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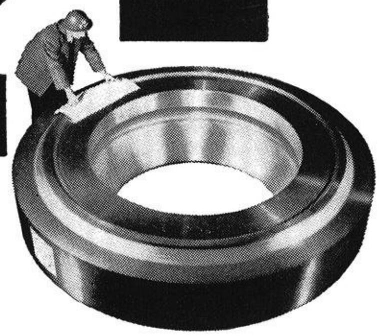

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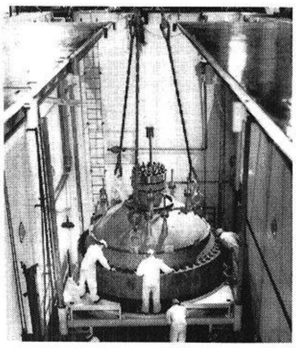

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FEATURES

DEPARTMENTS

JANUARY, 1961

THE WISCONSIN ENGINEER

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VOLUME 65, NUMBER 4

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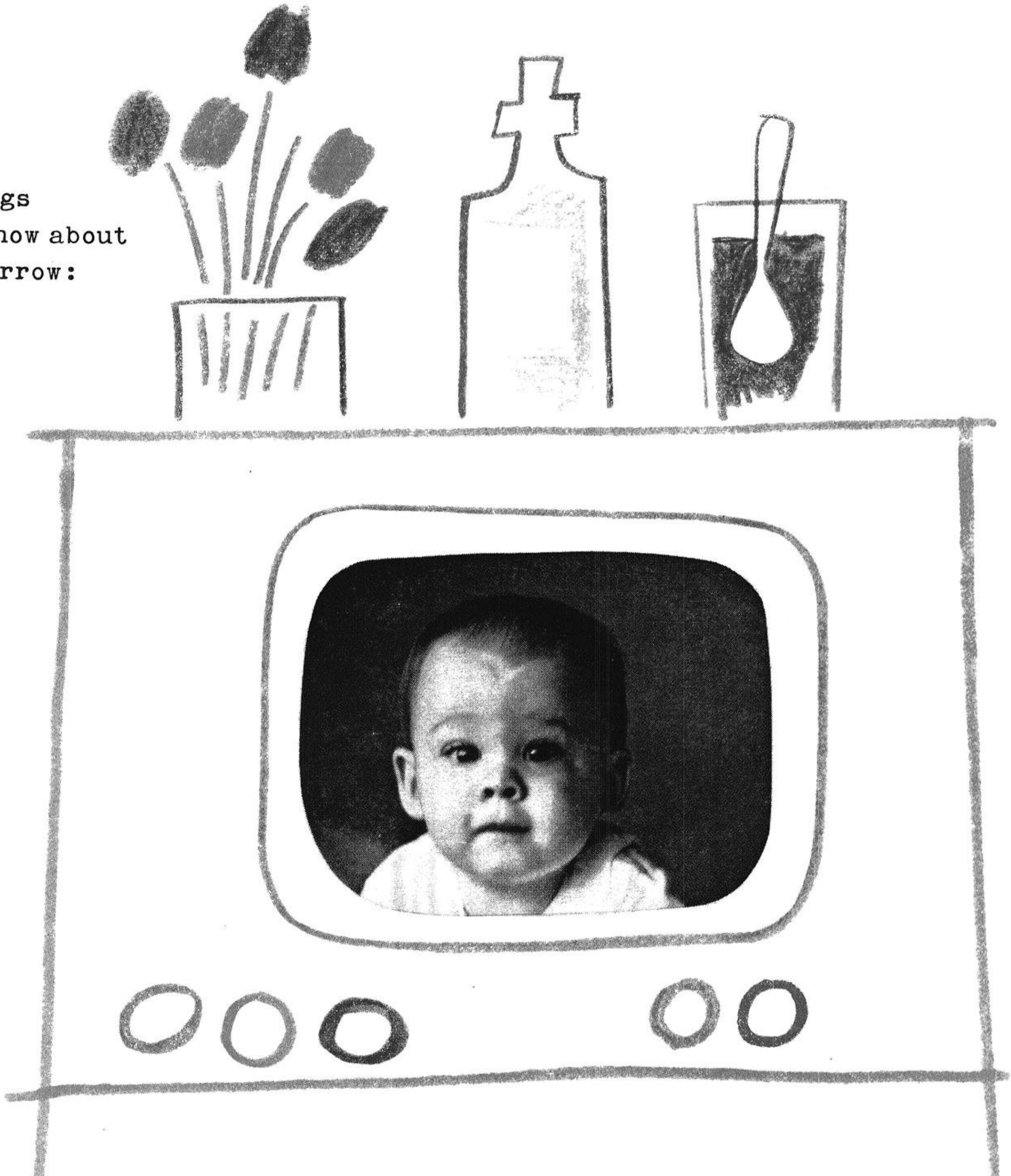

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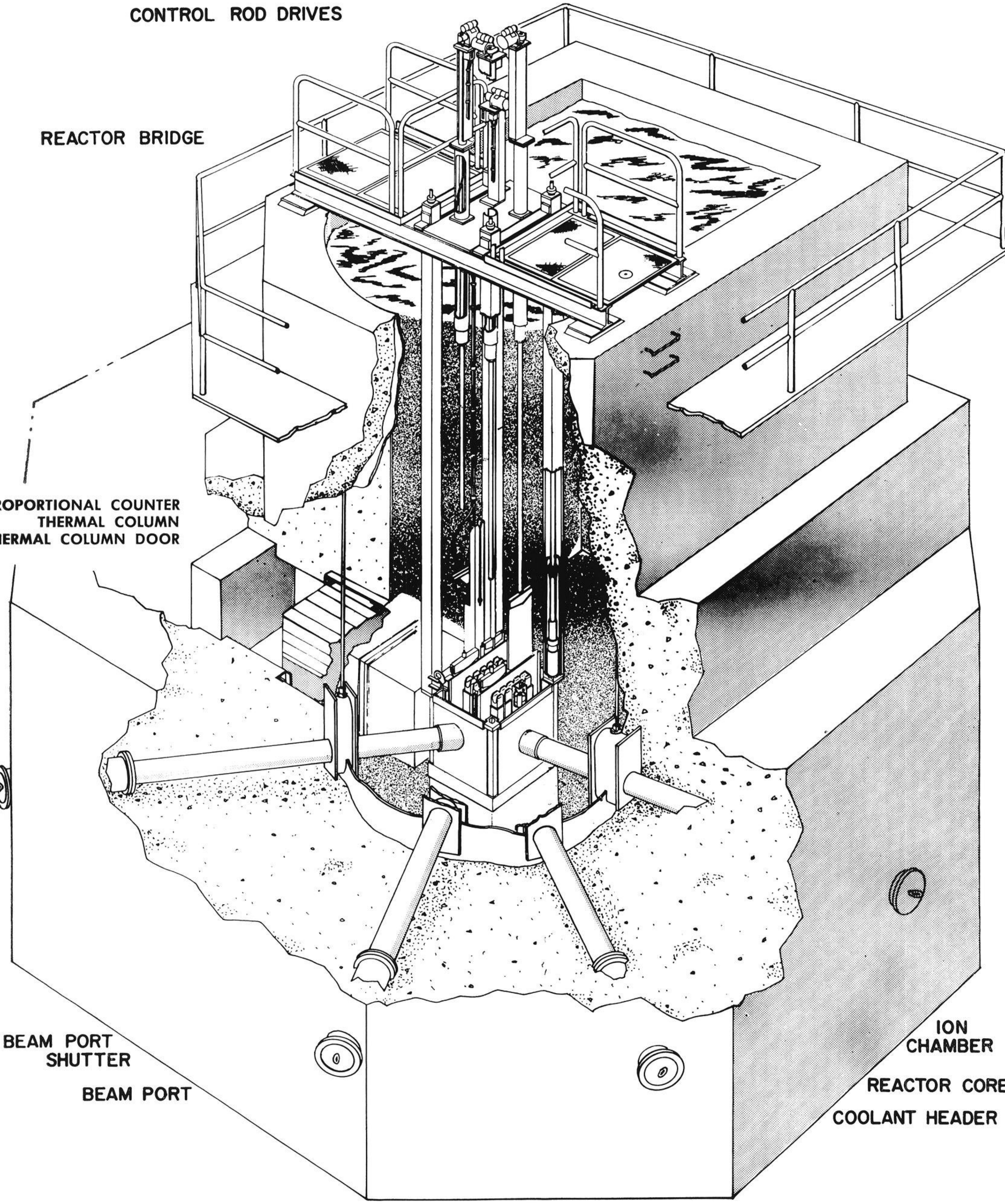
Rambling With The Editor

The University of Wisconsin entered a new era with the installation of a nuclear reactor. This is just another of the events that have made the University a leader in the field of education and put the College of Engineering in the nuclear engineering field. There has been a nuclear engineering program at the University since 1958, but until the reactor was installed, the program could not get off the ground.

If the University is to keep up with times in education it must have new tools to work with, such as the new reactor. The Engineering Department has been a leader in space age education and with the help of the government has become one of the most modern departments of its kind.

The Atomic Energy Commission, a department of the federal government, provided the money for this reactor. The government, through its many departments, gives money to many universities and colleges for the purchase needed equipment. The University would not have many of its important and expensive pieces of equipment for use if it was not for the government giving it grants. The new CDC 1604 computer is only one of the many gifts the government has given.

Nuclear Engineering is one of the new romantic sciences. The whole thing started with the atomic bomb and the end is beyond the imagination. New things are being produced every day and this new reactor may help to teach some engineer who will invent a new use for atomic energy that will benefit all mankind.—W.S.H.



New Reactor at the University of Wisconsin.

U. W. Reactor

by Bob Foss, University of Wisconsin News Service

ONE of the newest programs in engineering at the University of Wisconsin—the graduate program in nuclear engineering—will get into high gear by the end of this year.

Installation of a 10-kilowatt nuclear reactor as well as a subcritical assembly of uranium and water, a reactor simulator, and a nuclear metallurgy laboratory now make the Wisconsin campus one of America's big-time training grounds for nuclear engineers.

All of these facilities, except the 10-kilowatt reactor, are now in use, and the reactor, which has just been installed, is due to go into action any time.

Installation of this equipment illustrates how the UW College of Engineering, set up in early years of the 20th century, is keeping pace with demands of the space age.

