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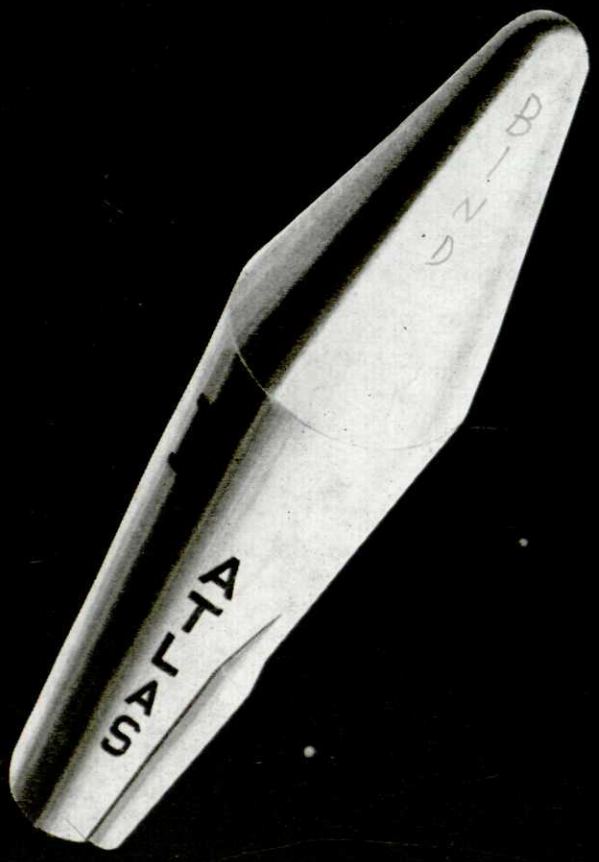

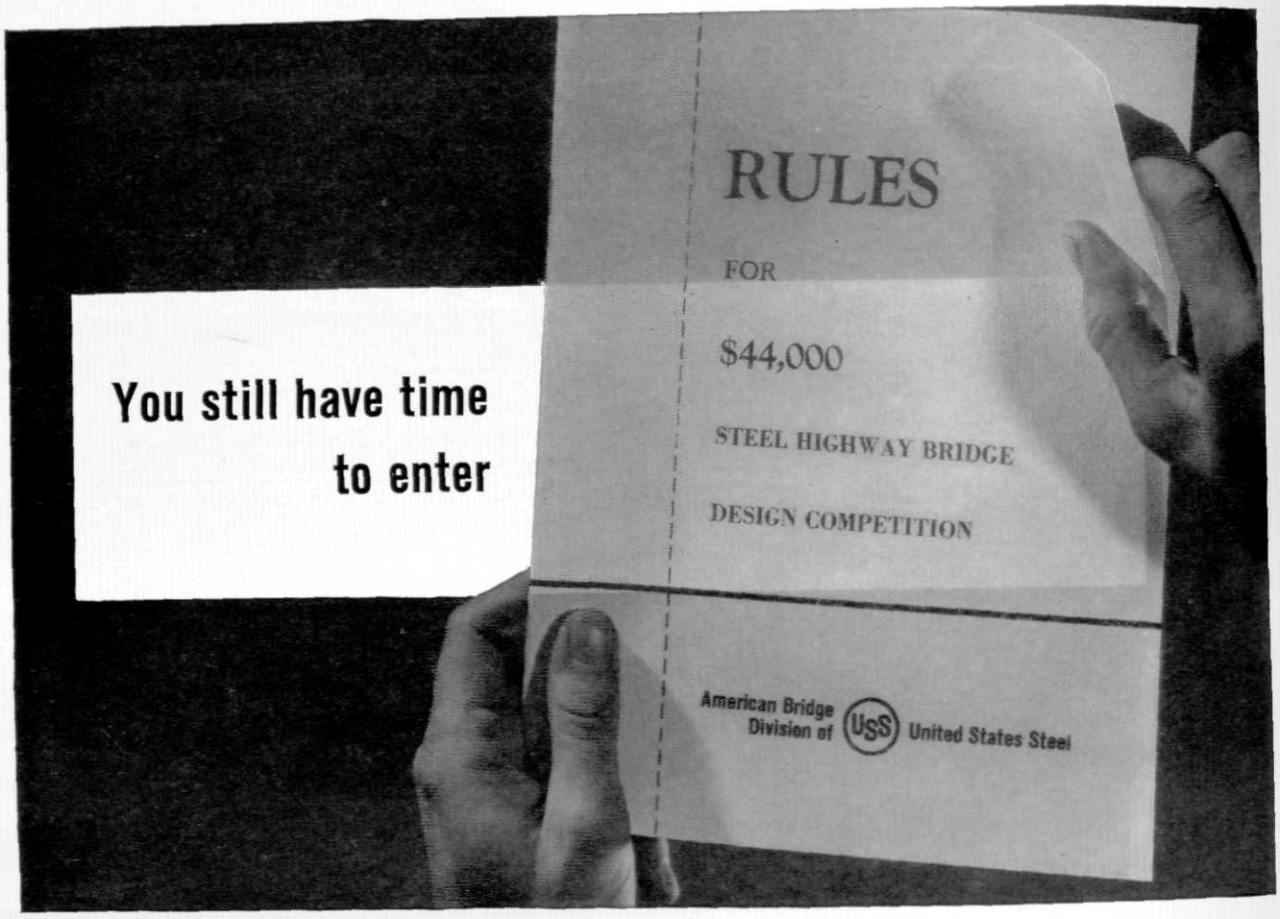

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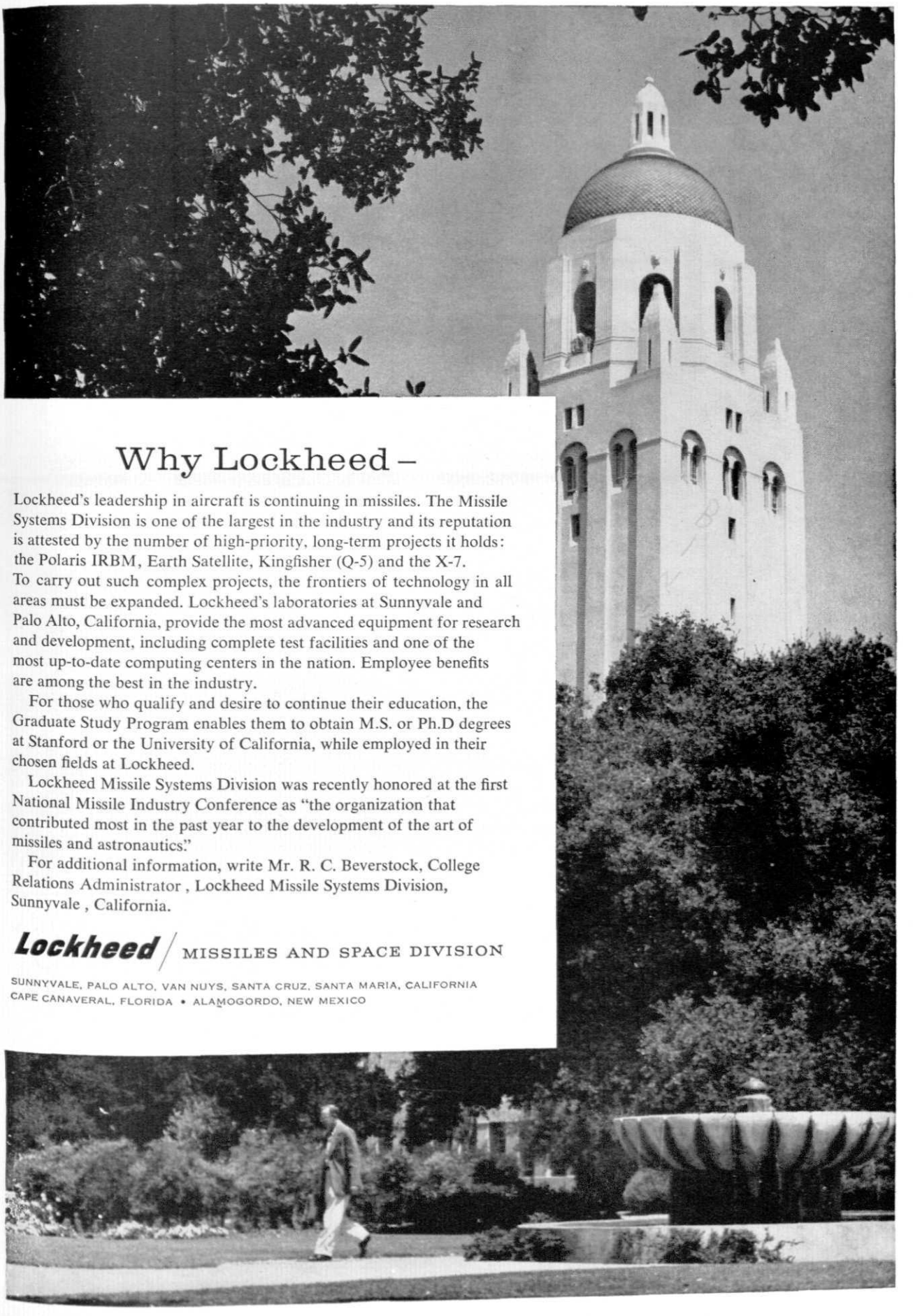

Why Lockheed –

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.

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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 Administrator , Lockheed Missile Systems Division, Sunnyvale , California.

Lockheed / MISSILES AND SPACE DIVISION

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STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

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Dean's Letter

WHY DID YOU DECIDE TO BECOME AN ENGINEER?

Is your father an engineer, does your family have an engineering friend, did your high school experience persuade you, or did you read about the profession? Or were you always curious about nature, about things and why they operated the way they did? Are you intrigued and challenged by the engineering problems you read about, and which you know are going to need solutions?

These are questions about which the engineering profession knows very little. The abrupt drop in engineering college enrollment of last fall has brought the need for answers once more to the fore, and several groups, including the Engineering Manpower Commission, are seeking to determine the means by which high school boys are attracted to engineering for their life work.

For our part we are trying to find the reasons behind many of our freshman and sophomore drop-outs. In some cases the reasons are obvious—a student is attracted to engineering because his close friend is going to take it, over-looking his own obvious abilities in some other direction. In other cases the willingness to work, a necessity for ANY profession, is just not present and the student gives up, transferring to some other vocation which he hears is "easier."

We wonder if there are not other deeper-laid and more fundamental causes, perhaps within the engineering profession or in engineering teaching, which are important in influencing a student after he begins an engineering course. What is a freshman in engineering looking for as he enters a engineering college? Does he find it or is he disappointed? Is it our fault or is it within him?

We are attempting to obtain some indications of the answers to these questions by surveying our fall quarter transfers from engineering at all levels. Where the reason for transfer is not obvious on our records we hope to follow up with questionnaire, and an interview if it can be arranged.

If any of you readers have ideas or suggestions, whether now engineering students, or former students, we would be glad to talk with you or to receive a note giving your ideas and reactions to your own experiences.

J. D. Ryder

MEMBER, ENGINEERING COLLEGE
MAGAZINES ASSOCIATED

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Spartan Engineer

of michigan state university

VOLUME 12 NO. 3 MARCH, 1959

FEATURES

DEPARTMENTS

COVER: ATLAS SPACE STATION BUILDUP—First step in establishing a permanent four-man Atlas space station would be the placing of an Atlas intercontinental ballistic missile in orbit 400 miles above the earth to serve as the shell of the station. Atlas space station could be in operation within five years. After Atlas shell reaches orbit, supply vehicle and personnel carrier would be launched and guided to the station by proportional navigation. Both supply and personnel carriers are second-stage rockets boosted into space by other Atlases. Personnel vehicle carries two two-man gliders at tip that break away when orbit is reached. Crews would dock gliders at Atlas station by small steering rockets. These two gliders would remain at the station to serve as lifeboats. Crew exchange during construction and operation of the station would be by similar second-stage gilders. Station could be completely fitted out by three cargo carriers.

Why metals corrode... and how to prevent it

The equipment you will design most probably will have to stand up against one or more of these 6 different forms of corrosive attack:

1. General tarnishing or rusting with occasional perforations in highly affected areas.

2. Highly localized attack by pitting.

3. Cracking induced by a combination of stress and corrosion.

4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.

5. Corrosion of one of an alloy's constituents leaving a weak residue.

6. Corrosion near the junction of two different metals.

HOW CORROSION OCCURS

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

The electrolyte in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

The plates of the battery correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

Briefly then, for corrosion to occur, there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

When you plan against galvanic corrosion it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

GALVANIC SERIES TABLE

•
Magnesium
Magnesium alloys
•
Zinc
•
Aluminum 25
•
Cadmium
•
Aluminum 17ST
•
Steel or Iron
Cast Iron
•
Chromium-iron (active)
•
Ni-Resist*
•
18-8 Chromium-nickel-iron (active)
18-8-3 Chromium-nickel-molybdenum-iron (active)
•
Hastelloy "C"
•
Lead-tin solders
Lead
Tin
•
Nickel (active)
Inconel* (active)
•
Hastelloy "A"
Hastelloy "B"
•
Brasses
Copper
Bronzes
Copper-nickel alloys
Monel*
•
Silver Solder
•
Nickel (passive)
Inconel (passive)
•
Chromium-iron (passive)
•
18-8 Chromium-nickel-iron (passive)
18-8-3 Chromium-nickel-molybdenum-iron (passive)
•
Silver
•
Graphite
Gold
Platinum

HOW TO USE THE CHART

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

When you plan against local action, keep in mind that the corrosion process is similar to galvanic action . . . a movement of electrons from one point on the metal to another. Naturally, the easiest way to avoid local action is to use a metal with little or no impurity . . . or an alloy with constituents that are listed closely on the galvanic series table. Local action on other metals, however, can be controlled by stopping any flow of electrons . . . such as with protective coatings. Environment, too, is a factor for consideration.

FILM ON CORROSION AVAILABLE TO ENGINEERING CLASSES

Inco's full-color sound film — "Corrosion in Action" – gives a graphic explanation of corrosion and how to control it. The film is in three parts: The Nature of Corrosion, 20 minutes running time; Origin and Characteristics of Corrosion Currents, 26 minutes; Passivity and Protective Films, 17 minutes. 16mm prints can be loaned to engineering classes. For details, write Inco for descriptive folder on "Corrosion in Action."

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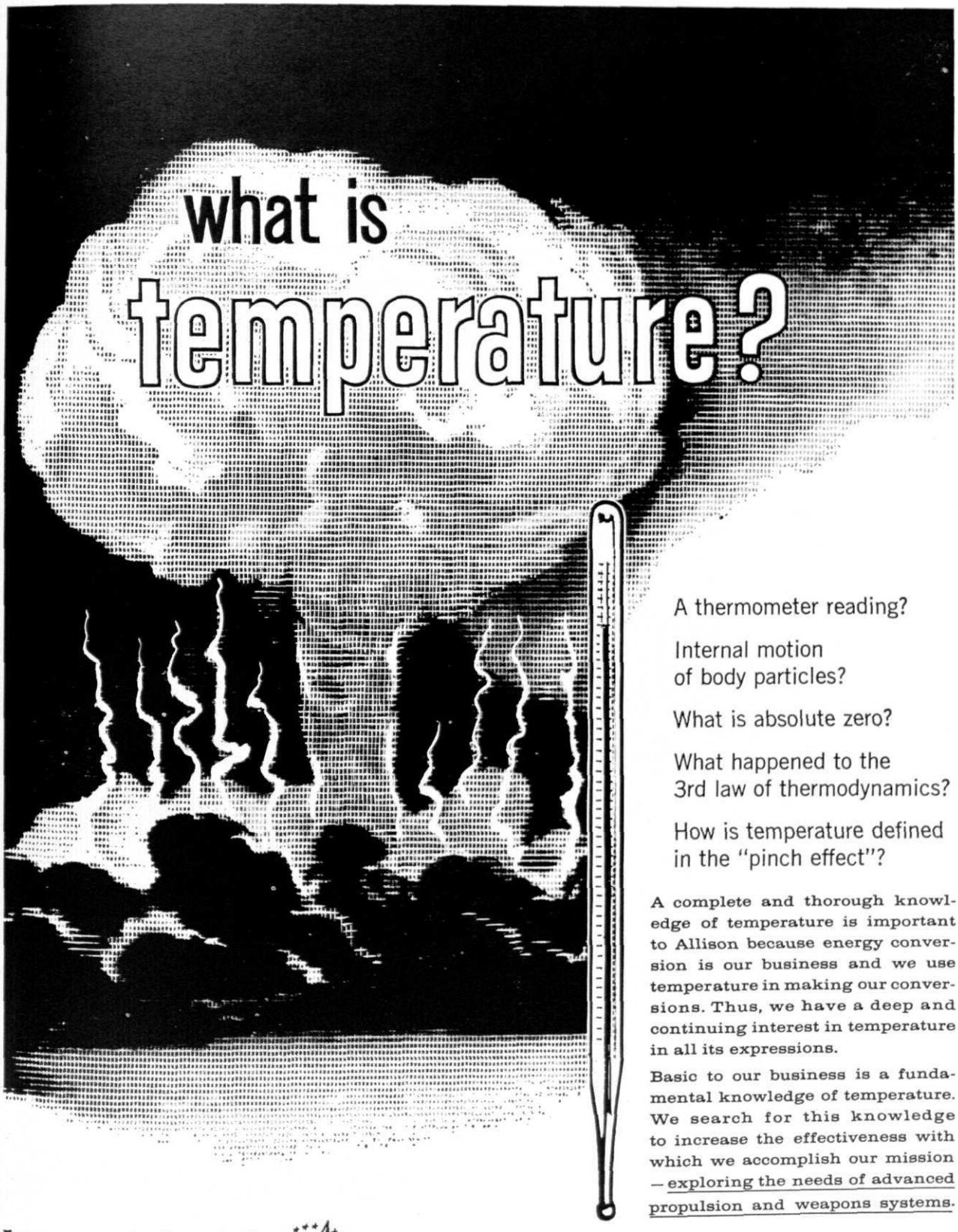

A thermometer reading?

