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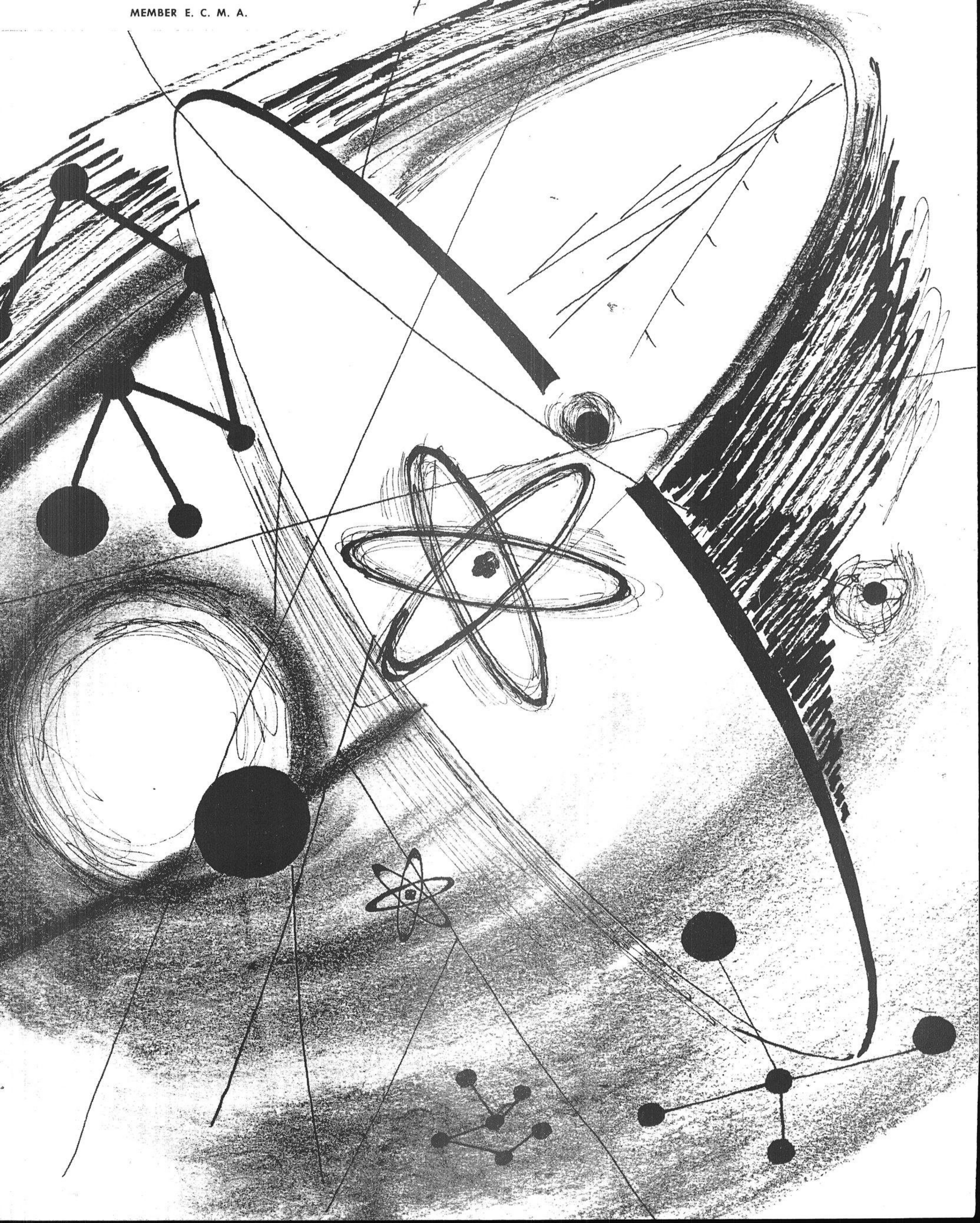
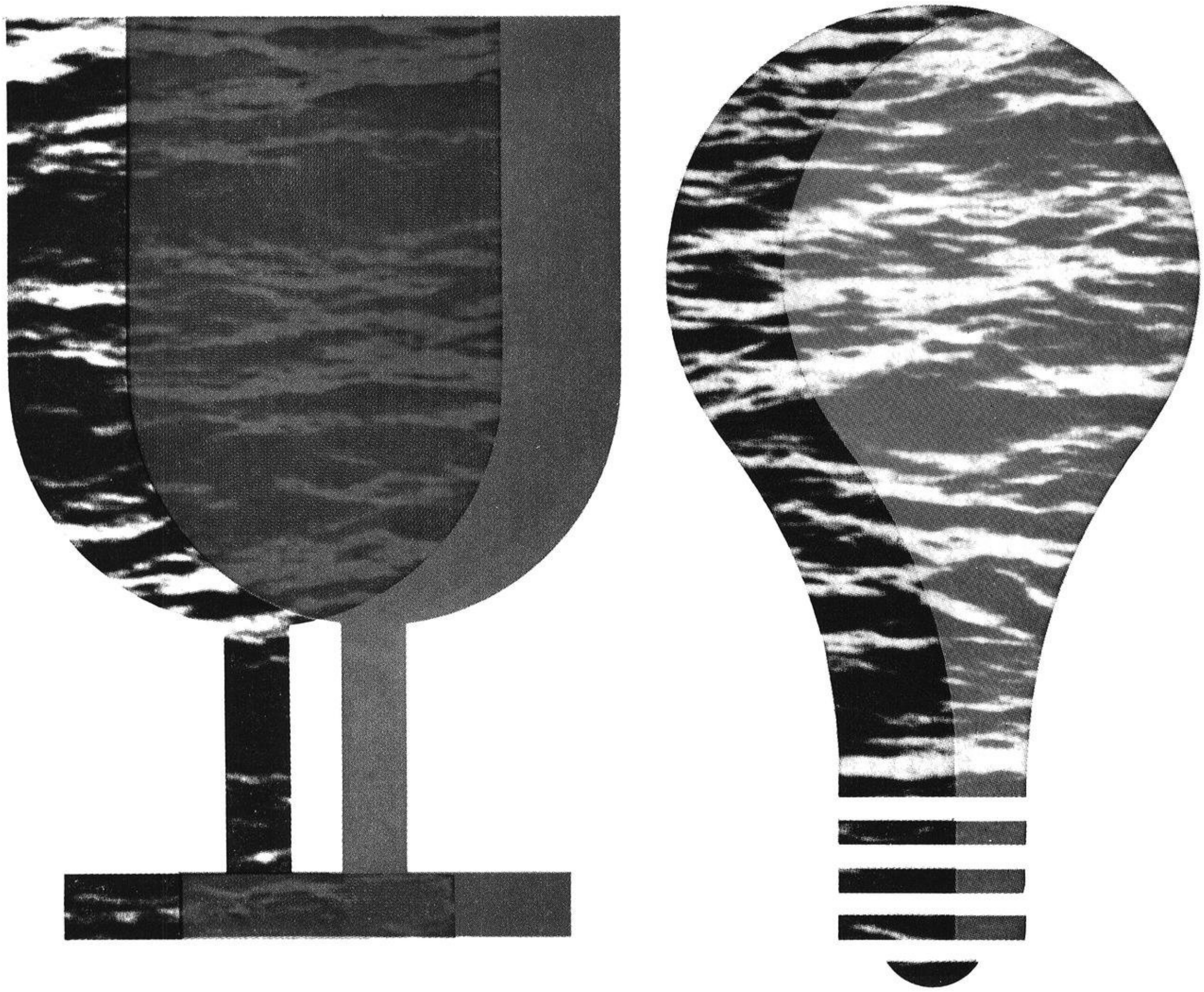
THE WISCONSIN ENGINEER

MAY 1964 • 25 CENTS

MEMBER E. C. M. A.





Fresh water and electricity...from one Westinghouse super-factory

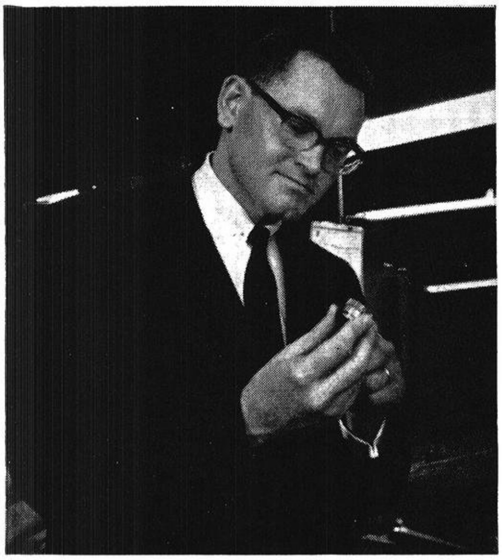
Imagine a modern factory that can produce 500,000 kilowatts of electric power—and at the same time take water from the sea and make it drinkable at the rate of 50 million gallons a day. That's enough power and water for a population of half a million.

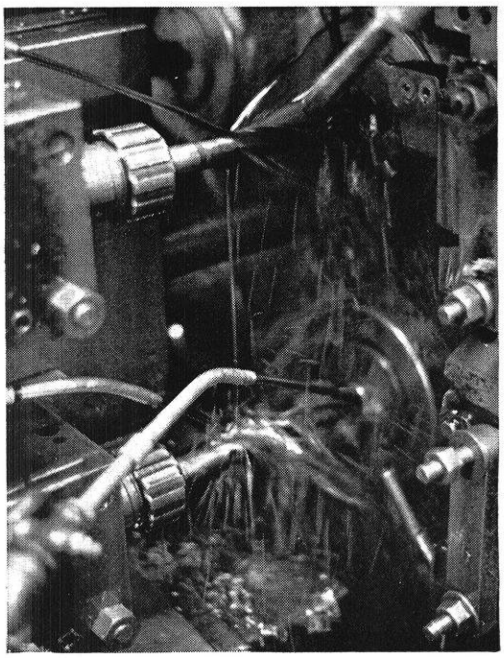
No such super-factory exists anywhere in the world. Not yet. But a small-scale version of the Westinghouse system is being built by Burns and Roe, Inc. for an electric utility in the Canary Islands. Waste heat from the electric power turbines will convert sea water to fresh by a flash distillation process, providing abundant electricity and water for industry, agriculture and home uses. And at a lower cost than now exists in many parts of the world.