The nuclear program has been under way on the UW campus since 1953, but up to now students and faculty members have had to travel 150 miles to Argonne National Laboratory near Chicago for some of their highly technical courses.

A contract was awarded last January to the General Electric Co. for construction of the 10-kilowatt reactor with assistance of a $150,000 grant from the Atomic Energy Commission.

Nuclear engineering is a new and rapidly growing field, developed by scientists trained in nuclear physics, mathematics, and the conventional engineering fields. It encompasses a wide variety of applications—from manufacture of atomic bombs and powering of rockets for space flight to use of radioisotopes for measuring flow of oil through cross-country pipe lines or the wear of piston rings in an engine. One of the most promising applications is the use of nuclear energy to generate electricity in central station power plants.

Such use of nuclear energy has been held back in the past because electricity could be produced from coal more cheaply. However, this cost differential has been rapidly decreasing. Some public utility companies in California feel now that the differential has disappeared entirely. If true, the advent of competitive nuclear power may not be long in reaching Wisconsin, especially the northern part of the state.

The 10-kilowatt reactor, Wisconsin's first of this physical and power magnitude, is designed expressly for education and research. It consists basically of about eight pounds of uranium-235, a few gallons of water to allow nuclear reactions to occur, and about 30,000 gallons of water and 1,000,000 pounds of concrete to shield personnel from intense nuclear radiation present near the uranium.

There are also a few hundred pounds of aluminum, primarily for structural purposes; four boron-aluminum blades about two feet square for controlling reactions; and a wide array of instruments to monitor and study the chain reaction which takes place within the uranium.

It is interesting to note that the eight pounds of uranium would form a ball less than 1½ inches in diameter if it were melted together —yet these eight pounds can give off as much heat as could be obtained by burning 20,000,000 pounds of coal.

Students will perform experiments on the reactor to study many aspects of nuclear engineering. They will make measurements to determine the exact amount of uranium needed to make the reactor operate and to determine the effect of inserting poisoning materials into the reactor. They will also experiment to determine effectiveness of many materials which could be used for shielding, to measure the number of radiation particles present in the reactor at any one time, and to determine many of the properties of these radiation particles.

They will actually operate the reactor individually, not only to learn operation procedure but also to gain an appreciation of problems involved in operation and design of reactors.

The reactor can be used in areas other than engineering. It may prove useful for research in biology, chemistry, medicine, and agriculture. With this tool, effects of radiation on plant growth, animal behavior, or material behavior can be studied. By-products of the reactor can be used for research into such areas as treatment of cancer or determination of how plants grow.

Safety is an important consideration with nuclear reactors. Elaborate steps have been taken to insure that the reactor will not present a hazard to the public. The reactor, designed by engineers with wide experience in the field, is similar to other reactors found to perform satisfactorily. This design has been checked by University personnel and has been analyzed by trained safety engineers in the AEC.

These engineers inspect not only the design but also the actual construction, and their approval is required before uranium can be loaded into the reactor. They subject all prospective reactor operators to extensive examinations, and they continue to make frequent inspections of the facilities and the operators after the reactor goes into use.

Many additional safety precautions are taken by the University.

The nuclear engineering students also have use of the subcritical assembly of uranium and water in their instruction and research. This

(Continued on page 42)

${}_{92}U^{235}$ Both a Lock and a Key

by John P. Ritzenthaler

THE fuel needs of modern civilization are increasing enormously as progress is made in science and industry. It has been stated that between 1945 and 1955 the electric-power consumption of the United States alone rose from 222.5 billion kilowatt hours to 547 billion kilowatt hours, an increase of approximately 150%. To be sure, some of this electric power was produced by hydroelectric installations, but most of it came from coal- or oil-fired steam-turbine power plants. Similar increases occurred in the consumption of coal, oil, natural gas, and other related nonnuclear fuels. The world's nonnuclear fuel resources are not inexhaustible; it has been estimated on the basis of present trends in consumption-increase that our known supplies of conventional fuels will last us less than a century. At present, new supplies of nonnuclear fuels, especially oil and natural gas, are rapidly being discovered and exploited; but these merely serve to push the inevitable day of resource-exhaustion a little farther forward into the future. The need is for a process which will produce more energy per given amount of fuel than can be presently obtained by conventional combustion. In this sense, nuclear fission is at least the medium-range answer to mankind's power-supply problem; it has been estimated that the quantity of heat evolved in the normal fission of one pound of ${}_{92}U^{235}$ is equal to the amount generated by burning three million pounds of coal. A conservative estimate indicates that the vast reservoir of energy locked up in presently-known supplies of nuclear fuels will supply humanity's ever-expanding power needs for at least 2,000 years more. Uranium and thorium, the most important raw materials for reactor-fuel production, are quite plentiful, uranium making up some 0.0003% of the earth's crust and thorium about 0.001% to 0.0015% of it.

The production of workable nuclear fuel from natural uranium and thorium is the primary obstacle to widespread, large-scale use of nuclear power plants. Only three known substances will sustain a nuclear chain reaction ${}_{92}U^{233}$, ${}_{92}U^{235}$, and ${}_{94}Pu^{239}$. This is because only these three types of atom become sufficiently unstable to split apart on absorbing a comparatively low-energy fission-produced neutron. If a sustained chain reaction is to occur, some part of the fission products of one atom must initiate the fission reaction in one or more other atoms; the neutron is the only fission product having this capacity, and any substance which is to be used as a nuclear fuel must therefore be fissionable by neutrons of the "fast" energy level. Neutrons produced by nuclear fission, although called "fast" neutrons, possess insufficient energy to cause fission in any but the three fissionable substances. In this fact lies one of the basic problems of nuclear reaction technology: the problem of neutron loss.

If too many fission-neutrons are absorbed by the impurities, such as nonfissionable isotopes, there may not be enough left to sustain the chain reaction, which will then die out. This principle can then be used to control the rate of fission in a reactor. It is true, natural uranium can be used to fuel certain types of nuclear reactor, but by their nature, such reactors are heavy, bulky, primitive in design, comparatively inefficient, and difficult and expensive to build. This is because a thermal, or slow, neutron system must be used to prevent excessive neutron absorption by the nonfissionable ${}_{92}U^{238}$ which makes up over 99% of natural uranium. Those few materials which are suitable from a thermal-neutron-absorption standpoint are usually either expensive, like heavy water, very disadvantageous in other physical and chemical properties, like beryllium, or both. If fission neutrons are not slowed down to thermal energy levels by a moderating substance, too high a percentage of them will be captured by the ${}_{92}U^{238}$ to permit the existence of a sustained chain reaction, and natural uranium becomes useless as a nuclear fuel. If more efficient, more compact, lighter, simpler, and less expensive reactors are desired, fuel much richer in fissionable material than natural uranium must be used so that fast or intermediate-range neutrons can be utilized as such. Nuclear weapons reinforce this demand for purified fissionable material; they require absolutely pure fissionable material for their manufacture, since a comparatively small decrease in purity of bomb fissionables results in a large increase in the mass of material required to produce the same effect. Thus the use of impure fissionables could result in a weapon too heavy and unwieldy for practical use, and could affect the quality of the explosion as well. Therefore, it can easily be seen that both military and civilian use of atomic energy depends upon the production of purified fissionable material.

Of the three known substances fissionable by fast neutrons, only one—${}_{92}U^{235}$—occurs in nature. Both ${}_{92}U^{233}$ and ${}_{94}Pu^{239}$ are "artificial isotopes", and can be produced at present only by bombarding other substances with neutrons. When bombarded by neutrons, ${}_{90}Th^{232}$ is transformed into ${}_{92}U^{233}$ and ${}_{92}U^{238}$ is transformed into ${}_{94}Pu^{239}$ by the process of neutron absorption and radioactive decay. These two starting materials are known as "fertile materials", and are quite plentiful in the earth's crust, as was pointed out above. Unfortunately, at present the only large-scale source of neutrons is the neuclear reactor itself. This means that, at present, fissionable materials can be created from fertile materials only by the consumption of fissionables already on hand. Until a large-scale, efficient neutron source other than the nuclear pile is discovered, fissionables other than ${}_{92}U^{235}$ can be produced only by the fissioning of this isotope. At present, "breeder piles", or nuclear reactors used to produce fissionables by neutron bombardment of thorium and non-fissionable uranium isotopes, generally consume more fissionable material than they produce; for this reason, they are more properly called "conversion reactors." However, true "breeder reactors", reactors which actually produce more fissionable material than they consume, are now being operated. The fast-neutron breeder reactor seems especially promising at present, and it may well be that some day this type of reactor will remove the present fuel-production bottleneck which isotopic separation causes. Unfortunately, that day is still far in the future, since fast-neutron breeder-reactor technology still contains many unsolved problems, and even when these are solved, a network of such reactors will not be built overnight. Until such a system is established, nuclear energy programs everywhere must remain dependent upon a supply of scarce, expensive ${}_{92}U^{235}$. Thus it can be seen that the whole problem of large-scale use of atomic energy hinges on the separation of ${}_{92}U^{235}$ from natural uranium for use in fuel elements. ${}_{92}U^{532}$ is the keystone of the entire atomic-energy program.

The separation of ${}_{92}U^{235}$ from natural uranium is no easy task. Uranium itself is a very difficult metal to work with; so active and so chemically unpredictable that not until 1940 was it produced in pure enough form to accurately determine its density and melting point. Natural uranium consists of 0.712% ${}_{92}U^{235}$, 0.006% ${}_{92}U^{234}$, and

99.282% $_{92}U^{238}$; the percentage of non-fissionable $_{92}U^{234}$ is so small that this isotope is simply ignored, which simplifies the problem of separation somewhat. Nevertheless, the basic difficulty remains. The chemical identity and high atomic weight of uranium isotopes rule out all present means of chemical separation. Physically, $_{92}U^{235}$ differs from $_{92}U^{238}$ only in mass, and in that respect only by a factor of 3/238, a very small difference indeed. Nevertheless, it is the utilization of this difference in mass which forms the basis of all separatory processes since there is no other known difference from which a separatory process can be derived.