Internal motion
of body particles?

What is absolute zero?

What happened to the
3rd law of thermodynamics?

How is temperature defined
in the "pinch effect"?

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Energy conversion is our business

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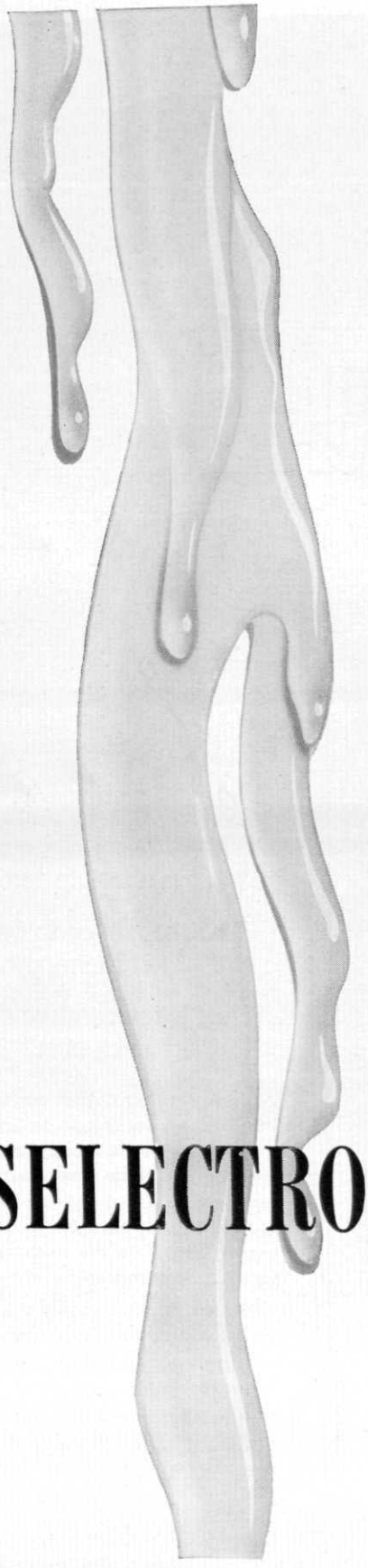

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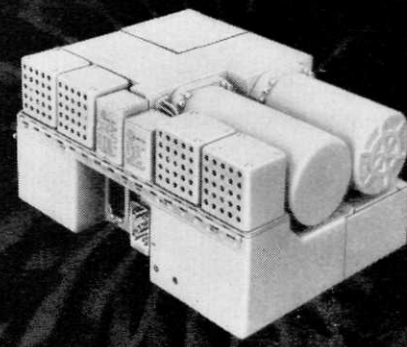

This electronic centralized air data computing system, pioneered by AiResearch engineers, now enables aircraft to operate at maximum efficiency continuously. By sensing air conditions surrounding the airplane, it automatically makes in-flight adjustments and feeds vital information to the pilot. This centralized combination of transducers, computers and indicators is the most complete air data computing system ever produced by any manufacturer.

Many such pioneering developments are underway in challenging, important work at AiResearch in missile, electronic, nuclear, aircraft and industrial fields.

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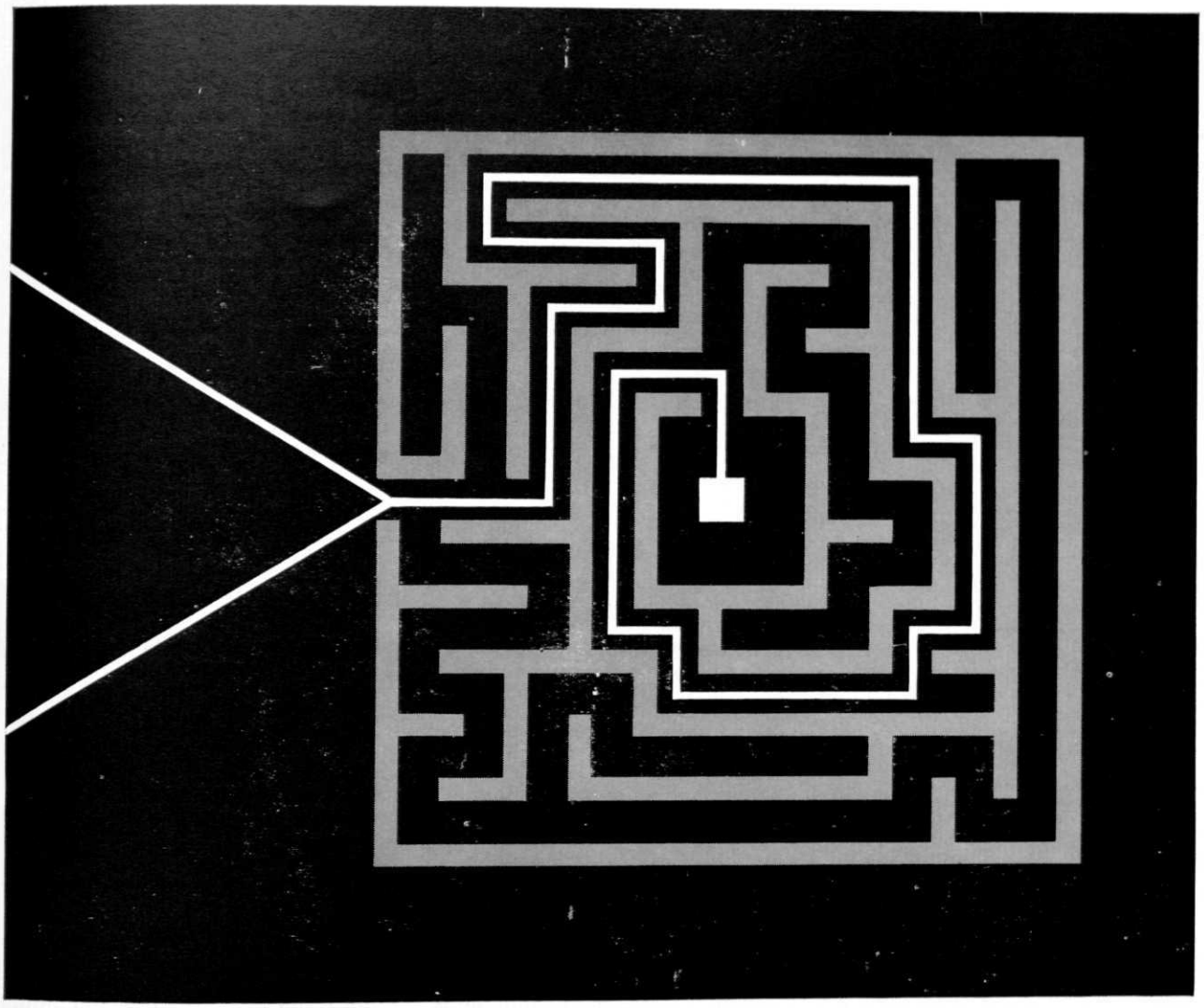

A RESUME IS A TWO-PARTY AFFAIR

Throughout your engineering career, the name of the first employer appearing on your resume can be as significant as your education. But, in selecting that first employer, you should also consider his resume.

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The scope and volume of work entrusted to us by industry and the government opens a broad range of highly diversified engineering and technical positions in all areas of our work . . . from tiny diodes to complex digital computer systems and a massive network of global communications.

In addition to the opportunities for work and association with distinguished engineers and scientists, our graduate education tuition refund program encourages engineers to continue their formal training . . . and the facilities for graduate work near ITT locations are superior.

This is an all too brief resume. It would be hard to associate yourself with a company that offers the engineer greater choice of assignment. Write us about your interests — or see our representatives when they visit your campus.

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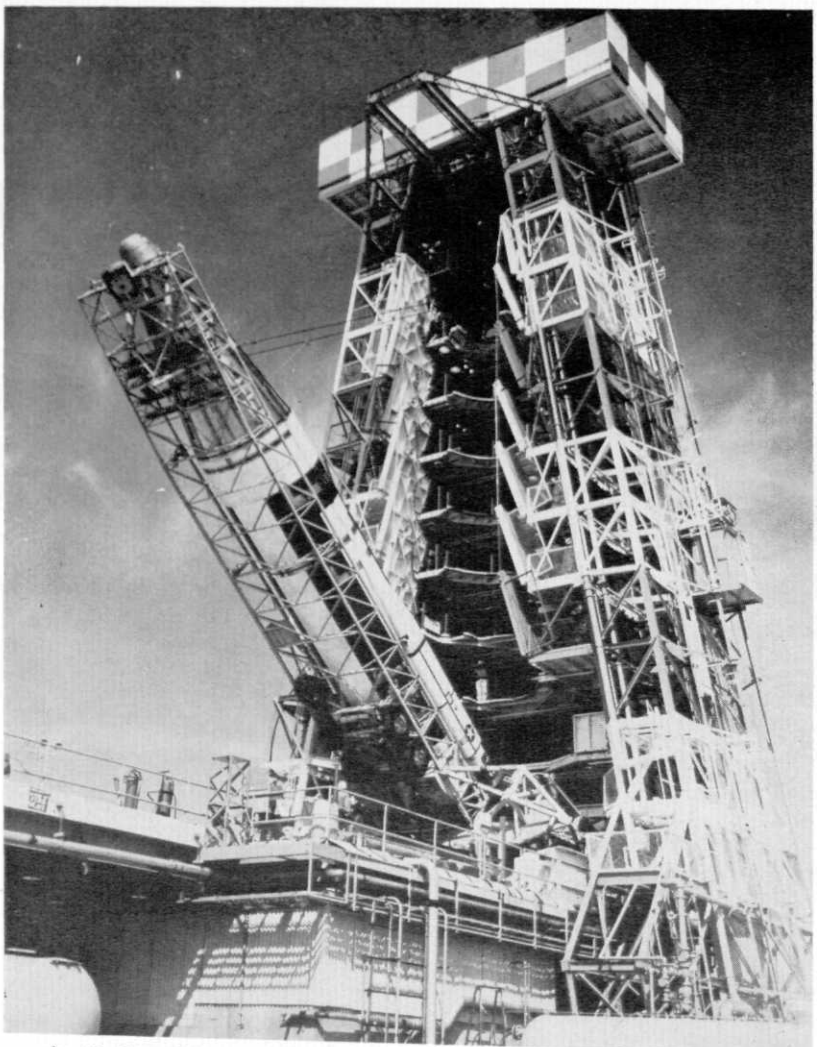


An Air Force Atlas intercontinental ballistic missile is slowly raised into position on a launching platform at the Air Force Missile Test site. Still resting on the missile-handling trailer on which it was transported from San Diego, Calif., the missile is erected by cables from the upper part of the service tower on which several service platforms are located.

THE Atlas, America's first intercontinental ballistic missile, has recently hit the newspapers with its remarkable feats. However, many facts not disclosed in the news articles are of interest to engineers, and, hence, are presented in this article.

The missile is approximately 75 feet long and 10 feet in diameter, and is powered by a cluster of liquid propellant rocket engines burning liquid oxygen and RP-1, a kerosene-like hydrocarbon fuel.

The power package consists of two large booster engines and one large sustainer engine, plus a pair of small "vernier" rockets.

All five rockets are ignited prior to launching. After a few minutes of flight, during which the missile is lifted well into its trajectory, the booster engines and associated equipment are jettisoned to lighten the load. The sustainer engine continues to accelerate the missile until it has attained a velocity on the order of 16,000 m.p.h. Then the sustainer is shut off, and the small vernier rockets are used to "trim" velocity to the exact value required. After vernier shutdown, when the missile is following a purely ballistic (unguided) course, the nose cone is separated from the rocket structure. Both parts travel together until the atmosphere is re-entered. Then the unprotected structure (largely tankage) is destroyed by aerodynamic heating.

Conventional long-range missiles consist of two or more rockets, one

mounted on another. The bottom or booster rocket furnishes all power until it burns out. Then it drops away and the next stage is ignited. The Atlas system—so-called "one and one-half" staging—is unique in having two sets of engines but only one rocket tank structure. This permits lighting the upper-stage (sustainer) engine on the ground. There is no risk that the missile will abort through failure to achieve ignition many miles in the air.

During powered flight the missile's course and speed are governed by the guidance system. Atlas will employ radio-inertial guidance (requiring a station on the ground) through the period of early operational use, but convert to all-inertial guidance when this method has been fully perfected.

The Atlas tank structure is made of thin-gage stainless steel. The missile contains more than 40,000 parts (not counting the nose cone, guidance and engines).

The missiles assigned to flight testing are trucked on special missile-handling trailers from the Convair factory in San Diego, California to the Air Force Missile Test Center at Cape Canaveral, Florida. Here Convair puts each missile through ground testing, final checkout and test flight.

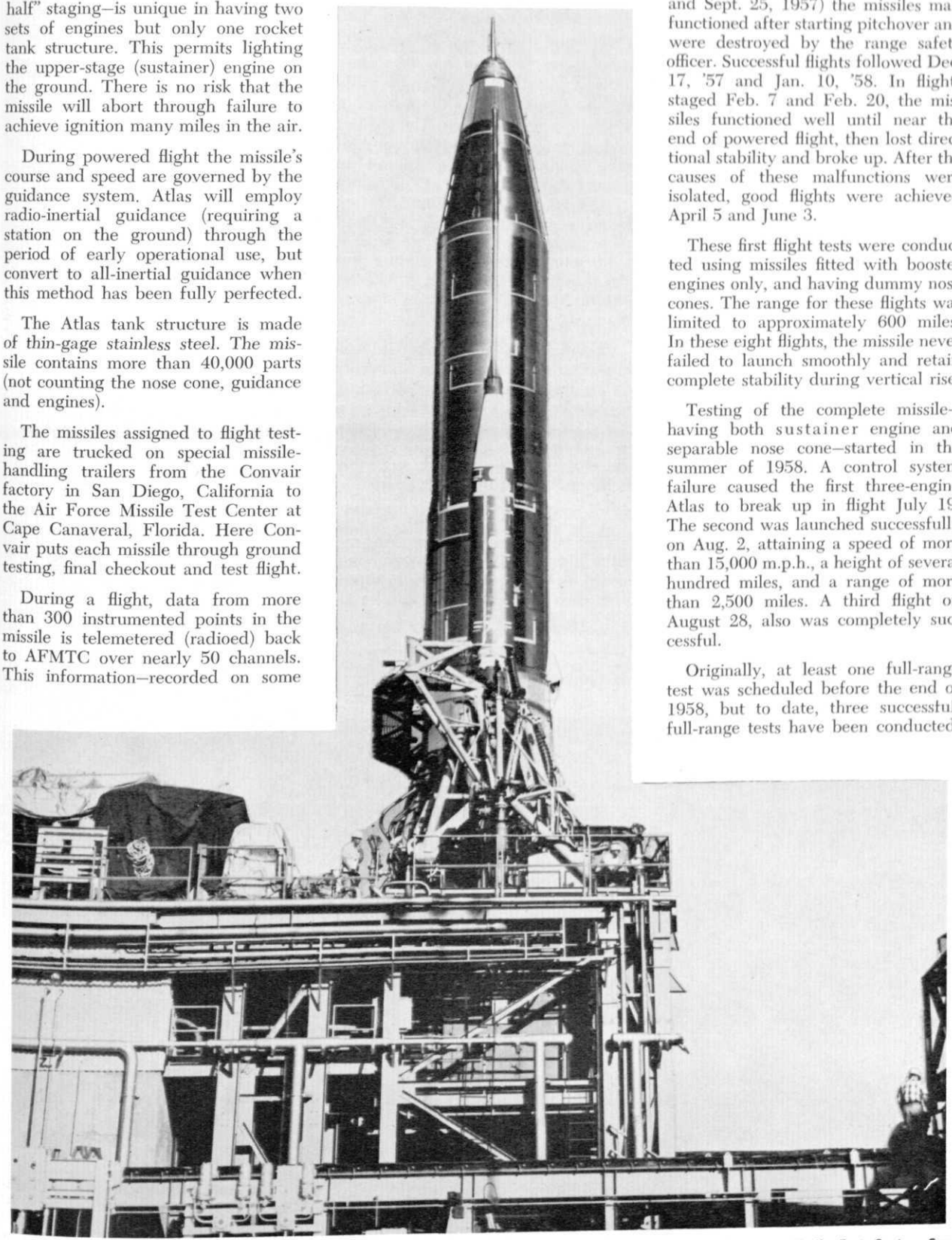
During a flight, data from more than 300 instrumented points in the missile is telemetered (radioed) back to AFMTC over nearly 50 channels. This information—recorded on some 10 miles of magnetic tape—includes temperatures, vibrations, accelerations, liquid flow rates, etc.

On the first two flights (June 11 and Sept. 25, 1957) the missiles malfunctioned after starting pitchover and were destroyed by the range safety officer. Successful flights followed Dec. 17, '57 and Jan. 10, '58. In flights staged Feb. 7 and Feb. 20, the missiles functioned well until near the end of powered flight, then lost directional stability and broke up. After the causes of these malfunctions were isolated, good flights were achieved April 5 and June 3.

These first flight tests were conducted using missiles fitted with booster engines only, and having dummy nose cones. The range for these flights was limited to approximately 600 miles. In these eight flights, the missile never failed to launch smoothly and retain complete stability during vertical rise.

Testing of the complete missile—having both sustainer engine and separable nose cone—started in the summer of 1958. A control system failure caused the first three-engine Atlas to break up in flight July 19. The second was launched successfully on Aug. 2, attaining a speed of more than 15,000 m.p.h., a height of several hundred miles, and a range of more than 2,500 miles. A third flight on August 28, also was completely successful.

Originally, at least one full-range test was scheduled before the end of 1958, but to date, three successful, full-range tests have been conducted.



The mighty Atlas intercontinental ballistic missile points skyward on its launching pad at the Air Force Missile Test Center, Cape Canaveral, dwarfing the technicians who stand on the platform below checking equipment. The tall gantry crane used to service the missile has just been moved away, its part in the pre-launch preparations having been completed.