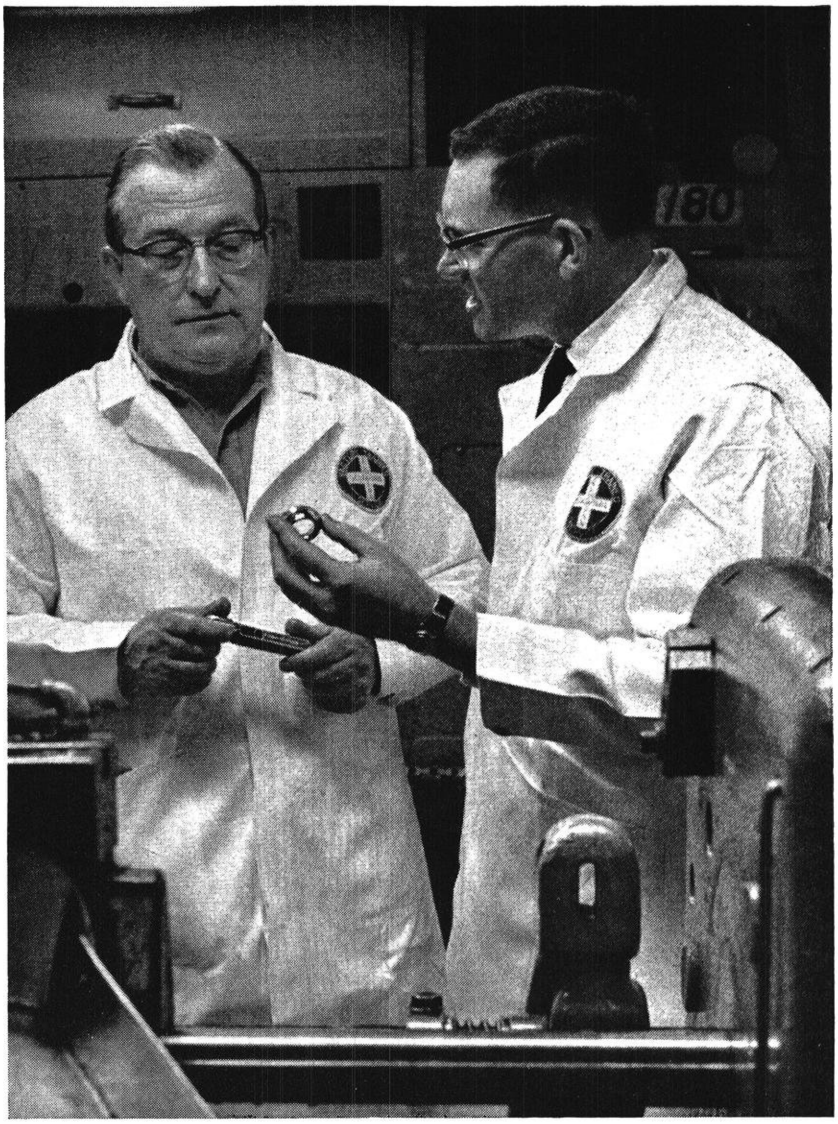
Westinghouse can build large or small sea water super-factories for electric utilities in any coastal area. And as research continues, scientists may find a practical way to harvest chemicals from sea water in the same process.

You can be sure if it's Westinghouse

For information on a career at Westinghouse, an equal opportunity employer, write L. H. Noggle, Westinghouse Educational Department, Pittsburgh 21, Pa.







Bob Turley, on right, American Oil Company Sales Engineer discusses cutting oil problem with Walter Binkley of Schwinn Bicycle Company.

When you drill • tap • form • mill • shape all in 22 seconds... what do you use for oil?

That's the kind of problem a sales engineer here at American Oil comes up against. It actually happened to Bob Turley when the Schwinn Bicycle Company asked him what oil he'd recommend for this complicated metal cutting problem. He had the answer—one of our special cutting oils—he solved the problem, and made the sale.

Bob's a graduate of Purdue—and the American Oil Company Sales Engineering School. He knows machines and oils. He's our "outside" man with the inside track on lubricants. And, he likes meeting people. That's why he's a sales engineer, combining two fields into a successful career.

Bob's a mechanical engineer. Yet, he might have been working for us if he were a metallurgist, chemist, mathematician or physicist. Petroleum takes on a multitude of uses and requires people of every skill. For information regarding a career in sales engineering or other fields, write to C. L. Wells, Room 1036, American Oil Company, 910 S. Michigan Avenue, Chicago, Ill. ZIP Code 60680

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VOLUME 68, NUMBER 8 MAY 1964

ARTICLES

THE WISCONSIN ENGINEER

The Student Engineer's Magazine Founded in 1896

FEATURES

THIS MONTH'S COVER

Jim Lawton has artistically depicted a futuristic abstraction of the neutrino.

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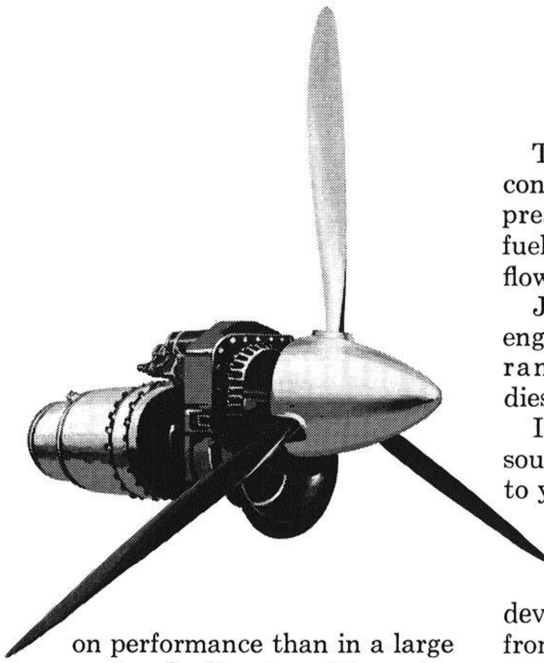
Everything we learned from building 10,000 small gas turbine engines has been packed into this new 600-horsepower turboprop engine —and it shows!



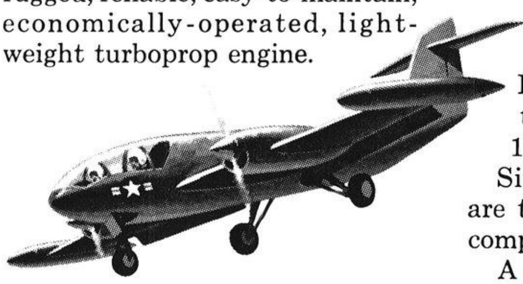
You'd probably expect the world's largest manufacturer of small gas turbine engines to turn out the world's finest small turboprop job.

And we have.

We call our new engine the TPE-331. (The military version is designated T-76.) It is a versatile turbine capable of powering many vehicles. Its 600-horsepower category makes it particularly suitable for the new generation of executive and military fixed-wing aircraft.

More specifically, our new prime propulsion engine is designed to fill the gap between reciprocating engines and larger turboprops.

And the reason we built it, is because both civil and military sources have asked for a simple, rugged, reliable, easy-to-maintain, economically-operated, lightweight turboprop engine.



The Garrett-AiResearch TPE-331 more than fills the bill.

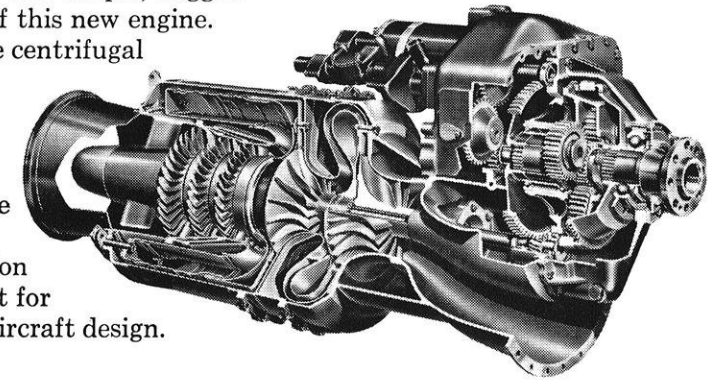
Obviously, building such an engine is a specialized art that demands experience, especially in miniaturization of controls, oil pumps, and starter motors.

Manufacturing tolerances are precise and have a greater effect on performance than in a large engine. Scaling down big engine techniques is not the answer.

The TPE-331 has a specific fuel consumption of .62 pound per shaft horsepower hour. Its weight to power ratio is .45 pound per horsepower. Response rate from flight idle to full power is approximately 1/3 of a second.

Single-casting turbine wheels are typical of the simple, rugged components of this new engine.

A two-stage centrifugal compressor is driven by a 3-stage axial turbine. Propeller drive is through a 2-step reduction gear box offset for flexibility of aircraft design.



The fuel system of the TPE-331 consists of a fuel filter, single high-pressure pump, speed-governing fuel control, manual shutoff valve, flow divider and fuel nozzles.

JP-5 is the normal fuel, but this engine will take all kinds of fuel, ranging from AV-gas to light diesel fuel.

If this new turboprop engine sounds like something very special to you, we've made our point.

The TPE-331 *is* an exceptional engine.

It's the kind of a power development you'd expect to come from Garrett. For when it comes to turbine engines under 1000 horsepower...

Garrett *is* experience

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For further information about many interesting project areas and career opportunities at The Garrett Corporation, write to Mr. G. D. Bradley at 9851 S. Sepulveda Blvd., Los Angeles. Garrett is an equal opportunity employer.

Rambling With The Editor

Towards a More Profitable Summer

With the end of the semester fast approaching, most college students are happily looking forward to the summer vacation. This long-awaited vacation is viewed with feelings of relief from the constant tension of studies and anticipation of good times ahead. As the summer progresses, however, these feelings often tend to change rapidly to boredom.

Many engineering students obtain jobs with government agencies and industry during the summer, gaining experience in their field while earning sometimes substantial sums of money to help pay college expenses. They too may often fall victims to the boredom that free evenings breed and the tediousness that results from a regular daily routine.

We propose that these engineers use some of their free time for constructive activity, namely, reading a few good books. Our heavy load of technical courses does not permit this in our regular studies, although we feel that this could be beneficial. In addition to making the engineer a more well-rounded person with a myriad of general knowledge, his vocabulary and writing ability will benefit substantially. Besides, when he comes back to school in the fall, he won't find the feel of a book in his hand quite as strange as it sometimes is. Here are a few that we have tried and hope that you will too. Most of them are available in paperback editions for less than a dollar.