Most of the separatory methods which have been, or are now being successfully applied to the problem of isotopic separation of uranium were known in principle, and in many cases used to separate isotopes of other elements, long before $_{92}U^{235}$ began to assume its particular importance. For instance, the principles behind the gaseous diffusion method were known as early as the opening decades of the nineteenth century and the method itself was first put to work in 1913 to separate the isotopes of neon. Serious work on the centrifugation method of isotopic separation dates from the year 1919. Nevertheless, it was not until the discovery of the phenomenon of nuclear fission by the German scientists Hahn and Strassmann in 1938 that the problem of separation began to take on all the aspects of a life-and-death race. Further developments quickly followed. Within the year, $_{92}U^{235}$ had been recognized as the sole fissionable isotope in natural uranium, the feasibility of nuclear chain reactions had been demonstrated, and the tremendous potential and danger of atomic bombs and reactors had become generally recognized among scientists involved in the matter. Strenuous efforts were made by these scientists to awaken their respective governments to the vital necessity of intensive research into nuclear phenomena. In the United States, their efforts caused the initiation of an extensive top-secret program which in August, 1942, resulted in the creation of the United States Army Corps of Engineers' "Manhattan Engineer District," the famed Manhattan Project. In Britain, a similar though smaller-scale program was begun. Nazi Germany, however, was and remained an enigma; because of the efficiency of Hitler's security organizations, no word reached the free world concerning the atomic energy program she was assumed to have. All that was known was that Germany's world-famous scientists were quite capable of developing an atomic bomb, and that Hitler was quite capable of using it if it were developed. This knowledge acted as a spur to the free world, and the United States, in particular, spared no effort and expense to beat the Nazis to a workable atomic bomb. As it turned out, Germany's atomic energy program was divided and hopelessly misrun, and by the time the war in Europe ended, the Germans were still many years away from the production of an atomic bomb. However, these facts did not come to light until the end of 1945, and the idea of a nuclear race for life persisted among Allied nuclear scientists until the end of hostilities.

As was stated previously, the first step in any military or civilian nuclear energy program is the production of purified fissionable material. Because of the potentially decisive nature of the proposed weapon and the aforementioned fear of Nazi nuclear research, the Manhattan Project took no chances on encountering blind alleys. Parallel programs were instituted for the production of both $_{92}U^{235}$ and $_{94}Pu^{239}$. In each program, several processes were given both pilot-plant and full-scale tryouts. However, the plutonium program, started later than the uranium program, was given somewhat less emphasis than its rival, and resulted in installations which produced plutonium but were totally inefficient. These installations, at Hanford, Washington, were elementary conversion reactors of great size. Virtually none of the energy they produced was utilized, but was instead dissipated harmlessly into the Colombia River in the form of heat. These reactors neither produced useful power nor yielded as much fissionable material as they consumed; their sole advantage lay in the fact that they could use natural uranium as fuel to produce easily-separable plutonium. Only a wartime quest for "the ultimate weapon" could have produced such installations. The uranium program, on the other hand, resulted in efficient installations of continuing value to peacetime military and civilian atomic energy programs. For this and several reasons which have already been mentioned, the isotopic separation program will now be considered in detail.

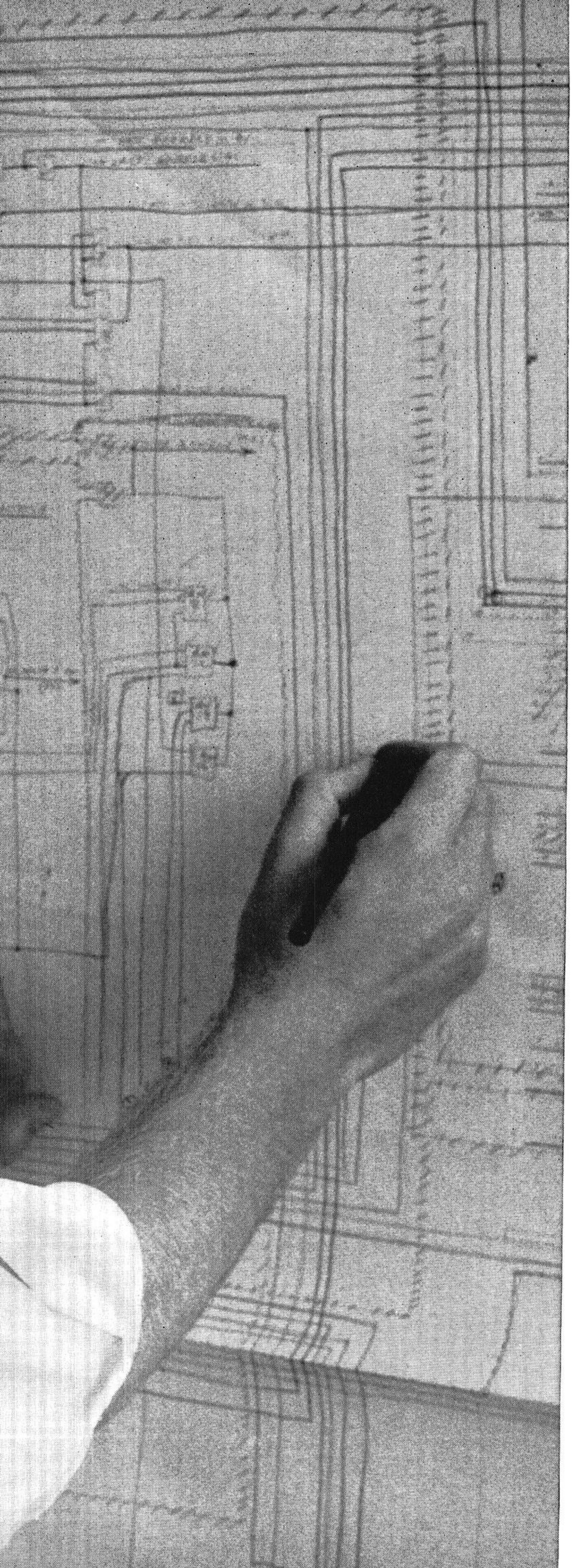
In the massive drive to perfect a method of producing pure $_{92}U^{235}$ from natural uranium, five main systems were tried: the mass spectograph, the calutron, centrifugation, thermal diffusion, and gaseous diffusion. The mass spectograph was the first device to succeed. In 1940 Dr. A. O. Nier used this device to produce the first measurable quantity of pure $_{92}U^{235}$. However, the mass spectrograph had one serious drawback: in a full day, a standard device of this type could produce approximately one microgram of pure $_{92}U^{235}$. While this was a great step forward and permitted vital research into the fission characteristics of the fissile isotope, it has been estimated that approximately 75,000 years would have been required to produce sufficient material for an atomic bomb. This lack of capacity is inherent in the design of the mass spectrograph; nevertheless, its successor, the calutron, is the direct offspring of the theory behind the spectrometer and the experience gained in its construction and operation. The theory behind the spectrometer is quite simple. A quantity of material to be processed is subjected to high-voltage electric current and thereby converted into ions. Two parallel plates having narrow, precisely-aligned slits in them are in position between the ion source and the spectrometer proper; a high voltage is applied across these plates so that all ions which manage to pass through both slits into the magnetic field beyond will have essentially the same kinetic energy and will be sharply focused into a narrow, sharply-defined ion beam. As the ions emerge from the second slit, they enter a magnetic field designed to divert them into a circular path. Since all the ions have the same charge and the lighter ones have less mass, the $_{92}U^{235}$ ions will be bent through a circle of smaller radius and the two types of ions will draw apart in flight so that they can be recovered in pure form merely by placing collectors at the proper points inside the ion-beam channel. This method is capable of effecting complete isotopic separation in a single stage; however, it is expensive and very inefficient energywise. Only a tiny fraction of the material ionized in the ion source passes into the magnetic field, and those ions which do get that far require a large energy expenditure per ion to bend their paths into the required circular shape. Thus it can be seen that the mass spectrograph was an invaluable tool for research but was totally useless as a means of large-scale production. Something with a higher yield was needed.

The next system to be put to use was the calutron. Research and development work was done on this system from late 1941 to the end of the war, after which date it continued on a reduced basis; this work resulted in a series of pilot and medium-scale plants which culminated in November, 1943, in the completion of a large-scale calutron-type separatory plant at Oak Ridge, Tennessee. It was a calutron which produced the first gram-quantity amounts of pure $_{92}U^{235}$, and it was the big Oak Ridge calutron plant which provided the fissionable material for the Hiroshima atomic bomb. For over a year, the big calutron plant was the only primary separatory plant in operation. In principle, the calutron very much resembles the mass spectrograph; it differs principally in application. A calutron's ion beams are very much wider than a spectrograph's, and are focused primarily by special electromagnetic fields. Ion sources are much improved in efficiency and rate of production. Multiple ion sources and slit-plates are used with each main magnetic field to take fullest possible advantage of the expensive, power-consuming primary-field equipment. Also special equipment is included to cancel the space-charge effect which is so troublesome with augmented ion beams. These are only the major improvements; many more—minor ones have been made as well. These modifications resulted in an apparatus which produced the first militarily-significant quantities of $_{92}U^{235}$, and did it at significantly-increased overall energy efficiency ratings, despite the fact that increases in quantity of material handled had resulted in decreased separatory efficiency and required two and sometimes three states to give the product-purity the mass spectrograph had given with one. Nevertheless, despite all the improvements, the electromagnetic separatory units did not produce as much fissionable material as the Manhattan Project desired. Unfortunately, it appeared as if the calutron had at that time reached, or was approaching its maximum practical materials-handling capacity; so those in charge of the overall program, besides intensifying research and development on other primary separatory methods, began looking about for means of increasing calutron yield without increasing the amount of input uranium handled by the calutron. One promising method was preliminary enrichment of the calutron input feed through use of the thermal diffusion method.

Thermal diffusion processing had been under serious investigation since the fall of 1940, but because of the necessarily empirical nature of such investigations when liquid input materials are used, it was not until the spring of 1943 that a pilot plant was constructed which gave appreciable separation of workably large quantities of input uranium. While the theory of thermal diffusion in gases had been fairly well worked out as early as 1919, the theory of such diffusion in liquids is "practically impossible," to quote the Smyth Report, and all work on such a system must be essentially trial-and-error in nature. Nevertheless, when the pilot plant was finally finished, it indicated that a full-scale installation could be built much more cheaply and rapidly than was possible for any other system, and that such an installation could handle very large quantities of natural uranium and still produce a workable degree of isotopic separation. The chief drawback of such an installation appeared to be its enormous consumption of steam, which made it seem impractical for the entire task of separation; however, since the yield of the full-scale plan would be used as feed for the calutron plant, this was no great drawback. The full-scale plant was erected in amazingly short time during the summer of 1944, was about as successful as expected, and did succeed in its primary purpose of considerably increasing the output of the calutron plant. As built, this installation consisted of banks of vertical pipes, each pipe being made up of three concentric pipes. The inner pipe carried steam, the middle channel carried the uranium in the form of liquid uranium hexafluoride, and the outer channel carried coolant; thus a large temperature gradient was set up across the UF_6 channel. As it turned out, the heavier isotope tended to accumulate near the cooler wall and then sink down, so that thermal diffusion was aided by a counter-current-flow reflux effect set up by thermal convection. Fresh uranium feed entered at the bottom and the enriched product was drawn off at the top. This combination of effects provided satisfactory separation.