The Atlas missile is not limited to just delivering a thermonuclear warhead against an enemy—it has been used successfully as a launching vehicle for earth satellites. On December 18, 1958, an Atlas missile placed a satellite weighing more than four tons into orbit around the earth. This being, by far, the largest satellite put into orbit.

Convair designers under Karel J. Bossart conceived and developed the MX-774 Hiroc research rocket. This introduced three innovations which have since become part of the universal art of rocketry:

1. First swiveling of engines for directional control. (The Germans controlled the V-2 with rudderlike graphite vanes placed in the jet stream.)
2. First "integral" tanks—the skin of the missile serving also as wall of the propellant tanks, thus achieving a tremendous weight saving. (The Germans had used separate internal tanks.)
3. First separable nose cone. (The Germans had re-entered the complete rocket structure.)

These changes in rocketry have furthered the development of missiles immeasurably.

The Atlas missile is completely assembled at the factory in San Diego, and then loaded on its special missile-handling trailer. It is then transported on this trailer to the AFMTC at Cape Canaveral. Still in the trailer, it is backed up on the launching platform and then slowly raised into position in the servicing (gantry) tower.

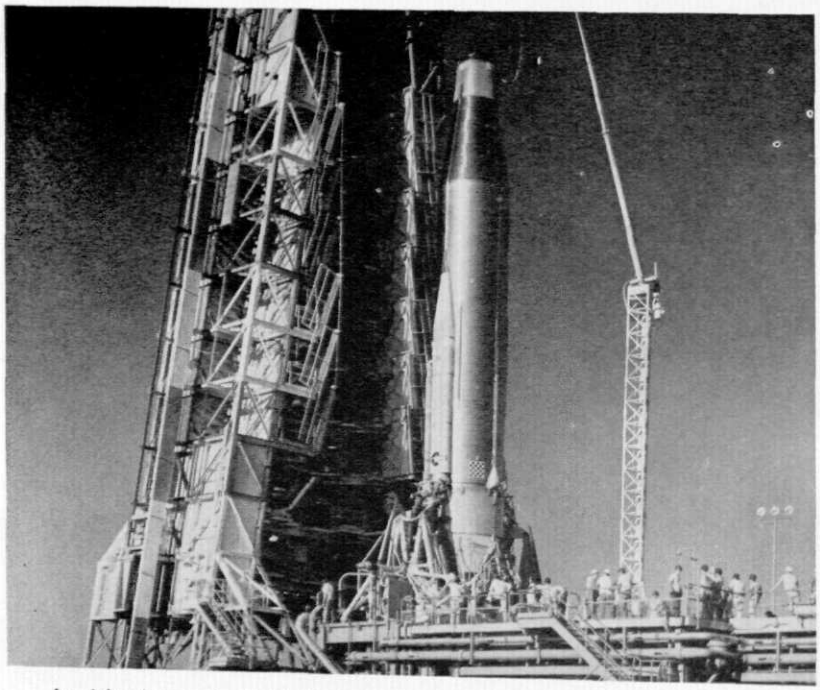
Malfunction of the entire missile can be effected by the breakdown of a single component part. The stresses and strains encountered during shipping might well cause failures of some component parts, misalignment of the guidance system, etc. Before launching, the missile is given a complete ground test to insure against malfunction at the time of firing, but the possibility of overlooking one or two faulty parts in the maze of more than 40,000 parts is great.

In the design of the complete missile as an operating system, simplicity is an important factor contributing to its reliability. If the missile is composed of, say, n essential major parts, each having its own reliability, R_1, R_2, etc., the overall missile reliability is the product of that of the parts.

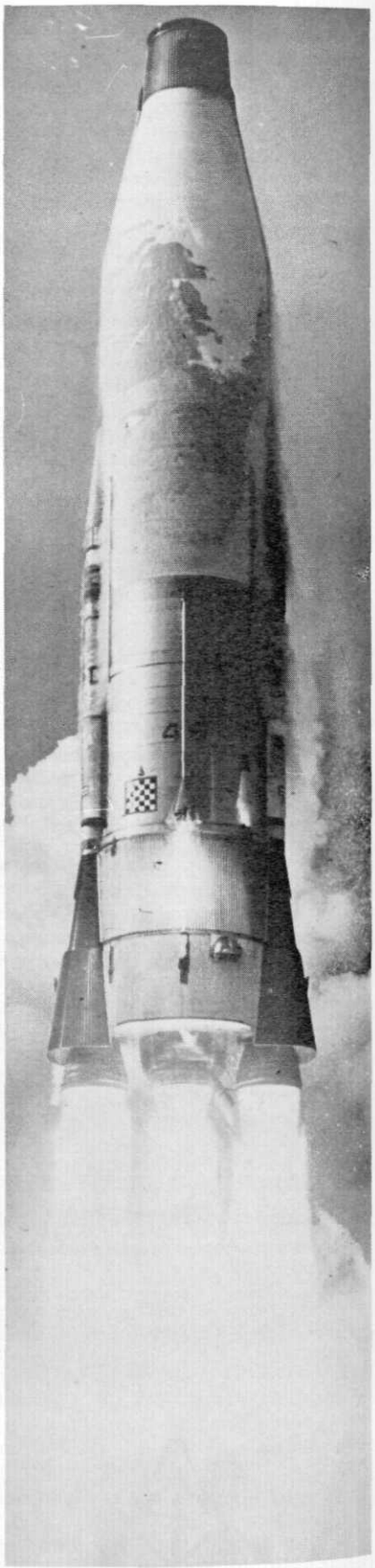
$$R = R_1 R_2 R_3 \ldots R_n$$

Let us suppose that the designers have designed a missile system composed of 100 parts, each essential, and each 99% reliable. Now let us

(*Continued on Page 49*)



An Atlas intercontinental ballistic missile stands alone on the launch pad after withdrawal of mobile steel gantry tower, at left. The gooseneck boom at right carries power and instrumentation connections to the nose cone. This is one of four Atlas launching complexes at the Air Force Missile Test Center, Cape Canaveral, Fla.



Pouring a torrent of fire from its three rocket engines, an Atlas intercontinental ballistic missile rises from its launch pad starting the successful flight of Aug. 2, when the Air Force missile hurtled more than 2,500 miles across the Atlantic to a preselected impact area.

Versatile electronic . . . .

"BRAINS"

labor for industry and government.

by Bob Slade, E.E., '59

A computer in Washington, D.C., has been demonstrating an amazing ability. It has developed a photographic memory. By merely glancing at a photograph, it can reproduce at any time a nearly exact copy of it. The computer is called SEAC, short for Standards Electronic Automatic Computer, and is the highly versatile electronic "brain" of the National Bureau of Standards.

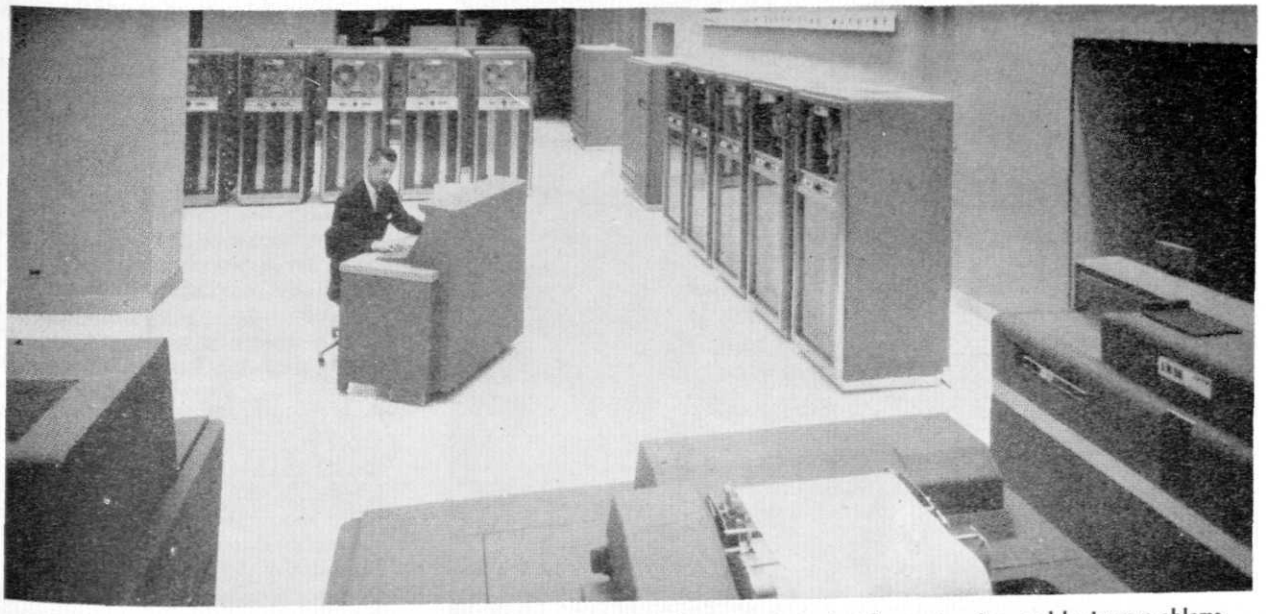
SEAC's new ability is another of the many once reserved to human minds and senses, but now being developed in computers. Its eye is a special photoelectric cell and scanning device which enables it to scan a photograph, store the image in its "memory" as 30,000 bits of information and reproduce it when needed. The reproduction appears in the form of 30,000 tiny light or dark squares on an oscilloscope, a device similar to a TV picture tube.[1]

Right now SEAC can only memorize the pictures it sees, but it is learning to recognize patterns such as printed letters and numbers. This ability, though limited, is nearly perfect, for no matter how complex a pattern may be, once learned, it will never fool the machine. Furthermore, SEAC can ignore specks of dirt or anything else not a part of the printed pattern.

In the very near future the Bureau hopes to have SEAC recognize and identify detailed diagrams and even chemical formulae. After this, expectations are even more promising. For instance, it is hoped that the machine will eventually be able to produce

(Continued on Page 30)

1. This kind of picture is similar to the photoengravings printed in your daily newspaper. These pictures consist of many light and dark dots, and, in fact, a 2 by 2 inch newspaper picture contains just about 30,000.



The IBM 704 is a large-scale electronic digital computer used for solving complex scientific, engineering, and business problems. Magnetic cores and magnetic tapes store information accessible in thousandths of a second. Magnetic tape input-output units, supplementing punched card readers, permit masses of data to enter and leave the machine's "memory" at high speed. The machine executes most instructions at a rate of 40,000 per second.

Courtesy of International Business Machines Corp.

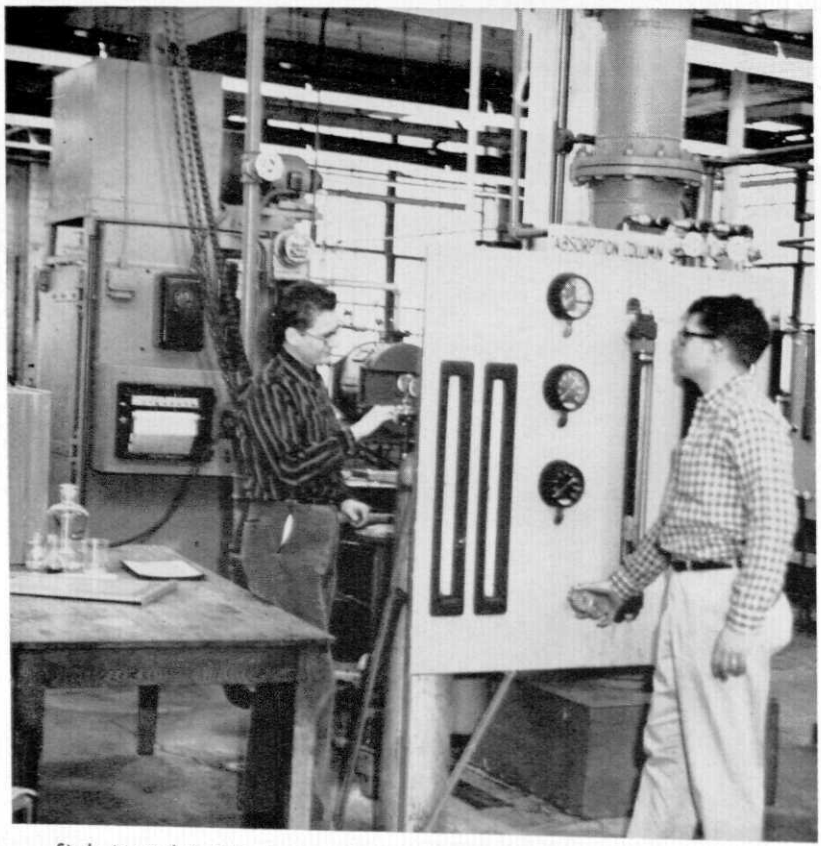
CHEMISTRY AND ENGINEERING...

principles are combined in a relatively new profession.

CHEMICAL engineering is the most recent major branch of the engineering profession, and has been recognized as a profession for only about fifty years. During this half-century, however, because of its strong roots in chemistry, chemical engineering has been a leader in research and development. The industries based on chemical engineering are fundamental to present-day civilization and to the preservation of that civilization.

Traditionally, the chemical engineer is responsible for development and practical application of discoveries made by the chemist. Thus nylon has been advanced from a test-tube product of the laboratory into its present mammoth scale of manufacture largely through the efforts of men trained and experienced in chemical engineering. The atom bomb was built by chemical engineers, starting with the new discoveries in atomic physics.

However chemical engineering is not entirely practice and application. As this union of engineering and chemistry has developed, it has become a science in its own right. An understanding of the complex processes and operations of a modern processing plant can be achieved only by seeking out and studying the principles and basic phenomena involved. Part of this task belongs to the chemist, part to the physicist and the mathematician, but much must be done by the chemical engineer, who has had training in all of these sciences and possesses the ability to integrate them into his own profession.



Students regulate packed column for gas absorption, and analyze samples to determine its operating efficiency.

Molecular Approach

The chemical engineer is inclined to attack his problem by a molecular approach, or by investigating even smaller particles if necessary. Although his immediate problem may involve bulk movements or large-volume reactions, his basic understanding of these problems comes from a consideration of submicroscopic changes. Equilibrium, to the chemical engineer, is usually a dynamic rather than a static condition. Molecules, atoms, ions and other particles are continually in motion, often traversing phase boundaries in both directions.

In systems not at equilibrium, the molecular approach is even more useful. In the rectification column of a petroleum product still, light hydrocarbon molecules are continually escaping from the liquid phase into the contacting vapor. Simultaneously, those light molecules already in the vapor move across the interface into the liquid, but this reverse movement is usually slower than transfer into the vapor. Many variables are involved in this relationship, especially the relative concentrations in the two phases. Heavier hydrocarbon molecules have a greater tendency to accumulate in the liquid, and the movements of light and heavy molecules across the interface in opposite directions are governed by heat or energy

by C. Fred Gurnham, Head, Department of Chemical Engineering

balances as well as concentration effects.

In the petroleum still, the overall result of these interphase transfers is that the liquid flowing from the bottom of the column is relatively rich in high-boiling or heavy hydrocarbons. The vapor stream coming from the top contains most of the light molecules. Even with multi-stage or continuous contacting within the tower, complete separation is not possible, and the degree of separation depends on both molecular equilibrium relationships and engineering design.

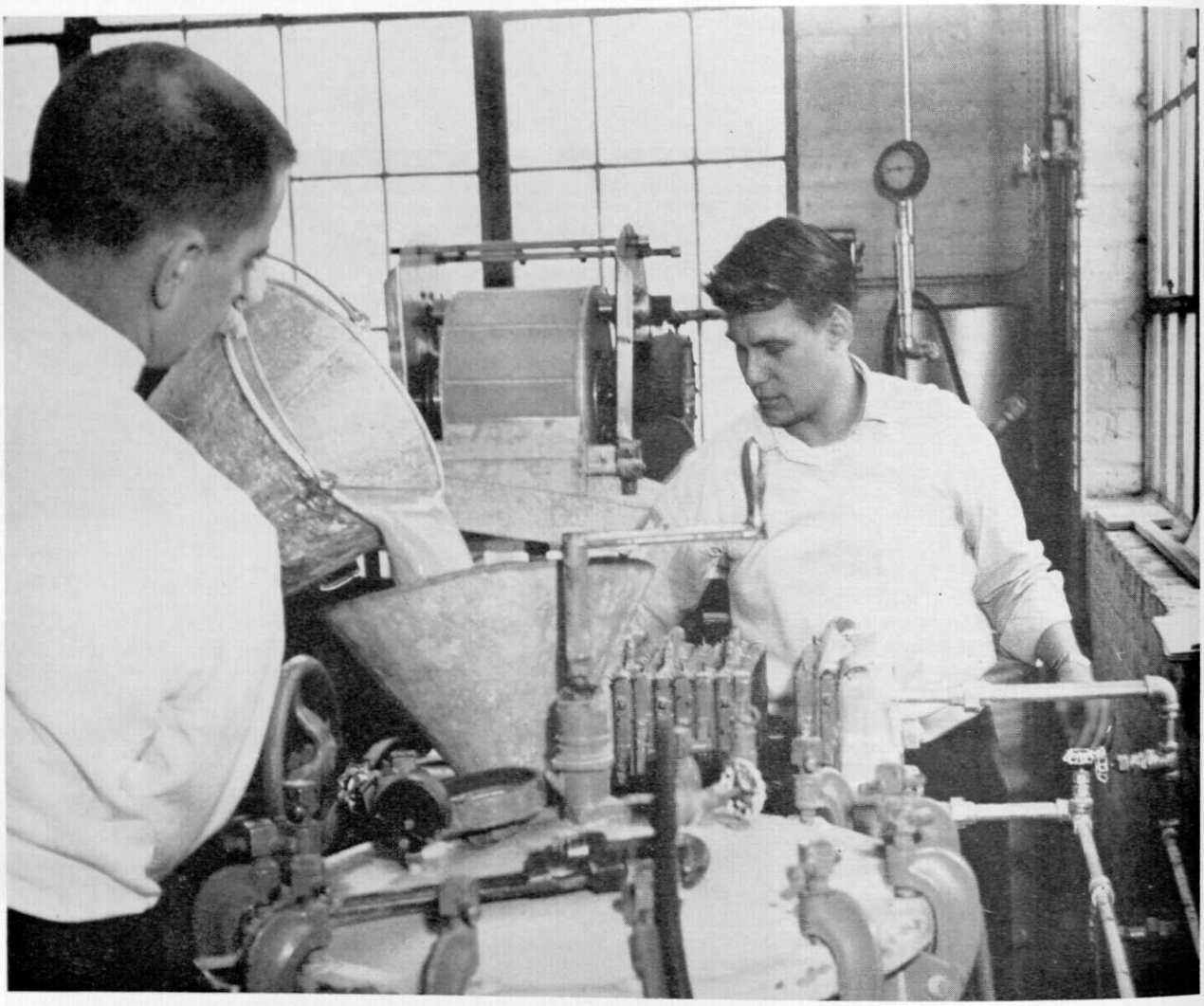
M.S.U. Curriculum

The chemical engineering curriculum at Michigan State University recognizes the importance of basic sciences to this profession. Mathematical training is presented as early as possible, including a course in differential equations; and further mathematics is recommended at least for graduate study. Mathematics is an extremely useful tool to the chemical engineer, although it is not always feasible to apply mathematical theory to the complexities of many chemical engineering operations. A great deal of current research is directed toward closing the gap between the science of chemical engineering and the necessarily empirical calculations and judgments required in practice.