Catch 22, Heller
The Thin Red Line, Jones
Fail-Safe, Burdick & Wheeler
Profiles in Courage, Kennedy
8 Years of Crisis, Stevenson
Silent Spring, Carson
Six Crises, Nixon
Walden Two, Skinner
Mandate for Change, Eisenhower
The Conscience of a Conservative, Goldwater
The Making of the President—1960, White
Franny & Zooey, Salinger

Best wishes for a happy and profitable summer!—RJS

Reliability Engineering

By Ronald L. Martin, EE'64

Ron Martin is a senior in electrical engineering. He is married and has worked for Remington Rand as an assistant reliability engineer. His article won second place in the IEEE paper writing contest.

THE major function of a reliability engineering group is to obtain the appropriate degree of probability of success for a given time interval for a given system. In commercial engineering applications this group will try to achieve the lowest probability of success using lower costs while maintaining customer satisfaction. In missile or computer installations where most failures are extremely costly, this group will strive to obtain the highest degree of probability of success. In other applications this group will try to achieve the most economical crossover point between design costs, construction costs, and maintenance costs using reliability considerations.

A definition of reliability is: the *probability* of a device giving *adequate performance* for a certain length of *time* under specified *operating conditions.* There are four key terms in this definition of reliability. These are:

a. Probability—a number from zero to one, or per cent from zero to one hundred, signifying how many times an event may occur out of a total number of trials. It is usually signified as Ps.
b. Adequate Performance—criteria must be established which clearly specify satisfactory operation.
c. Time—the cornerstone of all reliability concepts. It represents a measure of the period during which a certain degree of performance is expected.
d. Operating Conditions—includes such factors as temperature, humidity, shock, and vibration.

Probability and time are the two major terms of interest to a Reliability Engineer.

The overall system reliability of a typical piece of equipment is shown in Figure 1. The support reliability is due to the external effects on the equipment. The reliability engineering group has very little to do with the support reliability. This is determined by capability of personnel, environmental conditions encountered, maintenance procedure used and operational suitability. The inherent reliability is the built-in reliability of the system. Of the five headings under inherent reliability, the component parts and application along with component operational parameters are of major concern to the reliability engineer. The overall system reliability is the product of the support reliability and inherent reliability ($R1 = R2 \times R3$). If the reliability group succeeds in obtaining a large value for R3, the overall system reliability will be increased as shown in the above relationship.

There are two basic concepts which form the foundation for all rules governing the numerical re-

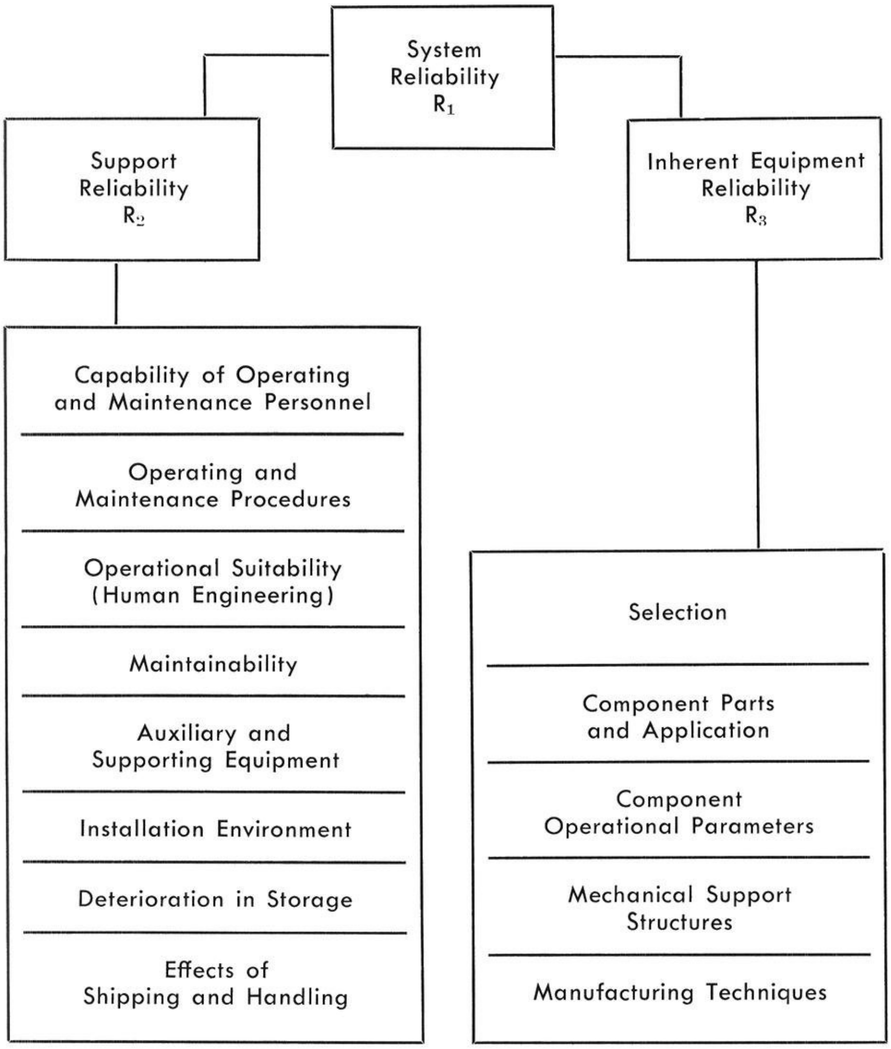


Figure 1. Overall system reliability.

liability predictions for electronic equipment. These are:

a. All equipments fail due to performance degradation.
b. In addition to performance degradation, all equipment fails because of catastrophic failures.

Catastrophic failures are impossible to eliminate and very difficult to decrease. A common practice to decrease the effects of catastrophic failures in vital locations is using redundancy in design. The reliability engineering group deals mainly with trying to decrease the effects of performance degradation.

There are three types of products usually encountered in reliability work. These are:

a. Products which must operate continuously over a period of time. Examples of this type are radar, sonar, and computers.
b. Single use "one shot" products which can be tested before use. Examples of this type are inertial guidance systems.
c. Single use destructive products which cannot be tested before use. Examples of this type are igniters and rockets. The reliability does not degrade with time. It is a "Go—No Go" type of mission.

This article will be limited to the products which operate continuously as described in "a". Reliability considerations for the single shot type are very similar to those that operate continuously except for the extensive checkout procedures required for the single shots. A very high reliability goal is required in these installations as most failures are extremely costly. The difficulty encountered in obtaining a high degree of probability with time may best be illustrated by the following example:

> If a machine had 1000 series building blocks and the Ps of each block is 99.99% for 24 hours, the probability of the entire system working for 24 hours would only be 91%.

A typical common life characteristic curve for an electronic system is shown in Figure 2, giving failure

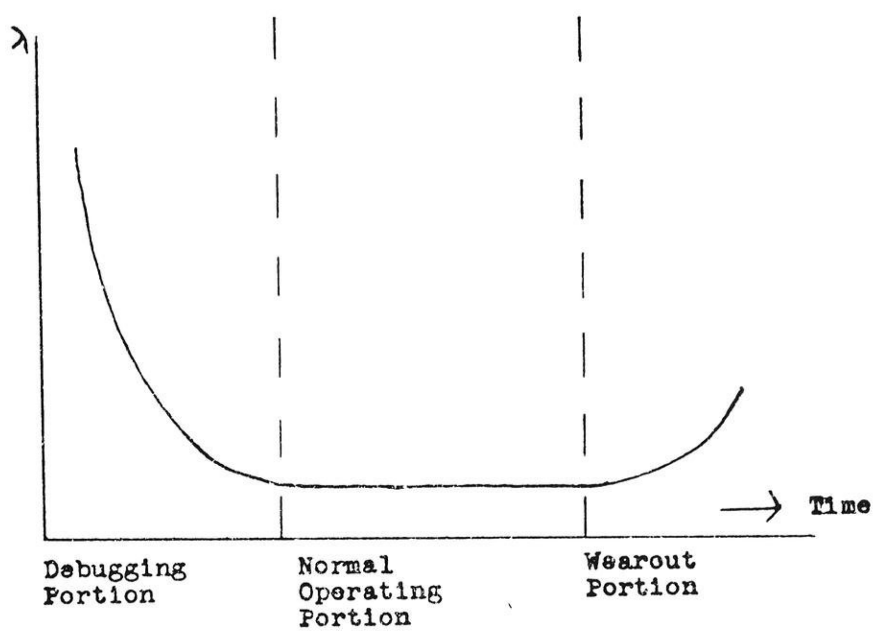


Figure 2. Failure rate of an electronic system.

rate λ vs time. There are three major portions of this curve. These are:

a. Debugging—well known throughout most industries. Examples are the initial miles clocked by the auto manufacturers and the initial hours played by the TV manufacturers.
b. Normal Operation—the curve appears flat in this portion. All failures are considered random and independent according to Poisson's process.
c. Wearout—normal end of life failures.

The reliability engineer is mainly interested in the flat portion of the curve. For a given curve plotted for a system, a Kolmogorov–Smirnov Test for goodness of fit is used to determine if the cumulative probability of the observed failure data on the flat portion fits the theoretical cumulative probability distribution for the exponential case derived from using the Poisson approach. This simply means that the maximum difference between deviations in the flat portion of the curve is within a certain critical value specified on the Kolmogorov–Smirnov chart. If the goodness of fit test is failed, the reliability predictions from any test must be based on an exact knowledge of the full life characteristics curve for each piece of equipment. If the goodness of fit test holds, the Poisson approach to the probability predictions hold.

Poisson's Probability Derivation is given in Figure 3. The final result is the equation:

$p = \exp(-t/m)$ or $p = \exp(-tb)$

where p = probability of success
t = time of test
m = mean time between failures
f = failure rate

This exponential law applies to the distribution of the time intervals between failures and holds only for the flat portion of the curve. Referring to the flat portion of the curve in Figure 2, a constant failure rate is observed. If the quantity of each length of time between failure is plotted, that is, the number of the shortest intervals, the number of the next longest intervals and so on, the envelope established will form the exponential curve of Figure 4.