The centrifugation system was put into actual practice about the same time as the thermal diffusion system but, unlike the thermal diffusion system, it never progressed beyond the pilot-plant stage. The single centrifugation pilot-plant which was built gave approximately the degree of separation predicted by theory but also pointed out the magnitude of the engineering problems involved, especially in the construction and maintenance of large quantities of high-speed rotors. For this reason, and because of the low capacity of individual machines and the large power input required to overcome friction, centrifugal separation was recognized as a blind alley, at least for the time being, and the pilot plant was shut down and research along these lines discontinued. This was somewhat surprising,

(Continued on page 37)



Paul Farbanish (B.S.E.E., Lehigh '58) is a development engineer with design responsibilities for IBM's new solid state 1401 computer system.

HE'S MAPPING NEW WAYS TO BEAT TRAFFIC JAMS IN LOGICAL SYSTEMS

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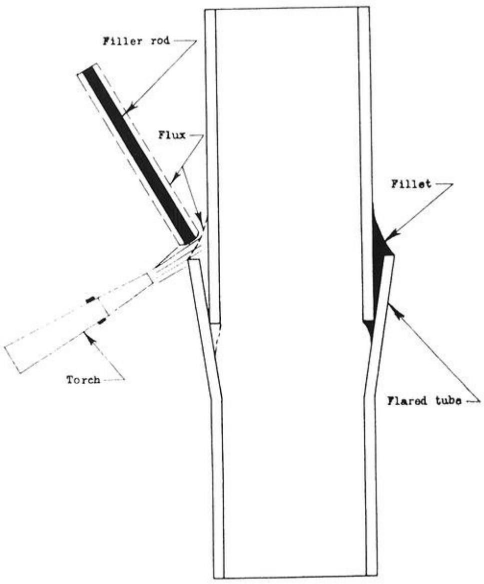


Brazing Aluminum

by Jerome H. Kilthau met'61

TORCH BRAZING

ALUMINUM parts are brazed when it is desired that they have a smooth, neat-looking finish combined with strength, light weight and corrosion resistance. The aluminum brazing method is a joining of aluminum parts with an alloy whose melting point is generally only slightly below the melting range of the base alloy. The fact that the base metal never becomes hot enough to melt constitutes the chief difference between brazing and welding.

A rule of thumb used in industrial brazing is that the filler alloy melt at a range about 100° F below the melting range of the aluminum parts to be joined, although in special cases the melting ranges can be as close as 10–20° F if special care is exercised. When the brazing temperature is reached, the melted filler alloy becomes liquefied and is drawn into the joint by capillary action. The result of this capillary flow is a smooth fillet which requires little or no finishing.

An advantage in brazing aluminum parts is the high production rate possible since, in most commercial operations, a multiplicity of joints can be brazed simultaneously. In the furnace and dip methods of brazing, up to several thousand joints can be brazed in one operation. Because the liquid filler is allowed to flow into the joint, the result is a union with good stress distribution and fatigue resistance.

Another big advantage is that brazing produces an all-aluminum structure which retains aluminum's high resistance to corrosion, good strength and uniform finishing characteristics. The brazed joint blends with the base metal and can be made to match in appearance so closely as to defy detection.

Since brazing temperatures, ranging from 1000–1200° F, are higher than annealing temperatures, certain aluminum alloys cannot be brazed. Castings, for instance, blister at brazing temperatures because of their low melting point. Non-heat-treatable wrought aluminum alloys will be in the annealed (softened) temper upon leaving the furnace or dip bath. On the other hand, wrought aluminum alloys which can be heat treated, if quenched after furnace or dip brazing, and then aged, will have the equivalent of a solution heat treatment. Obviously, the result is elimination of a separate heat-treatment.

The requirements for good brazing are essentially few and quite simple. The most important point to keep in mind is to make sure that all foreign matter, especially dirt and grease, is completely removed. The molten filler metal has a tendency to flow around foreign matter causing a weakness in the structure of the brazed joint. Oil and grease cause the liquid filler to stop flowing. This phenomenon is employed in commercial processes. If an oil (usually SAE 30) is brushed onto fixtures carrying an assembly through a brazing process, the filler will definitely not adhere to any part of that fixture in contact with the filler, which has the oil on its surface. The oil then, was employed as a stop-off. Commercially prepared stop-offs are also available.

Cleaning of parts to be brazed is effected by mechanical and chemical means. Mechanically, a wire brush will clean the assembly of large particles of dirt and scale. Brushing must always be followed by chemical cleaning, however, since even tiny particles can prevent good capillary flow.

An inexpensive cleaning solution is a 5% sodium hydroxide bath at 150° F. A thirty second immersion should clean most pieces. After the chemical bath, the parts must be rinsed in water, dipped in a 10% solution of nitric acid, and rinsed thoroughly with water. It should be noted that chemical cleaning affects tolerances. This should be accounted for in the designing of assemblies.

FLUXES

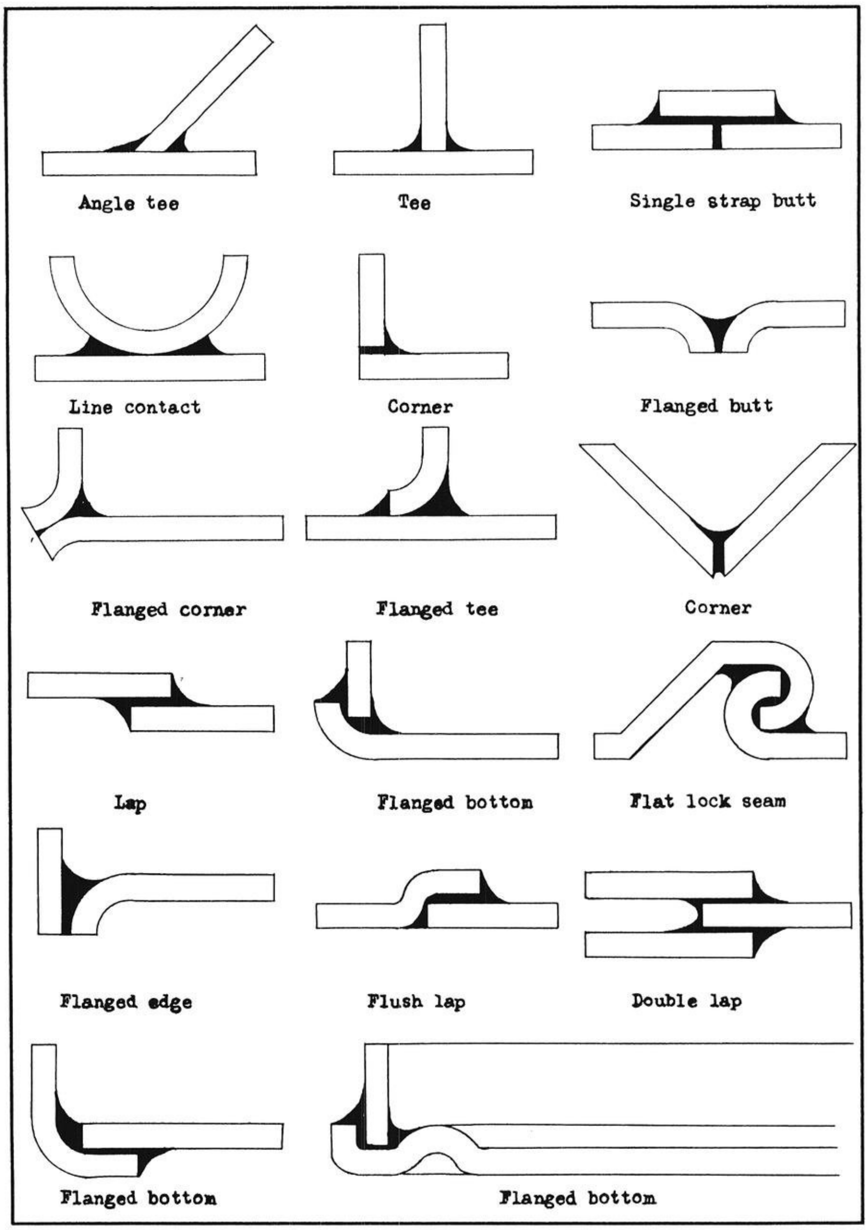
Chemical cleaning reduces the amount of surface oxide present and allows the flux to work faster. This chemical cleaning is necessary since fluxes are comparatively more expensive. The purpose of a flux is to remove oxides and promote capillary flow. An inherently bad characteristic, then, is the fact that all fluxes are highly corrosive and must be used with caution. This corrosiveness dictates that an assembly should be brazed within forty-five minutes after flux application, or the metal parts will be attacked. Fluxes, consisting of combinations of chlorides and fluorides, are shipped in a dry powder form in air-tight containers. They can be stored for long periods of time if the seal is maintained. Dry fluxes are hygroscopic and should be used as quickly as possible once their containers are opened.

Fluxes may be applied by paint-spraying, or dipping. For painting, a mixture of 2/3 flux and 1/3 water by weight provides a solution of desirable consistency. For spray or dip applications, the mix should be made thinner, as desirable, by trial.

The brazing operation seldom uses all of the flux present, and because of its corrosive qualities, residual flux must be removed. An effective method is immersion of the assemblies in boiling water immediately after brazing. If this method distorts the assembled units, though, they can be first allowed to cool slightly, and then dipped in water. Water immersion never effects complete removal and should always be followed by a chemical flux removal.

DISTORTION CONTROL

Distortion control is seldom a problem during brazing, except in very thin-walled sections. Distorting usually occurs during a process in which the assembly is not uniformly heated, as in torch brazing. If this problem occurs, an alternate method of brazing should be chosen, or else designing methods should be employed to combat this problem.