The chemical engineer obtains his viewpoint for the molecular approach by extensive studies in physics and chemistry. After a year of general chemistry and a brief exposure to the principles of chemical analysis, the student takes a full year each of physical and organic chemistry. Largely because of these courses and their accompanying laboratories, the junior year is discouraging to those students who fail to grasp the necessity for

(*Continued on Next Page*)

Senior chemical engineering students operate the double-effect evaporator in the Unit Operations Laboratory.



Students prepare slurry for filtration tests (plate-and-frame filter in right foreground; continuous vacuum rotary filter in background).

basic knowledge in the practice of engineering. This is one reason that the chemical engineering curriculum has a reputation for difficulty, and that its graduates are appreciated and welcomed by industry.

Courses in the chemical engineering department start in the Spring term of sophomore year with stoichiometry, the application of material and energy balances to chemical or molecular changes. This leads into thermodynamics, starting in the junior year. Unit operations, the traditional basic course of chemical engineering, is the study on an organized plan of the multitude of chemical and physical operations used in the chemical and process industries. The concept of unitizing these processes, grouping their basic similarities and minimizing the superficial differences among various industries, was originated by chemical engineers and is being emulated by others. In the unit operation of filtration, for example, the molecular phenomena and mass movements are studied with only minor regard for individual variations in the filtration of paint pigments, water softening sludge, electroplating solutions, and the hundreds of other industrial slurries that require filtering. During his senior year, the chemical engineering student takes a design course that serves to integrate his knowledge from all previous courses, and to instill in him a professional viewpoint.

Graduate Study

Chemical engineering has long been the leader among branches of engineering in graduate study. There is much demand by industry for chemical engineers with the M.S. or Ph.D. degree, both of which are offered at M.S.U. Graduate study provides the better student with an opportunity to delve more deeply into the fundamentals of chemical engineering science, and thus to ensure a continuing place for himself in the rapidly changing modern technology.

Research activities among the M.S.U. faculty and graduate students are varied, with major emphasis on material transport operations, such as distillation and liquid-liquid extraction. Heat transfer research is also active, and various processes of chemical reaction. Chemical engineering researchers in distillation and heat transfer have been the principal users of the MISTIC computer, but this is only one phase of several active projects. The varied interests of the faculty make it possible for the graduate student to choose among several areas, and insure him an interesting topic for his thesis.

Challenging problems in . . .

SYSTEMS

require engineering teamwork.

by Don Oglesby, E.E., '59

SYSTEMS engineering, the job of integrating the whole, as distinct from the invention and design of its parts, has been receiving increased emphasis throughout industry. The reason for this, perhaps, is because engineering solutions to man's problems have become increasingly broad and complex.

In transportation, for example, within the past 60 years man has progressed from the horse and cart to rockets that will take him to places which were once thought to be unreachable. Compare the early factory system of Arkwright to the manual assembly lines and the automatic factories of today. Follow the accounting systems from the frugal bookkeeping of Benjamin Franklin to the cash registers and small calculators, to today's punched card and digital computing systems that amaze even the scientists of our time.

With these transitions, it has been impossible for men individually to keep abreast of progress in all phases of engineering. It has even been impossible to acquire the vast store of information in a sub-catagory of one area of engineering (electrical, mechanical, etc.). This among other things has tended to produce specialized fields in electronics, hydraulics, astronomy, and metallurgy.

In the past when a particular item, for example an airplane, was built, little thought was given to the type or size of armament, radar, or navigation systems until the craft was well on its way to being designed. The various engineers were than approached and asked to develop certain specialized components to be used in the function of the whole. However, because their tools and terminology were different, communication between these groups was difficult. The consequence was that they did not get the best overall system that was available. As a result a need arose for someone to integrate the various specialized fields and arrive at the "best" system. This someone has come to be known as the systems engineer.

It might be well at this point to describe what is meant by a system. A system is an orderly combination or arrangement of parts, each of which has a separate identity, into a unit which performs an operation that cannot be performed by the parts alone.

What actually constitutes a system depends upon the views and the objectives of the men who are describing it. Nevertheless, in every case, all the parts of the system have some common purpose. They all contribute to the production of a single set of optimum outputs from the given set of inputs, with respect to some appropriate measure of effectiveness. To a tube designer the tube is the total system and the hardware that makes up the tube is a subassembly. On the other hand, the tube, transistor and resistor are subassemblies to a circuits designer.

A system at its most complex level is a complete factory. On a lower level of complexity one may consider the complete integration of an aircraft. It is within this framework of a large scale system that we will investigate the duties and responsibilities of the systems engineer.

In cost cases the systems engineer will be either an electrical or mechanical engineer usually with advanced formal or on-the-job training. He should have a good knowledge of computers and computer techniques and an above average background in applied mathematics.

There are a number of approaches where the systems engineer may enter the design process. If we are working with limited funds we may ask: "What do we expect to buy with our dollars?" Cost study may be our first consideration. The systems engineer may approach the system at the initial input. For example, in a SONAR set he may examine the type of signal that will trigger the system, or seek a way to best maximize a particular input while minimizing unwanted water noises, etc. In other cases the product (or output) may already be designed. How best to produce it in an automated production may be of major importance. In any case we are interested in the system as a whole including the type of personnel that will be operating it and maintaining it, so even human engineering can not be excluded. In fact, human engineering may be the most important consideration.

Assuming that the point of entry has been established, the systems engineer who is responsible for the integration of the overall system will decide on the broad policy decisions which determine the systems philosophy.

It will be the decision of the original group to decide what specialties should join the team. The heads of these groups should have broad scientific backgrounds, but each should be very strong in his field. One may be a mathematician, one an aeronautical engineer, and maybe a marine engineer will be desired depending on the nature of the project. Other technical people and sales personnel will be added when needed.

With this group it will now be possible to rewrite the problem statement with much more detail. The set of documented solutions and any alternate solutions that may come up should be discussed thoroughly with as much supporting data as possible. One solution should be chosen. It be-

(*Continued on Page 38*)

Tri-rocket system provides . . . .

PROPULSION

for the Atlas Inter-Continental Missile.

Edited by Herb Harman, E.E., '60

THE free world's most powerful propulsion system, capable of propelling the mighty Air Force Atlas better than 15,000 m.p.h. and a range over 5,000 miles is now under intensive flight test and production.

Following the successful long-range flight tests of the Atlas at Cape Canaveral, the Air Force released information and photographs of this powerful system.

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

Like many other missile propulsion systems, this was developed specifically for a single missile—the Atlas. It was designed and developed by Rocketdyne and is now in production in California.

History

The actual work on the propulsion system began almost five years ago.

It's original design was based on then existing technology which was on somewhat of an experimental basis and not one of a proven system. Intensive studies led to an early incorporation of major design and manufacturing refinements.

The first flyable system was delivered on schedule to Convair in June, 1956, and the initial flight test came less than one year later, using booster and vernier power only.

Subsequent engines of the series have been modified and now incorporate the latest technical advances developed in static and flight tests. The complete propulsion system, including sustainer, had been thoroughly tested by Rocketdyne and Convair for a year and a half before entering flight test this year.

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.

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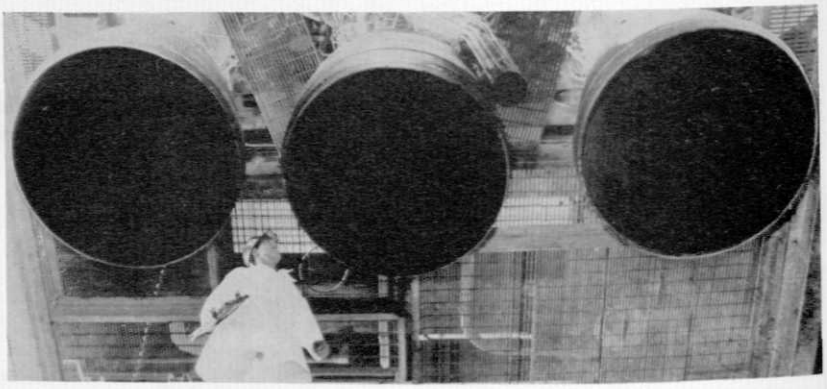
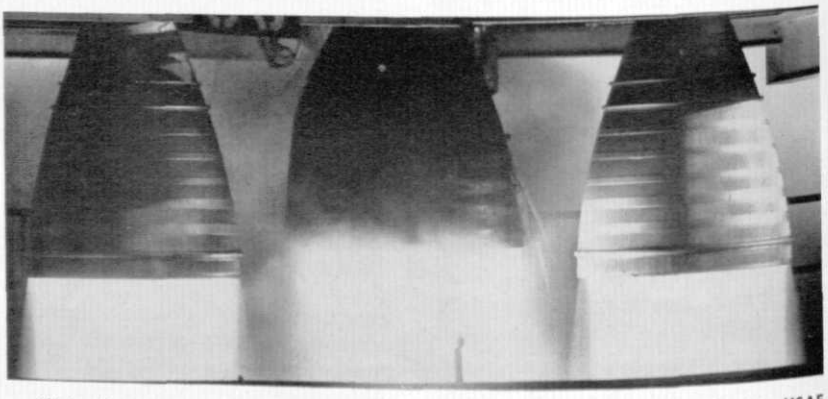


This is the first photograph of the free world's most powerful cluster of rocket engines, the Atlas ICBM. The primary units are composed of a twin-chambered booster at left and right and a sustainer in the center. The propulsion system also includes two small vernier or stabilizing engines mounted on the missile frame to prevent roll.



Slight distortion in center chamber, which is the sustainer engine of the mighty USAF Atlas intercontinental ballistic missile propulsion system, is caused by gimbaling of the engine during full-power test firing. Twin chambers on either side make up the booster engine, which lifts the massive ICBM from the ground and through the heavy atmosphere.

Modern achievements show critical need for new techniques

OPERATIONS RESEARCH

by Lowell Brigham, E.E., '59

THERE are many definitions of operations research. Usually the difference is determined by the definer's background and verbosity. A scientist, engineer, psychologist, or businessman might each emphasize a different aspect of operations research in his definition. Its length and meaningfulness could depend a lot on his flair for words. Hence, my own definition is flavored by others, and by experience as an electrical engineering student with an interest in management theory and application.

Operations research:

> A scientific method to achieve maximum output from men, money, and machines, by changing the methods whereby these resources interact with one another to produce a product.

The term *"scientific method"* as used here has the broadest possible connotations. It implies not only problem solving but recognition of the problem and gathering, interpreting, and presenting data so that sound decisions can be made. While it is not necessary to be a scientist to do operations research, there seems little doubt that a strong background in a science, especially mathematics, is required to apply operations research in its most highly developed and sophisticated form. Since operations research may be called upon to study a wide variety of problems, it is advisable to have an operations research group with as many of the sciences represented as possible.

An interesting sidelight of operations research is its beginning. Most authors credit a British scientist, P. M. S. Blackett, as the first to use operations research under that name while doing developmental work on radar early in World War II. Much of the early operations research was done for the military.

The Navy used operations research to determine the most effective method of bombing submarines. It was proven that a bomb set to go off on contact with the water was more effective than one with a delayed action.

The Air Force determined a more effective way to bomb targets through operations research. A few of the operational changes were to use fewer bombers in a group and have one bombardier act for the entire group. The result was to increase by 45 per cent the number of bombs within 1,000 feet of the actual target.

An Army operational research group discovered that a machine gun was more effective if fired in long bursts. After the first few rounds, the gunner became used to the vibration, and it was the last few rounds, not the first, that entered a target.

In each of these cases, it was the methods, not the men and machines, which were changed. The change in method alone was responsible for the increase in efficiency.

Where Does Operations Research Belong In Industry?

The first thing that should be said about operations research or an operations research group is that not all

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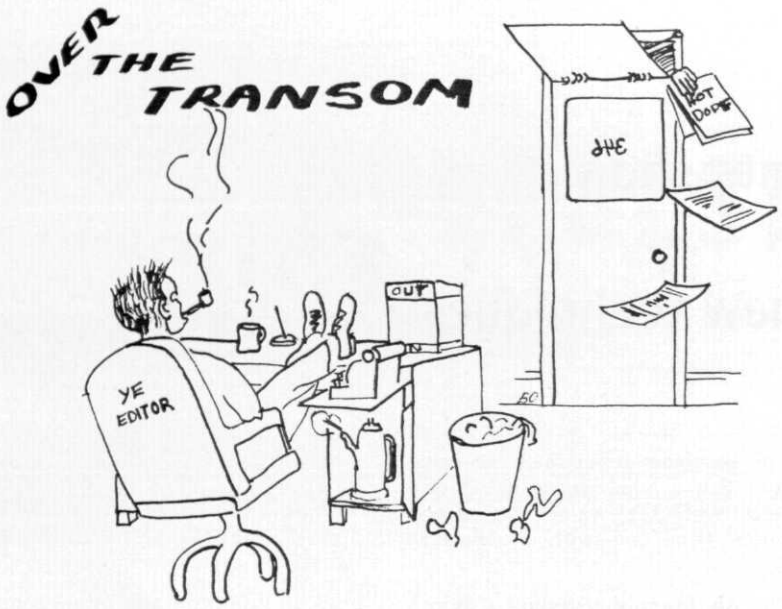

For the first time in seven years, and despite still-critical demands for engineering talent, enrollment in American engineering schools is on the decline.

The 153 accredited American engineering colleges had 2.9% less students in the fall of 1958 than in the fall of 1957. And the freshman class which entered last fall was 11.6% smaller–59,164 instead of 67,071–than 1957.

Declining enrollments have not yet affected the number of engineering graduates–31,216 in 1957-58 compared with 27,748 the previous year. But the numbers are far short of the record graduation of eight years ago, when World War II veterans were finishing their delayed college careers.

Fears of dropping engineering enrollments were confirmed by the official figures. Engineering students are now less than 7.7% of all American college students, compared with nearly 8.5% in 1957. Enrollment of second-year students is down 6% from last year, and third-year students are down 4%. Only in the fourth-and fifth-year category does this year's enrollment total as large as last year's. This gives promise of more graduates in June, 1959; but there may be fewer in the years thereafter.

Graduate study in engineering continues to increase sharply, and enrollment is now at record levels. This fall 27,456 students were enrolled is master's degree programs, an increase of 14.7% over 1957; and 4,762–up 14.3%–were studying for doctor's degrees.

Last year 5,751 master's degrees were given in engineering, nearly 10% of all master's degrees given in the United States during the year. There were 653 Doctor's degrees, 8% of doctor's degrees given in all fields.

Electrical engineering with slightly over 56,000 undergraduate students is by far the most popular engineering field; just over 8,700 bachelor's degrees in electrical engineering were awarded in 1957-58. Next comes mechanical engineering, with nearly 44,000 students and 7,850 graduates. Civil engineering, third in popularity, accounted for just under 15% of the bachelor's degrees, a proportion somewhat lower than in recent years.

Electrical engineering is also most popular among graduate students, with chemical engineering second and mechanical engineering third.

In all, 1,396 women were studying for bachelor's degrees in accredited engineering schools in the fall of 1958, less than 1% of the total enrollment.

All figures released today cover only the 153 American colleges with one or more of their engineering curricula accredited by Engineers Council for Professional Development. In 70 other schools, there were 39,047 undergraduate engineering students enrolled this fall, and 4,116 degrees were awarded in engineering in 1957-58.

Congratulations to the following fall term four-pointers in engineering:

SENIORS
- Charles Anderson, E.E.
- James Feller, E.E.
- Carl Ferrar, E.E.
- Carl Helquist, Ag.E.
- James Resh, E.E.
- Richard Schmal, E.E.
- Bobbie Trantham, E.E.
- Robert Williams, Mte. E.

JUNIORS
- Edward Daniels, E.E.
- Donald Feirtag, E.E.
- Ping Yu Ip, Mte. E.
- Milton Lutchansky, M.E.
- Jack Rink, E.E.
- Paul Shoemaker, M.E.
- Aldred Stevens, M.E.