Let n = initial number of items under test
s = # of items still surviving at time t
$P = s/n$ = proportion of surviving items at t
f = failure rate at t

$$\frac{ds}{dt} = -fa$$

$$\frac{dP}{dt} = -fP$$

$$\frac{dP}{P} = -fdt$$

$$\ln P = -ft + c$$

$$@t = 0,\ P = 1$$

$$\text{thus } c = 0$$

$$P = e^{-ft} \text{ of } P = e^{-t/n}$$

Figure 3. Poisson's probability derivation.

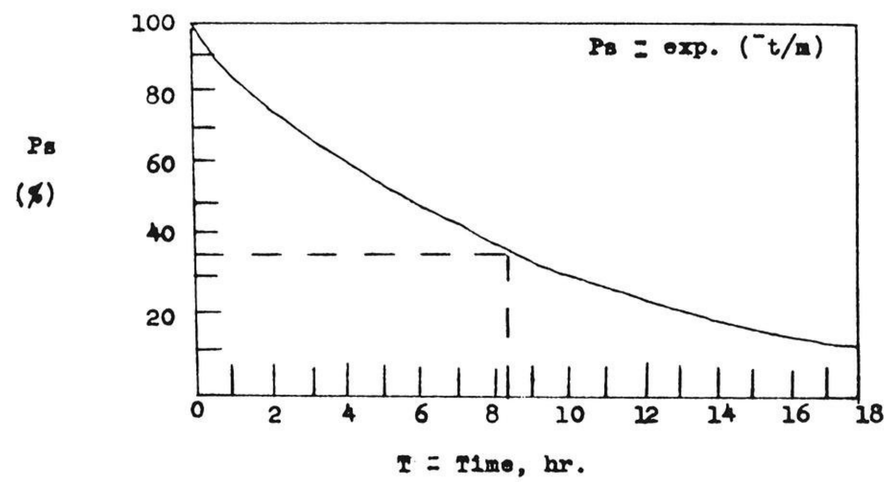


Figure 4. Reliability curve.

A typical Poisson reliability curve shown in figure 4 can be used to predict the probability of success for any time t using $Ps = \exp(-t/m)$. The probability of occurrences of failures can be found by subtracting Ps from one. A failure is defined as an operation outside specified tolerances.

The reliability curve is used extensively by reliability engineers. Using data from short time test, reliability predictions can be made for any time t. When the time of test (T) equals the mean time to failure (m), the probability of success (Ps) equals 37%. It can be seen that the way a reliability engineer can increase the probability of success of a device is to decrease the failure rate. If it is assumed that mature design is considered, the selection of components will be a major factor in decreasing failure rate.

Another major factor in decreasing failure rate is by extensive use of failure analysis. All test failures should be considered as a source of reliability information, keeping in mind the objective is to determine the cause of failure and to eliminate the cause.

A good example of what a conscientious reliability program can accomplish may be best illustrated by results reported for the Athena computer. Athena is a Digital Guidance Computer developed by Remington Rand Univac for the U. S. Air Force Intercontinental Ballistic Missile Program. This computer has been used to launch 26 Titan missiles, 6 Thor Able missiles, and 5 space vehicles. Eight of the computers are reported to have operated 13,540 hours with only 7 failures prior to March, 1961. This represents less than 1 failure per computer for each 7 months of operation and mean time to failure of 1700 operating hours. With more than 75,000 components per computer, the failure rate of the electronic parts is less than 1 failure per billion component hours. What this means is that if one billion of the components were operated for one hour, one faiure would occur.

The state-of-the-art is rapidly advancing so it is highly probable that further reduction in failure rate may be accomplished in the near future.

THE BELL TELEPHONE COMPANIES SALUTE: JOHN M. CORUTHERS

A challenging job dealing with people and figures—that was John M. Coruthers' career goal when he left college seven years ago with an electrical engineering degree.

And John found the job, responsibilities and long-range career opportunities he wanted with the Illinois Bell Telephone Company.

His first assignment was supervising telephone installation and repair crews. Recognizing his leadership abilities, John's company promoted him to District Installation Superintendent. And in only a short time, he was advanced to his present position of District Plant Manager—an even more responsible job.

But does the job deal with people? Well, thousands of businesses and residences in the heart of Chicago depend on John, and the more than 200 people he supervises, for the smooth flow of communications.

John M. Coruthers, like many engineers, is impatient to make things happen for his company and himself. There are few places where such restlessness is more welcomed or rewarded than in the fast-growing telephone business.

BELL TELEPHONE COMPANIES

TELEPHONE MAN-OF-THE-MONTH

THE NEUTRINO

By Richard J. Bethke, ME'64

Richard, a senior in mechanical engineering, plans to enter graduate school in January of 1965. He is a member of the A.S.M.E.

THE first clues to the existence of the neutrino came from beta-decay.

The nucleus of an atom contains two types of particles—protons and neutrons. Each atom of a certain element has a definite number of each of these particles (disregarding isotopes for clarity). When the atom has this number, it is stable and remains unchanged indefinitely; however, when an atom has either extra protons or neutrons it is unstable and will change until it has the number of each needed to be stable. If the atom has one too many neutrons, a neutron transforms into a proton and an electron; the proton will remain in the nucleus while the electron will be shot out of the atom. If the extra particle is a proton, it will change to a neutron and a positively charged electron called a positron. Notice that electric charge is conserved in these transformations (i.e. proton [+] → neutron [o] + positron [+]).

If an ordinary aluminum atom, stable with 13 protons and 14 neutrons, is exposed to neutrons being emitted, say, from an atomic pile, the aluminum atom's nucleus will pick up an extra neutron, producing an unstable atom—aluminum 28. A spontaneous adjustment will take place in a few minutes. The extra neutron will change into a proton and an electron; the electron is ejected, leaving a stable nucleus of a different element, Silicon 28.

This type of spontaneous adjustment in the nucleus of unstable atoms is known as beta-decay. The electron or positron given off is a beta particle, producing beta radioactivity. This type of radioactivity has been known since about 1900 and is given off by such naturally-occuring radioactive elements as radium.

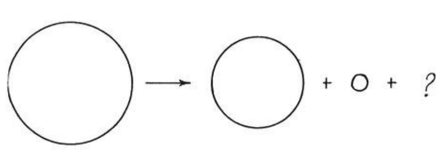
When a nucleus undergoes beta-decay, some of its energy goes into the kinetic energy of the ejected particle and is carried off. Since energy is always conserved, one would expect that the energy carried away would be equal to the energy lost by the nucleus. The energy lost from the nucleus comes originally from the conversion of a tiny amount of mass to energy; thus, the total mass of the beta particle plus the transformed stable nucleus is smaller than the original unstable nucleus by the amount of energy given up as K.E. in the emitted electron.

Even prior to 1930, the masses of the particles involved were known, and the energy gotten from mass conversion was easily calculated using Einstein's famous $E = MC^2$ equation.

In 1927 Ellis and Wooster measured the kinetic energy of emitted beta particles. This was done by placing a beta radioactive element in a thick lead tube. The beta particles emitted inside the tube crashed into the lead walls and were stopped. Their kinetic energy was converted to heat and the temperature rise of the lead was carefully checked. By knowing the amount of energy needed for a given temperature rise, and noting the rate at which the particles were emitted, the kinetic energy per particle was found.

Neutrino Clue 1

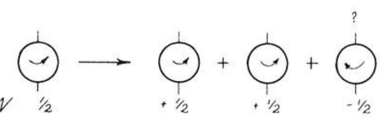
The kinetic energy was not, however, the same as that given up by the nucleus; the nucleus was losing more energy than that which was carried away by the beta particle. Other experiments showed that the beta particle took seemingly random amounts of energy; sometimes it took almost all the energy lost by the nucleus, and other times very little. The scientific world was perplexed. The conservation-of-energy law did not seem to hold for this case.



Clue #1 in beta decay, the kinetic energ. carried away by beta particle was not the same as that emitted by nucleus.

Neutrino Clue 2

The problem was compounded by the fact that angular momentum of the particles involved in beta-decay did not seem to be conserved either. (Each type of particle has its own intrinsic spin and angular momentum. Every neutron, for instance, is spinning on its axis at the same speed, and since all neutrons have the same mass, they all have the same angular momentum. Angular momentum is measured in units of spin which are arbitrary



Neutrino Clue #2 the spin of the decaying particle is not equal to the spin of the created particles.

units taking the spin of an electron as ½.) In beta-decay, the problem arose when it was found that the spin of the decaying particle was not equal to the sum of the spins of the created particles; one half unit of spin was left over.

Wolfgang Pauli's Postulation

In 1931 Wolfgang Pauli proposed a bold solution: there must be an invisible thief! If energy and spin were missing, something must have taken them and escaped unnoticed. The thieving particle must be electrically neutral, or it could not have slipped through the many devices which easily detect charged particles. The thief must also be very light, for Einstein tells us that even at rest a particle's energy is proportional to its mass ($E = MC^2$). Experiments showed that sometimes the emitted beta particle carried away almost all of the energy supplied by the nucleus transformation and very little was taken by the invisible thief. This minute amount must be divided into the thief's kinetic energy and its mass; so it follows that the mass must be very small (i.e. very light). It also must have a spin of ½ unit to make the conservation of spin law hold for the beta-decay transformation.

Hunting the Invisible Thief

The invisible thief was hunted at the scene of the theft (i.e. during the beta-decay process) and away from it. The main effort at the scene was used in trying to detect if the nucleus recoiled in an apparently random direction after decaying. The situation was much like that of a boy in a boat, with the boy being the electron (beta particle) and the boat being the nucleus. When the boy dives from the boat (beta-decay), the boat recoils in exactly the opposite direction. However, if there were two boys simultaneously diving from the boat, with the second boy representing the neutrino, the boat would recoil in a direction different from the original thrust. By studying the direction of recoil, the experimenters hoped to find out if one or two particles were released during beta-decay. The experiments were hampered by the crudity of the instruments and techniques until improvements were developed during World War II. With the more modern methods in use, the answer soon became clear; the nuclei were recoiling in apparently radom directions. This evidence of neutrinos was strong but indirect.

Catching the elusive neutrino after it has been emitted was found to be extremely difficult. Let's look at a few typical particle detection instruments and see why. All particle detection instruments rely on the interaction of the particle and the instrument. One type of instrument, such as the Geiger Counter, relies on the charge of a particle to make its presence known. This type of device will not detect the neutrino, for the neutrino has no charge. Another major type of instrument utilizes devices such as the cloud chamber. A particle passing through a cloud chamber will interact with the air in the chamber forming ions; vapor then condenses around these ions forming trails which are small-scale versions of the vapor trails left by high flying aircraft. But the invisible thief refused to leave his trail as other particles did. His small size lets him shoot between the atoms in the chamber's air and go on his way uninterrupted.