Above are some typical joint designs recommended for brazing aluminum.

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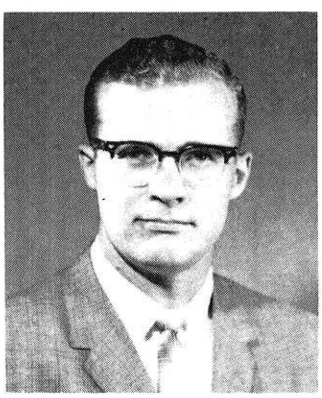


Jerome H. Kilthau, a senior in Metallurgical Engineering, chose this topic because it is his field of study. Mr. Kilthau is resident of Milwaukee and went to UW–Milwaukee for two years. He is a member of Mining & Metallurgy Club, Society of American Military Engineers, and the American Society for Metals.

METHODS FOR ALIGNING AND HOLDING PARTS DURING THE BRAZING OPERATION

Proper alignment of parts is often a problem. Whenever possible, the parts to be joined should be self-jigging. This can be accomplished by means of crimping, grooving, peening, keying flanges, riveting, or even spot welding. Many times fixtures, which carry or hold the assemblies through various processes, are used to align parts. When fixtures are employed, care must be taken in their construction since dissimilar metals expand at different rates at elevated temperatures. Disproportionate expansion could force assemblies out of alignment. Also, fixtures should be kept light and clean.

JOINT DESIGN

Assembly alignment may also be accomplished by use of various joint designs. The most common brazing joints are the lock seam, tee, and line contact. Butt joints are not recommended because of difficulties in obtaining complete filler distribution and good contour. Lap or flanged joints can be used where strength is not essential. Excessive lap should be avoided. In general, laps should be about twice the thickness of the thinner part. The line contact joint is most satisfactory because the resultant capillarity produces a symmetrical, strong and sound joint. In all joints, primary concern is for complete penetration of filler metal. To assure this, proper clearance is necessary when fitting joints.

In most cases, clearances should range from 0.006 to 0.010 inches. This is sufficient for laps less than ¼ inch long. Longer laps may require up to 0.025 inches clearance.

Joint designs must permit flux washout after brazing to eliminate corrosive after effects. When a hollow member is to be completely sealed, a small hole drilled in the member will serve as a relief vent. This will also prevent distortion or collapse by air pressure on the assembly. The hole may be closed later by torch brazing.

FILLER ALLOYS

Filler alloys are available in several types and forms. Fillers are essentially aluminum-silicon alloys. The four common alloys contain 5, 7½, 10, and 12% silicon and melt at approximately 1120°, 1105°, 1030°, and 1075° F, respectively. These alloys are available in several forms: wire, wire rings, shims, and brazing sheets.

A brazing sheet is simply alloy stock to which filler has already been bonded (usually during the roll-down from the ingot). The advantage of using brazing sheet is that preplacement of the filler in the form of washers and rings is unnecessary. When the sheet is subjected to brazing temperatures, the filler melts and is drawn into the joint by capillarity. Filler rods and brazing sheets are available in many commercial forms.

Brazing sheets, shims, and wire rings are used mostly in mass production operations, such as furnace or dip brazing. Torch brazing generally is limited to the use of filler rods.

COMMON METHODS OF BRAZING

Torch Brazing

One of the biggest limitations to torch brazing is that joints to be brazed must be accessible to the flame of the torch and the filler alloy.

The source of heat is provided by one of three types of flames; oxy-acetylene, oxyhydrogen, or oxy-natural-gas. Of these, the first is preferred because of the high heat output involved. Temperatures are as high as 6300° F, compared with 4300° F for oxyhydrogen and even lower temperatures for natural gas combinations. The type of flame used should be a reducing flame since this helps minimize the chances of oxidation. It is identified by a white inner cone and a large exterior blue flame.

Variations in temperatures produced, dependent upon nearness of flame to assembly, require an indicator of some sort to tell the operator when brazing has been reached. Here the flux plays an important role. The flux will fume and smoke slightly at brazing temperature. Care must be exercised at this point to avoid exceeding this temperature, since melting of the assembly parts will result.

Torch brazing procedure, if thought of in a step-by-step process, is quite uninvolved. The first necessity is, of course, to make sure that the parts are clean and in proper alignment. Cleaning is facilitated through use of the 5% sodium hydroxide solution described previously, and alignment is assured by means of assembly jigs.

Secondly, the assembly is painted or sprayed with flux. This is followed by a preheating of the parts to be brazed. Preheating is done by waving the torch slowly over the joint with the inner cone of the flame about two or three inches from the assembly.

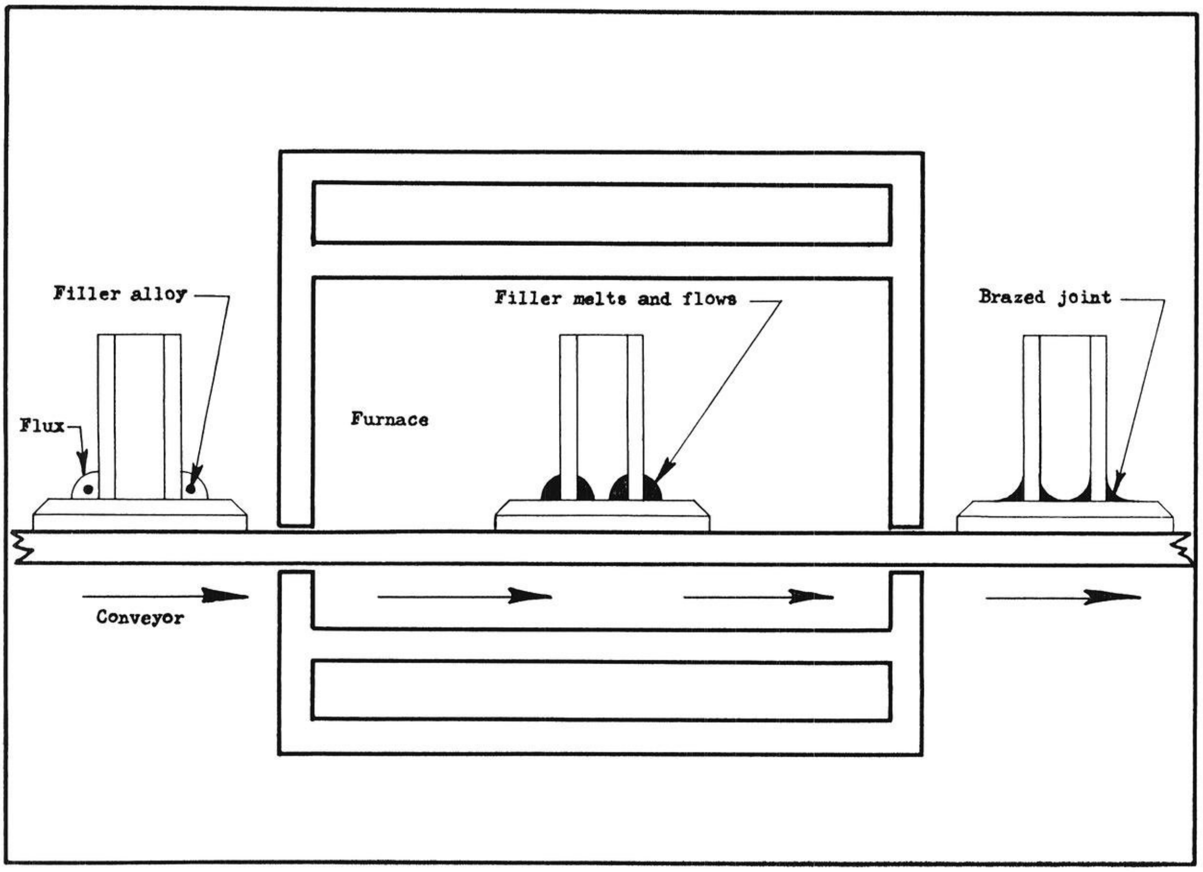
Preheating serves two purposes; bringing the joint up to brazing temperature and activating the flux. When heated, water is driven from the flux leaving a dry powder which shortly begins to melt, then turn gray, after which it becomes transparent, revealing the shiny, prepared metal beneath.

The assembly is now ready for the application of the filler metal. The white inner cone is brought to one-half inch away from the joint making an angle of 10–20° with it and directed against the filler rod. The rod is fed into the joint as rapidly as it melts, in a straightforward motion. Care must be taken to retain the flame in one place long enough to assure an even flow of metal into the joint. Capillary flow will assure a smooth, uniform joint. The filler is then allowed to solidify before moving any of the assembly parts. This is usually completed in only a few seconds. The brazed joint is now complete.

The final operations are quenching the assembly and removing any residual flux. Usually a fiber brush scrubbing in boiling water is sufficient to remove superficial particles; however, larger assemblies demand use of a water jet-spray. This mechanical cleaning must always be followed by a chemical cleaning. Finishing is seldom necessary, and at most a wire brushing would be used to remove any drippings or splatter.

Furnace Brazing

Furnace brazing is probably the most widely used of all brazing process. It differs, in essence, from torch brazing in that it requires as-



Furnace brazing permits the joining of aluminum parts on a continuous basis.

sembly of parts with the filler already in place. Next, the flux is applied, and the entire assembly, held in a suitable fixture is carried through a brazing furnace.

There are several types of brazing furnaces in use today. The better-known types are electrical resistance, direct combustion, forced air circulation and radiant tube furnaces. The direct combustion furnaces are inexpensive, but unfortunately not all assemblies can withstand the exposure to combustion gases. Temperatures in radiant heat furnaces are difficult to control, while electrical resistance furnaces provide very accurate temperature control. Electrical resistance furnaces usually cost more to install, but for mass production work they pay for themselves in a short time.

Control over this mechanized process of brazing depends upon the time the assemblies are in the furnace, the temperature of the furnace, and the time the filler metal must be exposed to heat to insure good flow. Since the pieces enter and leave the furnace by a conveyor system, the time in the furnace is controlled by the speed of the belt. Temperature is electrically controlled by thermocouple systems. Temperatures must be maintained within 5° F of the desired brazing temperature.

Since the furnace interiors are exposed to the corrosive flux vapors, they should, of course, be corrosion resistant. Aluminum clad steels and firebrick provide adequate protection.

In preparation for entry into the furnace, parts must be cleaned according to standard procedure with sodium hydroxide solution, filler must be placed, parts must be aligned, and joints must be fluxed.