BASIC COLLEGE
- James Anderson
- Richard Freeman, Jr.
- Richard Fuessel
- Wayne Granfors
- Larry Kirkby
- James Ledvinka
- Willard Matheison
- Larry Osterink
- Edward Scharmer
- Phillip Scheltema
- Harlow Schwartz
- Meriel Yoshida

The Tau Epsilon Chapter of Pi Tau Sigma elected the following officers for the remainder of the school year:

President–Ernest Kollar
Vice President–Duane Williams
Treasurer–Ronald Clark
Corresponding Secretary–Milton Lutchansky
Recording Secretary–W. C. Johnson
Faculty Advisor–J. T. Anderson

Charles H. Pesterfield, is seeking election in the non-partisan-at-large election in April for one of three places on East Lansing City Council. A professor of mechanical engineering, he is a recognized authority on air pollution control. He holds degrees from the universities of Arkansas and Minnesota. It is his first venture into local government activities.

S. M. Futral, Jr., assistant professor of mechanical engineering goes on leave of absence September 1, 1959, to August 31, 1960. He has a National Science Foundation fellowship for study at Case Institute.

C. C. Sigerfoos, associate professor of mechanical engineering, on leave February 1 to August 31, 1959, to do ICA work in Yugoslavia.

Burton Cargill, assistant professor in agricultural engineering, on leave to September 1, 1959. He is completing work for Ph.D. degree at the University of Wisconsin.

Lewis Swanson, instructor in agricultural engineering, goes to Columbia project, March 9th.

Richard Pian, associate professor of civil engineering, leaves August 31st.

A.S.M.E. will sponsor a field trip to the Enrico Fermi Atomic Power Plant April 16, 1959. All engineering students are invited. For more information contact LaVerne Root.

RECOMMENDED MINIMUM . . . .

STARTING SALARIES

FOR VARIOUS LEVELS OF EXPERIENCE HAS NOW BEEN MADE AVAILABLE BY "ENGINEERS AND SCIENTISTS OF AMERICA"

AN engineer needs to consider many factors before he accepts a new position, one of which is the starting salary. Although this report is concerned solely with starting salaries, this does *not* mean that we consider them to be of paramount importance. We believe that *no* engineer should consider *any* position, regardless of how attractive the salary offer might be, *unless it provides technical* and professional opportunities appropriate to his experience and interests. We also believe that the *most* important variables in an engineer's career earnings are his ability, his industry, and the quality of his work assignment.

ESA's Salary Schedule

Despite this, or perhaps because of it, we recognize that it is possible for an engineer to underestimate the importance of his starting salary on his future professional and economic development. However, we also recognize that few engineers have sufficient statistical data available with which to evaluate an employer's offer. To fill this need, the Engineers and Scientists of America have analyzed the salary data which we have available. From this we have developed a chart of minimum starting salaries which we believe represents the engineering salary practices which will be in effect during most of 1959.

This chart reveals the importance, for both employer and engineer, of evaluating an engineer's "quality." (His experience level, which is the other variable required to determine salary from this chart, is relatively easy to establish.)

Evaluating Engineers

Contrary to general belief, it is nearly impossible for an employer to determine an engineer's "worth" on an absolute scale. The only practical basis for evaluating "worth" is to estimate the "cost of replacement." In practice a supervisor ranks his engineers relative to each other in accordance with his estimate of their relative value to the Company. The absolute level of the whole engineering salary structure is then controlled in some way to remain roughly in balance with the market value, as established by the salaries required to hire engineers, competitors' salaries, etc.

The combination of those two factors—(1) large spread in salaries between various "quality" levels and (2) inability to determine absolute values of "worth"—causes an engineer's starting salary to have an unexpectedly large influence on his professional career. This happens in two ways.

Salary Influences Assignment

Most salary administration practices seek to maintain consistent relationships between an engineer's salary and his work contribution. Thus an engineer whose starting salary is higher is more likely to be assigned a some-

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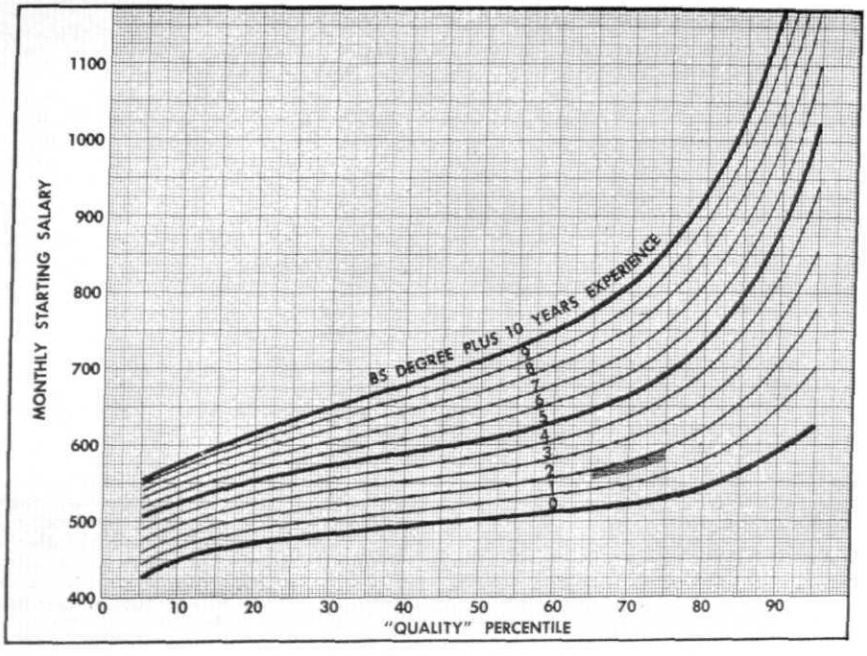
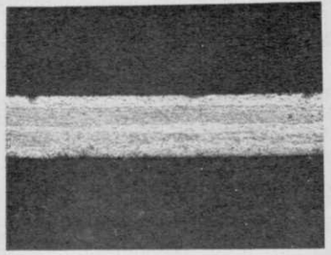




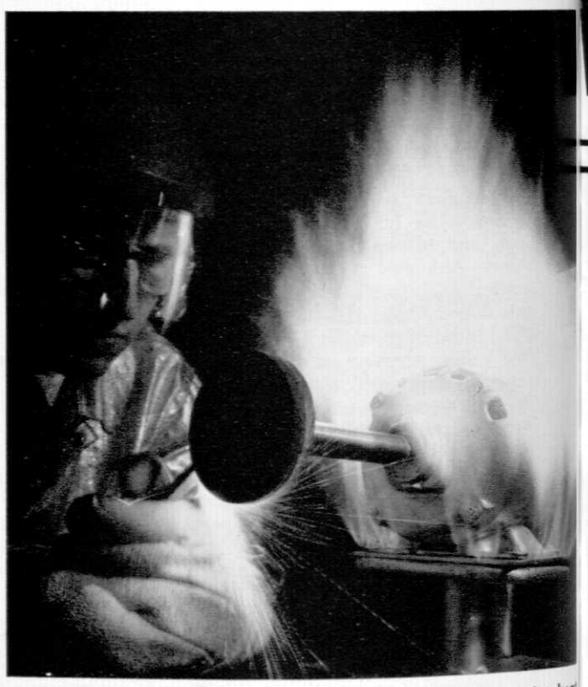
PHOTOMICROGRAPH OF AN ULTRASONIC SEAM WELD OF COPPER TO COPPER

PHOTOMICROGRAPH OF AN ULTRASONIC SEAM WELD OF ALUMINUM TO ALUMINUM

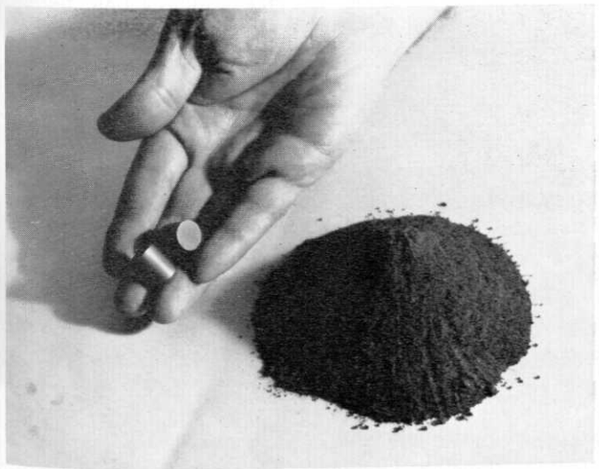
Nes. No. 30939

ABOVE—Magnified 100 times, the copper-to-copper seam weld (top) shows no line of demarcation in the weld. This seam weld shows a pronounced cold worked structure and there is no indication of a cast structure as might be obtained with fusion welds. The photomicrograph at bottom shows one edge of a seam weld. The unwelded area at the left was not part of the weld but was included to show the difference between welded and unwelded sections.

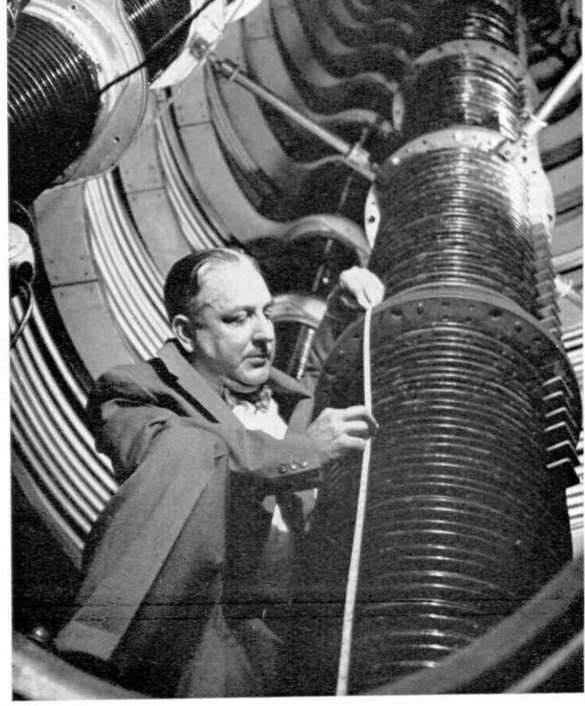
NEWS VIEWS



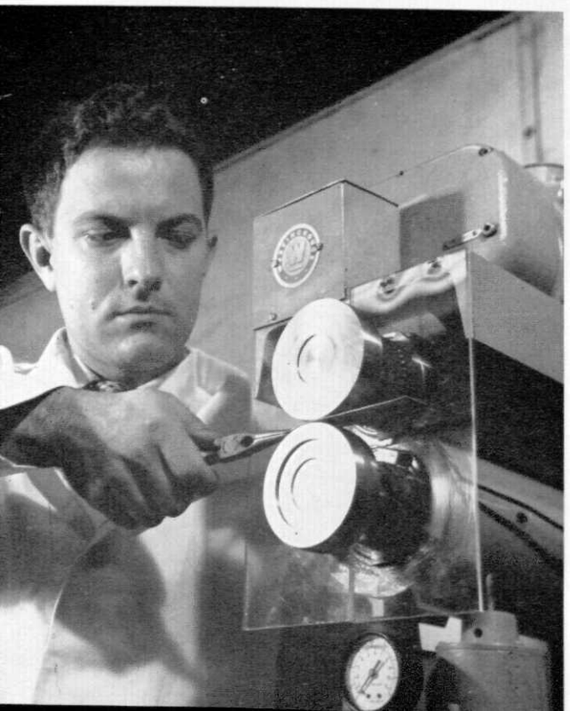
ABOVE—Even when almost "broiled" in the searing heat from jets of burning gas, this experimental Westinghouse electric motor performs efficiently enough to do useful work, such as this grinding job. The motor was built to test the performance of a new system of inorganic electrical insulation for high-temperature motors, transformers, and other apparatus. It has operated continuously more than 100 hours, with no indication of insulation deterioration when sealed inside an oven at 950 degrees F. The new insulation, offers promise for use in the electrical equipment in supersonic planes, rockets, and missiles.



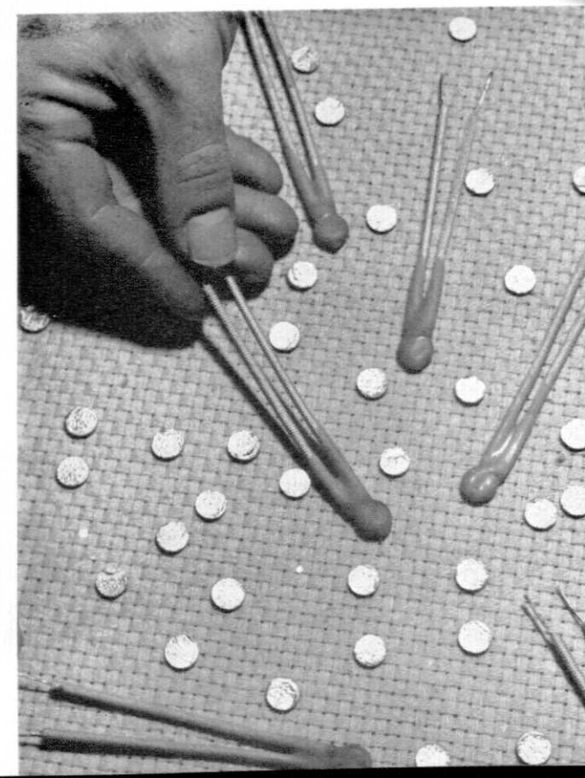
ABOVE—Looking like nothing more than a pile of black dirt, this is one member of a new "family" of thermoelectric materials for the direct conversion of heat into electric power. They are the first 'solid-state' thermoelectric materials capable of high-temperature operation—a prime requirement of materials useful for power generation. For experimental purposes, the powdery materials are pressed into pellets like those shown in the hand.



ABOVE—Inside the world's first industrial atom smasher, Dr. William E. Shoupp, is shown taking final measurements prior to the decommissioning and partial disassembly of the giant atomic energy research "tool." It was Dr. Shoupp who supervised the building of the 90-ton atom smasher and put it into operation in 1938. He is shown here checking the base of a 40-foot vacuum tube, which during the thousands of tests, served as a "racetrack" for sub-atomic particles which were shot down the tube at velocities ranging from 30 million to 100 million miles per hour. The atom smasher was the forerunner of the newest atomic research "tool" of the company—the Westinghouse Testing Reactor—now nearing completion some 30 miles from Pittsburgh at Waltz Mills, Pa.



LEFT—This laboratory model of the Westinghouse developed ultrasonic seam welder is shown completing a weld between two 10-mil-thick aluminum straps. The weld is performed by passing the aluminum sheets between the two wheels which vibrate at 20 kilocycles per second. The periphery of these wheels press against the metals and break up the oxide coating on the metal's surface. By a kneading action, the metal lattices on the surfaces weld themselves.



RIGHT—New switching thermistors announced by Westinghouse Electric Corporation are solid-state, temperature-sensitive devices whose resistance increases abruptly when their temperature reaches a critical value. Silvery discs in the photograph are ceramic wafers to which a matallic surface has been applied. Complete thermistors result when discs are fitted with leads, insulated, and encapsulated for proper mechanical, electrical, and thermal properties.

Genny Butz

MISS MARCH ENGINEER

GENNY BUTZ

Home town: Grosse Pointe Park, Mich.

Age: 20

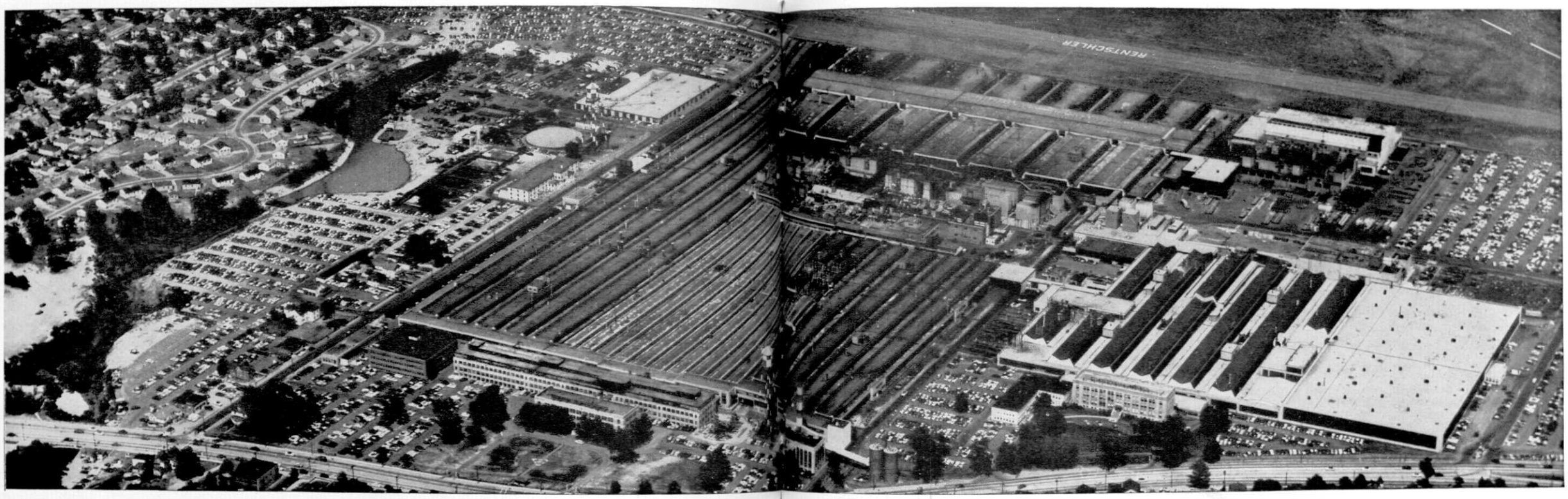
Sorority: Kappa Alpha Theta

Specs: 5′ 4″
Brown eyes
Brown hair
35-23-36

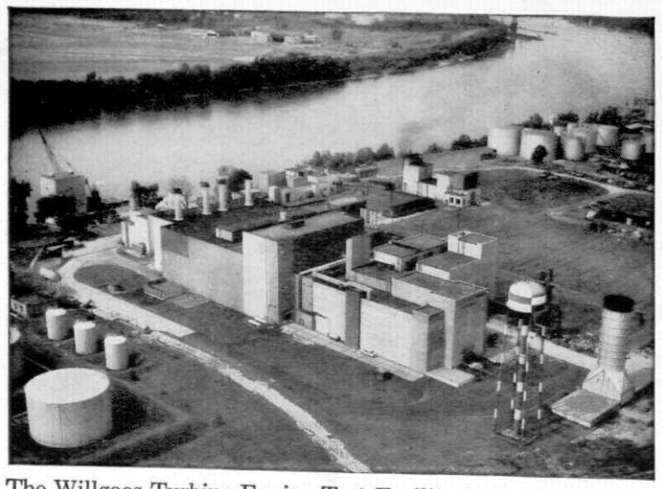
Major: Elementary Education Junior

Hobbies: Swimming
Water Skiing
Spectator Sports

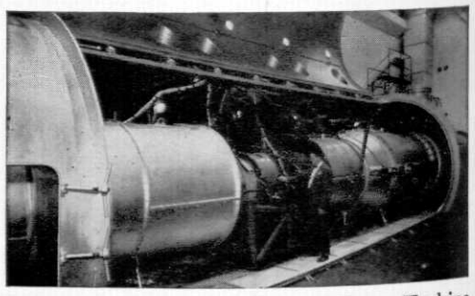
Status: Single



CONNECTICUT OPERATIONS



The Willgoos Turbine Engine Test Facility is the world's most extensive privately owned turbine development laboratory. Designed and built specifically to test full-scale experimental engines and components in environments simulating conditions at extreme altitudes and speeds, it is currently undergoing expansions that will greatly increase its capacity for development testing of the most advanced forms of air breathing systems.