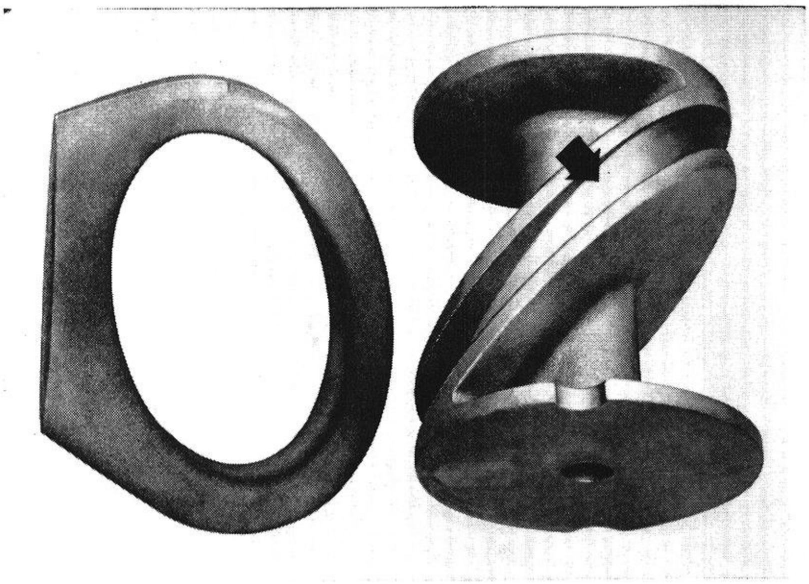
More dense materials, such as lead with closely packed atoms, were tried to no avail; the neutrino would not be stopped. Its extremely small size let it pass through all known barriers. Trying to capture and detect the neutrino was much like trying to catch light in a perfectly transparent glass box!

Discovery of the Neutrino

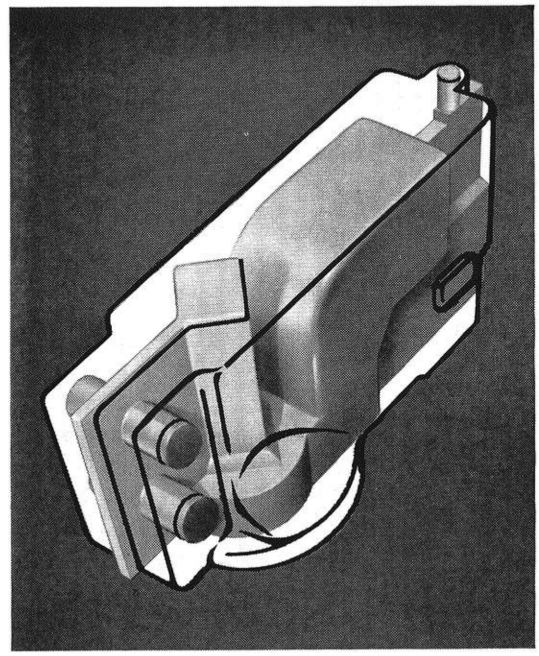
There was a limit, though; sooner or later, a neutrino must crash into an atom, thus revealing itself. The chances of this happening can be calculated mathematically and was done in 1939. The calculations showed that with the instruments and limited amount of neutrino-producing material available at that time, it was impossible to detect the collisions.

After World War II, however, Uranium piles had been built and were able to supply neutrinos in much greater quantities than the natural sources had. With the improved neutrino supply came a devoted hunt by Frederick Reines, a young American scientist, Reines used a special type of scintillation counter to look for the simultaneous formation of a neutron and a position; this simultaneous formation was the calculated result of a neutrino colliding with a hydrogen atom's nucleus. Reines used a tank containing about 100 gallons of water as the hydrogen-containing target. The tank was sandwiched between two tanks each containing a special fluid, thus serving as scintillation counters, and the tanks and equipment were then placed next to an atomic reactor. When one neutrino out of the torrent coming from the reactor struck a hydrogen nucleus in the water, the combination formed a neutron and a positive electron (positron). The positron at once annihilated itself by combining with one of the many electrons present in the atoms comprising the water. The matter of these two anti-particles turned to energy in the form of two quanta of gamma radiation which was emitted. This gamma radiation flashed through the water in opposite directions, entering the scintillation counters where the radiation's energy lifted some of the electrons present on the atoms in the scintillation fluid to a higher energy level. The electrons immediately dropped back, giving up

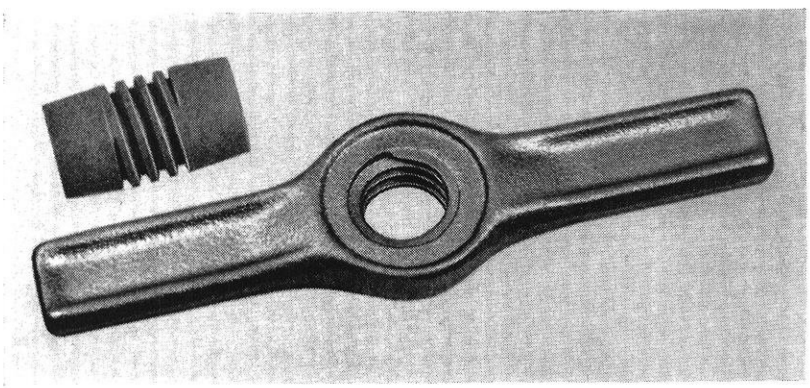
(Continued on page 16)



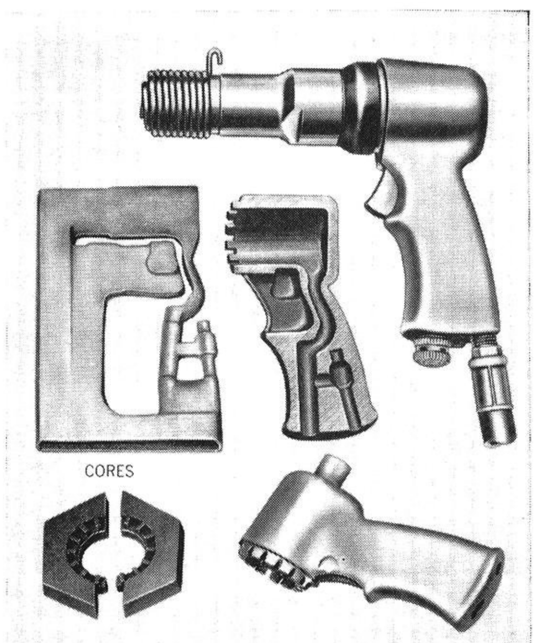
The groove on this Malleable iron cam for a packaging machine requires a fine finish. A shell core used on the outside of the part produces such a smooth, accurate surface that no machining is required.



The machining once required to produce this lever bracket included broaching the square hole, milling the slot, drilling and reaming the two large bolt holes, and drilling the small hole. All machining has been eliminated through the use of a single shell core.



Shell coring produces such exact detail that the acme thread on this Malleable iron trench brace wing nut is used without any machining. Previously produced with a standard oil sand core, it required reaming and tapping.



Precise dove-tails, intricate air channels and other interior details of this impact wrench handle are produced in the Malleable casting by the three shell cores shown. A variety of machining operations is eliminated by this relatively low-cost technique.

Solve Design Problems, Reduce Machining with Shell Cored Malleable Castings

Shell cores are most often used to create interior surfaces but, in addition, they can be utilized at other locations in a green sand casting to impart smoothness, provide closer tolerances, reduce machining, and solve a variety of design problems.

Shell cores create surface finishes of 50 to 250 microinch rms. Thus, excellent detail can be obtained in Malleable castings for gear teeth, holes, dove-tails, mating surfaces and threads with this modern casting technique.

The internal air passages and chambers in the pneumatic wrench handle, shown at right, are excellent examples of the amazingly complex details which can be created accurately and economically in Malleable castings with shell coring. They are produced—completely finished except for tapping—in the basic casting.

The advantages obtainable from shell coring in selected applications, combined with Malleable's high strength, ductility, easy machinability and reliable uniformity, make Malleable castings an outstanding choice for high-quality, low-cost parts.

Send for your free copy of this 16-page "Malleable Engineering Data File." You will find it is an excellent reference piece.

For further information on Malleable castings, call on any company that displays this symbol—

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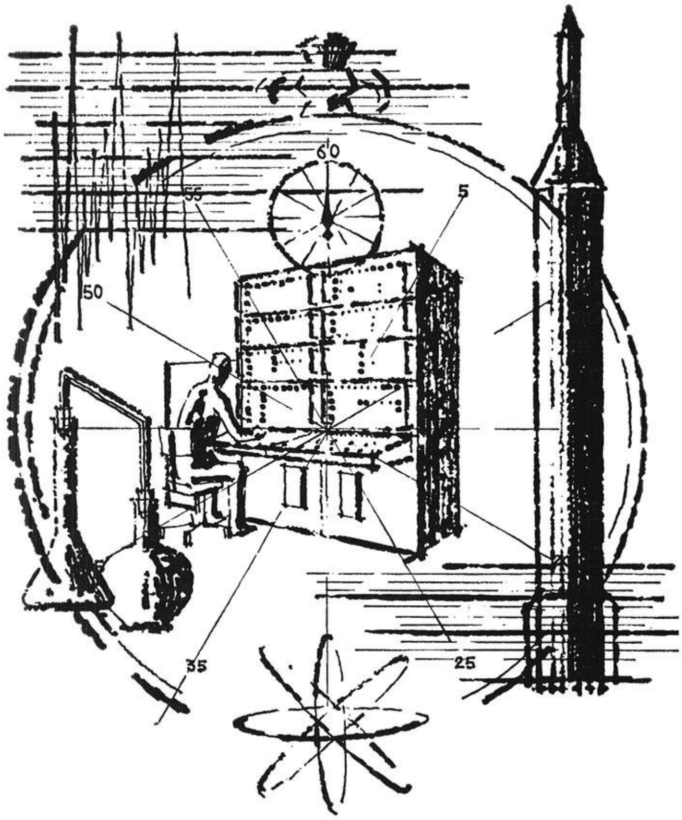

SCIENCE HIGHLIGHTS

By Harold Weber, ME'66

MECHANISM OF CRYSTAL GROWTH DISCOVERED TECHNIQUE RESULTS NEAR-PERFECT CRYSTALS

A new mundamental mechanism of crystal growth resulting in the formation of near-perfect crystals has been discovered by metallurgists at Bell Telephone Laboratories. It is termed the vapor-liquid-solid (VLS) mechanism. VLS growth occurs when a droplet composed of a saturated solution of a crystalline material and an impurity receives atoms from a vapor and deposits these atoms at the interface between the droplet and a crystalline substrate.