The importance of conveyor speed cannot be overemphasized. Assemblies must be in the furnace long enough to assure proper flow of the filler metal, yet overheating will cause the parent metal to wash into the joint. In thin-walled sections this could result in a hole in the assembly wall.

Better furnaces have graduated temperature zones. These gradually heat the assembly, avoiding warpage. Usually the first three of five zones are devoted to preheating. The fourth zone is the brazing zone. Here the temperature developed is high enough to melt the filler metal. This zone is long enough in length to assure proper flow of the filler. The fifth and final zone facilitates gradual cooling of the assembly. If a quench is desired, a boiling water jet-spray may be used here.

After leaving the furnace, pieces are flushed of residual flux. This is usually done with a three-stage pressure washer. The first stage uses a boiling water spray, the second a boiling water rinse, and the third a hot air blow-off. As always, a chemical flux removal must follow.

Dip Brazing

Another popular mass production brazing operation is dip (salt bath) brazing. In use, this method eliminates the need for a separate fluxing operation. The parts are held in place with a suitable fixture, filler placed in the joint, and then immersed in a pot containing molten flux at the proper brazing temperature. An advantage in using this method is that like furnace brazing, it affords the equivalent of a solution heat treatment if the pieces are quenched and aged after the brazing operation.

Another advantage is the saving of time in this method since the fluxing and brazing steps are combined. Heating is extremely fast, being completed in two to five minutes. Still another desirable factor is that even the most tiny, inaccessible joints may be brazed. The assemblies brazed in the dip process are the smaller, lighter, and cheaper to produce.

On the other hand, this method has one noteworthy drawback. There is considerable waste of flux due to surface drag-out. In many instances, however, this is outweighed by the desirable qualities of the process.

The pot in which the molten bath is kept is carefully and specially constructed. Smaller units may be constructed of heat-resistant glass, silicon carbide, or nickel, while larger units are constructed of high-alumina acid-proof brick lining, clay brick insulation, and a steel outer wall.

Heating elements are nickel or inconel, since these substances are least attacked by molten flux, and result in minimum contamination of the bath. The heating elements are installed horizontally submerged because the air-flux corrosion at the surface is strong enough to erode even nickel and inconel. Temperature is controlled by thermocouples.

Because the flux is an oxide remover, a sludge is formed at the bottom of the vat. This must be removed periodically. A perforated dipper is best used since it will not interrupt the operation. The flux level is maintained by addition of small quantities of flux powder.

A hood and vent must accompany each pot since the flux vapors are obnoxious and undesirable. Workers should be provided with safety masks, gloves, and suitable protective clothing.

The dip process is simply run. Cleaning, assembly, and placement of the filler metal precede the preheating. This preheating avoids warping of the pieces which might occur if they are dipped into the molten flux when at room temperature. Preheating takes place in a hot air furnace until the assemblies are about 1000° F. The fixtures used to lower the pieces into the pot should tilt the assembly before immersion to avoid entrapment of air. When removing the assemblies, care must be taken not to tip them since the filler in the joint will not yet be solidified. Quenching or annealing may follow.

SPECIAL BRAZING METHODS

Although the most widely used brazing processes are torch, furnace, and dip brazing, there are many special methods of brazing which may be adapted to special problems. Just a few of these are induction, resistance carbon block, and block brazing which utilize heated metal discs. Other methods are mechanized flame and metal dip brazing.

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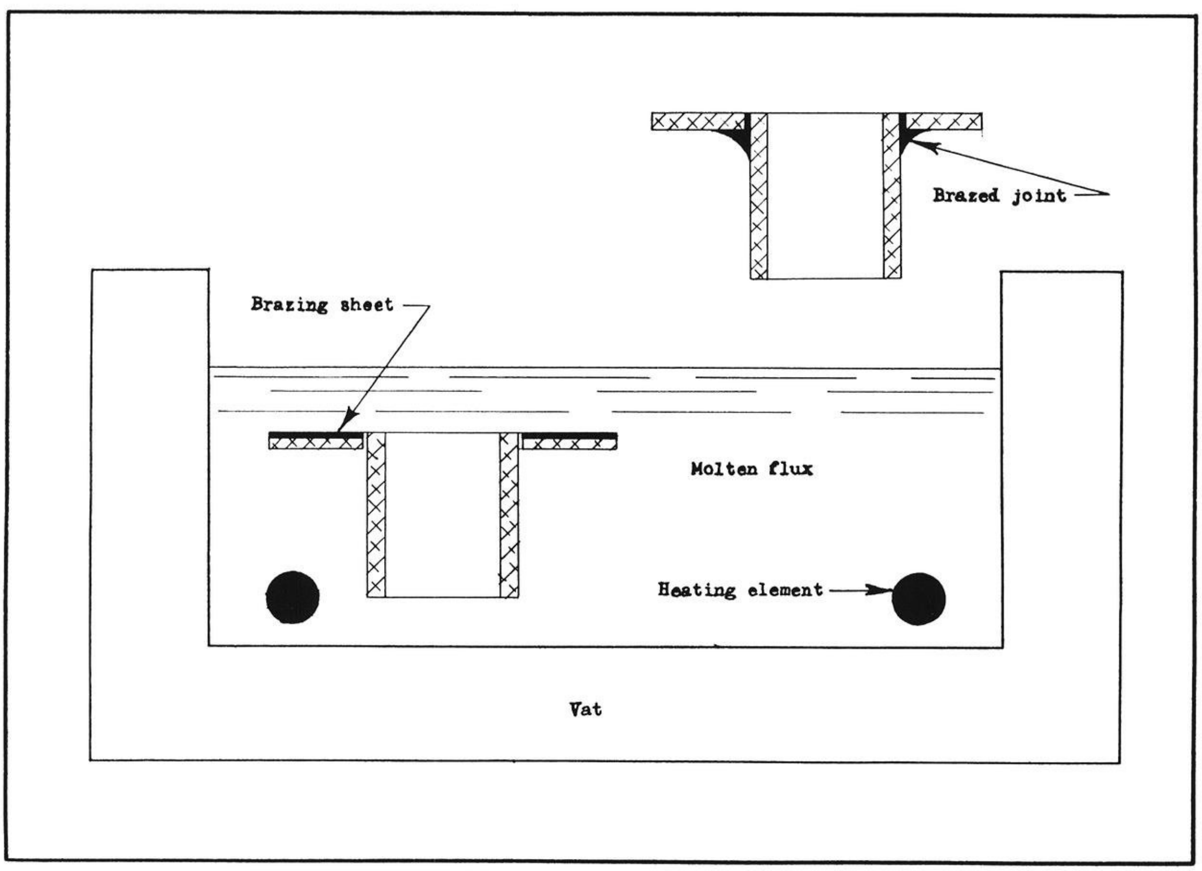
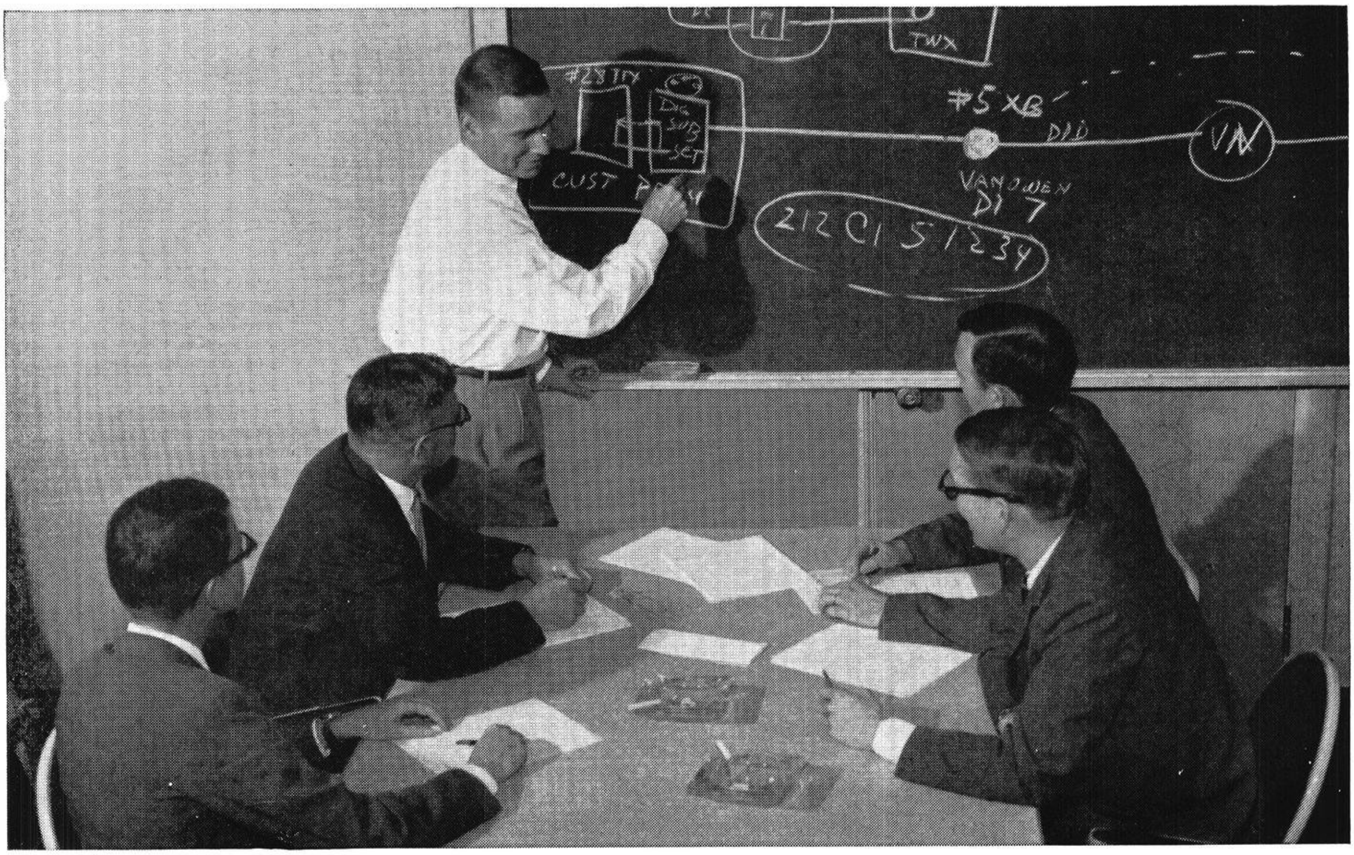


Dip brazing eliminates the need for a separate fluxing operation.