In chambers like this at the Willgoos Turbine Engine Test Facility full-scale engines may be tested in environments which simulate conditions from sea level to 100,000 feet. Mach 3 conditions can also be simulated here.

In the new Fuel Systems Laboratory engineers can minutely analyze the effects of extreme environmental conditions on components of fuel systems — conditions such as those encountered in advanced types of flight vehicles operating at high Mach numbers and high altitudes. Fuel for these tests can be supplied at any temperature from −65°F to +500°F.

Unmatched Engineering Facilities for Developing Advanced Flight Propulsion Systems

Operations at Pratt & Whitney Aircraft are essentially those of an engineering and development organization. As such, an engineering atmosphere dominates the work being done, much of which directly involves laboratory experimentation.

In the past three decades, expansion at Pratt & Whitney Aircraft has been almost tenfold. In recent years, greatest emphasis has been on extending engineering facilities to meet the needs of advanced research and development programs in flight propulsion.

Among the Connecticut P & W A facilities are many that are unequaled in the industry. Thus today, Pratt & Whitney Aircraft is better prepared than ever to continue development of the world's best aircraft powerplants . . . to probe the propulsion future . . . to build and test greatly advanced propulsion systems for coming generations of flight vehicles — in whatever form they take.

The Connecticut Aircraft Nuclear Engine Laboratory, operated by Pratt & Whitney Aircraft, is situated on a 1,200-acre tract near Middletown. The Laboratory was specially built for the development of nuclear flight propulsion systems.

For further information regarding an engineering career at Pratt & Whitney Aircraft, consult your college placement officer or write to Mr. R. P. Azinger, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

CONNECTICUT OPERATIONS — East Hartford

FLORIDA RESEARCH AND DEVELOPMENT CENTER — United, Florida

Brains . . .

(*Continued from Page 15*)

contour maps from air photos, or pick out a face from a rogues' gallery even through such disguises as beards and eyeglasses.

Computers Guide Missiles

SEAC is not alone among computers capable of performing startling and often incredible feats. Consider the guidance system of a ballistics missile in flight. Such a projectile must travel hundreds, even thousands of miles at speeds well over 15,000 mph to hit its target. During flight its course must be adjusted to wind variations, temperature changes, rotation of the earth, and many other variable factors. Needless to say, no human mind could correlate these variables rapidly enough to keep this missile on course. Computer speed is the only answer. Capable of handling from 40,000 to 60,000 calculations in only one second, an electronic brain, acting on data radioed back from the missile, can easily guide it directly to its target.

Such computer use is by no means restricted to missiles. These techniques are also used to guide superspeed jet aircraft such as the B-52 and B-70 between cities thousands of miles apart.

Another computer application, though perhaps less dramatic, is just as impressive as missile and aircraft control. The computers used by the Social Security Administration in Baltimore, Md., maintain continuous records on 160 million names and 1,750 billion dollars. This is more than simply a massive electronic filing system. These computers are programmed to discover and correct 83 per cent of the errors occurring in data supplied by their less-than-perfect human assistants.

The Social Security's computer system potential has not been exhausted. A future application with great potential for both good and evil may exist. Within decades it may be possible to keep a complete record on every person in the country from birth to death. Such a record, obtainable in seconds from a giant computer system, could contain everything from the person's blood-type to his credit rating. This information already exists on most of us, but in widely scattered places. A computer could cross-check for accuracy, and consolidate all of these records. The good in such a system is apparent in its great time and money saving possibilities. Abused, however, the system could lead to a "1984" police state undreamed of even by George Orwell.

Biblical Translations Tackled By Computers

Computer advances have by no means been restricted to government and defense projects. One of the most useful tools in Bible study is the concordance. This is a cross indexing of the Bible's 800,000 words to aid in their accurate translation and definition. The concordance, used until recently, took nearly 30 years to complete. The latest method took only a few months of programming and a few hours of computer time.

Computers now exist which can translate hundreds of documents from one language into another in a day's time. These translations take considerable time and an editor must complete the job. However, improvements are continuously being made. It is entirely possible that future electronic machines will not only produce polished written translations, but will be able to hear a sentence spoken in one language and reproduce it in another complete with tone of voice and inflection.

Such facts and speculations bring up a question both fascinating and frightening: will machines ever be able to think? There seems to be a good deal of evidence to support the contention that they will. In fact, there are a number of things done by computers today which, if not actually thinking, certainly resemble thought.

IBM 704 Plays Chess

One such performance is found in the International Business Machine computer, IBM 704, which has recently been programmed to play a fairly decent game of chess. (*See Spartan Engineer, January '59*) IBM is easily the nation's largest producer of computer devices, and the 704 is one of their most advanced machines in operation.

Even to a person not very familiar with chess the problem of programming the game could seem deceivingly simple. Since each piece must move strictly within a known set of rules, and since there are only so many possible plays for any given move, the obvious method seems to be to let the computer examine all possible moves and select the best. Unfortunately even the fastest machine conceivable could not do this in a practical amount of time.

In a game of chess each move presents approximately 30 possibilities, and each game lasts about 40 moves. At this rate there are approximately 10^{120} different possible games of chess.[2] A computer operating at the rate of 1,000,000 calculations a second, or 20 times faster than most computers today, would require 10^{108} years to play all possible games. This, in effect, is exactly what the machine would have to do in order to play one game.

The solution to the problem has been solved in part by programming the 704 to select only the seven most practical plays on the board and "mentally" carry them through two complete moves. This done, it makes the best move of the seven according to its programmed criteria. Each move takes the machine a little over eight minutes. The study of eight rather than seven possible moves would increase this time to 15 minutes, while planning through three rather than two complete moves would increase the time to 6½ hours.

The game played by the 704, though generally only mediocre, often contains surprisingly good chess "thinking." Improvement, however, does not come through repetition. Unlike a human player, the machine cannot learn from its mistakes, and may lose game after game for substantially the same reasons. The possibility of programming a machine to learn through playing is the next step to be worked out. There is little reason to assume it will not be.

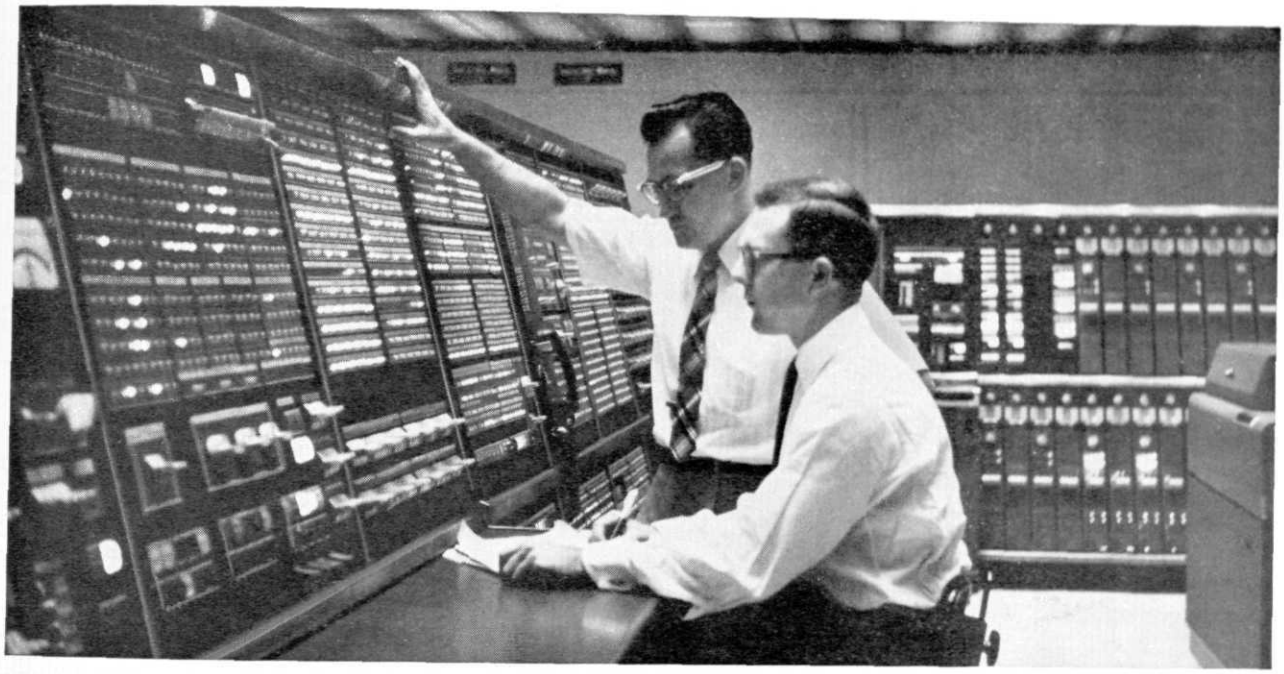
Some Day Computers May Think For Themselves

In an article written several years ago, the late A. M. Turing explored at great lenght the question of "thinking" machines. In his article, Turing has cited a number of the arguments against the possibility of such devices. He has then carefully and logically denied each objection. From this he goes into the problem of developing a machine capable of learning as well as thought, and he concludes with the opinion that machines will, indeed, some day compete intellectually with men.

Probably the most frequently heard objection debated by Turing is the theological question. This argument claims that thinking is the result of man's immortal soul. Since God has

(*Continued on Page 44*)

2. 10^{120} = 1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000. This number is so vast in magnitude that it has no conceivable physical analogy.



W.E. DEFENSE PROJECTS ENGINEERS are often faced with challenging assignments such as systems testing for the SAGE continental air defense network.

ENGINEERS explore exciting frontiers at Western Electric

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In our main job as manufacturing and supply unit of the Bell System, Western Electric engineers discover an even wider range of opportunity. Here they flourish in such new and growing fields as electronic switching, microwave radio relay, miniaturization. They engineer the installation of telephone central offices, plan the distribution of equipment and supplies . . . and enjoy, with their defense teammates, the rewards that spring from an engineering career with Western Electric.

Western Electric technical fields include mechanical, electrical, chemical, civil and industrial engineering, plus the physical sciences. For more detailed information pick up a copy of "Consider a Career at Western Electric" from your Placement Officer. Or write College Relations, Room 200D, 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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SIDETRACKED

The Soviet commissar was examining a young Czech boy to determine whether he had been properly indoctrinated. When asked who his father was the boy replied, "Josef Stalin."

Beaming, the examiner then asked who his mother was. "The great Soviet Union," came the prompt reply.

"Splendid," grinned the commissar, "You'll make a fine Red Army soldier. Now tell me," he continued, "what do you want to be when you grow up?"

"An orphan!" snapped the boy.

° ° °

The moon was full, the night was warm and the car radio was playing romantic music.

"Kiss me," pleaded the boy.

"No!" said the girl. "Drive to another place."

So he drove for a few minutes and parked again. This time the girl launched the offensive. When the boy came up for air he asked the girl why she'd changed her mind.

"Oh, I knew what I wanted," said the girl. "I just don't believe in love at first site."

° ° °

A policeman sees a drunk knocking on a street lamp pole. The policeman jokingly says, "I don't think anybody is home."

"There mush be," replies the drunk, "theresh a light upstairs."

° ° °

Boss: "How come you're only carrying one sack, when the other men are carrying two?"

Workman: "Well, I suppose they're too lazy to make two trips, the way I do."

° ° °

One cigarette said to another, "I hope I don't get lit tonight and make an ash of myself."

° ° °

Dinner guest at an Engineering Banquet: "Will you pass the nuts, Prof?"

Preoccupied Professor: "I suppose so, but I really should flunk most of them."

° ° °

Attention! You can cure your roommate of snoring by good advice, cooperation, kindness and by stuffing an old shirt in his mouth.

Prof: "Well, what did you think of the course?"

C.E.: "I thought it was very well covered. Everything that wasn't covered during the semester was covered on the final?"

° ° °

"What is your name, Sir?" the bank teller asked politely.

"Don't you see my signature?" snapped the indignant patron.

"Yes, Sir; that's what aroused my curiosity."

° ° °

"Pa, what does it mean here by diplomatic phraseology?"

"Son, if you tell a girl that time stands still while you gaze into her eyes, that's diplomacy; but if you tell her that her face would stop a clock, you're in for it."

° ° °

The girl greeted her boy friend with, "Notice anything different about me?"

"New dress?"

"No."

"New shoes?"

"No, something else."

"I give up."

"I'm wearing a gas mask."

° ° °

Little Johnny came home from school crying, "Hey, Ma, all the boys are picking on me. They say I have a big head."

"You don't have a big head, Johnny. Now run along and play."

The same thing happened the next day, and the next, and each time Johnny's mother comforted him. The fourth day Johnny came home with the same story.

"For once and for all, Johnny, you don't have a big head. Now please go down town and get me ten pounds of potatoes."

"O.K., Ma, give me a sack."

"Sack? What do you need a sack for? Use your cap."

° ° °

Dean of women: "Didn't you read the letter I sent you?"

Co-ed: "Yes, ma'am. I read it inside and outside. On the inside it said, 'You are requested to leave college,' and on the outside it said, 'Return in five days,' so here I am."

A window washer related this experience to his friends:

"One day I was cleaning a window when a young woman entered and started to undress. She took off her shoes and stockings and then her dress, when suddenly the ladder broke."

"What a calamity at a time like that," remarked one of the listeners.

"It sure was," answered the window washer, "but what could you expect with twenty guys on the ladder?"

° ° °

He: "Please?"

She: "No!"

He: "Oh, just this once?"

She: "I said definitely not!"

He: "Oh, it won't hurt."

She: "I said definitely not!"

He: "Oh, shucks, Mom, all the other kids are going barefoot."

° ° °

"When you were courting me," Mrs. Recentwed complained, "you used to catch me in your arms every night."

"Yeah," bassoed her disillusioned husband, "and now, I catch you in my pockets every night."

° ° °

A well known orthopedic surgeon was being conducted through a hospital ward on a trip of inspection. His host showed him a patient and said, "This child limps because his right leg is shorter than his left. "What would you do in his case?"

"I'd probably limp, too," replied the doctor.

° ° °

Little Jackie entered first grade, where his teacher was a very well-proportioned young lady who enjoyed very loose-fitting blouses. One evening, several hours after school was over, she was having dinner in a restaurant when little Jackie and his parents came in.

"Daddy," the kid yelled, and all the diners turned toward him. "There's Miss Smith. You shoulda been in school today. She leaned over too far, and one of her lungs fell out."

° ° °

Social Worker: "Sir, would you be interested in contributing something to the old ladies home?"

(*Continued on Page 50*)

. . . a hand in things to come

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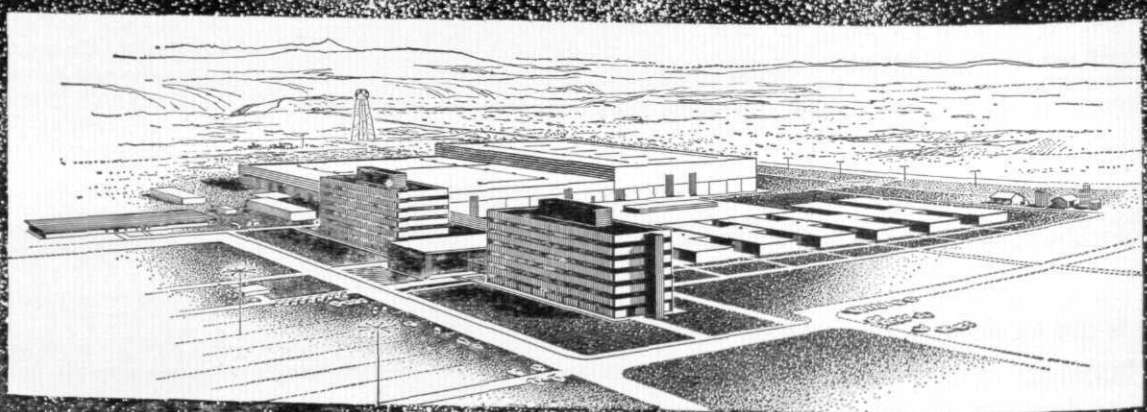

Du Pont

training is tailored to the individual

Training at Du Pont begins the day the new graduate joins the Company, and it continues throughout his career. He is usually given a specific assignment at once, so he learns informally in consultation with his supervisor and his associates assigned to the same project. This informal approach to training is supplemented by frequent meetings and seminars and by scheduled performance reviews by each man's supervisor.

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Texas

Engineer Larry Klivans reviews the results of a computer-simulated ground checkout of Radioplane Division's near-sonic RP-76 rocket-powered target drone. Formerly at Norair Division, Larry came to Radioplane in 1955. At 31, he is Manager of the Division's 140-man Electronic Support Group, is working toward his doctorate at UCLA.