The VLS mechanism can be applied to most crystalline substances and can be used to grow diverse crystalline forms, varying from whiskers to epitaxial layers. The crystals are near-perfect in structure, and they can be grown at temperatures much lower than those required for current vapor-phase crystal growth processes. Hence, the technique has great technological potential for semiconductor, laser, piezoelectric, and magnetic devices, all of which require precisey grown crystals.

To grow whiskers or rod-like crystals of silicon by the VLS mechanism, small particles of gold are placed on a silicon substrate crystal and heated in a furnace to form droplets of gold-silicon alloy saturated with silicon. Then a vapor of silicon tetrachloride and hydrogen, which can react to produce elemental silicon, is passed over the droplets. The droplets receive silicon atoms from the vapor, or perhaps more likely, serve as a catalyst for the reaction. Silicon atoms entering the liquid supersaturate it, thereby causing silicon and minute quantities of gold to freeze out (solidify on the crystal substrate. As this process continues, the alloy droplet becomes displaced from the substrate crystal and rides atop the growing whisker.

Early in their research, it was found that screw dislocations were

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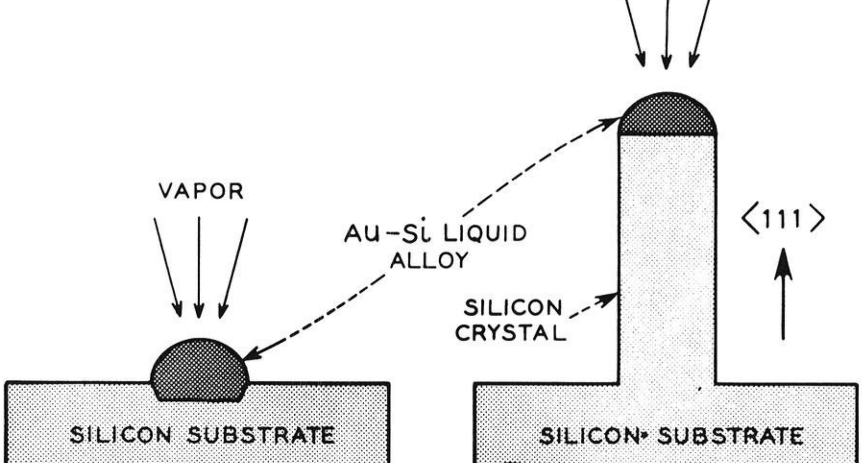

VLS growth as discovered by Bell Telephone Laboratories.

Neutrinos

(Continued from page 13)

the energy as two small flashes of visible light, one flash per gamma ray. The flashes were picked up by very sensitive electric eyes called photomutipliers and recorded electronically. Meanwhile, the second of the two particles, the neutron, formed by the neutrino and the hydrogen nucleus, were slowed down after about 10^{-5} seconds by the water and captured by a cadmium nucleus (cadmium salt added to water). The result of the combination was two gamma quanta emited from the cadmium nucleus. The electronic recording equipment, however, was set to record only the previously mentioned pattern of flashes. The instrument recorded only a few dozen sets of flashes per day. As a check to support the belief that these charges were nutrinos, a thick concrete wall was placed between the reactor and the instruments, the wall being thick enough to stop all particles but the neutrino. The recorded flashes did not diminish. By 1956 the conclusive evidence was in. After ten years and several hundred thousand dollars, Reines had proven the existence of the invisible thief which Pauli had postulated a quarter century before.

Facts Gained Since Discovery Anti-Neutrinos

Most atomic particles have anti particles, such as the electron with its positive electron, or positron. Some, however, like the photon, do not have anti-particles.

After the neutrino was proved to exist, the following question was raised: is there an anti-neutrino? Scientists reasoned that the neutrinos emitted with electrons should be the anti-particles of those emitted with positrons. Other types of radioactive decay indicate that there are two types of neutrinos that differ by their spin in opposite directions; the neutrino spins clockwise and the anti-neutrino spins counterclockwise, as seen by an observer toward whom they are coming.

At first glance this definition seems to be false, for an anti-neutrino coming toward an observer would be a regular neutrino if the observer were overtaking it from behind. This argument, however, cannot exist if the particle has no mass and therefore must move at the speed of light; for an observer, who naturally has mass, cannot travel at the speed of light, and therefore could never be overtaking the neutrino from behind. At the present time there is every reason to believe that the neutrino does indeed travel at the speed of light, and has no mass.

Comparison With Light

The neutrino is much like the light we see with our eyes, light being made up of particles called photons which, like the neutrinos, have no mass; therefore both neutrinos and photons travel at the same speed (i.e. the speed of light). The big difference is in penetrating power. Light can be stopped with a paper window shade, whereas neutrinos go right through the whole earth with less than one chance in a million million of being stopped on the way.

The Universal Iceman

Although neutrinos are created in many types of atomic particle transformations, those produced in the proton-to-neutron changes are perhaps the most important. This type of transformation takes place on a very large scale in the sun.

Energy is produced in the sun by the building up of protons into helium nuclei. This atomic fusion is accompanied by the proton-to-neutron change and the formation of neutrinos; about one-seventh of all the energy created in the sun escapes in this form. Our thief, the neutrino takes the energy and, with the speed of light, carries it off into the depths of space, stopped by nothing. This, of course, means that one-seventh (fifteen percent) of the energy which strikes the earth from the sun is also carried by neutrinos that pass right through and get away. If the neutrinos were stopped, their energy would be turned to heat and the earth would be fifteen per cent warmer. This emission of neutrinos is not limited to our sun but is common to every sun in the universe as far as we know. And so the invisible thief is also the universal iceman. By taking energy from countless suns away to the depths of space he does much to keep the universe cool.

Until last spring, neutrinos from space had not been detected. Since then, a university physicist, Clyde Cowan, has recorded 500 in a Maryland laboratory cave. His search was carried out in the cave to keep unwanted particles from his instruments; the neutrinos, of course, had no trouble penetrating the earth into the cave. This detection has opened the door to a very bright future for the use of neutrinos as scientific tools to unlock secrets of the Cosmos. Both American and Soviet scientists suggest that the thief may well be the cause of exploding stars or supernovas, and possibly of cosmic rays.

The birth and death of stars is but a small part of the cosmic mystery being brought to us this instant by the ellusive messenger, thief and iceman, the neutrino.

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Science Highlights

(Continued from page 15)

not present in their silicon whis, ers. They also knew that impuriti played a role, abeit a mysterio one. The demonstration that a l uid droplet containing an impu existed at the top of a gro whisker clarified the role of th purity: VLS growth depend

(Continued on page 17)

Science Highlights

(Continued from page 16)

the presence of a critical impurity, but does not require a dislocation or other crystal imperfection.

PLASMA-JET RADIATION SOURCE PRODUCES INTENSE BEAM

A new concept in radiative energy sources has been applied by scientists at the Westinghouse Research Laboratories in developing a powerful source of intense light. A high-pressure plasma-jet arc generates radiation that emerges from the self-contained unit through a quartz window in a converging beam. Collected radiant power is greater than has heretofore been possible with other continuous radiation sources.

The source consists of a stainless steel vessel designed for operation at high pressure—up to 600 pounds per square inch—for maximum emissivity of the plasma-arc discharge. One half of the pressure vessel is a deep elliptical mirror that collects radiation from the arc and beams it through a quartz lens-window set into the other half. An inert gas flows continuously through the device, entering near the window and leaving as a plasma jet through a hole in the anode. The gas flow stabilizes the arc and also flushes out vapors to prevent mirror contamination. Both cathode and anode arc water cooled. The cathode is made of tungsten and the anode either of copper or tungsten. Both electrodes can be adjusted for starting the arc and for regulating the length and position of the arc.

The plasma-jet radiation source has been operated at an input power of 15 kilowatts. At this power, the beam concentrates nearly five kilowatts of radiant energy on a spot about half an inch in diameter. Although operation has been restricted so far to power inputs up to 15 kilowatts, the source is designed for power inputs of 50 kilowatts or more. Tests indicale that units with inputs up to 100 kilowatts may be feasible.