STU'S EXPLAINING HOW MACHINES WILL SOME DAY "OUTTALK" PEOPLE

"Stu" Smith graduated from Southern Cal with a powerful yen for excitement. His kind of excitement—Engineering.

He got what he bargained for (and a little more) when he joined Pacific Telephone. One of Stu's early assignments was to find out how existing Long Distance networks could be used to pipeline high speed "conversations" between computers in distant cities.

The fact that he did a fine job did not go unnoticed.

Today, four years after starting his telephone career, Senior Engineer Stuart Smith heads a staff of people responsible for telegraph and data transmission engineering in the huge Los Angeles area. As a pioneer in this new data transmission field Stu predicts data processing machines will some day do more Long Distance "talking" than people.

Stu contacted 12 other companies before joining Pacific Telephone. "I don't think there's any limit to where a man can go in the telephone business today. Of course, this isn't the place for a guy looking for a soft touch. A man gets all the opportunity he can handle right from the start. He's limited only by how well and how fast he can cut it."

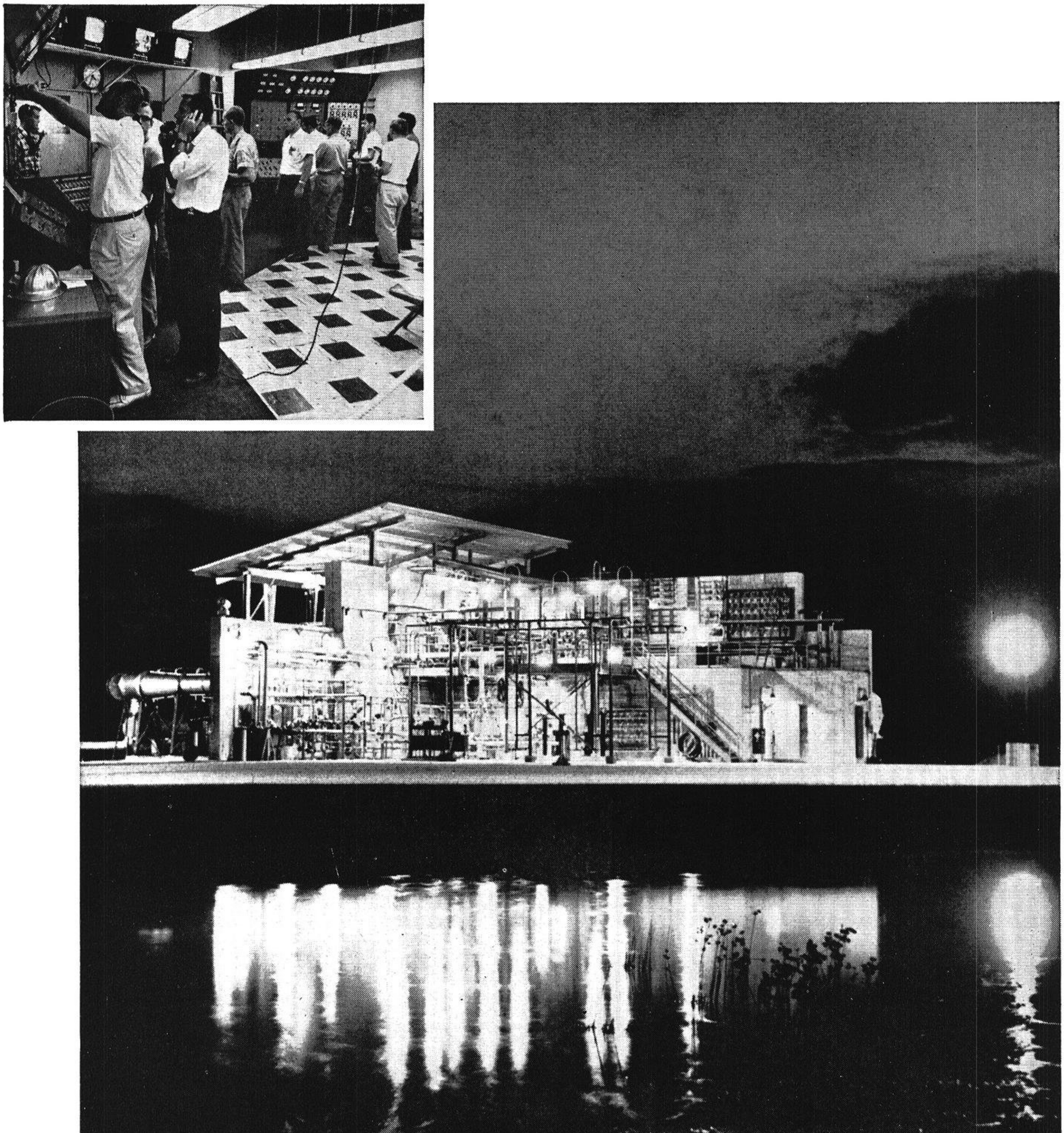
If Stu's talking about the kind of opportunity you're looking for, just visit your Placement Office for literature and additional information.

"Our number one aim is to have in all management jobs the most vital, intelligent, positive and imaginative men we can possibly find."

Frederick R. Kappel, *President*
American Telephone & Telegraph Co.

BELL TELEPHONE COMPANIES

What would *YOU* do as an engineer a



Development testing of liquid hydrogen-fueled rockets is carried out in specially built test stands like this at Pratt & Whitney Aircraft's Florida Research and Development Center. Every phase of an experimental engine test may be controlled by engineers from a remote blockhouse (inset), with closed-circuit television providing a means for visual observation.

'ratt & Whitney Aircraft?

Regardless of your specialty, you would work in a favorable engineering atmosphere.

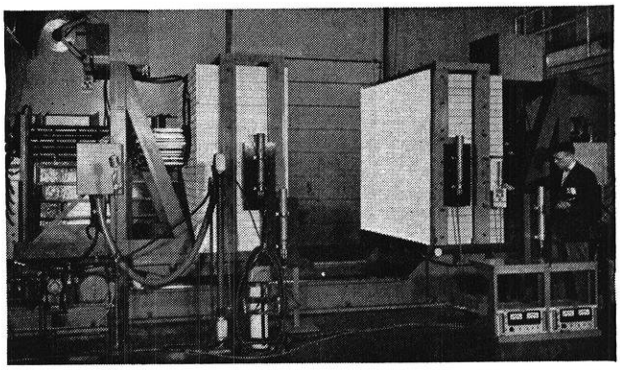
Back in 1925, when Pratt & Whitney Aircraft was designing and developing the first of its family of history-making powerplants, an attitude was born—a recognition that *engineering excellence* was the key to success.

That attitude, that recognition of the prime importance of technical superiority is still predominant at P&WA today.

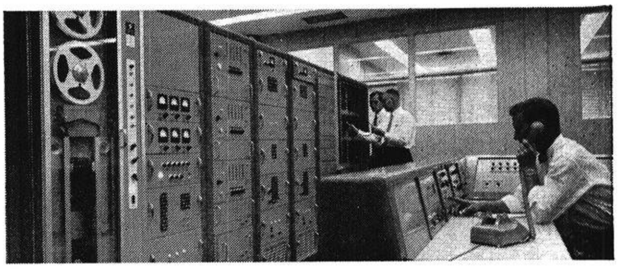
The field, of course, is broader now, the challenge greater. No longer are the company's requirements confined to graduates with degrees in mechanical and aeronautical engineering. Pratt & Whitney Aircraft today is concerned with the development of all forms of flight propulsion systems for the aerospace medium—air breathing, rocket, nuclear and other advanced types. Some are entirely new in concept. To carry out analytical, design, experimental or materials engineering assignments, men with degrees in mechanical, aeronautical, electrical, chemical and nuclear engineering are needed, along with those holding degrees in physics, chemistry and metallurgy.

Specifically, what would *you* do?—*your own engineering talent* provides the best answer. And Pratt & Whitney Aircraft provides the atmosphere in which that talent can flourish.

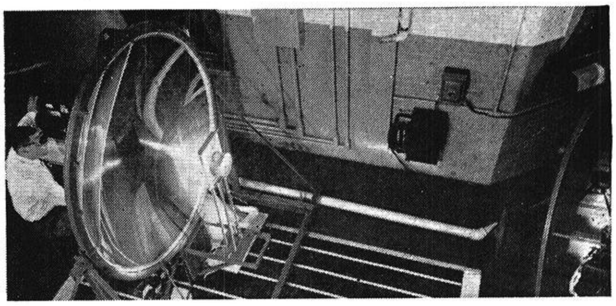
For further information regarding an engineering career at Pratt & Whitney Aircraft, consult your college placement officer or write to Mr. R. P. Azinger, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.



At P&WA's Connecticut Aircraft Nuclear Engine Laboratory (CANEL) many technical talents are focused on the development of nuclear propulsion systems for future air and space vehicles. With this live mock-up of a reactor, nuclear scientists and engineers can determine critical mass, material reactivity coefficients, control effectiveness and other reactor parameters.



Representative of electronic aids functioning for P&WA engineers is this on-site data recording center which can provide automatically recorded and computed data simultaneously with the testing of an engine. This equipment is capable of recording 1,200 different values per second.



Studies of solar energy collection and liquid and vapor power cycles typify P&WA's research in advanced space auxiliary power systems. Analytical and Experimental Engineers work together in such programs to establish and test basic concepts.

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

CONNECTICUT OPERATIONS — East Hartford

FLORIDA RESEARCH AND DEVELOPMENT CENTER — Palm Beach County, Florida

Glueing Process of Laminated Beams

by Charles Heath Ci e'63

INTRODUCTION

THE laminating of lumber to make beams is a relatively young industry in this country. The idea was brought over from Europe in 1934, and only now is it gaining wide recognition. Laminated members are the favorites of many people. The layman enjoys their beauty, and the builder, their durability and inexpensiveness.

The complete process of fabrication of a member consists of engineering, laminating, and machining. In the engineering department, the beam is drawn and designed. In the laminating stage, with which this article deals, the actual fabricating is done. Then comes machining, which consists of the detailed work such as drilling, notching, and sanding.

Two basic adhesives are used, casein when the beam will be placed in areas of low humidity, and phenol-resorcinol when the beam will be placed in areas of high humidity.

