineering research throughout the world.

Topics covered include reactor technology, plans for construction of nuclear power plants, properties of reactor materials, radiation effects on materials, use of isotopes in industrial technology, and hazards involved in disposal of radioactive products.

The lists may be obtained free by writing to: Engineering Document Service, The Chronicle of United Nations Activities, 234 West 26 Street, New York 1, N. Y.



HARVARD



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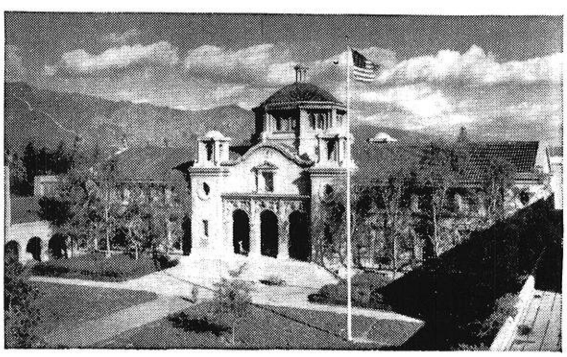


CALTECH

THE FERROUS WHEEL

exhumed and cartooned
by Joe Coel

Laugh, and the world laughs with you; cry, and your mascara runs.

° ° °

After all is said and done, there is usually more said than done.

° ° °

Thanks to the guy who invented venetian blinds. Without him it'd be curtains for all of us.

° ° °

Here's a good, fast way to make a cigarette lighter: take out the tobacco.

° ° °

Sweet young thing: "Am I the first girl you ever kissed?"

Engineer: "Now that you mention it, you do look familiar."

° ° °

Have you heard the new radio program about the girl who wanted two bathrooms? It's called "The Wife's Other John."

° ° °

I hear that every five minutes somebody in New York gets hit by an automobile. I don't know who this guy is, but he sure takes a beating.

A vulgar man is one who stares at a co-ed's figure when she's doing her best to display it.

° ° °

Book Salesman: "Young man, you need this book. It will do half your college work for you."

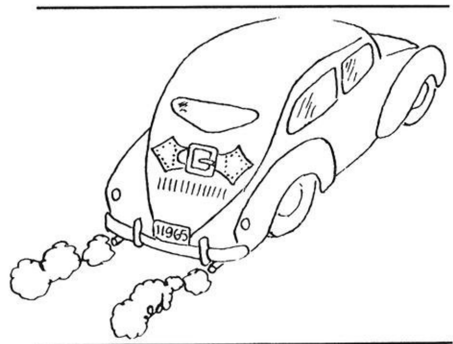
Electrical Engineer: "Fine, give me two."

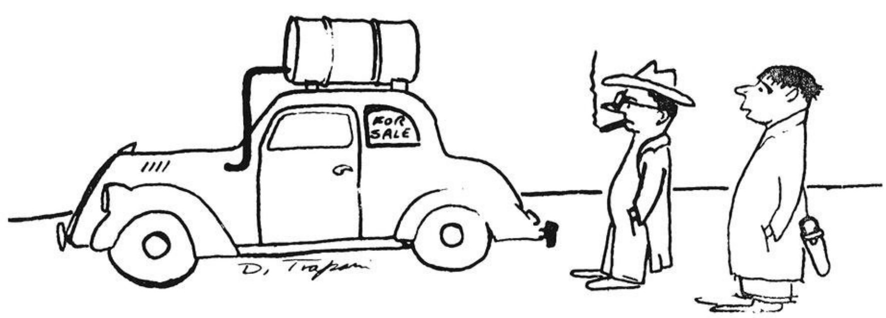
° ° °

Helpful Coed: "Isn't it funny that the length of a man's arm is just equal to the circumference of a girl's waist?"