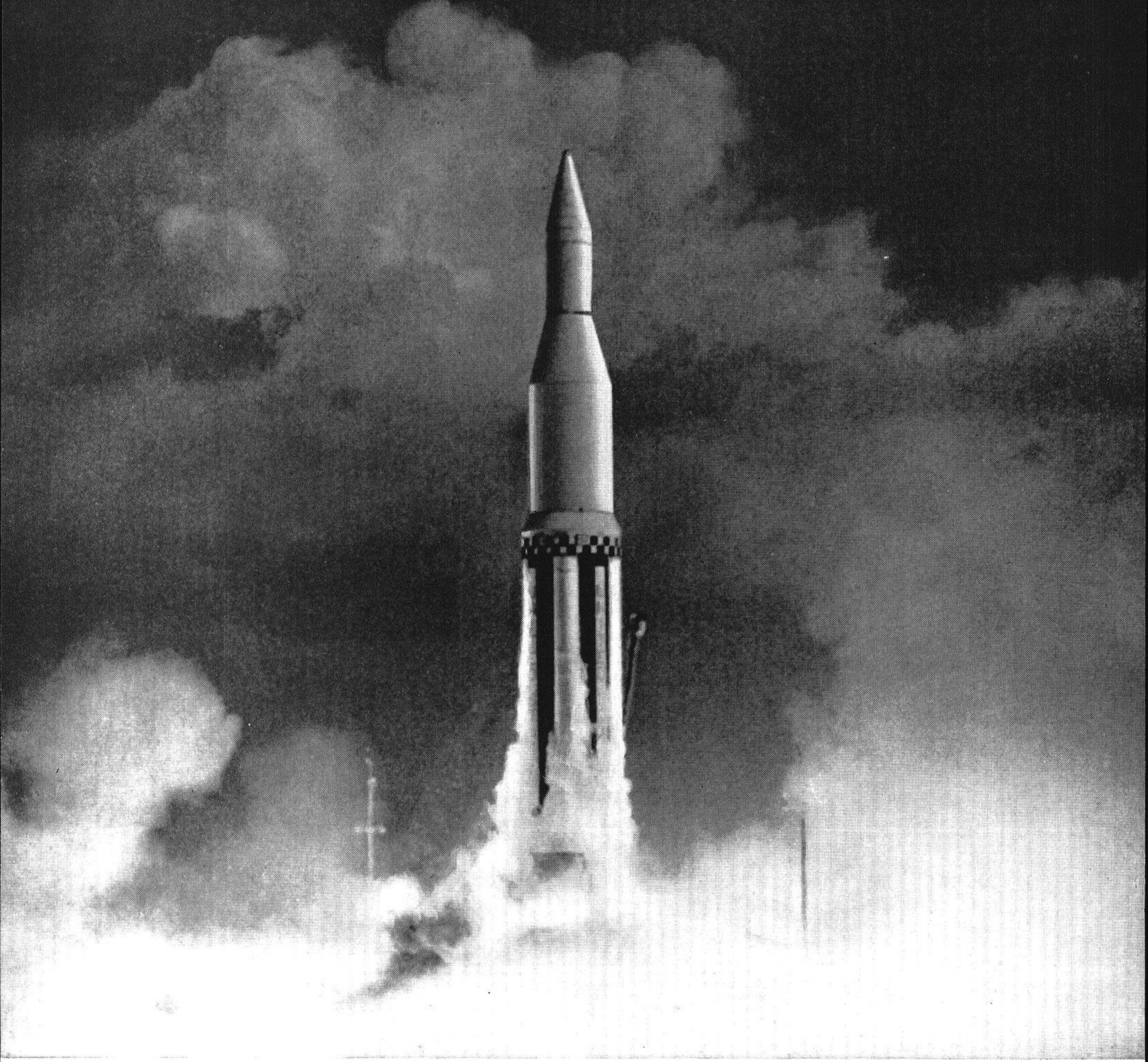
The output of the radiation source is intense in the visible light spectrum and very rich in the ultraviolet region. Possible uses are in simulation of re-entry heating, high-intensity searchlights, laser pumping, arc imaging furnaces for melting metals and ceramics, solar simulation, catalyzing chemical reactions, welding, image projection, airport illumination, and advanced military applications.

Temperature and emissivity of the plasma arc are controlled by controlling the arc power and the chamber pressure. Radiation wavelength decreases as arc temperature increases, and spectral line widths increase with chamber pressure. Any inert gas or mixture of inert gases can be used, and the spectral distributions radiated are characteristic of the gas used.

NUCLEAR PROPULSION FOR SHIPS COMPETITIVE WITH CONVENTIONAL POWER

Nuclear propulsion for merchant ships already is competitive with ordinary marine power plants, and in many instances is more economical.

That is the verdict of The Babcock & Wilcox Company, which designed and supplied the atomic plant for the N. S. Savannah, world's first nuclear merchant vessel.



Must you join a giant company to work on giant projects?

"Kaowool" ceramic fiber was developed by Babcock & Wilcox to handle many tough assignments throughout industry. Now it has been selected to insulate the liquid oxygen system on the Saturn rocket where temperatures range from −300F to more than 2,000F above.

You can share in development work on exciting new products at B&W. Besides ceramic fibers, these recently included a second-generation nuclear ship reactor, steam generators to utilize waste heat and the continuous casting of steel. Yet B&W is small enough to give you a chance to work on such products early in your career. Its management can take a personal interest in your progress.

B&W, with annual sales of more than $375 million, offers the advantages of a large company: indoctrination training program, paid tuitions, wide variety of job openings (18 plants in ten states), security and other benefits.

Growth opportunities are enormous. Yet only 59 bachelor-level students will be hired in 1964. B&W has interesting positions for graduate and undergraduate engineers and scientists, including M.E., E.E., Ch.E., Met.E., Cer.E., Nuc.E., C.E. and physicists. For more information, talk to a B&W interviewer when he visits your campus, or to your placement director. The Babcock & Wilcox Company, 161 E. 42nd Street, New York, N.Y. 10017

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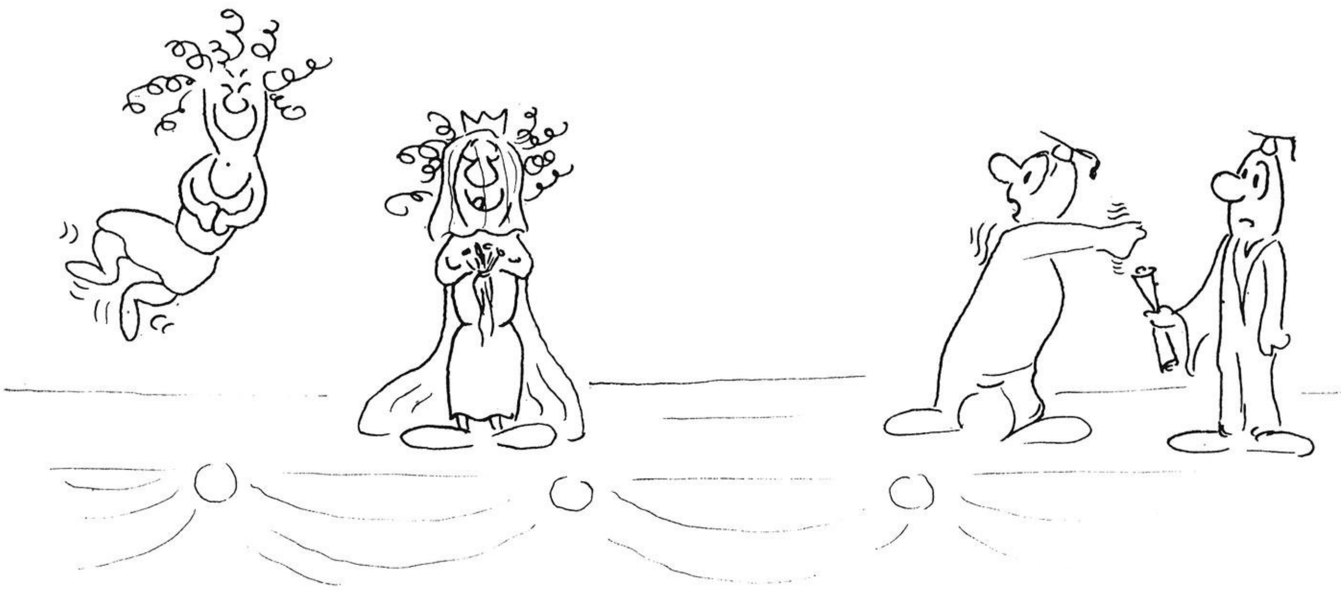


Fill in your Own Lines

"I can't marry him, Mother; he's an atheist and doesn't believe there is a Hell."

"Marry him, my dear, and between the two of us we'll convince him."

* * *

Two kinds of families are likely to have a house full of antique furniture: the kind with money and the kind with kids.

* * *

To a bachelor a wedding ring is just a tourniquet. It stops circulation.

* * *

A husband is what is left of a sweetheart after the nerve has been removed.

* * *

Any man who has half a mind to get married is well equipped for the venture.

* * *

Legally the husband is the head of the house and the pedestrian has the right of way. Both are fairly safe unless they try to exercise their rights.

* * *

"Did you propose on your knees?"

"Yeah, and I've been ten years getting back on my feet."

* * *

Don't start vast projects with half-vast ideas.

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

* * *

When she starts stroking your hair, brother, she's after your scalp.

* * *

A little boy went to school for the first time and the teacher explained that if he wanted to go to the washroom he should raise two fingers.

The boy, looked puzzled, asked —"How's that going to stop it?"

* * *

Traveling faster than sound will at least eliminate the voice from the back seat.

* * *

The guy was walking down the street dressed only in a barrel when a cop stopped him.

"Are you a poker player?" asked the law.

"Not me," replied the character, "but I left a couple of guys who are."

* * *

The only exercise some folks get is jumping at conclusions, running down their friends, sidestepping responsibility and pushing their luck.

* * *

A drunken lawyer was lying in the gutter with one elbow on the curb screaming, "If it takes me all week, I'll get over this wall."

Very proud parent: "Edith is taking a correspondence course in trigonometry. Speak a few words in trigonometry dear."

* * *

CONSCIENCE is defined as the thing that hurts when everything else feels great.

* * *

Doctor: "Your husband must have absolute rest and quiet. Here are some sleeping pills."

Wife: "When must I give them to him?"

Doctor: "They're for you."

* * *

Judge: "Did you say this man stole your money out of your stocking?".

Gal: "Yes, your honor."

Judge: "Well why didn't you put up a fight?"

Gal: "I didn't know he was after my money."

* * *

Next to being shot at and missed, nothing is quite so satisfying as an income tax return.

* * *

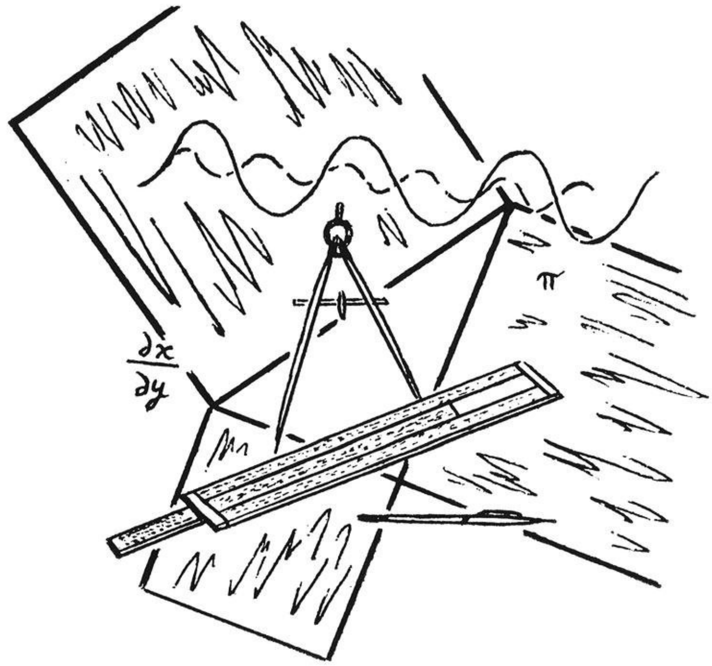
Introducing the new deacon to her deaf father, a young girl said:

"Father, this is the new deacon."