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Divisions of NORTHROP CORPORATION

Systems . . .

(Continued from Page 19)

comes impractical to be precise in accumulating all of the effects that contribute to the system's final performance in a quantitative sense, but by using all the tools available we can be reasonably assured that the decision made will be satisfactory.

Once the solution is decided upon, the project should begin to progress rapidly. Data should be collected on various phases of the solution. The component engineers should be approached to make final choices on the components as the systems engineer usually is not qualified to make these decisions. General hardware should be investigated, and the breadboard stage should begin.

The specific solutions will be continually changing, but this is the time for change. As circuits, etc., are designed and tested better ways may be found to accomplish the desired results. The purpose of the breadboard stage is to refine the functional design. No changes should be made in the design other than those suggested by the component designers. Subsystems should be built to react to the inputs expected and to deliver the required outputs at the proper time. Many of these sub-systems will be built by the original contractor, but today more sub-contractors are being sought for these contracts. This activity requires liaison men between the two or more companies. These men are often systems engineers because it is important to follow production of sub-assemblies with the integration of the whole in mind.

Progress reporting is extremely important. The reports must be accurate and clear. It will be necessary to compare progress in all areas and to make sure that particular sub-assemblies are ready when needed so that work can continue smoothly. This calls for excellent communication among the systems personnel. The product at this stage is required to meet the specifications set up by the customer, management, systems designers and the fabricator of equipment.

The prototype will be mostly hand made. If the design has been well done this should take a relatively small portion of the total time. During the construction of the prototype instruction and maintenance manuals should be made so that test and evaluation can be preformed. The pro-

(Continued on Page 47)

Deep Water and Deep Space open up Exciting Careers at Chance Vought

Outer space and ocean depths present a tremendous challenge to young engineers. Deep space and deep water are becoming new avenues of attack, and consequently broad studies are now going on at Chance Vought for safeguarding these approaches with advanced weapons systems.

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Earth's ocean basins, too, are potential theaters of war. Under the Office of Naval Research, Vought engineers are seeking improved ways of detecting and identifying the submarine – a weapon they know well. Since 1953, U. S. Fleet subs have carried *Regulus* missiles and support equipment.

Engineers of all academic specialties can find at Vought an unmatched career area . . . as new capabilities are forged . . . weapons for deep water and deep space defense.

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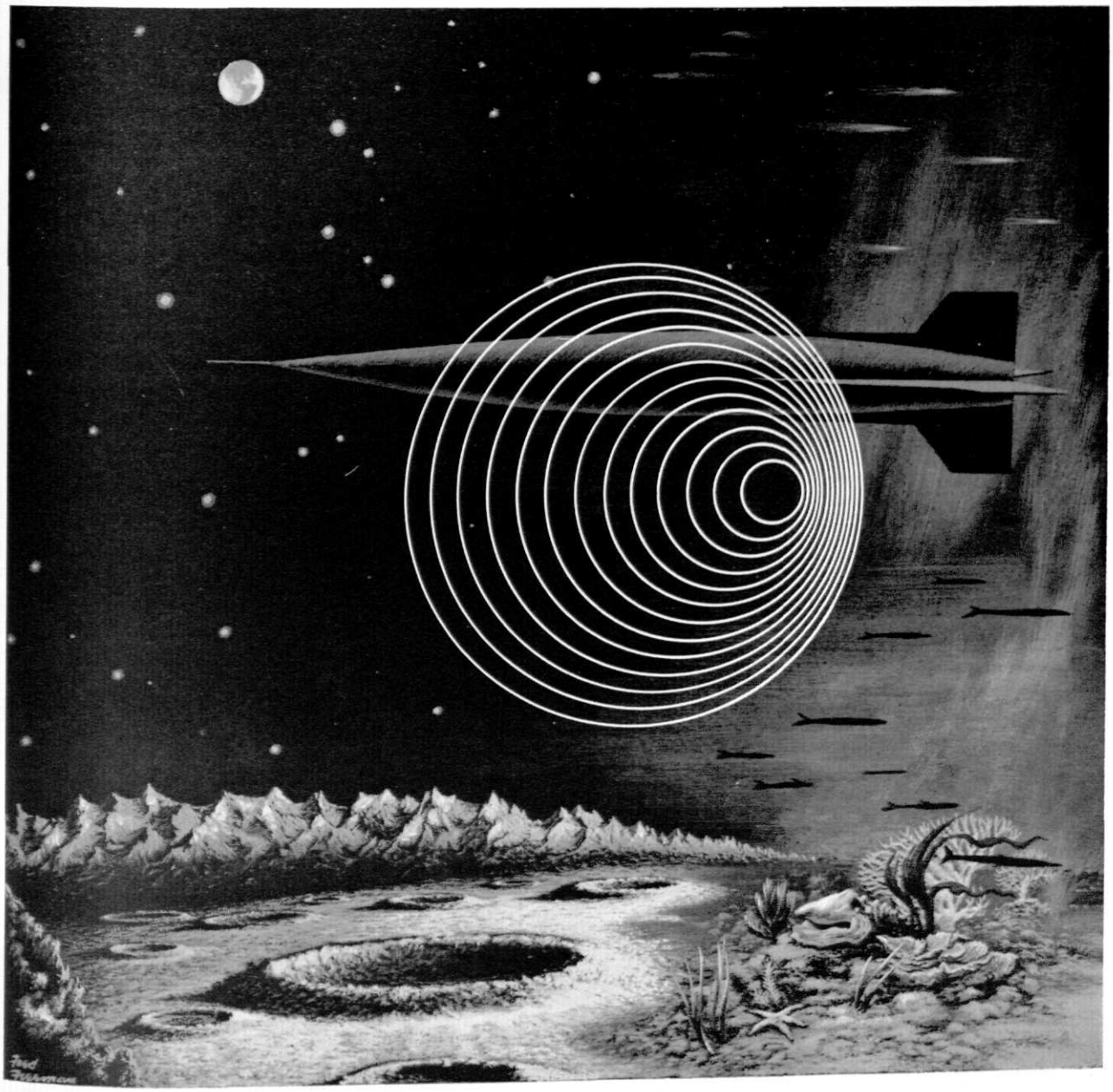


Operations Research . . .

(*Continued from Page 21*)

businesses should have one. By its very nature, an operations research group is expensive to staff, and, more important, few are qualified to do the work. For smaller businesses, operations research on a consultative basis would be more economical. An operations research group would find its greatest use in programs where either the variables were so numerous as to overwhelm the layman or measurement of indices were difficult to perceive, or both.

Since the operations research group may study problems ranging from the maintenance department to future company policy, it must impinge upon the line organization at a very high level. Because of this same diversification of interests, it must be an autonomous staff function. Its duties to the line organization are to advise and influence decisions—not make them. The operations research group must not let itself get trapped into doing ordinary staff work.

How Does Operations Research Effect Management?

Operations research means more to management than a group capable of solving specific problems in isolated areas. Just as management must look at a business enterprise in its entirety, so must the operations research group. Operations research should not be looked upon as a tool to solve numerous, unrelated problems, but rather as a means of aiding management in its entire programming procedure.

The procedure for a systematic solution to management problems can be broken down into five steps:

1. Determine the objective and state the problem.
2. Make a breakdown of the important studies or surveys involved.
3. Devise a formula for obtaining the objective.
4. Organize for action.
5. Arrange for effective follow-through.

By showing the reader how operations research could implement management in these five basic steps, the value of operations research should be illustrated.

Objectives

Management will usually become aware of a problem through some specific indice. Cost of production is up, sales are down, labor turnover is high, the accident rate is high, all are indices of a problem facing management. Management's objective is to reverse the trend. While the objective may be stated clearly and concisely, the problem, unfortunately, cannot be put into precise wording without detailed study.

Operations research has the duty of breaking the objective down into specific problems. Cost of production, for instance, might be high, not only because the price of labor and materials is high, but also due to the production system, inventory control, shipping methods, cost accounting system, or some other inefficient operating system. Operations research would have to be aware of and investigate the entire business enterprise to decide which areas were at fault.

Studies Involved

While the area at fault may be known, the total effect may not be known. To determine this effect might well result in a preliminary investigation to find what degree each area contributes to the initial problem. A preliminary study would eliminate areas of negligible importance. With the problem now firmly stated, the operations research group would begin its research in earnest. Objective data concerning the operations and interrelation of operations would be gathered and analyzed.

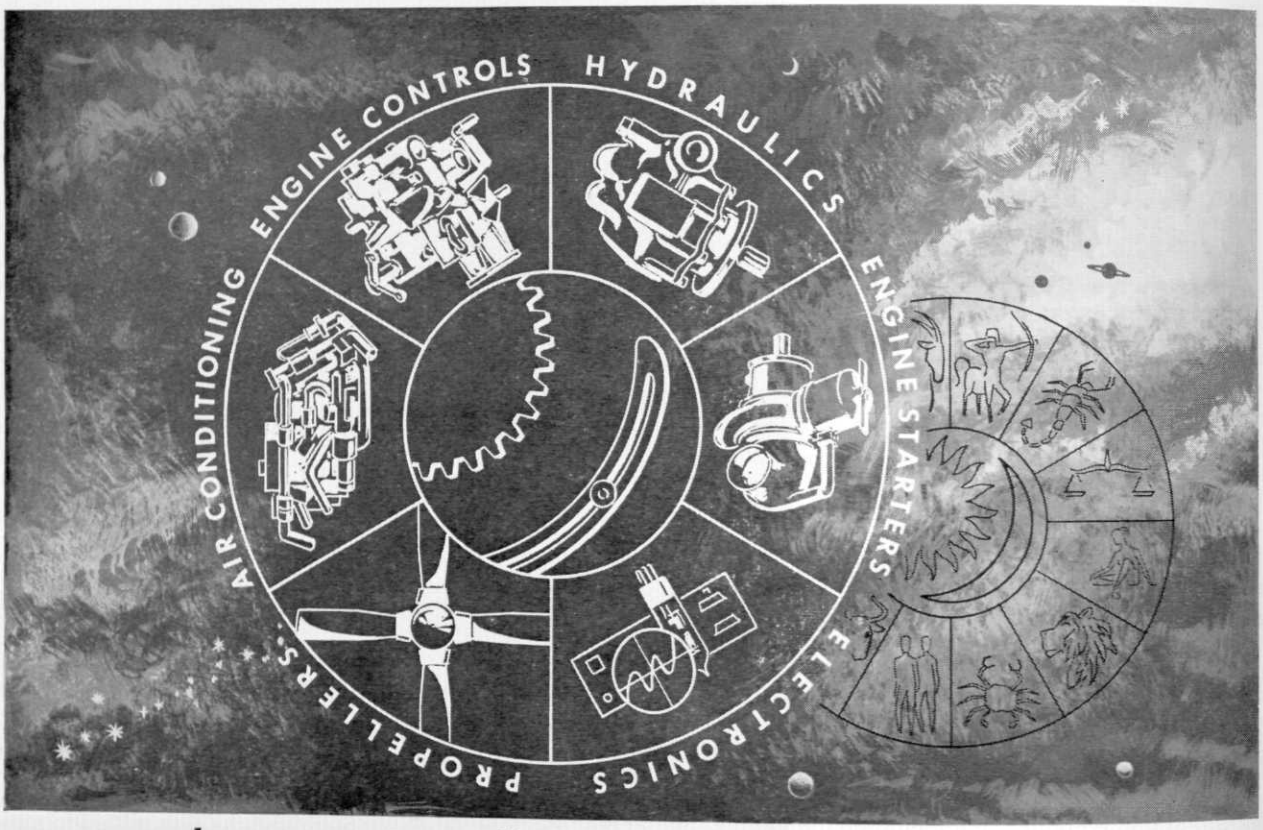
Devising a Formula

There is no general recipe, no panacea that can be applied to all situations. Each problem has to be analyzed in the light of available data. With a scientific background and the ability to work on problems analytically, the operations research group is now in a position to examine the problem quantitatively and qualitatively. The end result could be a simple mathematical model or equation of the operation involving only a few important veriables. It could also result in a model involving so many variables that an electronic computer is necessary to solve it. Finally, since operations research is not infallible, there may be no result at all, only a calculated guess from qualified observers.

Once the mathematical model is devised, the operations research group must check it in operation. They must determine if the proper weight was

(*Continued on Page 43*)

SIGN OF THE FUTURE



we make our own predictions

At Hamilton Standard, the future is in the hands of today's young engineers, from the analysis of untried, unproved systems and methods through the design and development of all our aircraft equipment.

Analytical problems are encountered in a wide range of engineering activity* as a prelude to solving the problems of design and development of environmental systems, engine controls, auxiliary power units and other vital equipment which Hamilton Standard will provide for such "out-of-this-world" aircraft as the North American B-70 bomber and F-108 interceptor. These assignments require outstanding engineers who will be working on the threshold of space. Their careers will progress as the space age advances.

The project system — small groups of engineers working together as teams provide the creative, stimulating atmosphere necessary in solving the problems of the space age.

*aerodynamics	therodynamics	control dynamics
heat transfer	stress analysis	mechanical analysis
mechanical metallurgy	vibration	systems analysis
fluid dynamics	measurement techniques	instrumentation development

reliability and statistical methods
IBM and analog computing; data deduction

If you are interested in designing and developing such products as these, contact Timothy K. Bye, Engineering Personnel Coordinator, or arrange for an interview with your college placement officer.

HAMILTON STANDARD

DIVISION OF UNITED AIRCRAFT CORP.
47 BRADLEY FIELD ROAD • WINDSOR LOCKS, CONNECTICUT

Operations Research . . .

(*Continued from Page 41*)

given to the variables, if there was a human element not taken into account, if the model really works. All the kinks must be worked out before proceeding to the next step.

Action

Once a problem has been solved to the satisfaction of the operations research group, it must be put into a form management can understand. The solution may take the form of a chart, graph, table, formula, or even a pictorial sequence. Whatever the manner of presentation, it must be cogent and germane. With this accomplished, management proper steps back into the picture to help set up a timetable for action.

The timetable must be realistic, and, if anything, a little on the long side. The plan has to take into account human actions and reactions. To lessen the human element, the explicit fixing of responsibilities should go along with the timetable. Management and operations research, authority and knowledge, must be again working hand in hand.

Follow-Through

It is the operations research group's responsibility to determine what type of statistical information should be taken and how often it should be taken. Management again, because of authority, has the responsibility to see that it is taken. To keep clerical work at a minimum, check sheets might be devised, periodic personal checks taken, and suggestions by others welcomed.

As intimated before, operations research is not a device for solving management problems miraculously. It offers management a tool for solving operational problems analytically and the thinking of men trained in being objective. The business world will obtain results only as it applies operations research with the same discriminating and objective viewpoint.

Joe: "I stayed in a hotel that had 25 rooms and no bathrooms."

Moe: "Incredible."

Joe: "No, uncanny."

° ° °

Hubby: "Of all the crazy things; that fellow on the third floor says he has kissed every married woman but one in this apartment house."

Wife: "I'll bet it's that stuck up Mrs. Bailey on the third floor!"

Brains . . .

(Continued from Page 30)

given souls to human beings alone, and to no animal or machine, it follows that no animal or machine can think.

Turing considers this view entirely too arbitrary. He points out, perhaps with tongue in cheek, that the Moslems contend that women have no souls, and that if their view is to be considered at all, the argument cannot stand up. Going further, he holds that restricting souls to mankind imposes an unreasonable restriction on the omnipotence of God, who can, it would seem, give a soul to anything he pleases. All of this, Turing admits, is nothing more than speculation, but he adds that speculation is by no means the exclusive proprety of orthodox Christians.

Arguments such as this and others presented by Turing will doubtless continue until either an actual thinking machine is perfected, or the invention proven impossible. Evidence available today points to the former eventually happening, but we cannot know for certain until it does.

In any event, whether or not computers of the future will actually think may not be too important, for whatever their capacities they will be the tools of their creators. They will certainly surpass the computers of today in all of the current applications, and will very probably perform feats undreamed of now in a civilization made far richer by their efforts.

Starting Salaries . . .

(Continued from Page 23)

what more responsible job. This assignment in turn results in a higher rate of development of the engineer's professional competence. This in turn results in his earning a larger merit raise. And so on. The compounding effect of even small differences can become very significant over an engineer's whole career.

Reverse Evaluation

An employer's task of properly evaluating an engineer-applicant is quite difficult. In these cases, it is common to (unconsciously, perhaps) reverse the usual procedure and actually "evaluate" the engineer's "worth," at least to a considerable extent, by his present salary. (It is common practice to offer an engineer more than he is presently making, but usually only a limited amount more.) Thus if an engineer is working for an employer whose salaries are uniformly low, he is likely to be in trouble if he decides to change employers. Even though his present salary will be low, his prospective employer will not be inclined to offer him more than the "normal" increase over his present salary. Thus he will fit into his new employer's salary structure as if he was a lower "quality" engineer than he really is. This "reverse evaluation" will often influence both his salary and his work assignments for many years to come.

Of course, most companies seek to rate the work performance of all the engineers relative to each other and to adjust the salary relationships to suit. There are, however, some factors which hinder the elimination of salary inequities, particularly starting salary inequities. Most salary administration schemes involve control over the maximum amount of money which can be dispensed in raises during each period of time. There are frequently limits as to the maximum raise which any one engineer may receive at any one time. Thus it sometimes happens that an "extra" increase for one engineer tends to reduce the amount of money available for other engineers. Although such adjustments are possible with most employers, in practice it is likely that more of his salary "error" will be rectified by "slotting" him lower on the "quality" curve than will be rectified by extra salary increases.

Summary

In summary, we have reached the conclusion that an engineer's hiring salary is much more important than it might appear. It is likely that his salary will tend to identify his "quality." It often influences his work assignments which in turn, influence his professional development. It can exert these influences for many years into the future. The longer an engineer works at a lower salary than his ability warrants—where this is the case—the greater is the likelihood that he will come to be thought of as a lower quality engineer, particularly by prospective future employers.