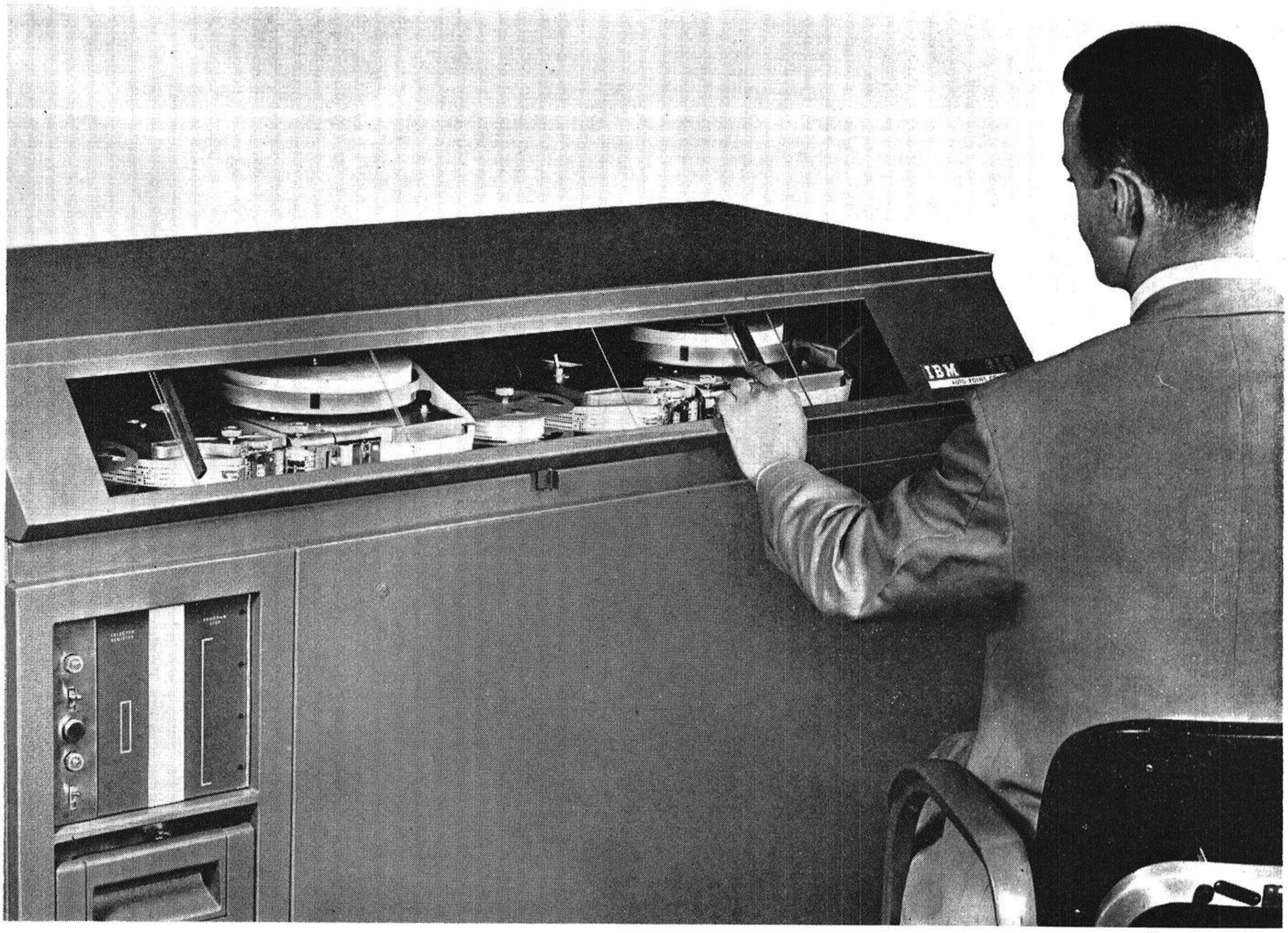
C.E.: "Let's get a piece of string and find out."

I think that I shall never see
A girl refuse a meal that's free;
A girl with hungry eyes not fixed
Upon the drink that's being mixed;
A girl who doesn't like to wear
A lot of junk to match her hair;
But girls are loved by guys like me
'Cause I don't like to kiss a tree.





. . . and how is it on oil?



—Courtesy IBM

This picture shows the easy access to the program tapes through the sliding plastic windows of the 610 Auto-Point Computer.

Computer

(Continued from page 65)

Programming Sheet

When the operator has his program well organized he can compose his machine instruction sheet or programming sheet. The programming sheet, when carefully written, promotes rapid, organized, accurate problem solution.

Execution

The computer proves its value during the final stage of problem solution. It is in this stage that the solutions are developed. Modern computers are very dependable and if errors occur at this stage the operator is generally at fault. Comparisons of time, effort, and accuracy of problem solution of the small computer to other methods show that, for nearly all problems, solution by means of a small computer is most economical.

THE END

—Courtesy IBM

This pretty young lady controls the Computer's Auxiliary Printing Tape Punch with as much ease as her typewriter. Note the compactness of this unit.

World's Biggest Eater Dines Without Interruption

Typical insulator and insulating bolts used on power shovels.

You are looking at 3 million dollars' worth of power shovel, a 14-story monster capable of biting off 70 cubic yards of dirt at a clip.

Continuous operation is essential because downtime on a shovel of this size could top 500 dollars an hour. Reliability is shared by many interrelated parts. Some are made of Synthane laminated plastics.

Why Synthane? Because Synthane laminated plastics have the right combination of properties—dielectric strength, mechanical strength, and ease of machining. And Synthane uses only first-quality raw materials, watches every step in the production and fabrication of the laminate, is deeply concerned about delivery requirements.

Good materials, competent people, excellent tools and workmanship may not guarantee reliability but they're strong assurance of it.

If you are interested in a reliable source of laminated plastics—sheets, rods, tubes, or completely fabricated parts, write for an interesting catalog or call our representative near you.

SYNTHANE

SYNTHANE CORPORATION, 13 RIVER RD., OAKS, PA.