"New dealer," exclaimed the father with surprise.

"No, no. Not a new dealer; a new deacon. He's the son of a bishop."

THE MENTAL MAZE



By Clifton Fonstad, Jr., EE'65

WE'VE just about come to the end of this year's Mental Maze. It's been a good trip—especially for the four Maze Masters—and the puzzles haven't been impossible to work. As a Texan would say, if the editor's willin' and the fees don't rise, the Mental Maze will be back next year.

The year is not over yet, though, so let's get started on the first puzzle—the first turn in this month's Mental Maze.

1. We heard a story from Tioga Tech the other day. The students and faculty do a lot of hunting up there and so when one of the engineers went home for vacation he decided to bring a gun back with him. He returned on the train and promptly ran into problems. The conductor told him, "You can't bring that gun in here," and the baggage-car attendant said, "Sorry—we're not allowed to accept anything over a yard long in any direction." The students gun was 5 feet long—a real relic—and couldn't be broken down. Was he able to take his gun to Tioga?

2. Now for a quick puzzle. A man has two eggs for breakfast every morning. He doesn't buy, beg, steal, or find them. He doesn't keep hens and no one gives him them as gifts. How does he get them?

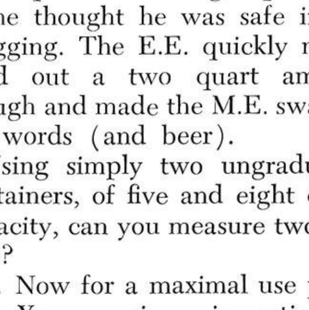
3. Last week-end an M.E. and a E.E. were having an argument down at the local pub. The M.E. claimed he could chug two quarts of beer and the E.E. said it was impossible. The M.E. knew that the only available containers were a five quart and an eight quart can so he thought he was safe in his bragging. The E.E. quickly measured out a two quart amount though and made the M.E. swallow his words (and beer).

Using simply two ungraduated containers, of five and eight quart capacity, can you measure two gallons?

4. Now for a maximal use problem. You are given six sections of chain each consisting of four lengths, and are told that the cost of cutting a link is 10 cents and of welding it together again is 25 cents. How much will it cost to have the pieces joined into one chain?

You can even have a hint—the answer is not $1.75.

5. If you like to doodle this puzzle will be for you. It's sort of a numerical doodle.



Arrange the digits 1 to 9 in a square so that every row, column, and diagonal totals the same amount.

6. The first puzzle in the Mental Maze this year was an ancient Greek problem. Let's end on another. This puzzle is about Diophantus, a Greek mathematician whose name is now associated with problems involving fractions and whole number answers.

Diophantus was a child for one-sixth of his life, a youth for one-twelfth, and a bachelor for one seventh. Five years after his marriage a son was born who lived one-half as long as his father and who died four years before his father. How old does that make Diophantus?

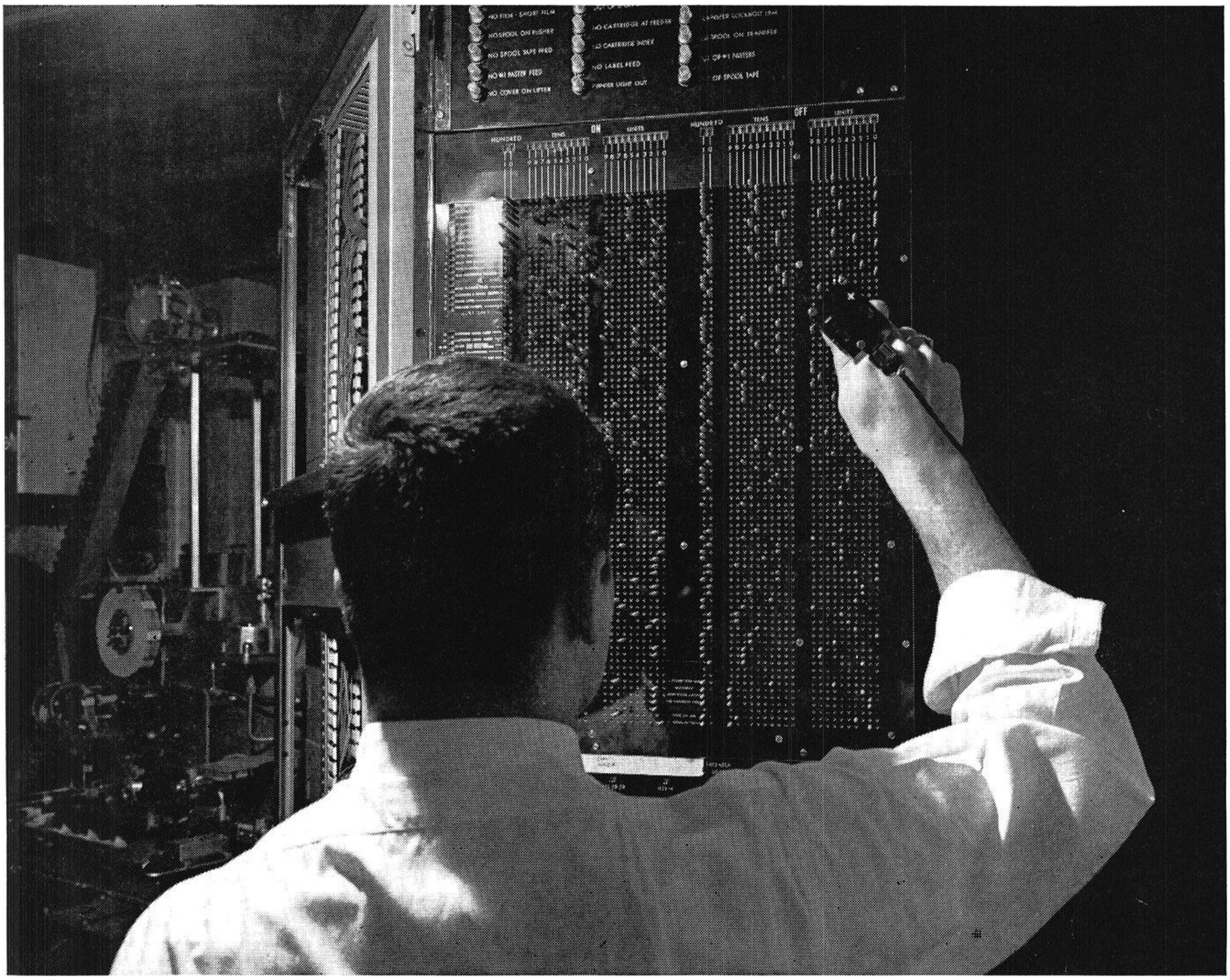
ANSWERS: Last month's answers are:

1. 48 inches
2. Go to bed while the sun is up.
4. 4½ feet.
5. One, from the van labeled "Black–White"

Since this is the last issue this Spring, we'll give you this month's answers; but first, last month's answers, but first, March's Maze Master was Jan Laarman from Oostburg, Wis., and April's winner was Gary G. Hardel, an ME from Madison.

Now, this month's answers are:

1. A box 1 x 1 x 1 yard will do.
2. He keeps ducks.
3. Fill the 5, empty into the 8, refill 5, empty enough to fill the 8, this leaves 2.
4. $1.40. Cut one section into four links and use these to join the other five pieces.
6. 84 years old.



Advancement in a Big Company: How it Works

An Interview with General Electric's C. K. Rieger, Vice President and Group Executive, Electric Utility Group

C. K. Rieger

■ Charles K. Rieger joined General Electric's Technical Marketing Program after earning a BSEE at the University of Missouri in 1936. Following sales engineering assignments in motor, defense and home laundry operations, he became manager of the Heating Device and Fan Division in 1947. Other Consumer-industry management positions followed. In 1953 he was elected a vice president, one of the youngest men ever named a Company officer. Mr. Rieger became Vice President, Marketing Services in 1959 and was appointed to his present position in 1961. He is responsible for all the operations of some six divisions composed of 23 product operations oriented primarily toward the Electric Utility market.

Q. **How can I be sure of getting the recognition I feel I'm capable of earning in a big company like G.E.?**

A. We learned long ago we couldn't afford to let capable people get lost. That was one of the reasons why G.E. was decentralized into more than a hundred autonomous operating departments. These operations develop, engineer, manufacture and market products much as if they were independent companies. Since each department is responsible for its own success, each man's share of authority and responsibility is pinpointed. Believe me, outstanding performance is recognized, and rewarded.

Q. **Can you tell me what the "promotional ladder" is at General Electric?**

A. We regard each man individually. Whether you join us on a training program or are placed in a specific position opening, you'll first have to prove your ability to handle a job. Once you've done that, you'll be given more responsibility, more difficult projects—work that's important to the success of your organization and your personal development. Your ability will create a "promotional ladder" of your own.

Q. **Will my development be confined to whatever department I start in?**

A. Not at all! Here's where "big company" scope works to broaden your career outlook. Industry, and General Electric particularly, is constantly changing — adapting to market the fruits of research, reorganizing to maintain proper alignment with our customers, creating new operations to handle large projects. All this represents opportunity beyond the limits of any single department.

Q. **Yes, but just how often do these opportunities arise?**

A. To give you some idea, 25 percent of G-E's gross sales last year came from products that were unknown only five or ten years ago. These new products range from electric tooth brushes and silicone rubber compounds to atomic reactors and interplanetary space probes. This changing Company needs men with ambition and energy and talent who aren't afraid of a big job—who welcome the challenge of helping to start new businesses like these. Demonstrate your ability—whether to handle complex technical problems or to manage people, and you won't have long to wait for opportunities to fit your needs.

Q. **How does General Electric help me prepare myself for advancement opportunity?**

A. Programs in Engineering, Manufacturing or Technical Marketing give you valuable on-the-job training. We have Company-conducted courses to improve your professional ability no matter where you begin. Under Tuition Refund or Advanced Degree Programs you can continue your formal education. Throughout your career with General Electric you'll receive frequent appraisals to help your self-development. Your advancement will be largely up to you.

FOR MORE INFORMATION on careers for engineers and scientists at General Electric, write Personalized Career Planning, General Electric, Section 699-11, Schenectady, N. Y. 12305

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