Use of the Chart

This chart plots the salary variation with "quality" at various experience levels. "Quality" is expressed as a percentile varying from the lowest (0%) to the highest (100%) within the entire engineering and scientific professions.

To use this chart, an engineer must first estimate his position in the "quality" spectrum and then determine the amount of "applicable" ex-

perience which he has acquired. The minimum starting salary which he can expect can then be read opposite the intersection of that "quality" percentile and the curve for that experience level.

Of course, no engineer, any more than any employer, can "pin-point" his position on this chart. An engineer can only estimate a range of possible "quality" evaluations. There also may be some uncertainty as to how much of his experience will be considered to be applicable. The shaded area on the chart is an example of the effect of this uncertainty. This is an example of the engineer who believes he falls between 65% and 75% in the "quality" spectrum and who has between 1½ and 2 years of experience. He should expect to receive offers between $555 and $595 per month.

In evaluating his position on this chart, a graduating engineer should consider not only his class standing but the probable influence on a recruiter of his extra-curricular activities, personality, etc. Education beyond the BS degree is considered as extra experience, usually on a year-for-year basis. The engineer who is currently employed needs to consider both his position in the "quality" spectrum within his present organization and the position of that organization within the "quality" spectrum of the entire profession.

This chart can also be used in another way. An employed engineer can enter the chart at his present salary and his current experience level. His apparent "quality" percentile, assuming his present salary is correct, can then be read at the intersection of his salary and experience lines.

Although these curves are intended to represent employed engineers and scientists rather than supervisors, they are also a reasonable approximation to the salaries of technical supervisors, at least in the range of experience levels covered.

"Dad," said a small boy, "why isn't a man allowed to have more than one wife?"

"My son," replied his father, "when you are older you will understand that the law protects those who are incapable of protecting themselves."

° ° °

Visitor: What's the name of this school?

Student: Sorry, I'm just a football player here.

Lubrication of enclosed parts can now be inspected without disassembly. Standard Oil scientists have developed the instrument system shown here which measures the presence or absence of the required lubricant on concealed parts by checking the ability of the entire assembly to cut down radiation passed through it.

How to "see" without looking

At a final inspection station how would you make sure that enclosed parts were properly lubricated? Until recently, if you really wanted to know, you had to remove the housing, disassemble the mechanism—a costly, time-consuming process—and take a look.

But now Standard Oil research has solved the problem with a new instrument system that does away with disassembly. It passes radiation through the assembly and measures the amount that gets through. Inspectors can tell whether or not the proper level of lubricant is present without looking inside.

This remarkable device is just one of hundreds of ways in which Standard has helped industry solve problems connected with lubrication. It was developed by a team of Standard Oil scientists and engineers who saw the need for a new approach to an old problem.

Such creative thinking is the product of the atmosphere in which Standard Oil scientists work. They have the time, the equipment and the opportunity to contribute to the progress of their industry and their country. That is why so many young scientists have chosen to build satisfying careers with Standard Oil.

STANDARD OIL COMPANY

910 SOUTH MICHIGAN AVENUE, CHICAGO 80, ILLINOIS

STANDARD

THE SIGN OF PROGRESS...
THROUGH RESEARCH

Systems . . .

(*Continued from Page 38*)

duction engineers work very closely with the systems personnel but generally the systems engineers enter into this phase only in an advisory capacity.

This relatively new area of engineering endeavor is becoming increasingly important in industry today. It is very likely that there is or will be a systems engineering company; a group of consulting engineers, scientists and business administrators whose aim will be to make the necessary decisions so that a particular system will be the most efficient within the stringent requirements specified by the customer.

Propulsion . . .

(*Continued from Page 20*)

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.

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.

With this tremendous power and its devasting payload, the Atlas now provides the U. S. with a weapon capable of hitting a target anywhere in the world with deadly accuracy. Retallitory weapons such as this provide an increasing safeguard to the peace of the world.

There's much more to it than just the size of the FISH and the size of the POND

O

We've been told that an engineering graduate is frequently attracted to companies our size because of his understandable human desire to be "a big fish in a little pond".

While it is true that (numerically speaking) our employee team is small compared to some, we encounter great difficulty in trying to think of Sikorsky Aircraft as a "little pond". Our contributions to the field of rotary-winged aircraft have not been small, nor can our field be considered limited or professionally confining. Quite the contrary. Sikorsky Aircraft is the company which *pioneered* the modern helicopter; and our field today is recognized as one of the broadest and most challenging in the entire aircraft industry.

And what of the size of the "fish"?

Unquestionably, that is a matter involving your own individual potential for growth. Like any far-sighted company, we're always willing to talk with "young whales"!

For factual and detailed information about careers with us, please write to Mr. Richard L. Auten, Personnel Department.

SIKORSKY AIRCRAFT

ONE OF THE DIVISIONS OF UNITED AIRCRAFT CORPORATION

BRIDGEPORT-STRATFORD, CONNECTICUT

The Atlas . . .

(*Continued from Page 14*)

apply the product rule. We find that the overall reliability of the missile is:

$$(.99)^{100}=.365 \text{ or } 36.5\%$$

This means that out of every three missiles fired, two will fail. A missile with 1000 parts (assuming the same component reliability) would seldom work.

One can readily see, by this, that a missile such as the Atlas (more than 40,000 parts), must have a very high percentage of component reliability or it would never work.

Complete failure of a component need not result to cause a malfunction of the complete system—a change in value of one or more of the electronic components due to changes in temperature or moisture invading the guidance-sensing system might alter the path of the missile sufficiently to cause its destruction.

For this reason, elaborate failure-reporting systems are used, and every bit of evidence is studied to provide evidence of parts needing redesign or better quality control. In this way it is possible to find out whether the reliability of certain components was increased by a new process; whether, say, one tube-type is preferred over another, or which components most need improvement.

The problem of reliability is always foremost in the minds of the missile engineers, ever striving to make improvements that will increase the reliability of their product.

The Atlas is one missile born in a long line of yet unconceived missiles which will some day be developed with a maximum reliability factor and have the "punch" to penetrate deeper into the endless space frontier.

An E.E. stared into a mirror one morning and, noting his bloodshot eyes, resolved never to go into a bar again. "That television," he muttered, "is ruining my eyes."

° ° °

A preacher at the close of his sermon discovered one of his deacons asleep. He said, "We will now have a few minutes of prayer. Deacon Brown you lead!"

"Lead?" cried Deacon Brown, suddenly awakening, "I just dealt!"

SIDETRACKED

(*Continued from Page 32*)

In Hungary, a commissar asked a peasant how the potato production was coming along.

"Oh, fine," answered the peasant. "We have so many potatoes that if we put them in a pile, they would reach clear up to God."

"But, you know there isn't any God," replied the commissar.

"Well, there aren't any potatoes either," said the peasant.

° ° °

Then there was the college basketball player who was so dumb that when he got his letter somebody had to read it to him.

° ° °

Have you heard about the two engaged nudists who decided to break it up because they had been seeing too much of each other?

A Colorado hunter climbed into a tree so nobody would take him for a deer. It worked, too—he was shot by mistake for a bear.

° ° °

The trouble with being best man at a wedding is that you don't have a chance to prove it.

° ° °

Telling some brides what they should know on their wedding night is like giving a fish swimming lessons.

° ° °

Stable Air: An atmosphere tinged with the odor of fertilizer.

° ° °

A professor is a man whose job it is to tell students how to solve the problems of life which he himself has tried to avoid by becoming a professor.

A manufacturer of ladies foundation garments has just introduced a new line of brassieres called the "Embargo." It doesn't make sense until you spell it backwards.

° ° °

A social service worker among some mountaineers was quizzing her class about the Bible.

"Lizzy," she asked, "please tell us who was the first man?"

The mountain girl blushed deeply then flared out, "I'd druther die than tell you!"

° ° °

Porter: "Did you miss the train, sir?"

Running Passenger: "No! I didn't like the looks of it, so I chased it out of the station."

(*Continued on Page 52*)

ENGINEERS AND SCIENTISTS

at Convair-San Diego find an unusual climate for professional development. Projects range from the great new Convair 880 and 600 Jet-Liners, to the F-106 Delta Dart interceptor and manned satellite vehicles. The company has a distinguished history of flight spanning more than a third of a century. Dynamic policies, forward-looking management, and joint projects with other divisions of General Dynamics Corporation all serve to broaden the scope of challenge and responsibility.

The extraordinary climate of San Diego is world famous. It varies from cool, breeze swept beaches, to warm, dry deserts. Hiking and camping are minutes away in the nearby Laguna Mountains, and Old Mexico is just 15 miles south of the city.

Engineers discuss 880 fuselage structure test data. This 360,000 gallon water test tank is just one example of the complete facilities provided engineers and scientists at Convair-San Diego.

We are particularly interested in undergraduate and graduate students majoring in
AERONAUTICAL, MECHANICAL, CIVIL, ELECTRICAL AND ELECTRONIC ENGINEERING
Plus graduate students majoring in **PHYSICS & MATHEMATICS**

A new brochure describing careers at Convair-San Diego is available upon request. Please write to Mr. M. C. Curtis, Industrial Relations Administrator-Engineering

CONVAIR/SAN DIEGO A DIVISION OF GENERAL DYNAMICS

3302 PACIFIC HIGHWAY, SAN DIEGO, CALIFORNIA

SIDETRACKED

(Continued from Page 50)

"He says I don't know how to dress, huh. Well, tonight I'll wear my low cut dress—and show him a thing or two."

° ° °

"Newport, or Atlantic City. I wasn't on the Pullman car of the New York Central last Tuesday. I know I'm good looking and I'm not bashful. I'm not going your way, and I wouldn't ride with you on a bet. I didn't go to school with you; I'm waiting for a streetcar; I don't want a light; and I know plenty of college boys. Furthermore, I have a fiance who weighs 220 pounds. Now, were you going to say something?"

He (still in car): "Yes. You're losing your underwear."

The customer approached the bar and kept his eyes on the attractive blonde at the other end of the bar. After a minute or two of gazing, the bartender approached him and said, "That's my girl down there so get those ideas out of your head!"

"What!" he said. "What ideas? I never thought such a thing. Give me an armful of beer, please."

° ° °

Woman: "Son, can you direct me to the bank?"

Small Boy: "Yassum, for a quarter."

Woman: "Isn't that mighty high?"

Boy: "No, Ma'am, not for a bank director."

"Say, dad," the college student asked, "What can I do about it? There's a very pretty girl who talks to me day after day in class so that I forget my studies."

"You can do many things," replied his dad, "Such as change seats or drop out of college. However, if she is like your mother, she'll get you anyhow."

° ° °

After a rather wild date with a charming young lady, her escort, a bit worried, asked: "Do you tell your Mother everything you do?"

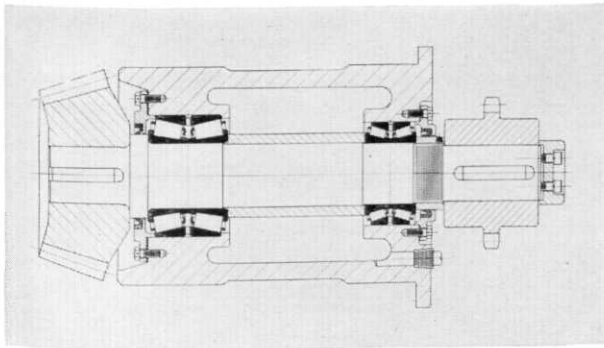
She looked up and said: "Certainly not. Mother doesn't care. It's my husband who's so inquisitive."

How to keep the world's largest clock sign turning on time

THIS revolving clock sign, the world's largest, weighs in excess of 77 tons, has numerals 25 ft. high. And it turns day and night atop the Continental National Bank in Fort Worth, Texas. To keep this giant clock turning, the engineers specified two double-row Timken® tapered roller bearings for the Brewster RSH 18″ Rotary Table which turns the clock.

Timken bearings are used because the full-line contact between their rollers and races gives extra load-carrying capacity. Their tapered construction lets them take both radial and thrust loads in any combination. And Timken bearings are geometrically designed and precision-made to roll true. They practically eliminate friction.

Timken bearings solve countless problems wherever wheels and shafts turn. Problems that you may face in your future job in industry. Our engineers will be ready to help you. And if you're interested in a rewarding career with the world's largest maker of tapered roller bearings and removable rock bits, the leader in special fine alloy steel, send for our free booklet: "Better-ness and your Career at The Timken Company". Write Mr. Russ Proffit, The Timken Roller Bearing Company, Canton 6, Ohio.



How Timken bearings are mounted in the Brewster RSH 18″ Rotary Table to take heavy loads, assure easy-rolling dependable performance.

BETTER-NESS rolls on

TIMKEN®

tapered roller bearings

First in bearing value for 60 years

Henri Bergson...on making gods

Humanity is groaning, half-crushed under the weight of the progress it has made. Men do not sufficiently realize that their future depends on themselves. They must first decide whether they wish to continue to live. They must then ask whether they want merely to live, or to make the further effort necessary to fulfill, even on our unmanageable planet, the essential function of the universe, which is a machine for making gods.

Les deux sources de la morale et de la religion, 1932

He's an Allis-Chalmers Engineer

He has confidence born of knowing where he's going and how he's going to get there. The graduate training program at Allis-Chalmers helped him decide on a *specific* career — and he had a choice of many. He knows his future is bright because Allis-Chalmers serves the growth industries of the world . . . produces the widest range of industrial equipment. He is confident of success because he is following a successful pattern set by Allis-Chalmers management.

Here is a partial list of the unsurpassed variety of career opportunities at Allis-Chalmers:

Types of jobs

Research
Design
Development
Manufacturing
Application
Sales
Service

Industries

Agriculture
Cement
Chemical
Construction
Electric Power
Nuclear Power
Paper
Petroleum
Steel

ALLIS-CHALMERS

A-5882

American Airlines

Equipment

Steam Turbines
Hydraulic Turbines
Switchgear
Transformers
Electronics
Reactors
Kilns
Crushers
Tractors
Earth Movers
Motors
Control
Pumps
Engines
  Diesel
  Gas

Fields

Metallurgy
Stress Analysis
Process Engineering
Mechanical Design
High Voltage Phenomena
Nucleonics
Electronics
Hydraulics
Insulation, Electrical
Thermodynamics

from GTC to "VIP"

The graduate training course helps you decide on your "Very Important Position," by giving you up to two years of theoretical and practical training. This course has helped set the pattern of executive progress since 1904. For details write to Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.

START TODAY TO PLAN TOMORROW

By knowing about some of the projects underway at the Babcock & Wilcox Company, an engineer may see his personal avenues of growth and advancement. For today B&W stands poised at a new era of expansion and development.

Here's an indication of what's going on at B&W, with the consequent opportunities that are opening up for engineers. The Boiler Division is building the world's largest steam generator. The Tubular Products Division recently introduced extruded seamless titanium tubing, one result of its metallurgical research. The Refractories Division developed the first refractory concrete that will withstand temperatures up to 3200 F. The Atomic Energy Division is under contract by the AEC to design and build the propulsion unit of the world's first nuclear-powered cargo vessel.

These are but a few of the projects — not in the planning stage, but in the actual design and manufacturing phases — upon which B&W engineers are now engaged. The continuing, integrated growth of the company offers engineers an assured future of leadership.

How is the company doing right now? Let's look at one line from the Annual Stockholders' Report.

CONSOLIDATED STATEMENT OF INCOME
(Statistics Section)
(in thousands of dollars)

1954	1955	1956—UNFILLED ORDERS (backlog)
$129,464	$213,456	$427,288

B&W engineers discuss developments in the Universal Pressure Boiler.

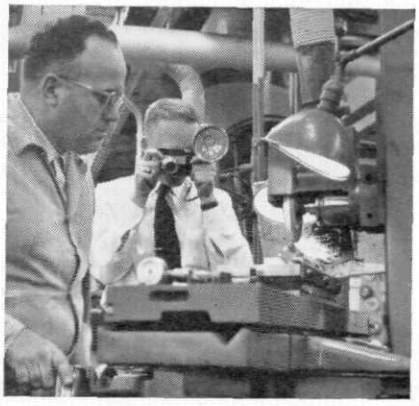
Ask your placement officer for a copy of "Opportunities with Babcock & Wilcox" when you arrange your interview with B&W representatives on your campus. Or write, The Babcock & Wilcox Company, Student Training Department, 161 East 42nd Street, New York 17, N. Y.

BABCOCK & WILCOX

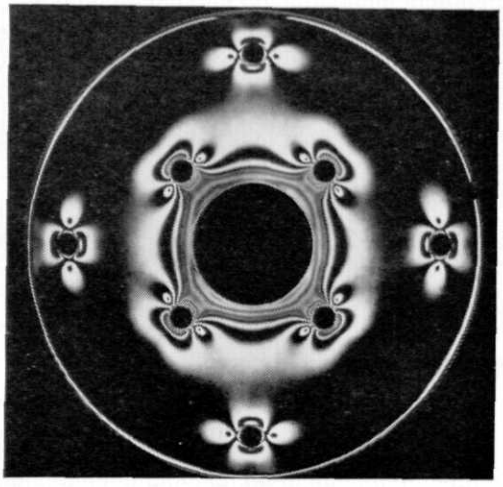
N-220

ADVERTISERS' INDEX

From research to finished product–
Photography works with the engineer



Sparks fly as the plant photographer records a grinding technique for study.



Photoelastic stress analysis helps the design engineer *pinpoint areas requiring extra strength.*

Giant machines produce a flow of photo-exact engineering drawings—save countless hours of drafting time.

Today photography plays many important roles in industry. It speeds engineering and production procedures. It trains and teaches. It sells. In whatever work you do, you will find photography will play a part in improving products, aiding quality controls and increasing business.

Careers with Kodak

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.

Color transparencies on the production line aid operators in assembly operations—save time and reduce errors.

EASTMAN KODAK COMPANY
Rochester 4, N.Y.

Kodak
TRADE MARK

Interview with Generc

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.**

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