PHOTOGRAPHY AT WORK—No. 34 in a Kodak Series

"Tree Rubber" made in U.S.A. for tires of tomorrow

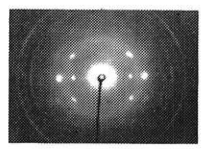
Photography and x-rays pointed the way for Goodrich-Gulf Chemicals Inc. to achieve a synthetic that matches natural rubber.

Heavy-duty truck and airplane tires always had to have tree rubber to assure acceptable performance. Usual man-made rubber didn't quite fill the bill. Its molecules didn't hang together like natural rubber.

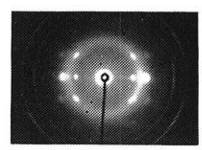
But now Goodrich-Gulf scientists, using x-ray diffraction photographs to check molecular structure, have produced Ameripol SN, a man-made rubber with the same physical properties as crude rubber even to tack and stickiness. It's an achievement that can mean a source of supply for the nation's new-rubber needs.

Playing a part in research like this is only one of the many ways photography is working for business and industry today. In addition, it also delves into problems of product design, production, and quality control. It trains employees, dealers and salesmen—does a selling job right to the consumer.

Photography is saving time and cutting costs for all kinds of businesses, large and small alike. It works for you in whatever occupation you choose.



Photographic negative showing the x-ray diffraction pattern produced by a molecule of natural, tree-grown rubber.



The x-ray diffraction pattern of a molecule of Ameripol SN rubber shows the scientist that this rubber is identical to natural rubber.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

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With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production. If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Kodak
TRADEMARK

One of a series*

Interview with General Electric's Earl G. Abbott Manager—Sales Training

Advancement in a Large Company: How it Works

Where do you find better advancement opportunities—in a large company or a small one? To help you, the college student, resolve that problem, Mr. Abbott answers the following questions concerning advancement opportunities in engineering, manufacturing and technical marketing at General Electric.

Q. In a large Company such as General Electric, how can you assure that every man deserving of recognition will get it? Don't some capable people become lost?

A. No, they don't. And it's because of the way G.E. has been organized. By decentralizing into more than a hundred smaller operating departments, we've been able to pinpoint both authority and responsibility. Our products are engineered, manufactured and marketed by many departments comparable to small companies. Since each is completely responsible for its success and profitability, each individual within the department has a defined share of that responsibility. Therefore, outstanding performance is readily recognized.

Q. If that's the case, are opportunities for advancement limited to openings within the department?

A. Not at all. That's one of the advantages of our decentralized organization. It creates small operations that individuals can "get their arms around", and still reserves and enhances the inherent advantages of a large company. Widely diverse opportunities and promotions are available on a Company-wide basis.

Q. But how does a department find the best man, Company-wide?

A. We've developed personnel registers to assure that the best qualified men for the job are not overlooked. The registers contain complete appraisals of professional employees. They enable a manager to make a thorough and objective search of the entire General Electric Company and come up with the man best qualified for the job.

Q. How do advancement opportunities for technical graduates stack-up with those of other graduates?

A. Very well. General Electric is recognized as a Company with outstanding technical skills and facilities. One out of every thirteen employees is a scientist or engineer. And approximately 50 per cent of our Department General Managers have technical backgrounds.

Q. How about speed of advancement? Is G.E. a "young man's Company"?

A. Definitely. A majority of all supervisors, managers and outstanding individual contributors working in the engineering function are below the age of forty. We believe that a job should be one for which you are qualified, but above all it should be one that challenges your ability. As you master one job we feel that consideration should be given to moving you to a position of greater responsibility. This is working, for in the professional field, one out of four of our people are in positions of greater responsibility today than they were a year ago.

Q. Some men want to remain in a specialized technical job rather than go into managerial work. How does this affect their advancement?

A. At G.E. there are many paths which lead to higher positions of recognition and prestige. Every man is essentially free to select the course which best fits both his abilities and interests. Furthermore, he may modify that course if his interests change as his career progresses. Along any of these paths he may advance within the Company to very high levels of recognition and salary.

Q. What aids to advancement does General Electric provide?

A. We believe that it's just sound business policy to provide a stimulating climate for personal development. As the individual develops, through his own efforts, the Company benefits from his contributions. General Electric has done much to provide the right kind of opportunity for its employees. Outstanding college graduates are given graduate study aid through the G-E Honors Program and Tuition Refund Program. Technical graduates entering the Engineering, Manufacturing, or Technical Marketing Programs start with on-the-job training and related study as preparation for more responsible positions. Throughout their G-E careers they receive frequent appraisals as a guide for self development. Company-conducted courses are offered again at all levels of the organization. These help professionals gain the increasingly higher levels of education demanded by the complexities of modern business. Our goal is to see every man advance to the full limits of his capabilities.

If you have other questions or want information on our programs for technical graduates, write to E. G. Abbott, Section 959-9, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: • Qualities We Look For in Young Engineers • Personal Development • Salary.**

GENERAL ELECTRIC