Individual laminates are made in three steps—scarfing, gluing, and planing. Scarfing, which is planing a sloped end cut on a board, is done by a machine that takes a first and a finishing cut. Glue is then applied by hand to the scarfs, and the joints are pressed. When the glue is dry, the laminates are planed to an exact thickness.

After planing, the laminates are glued together to form the rough beam. A double-roll spreader applies the adhesive to both sides simultaneously. The spread of the glue is just enough to allow some to be squeezed out under pressure.

When glue application is completed, the laminates are placed in jigs, and clamps are applied. The member is left under pressure, about 150 pounds per square inch, for about eight hours.

When the member is removed from the clamps, machining begins, after which the member is shipped to the customer.

Adhesives

There are two basic adhesives used for laminating beams—casein and phenol-resorcinol. Phenol-resorcinol is a resin and is prepared by mixing the glue powder with a hardener and water. Casein is prepared by mixing the glue powder with water. The speed of setting varies with the adhesive and, in the case of resins, a hardener is used to speed up the setting. Setting is also faster under higher temperature.

Casein, used with a suitable mold inhibitor, is the standard water-resistant adhesive. It is sufficient as long as the member is not exposed to repeated wettings or high humidity over a long period of time. Also, special attention must be given to the ends of the member because these surfaces are highly moisture absorbent and can become feathered. This does not cause a structural deficiency but is unsightly.

Where it is not advisable to use casein, phenol-resorcinol is used. This adhesive will withstand the most severe conditions of exposure. Because members laminated with phenol-resorcinol must be pressure treated, they are more expensive than those made with casein, and, consequently, phenol-resorcinol is used only when absolutely necessary.

There is no limit to the number of places where a phenol-resorcinol laminated member can be used, which is the main advantage of this adhesive over casein.

The time, after mixing, for which the adhesive is still useful is called the pot life of the glue. All assembling and clamping must be done in this time. The pot life and pressure period, the time for which the member must be clamped, vary with the speed at which the glue sets. Thus, to get the most use of jigs, an adhesive is chosen which has the maximum speed of set and for which the pot life exceeds the time required for gluing, assembling, and clamping the member. Casein and phenol-resorcinol meet these requirements better than other adhesives. However, the eventual use of the member determines which of these two glues is used.

Laminates

Laminates are individual laminations of a member and are made in three steps—scarfing, gluing, and planing.

A scarf is a sloped end cut, usually at a 1:12 pitch, which allows more gluing surface at the end of the board and distributes a high percentage of the permissible direct load on a laminate.

Scarfing is done by a machine which finger feeds the boards, laterally, into the part of the machine that houses the cutters. However, the boards must be manually loaded onto the finger feeding chain. Two cutters, set at the desired slope and placed at a 45° angle to reduce vibration, take a first and a finishing cut.

Glue is applied by hand, either by a brush or a small roller, after which all of the joints are clamped simultaneously. Before the boards are clamped, waxed paper is placed between the laminates to prevent accidental gluing.

After the scarf joints are glued, the laminates are planed to remove glue squeeze out and rough surfaces. This is done by running each piece through a double planer which surfaces both sides simultaneously. Planing should produce 20–30 scarcely perceptible knife marks per inch.

After planing, laminates should not deviate more than 1/64 inches in thickness along their entire length with adjacent boards forming individual laminates deviating no more than 0.01 inches. Nothing, such as sanding or sawing, which would roughen the surfaces, should be done after planing and before gluing.

Applying Adhesive to Laminates

Upon completion of planing, laminates are glued together to form the rough beam. Double-roll spreaders of rubber or steel are used to apply the adhesive to both sides of the laminate at once. The pieces are fed into and taken out of the spreader by trolleys, after which they are stacked by hand in the arrangement in which they will be clamped. In stacking, much care is taken to see that no two scarf joints are adjacent. If they were, the beam would be weak at that section.

The spread of the adhesive is given in pounds per 1,000 square feet of glue line. Double spread, the rates are about 75–100 lb for casein and 50–75 lb per 1,000 square feet of glue joint for phenol-resorcinol. The spread should be enough to allow a small but continuous bead of glue to be squeezed out under pressure. The spreader is adjusted to the appropriate spread which may be checked by putting a weighed and measured board through the spreader and reweighing to find the amount of glue that was added.

Pressing

When glue application is completed, the laminates are placed in a pressing assembly consisting of jigs and clamps. Here they are left for about eight hours.

The most common jigs are light-braced welded steel of an L pattern on which the members are laid with the laminates on edge.

A fixed row of jigs is laid down, about four feet apart, with camber being provided for by adding packing to the jigs. These jigs must be accurately aligned.

The clamping system should be easily adjusted, and accurate in applying pressure. It should continue to provide the same pressure after some dimensional change which results from squeeze out and absorption of glue. Also, it should be capable of moving with the member while still applying pressure.

Two types of clamps are used; those for vertical pressing and those for horizontal pressing. Horizontal clamps are a simple screw type tightened with air wrenches. Thick boards called cauls are used on each side of the assembly to distribute the concentrated pressure of the clamp.

Actual clamping pressure varies from 100 to 250 pounds per square inch with 150 pounds being the most frequent. A practical accurate method of applying a given pressure with a screw clamp is to apply a given torque to the screw and to calibrate, experimentally, the clamp in terms of torque and pressure.

The gluing pressure is obtained by dividing the load applied by the clamp by the area served by the clamp. Washers, four to six inches in diameter and up to ½ inch thick, and timbers are used for transferring the load from the bolt head or nut to the cauls. Vertical pressure is applied by horizontal bars, usually spaced at five feet, held by vertical threaded rods.

Clamping is done in two stages. First, there is a general clamping to align the member, and second, there is a systematic tightening of the clamps which proceeds from the center to the ends of the member. It is generally necessary to retighten the clamps after about an hour to allow for squeeze out and absorption of glue.

Upon removal of the member from the clamps, the gluing process ends. Now the beam is ready for its machining. After that is done, the complete fabrication process is finished, and the member is shipped to the customer.

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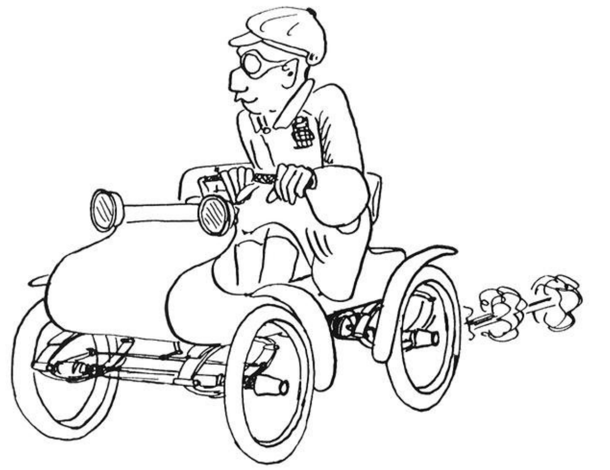
THE END

We are sorry we could not get a picture or information about author.



THE ENGINEER OF YESTERYEAR

by Reidar O. Nilsen, cie'61

THE STRUCTURAL DESIGN OF MEMORIAL UNION BUILDING

April, 1927

THE Memorial Union project is composed of three units of which the Memorial Union Building is the central primary feature. The Tripp Commons is the secondary unit on the east and the theater is the secondary unit on the west. The Memorial Union and Tripp Commons units are being built now, while the theater will probably be built later. Since Langdon street slopes downward from west to east, the future theater unit will occupy higher ground than the other two buildings. Therefore, the central unit had to be designed in such a way as to dominate the completed group. It may be some time before the theater unit is built, so a connecting element had to be provided which would look well from Park Street during the period which will elapse before the theater is actually constructed.

The Alumni Hall on the second floor of the Memorial Union Building constituted one of the main problems of the interior framing. This room was made 48 feet wide and 104 feet long with the requirement that there should be no interior columns. (In this way an excellent dance floor is obtained.) This became a serious problem structurally when rooms were provided over the two ends of the Alumni Hall.

The main dining room in the Tripp Commons building was made 55 feet wide and 68 feet long and two stories high. This room became another structural problem when it was decided to provide dormitory rooms overhead and to eliminate all interior columns. To add insult to injury, the architectural treatment of the interior and exterior made it necessary to use extremely shallow girders for the support of the floor above. In addition to this there were several smaller dining rooms in the Tripp Commons Building which were to be without columns.

Except for the ground floor, the floors are at different elevations in the two buildings. The differences are so great that the second floor of the Memorial Union Building is only 6 inches below the third floor of the Tripp Commons Building. The footings under the Tripp Commons Building and under the eastern one-third of the Memorial Union Building were to be carried about 5 feet deeper than those under the western two-thirds of the Memorial Union Building due to the natural slope of the ground.

A few preliminary calculations indicated that there would be some rather heavy column footing loads and so the character of the foundation soil was studied by making a number of test borings well distributed over the ground to be covered by the two buildings. Mr. Ernest F. Bean, State Geologist of Wisconsin, examined the samples of material. At his suggestion a soil pressure of 4,000 pounds per square foot was used for the poorest foundation material which was encountered under the front of the Tripp Commons Building. This was increased to 4,500 and 5,000 pounds per square foot, the latter value being used most often.

Plate girders 55 feet long and 3 feet deep were used over the main dining room in the Tripp Commons Building. Deeper girders would have spoiled the interior treatment of this room. The west end of the front roof truss of the Trip Commons Building comes directly over the corridor which connects the two buildings. At first thought this seems like poor design, but this position of the roof truss provides the simplest framing of the front part of the roof. A steel beam was placed across the corridor opening so as to carry the load of the truss to nearby columns. Several similar problems were encountered in designing trusses for the Memorial Union Building and the same general type of solution was adopted.

A concrete-joist floor constructed by the use of removable metal forms was adopted for all floors of both buildings. The necessity for long-span, shallow girders, irregular framing, and small column size meant that structural steel beams, girders, and columns, rather than reinforced concrete, should be used over a large portion of both buildings.

Since the ground floor was at the same elevation in both buildings it was chosen as the base above which structural steel beams and columns should be used. The ground floor beams were of reinforced concrete and were supported on reinforced concrete columns.

As the building progresses it will be noted that almost all of the steel columns (in fact all but two) are rolled Bethlehem H-sections instead of some form of built-up sections. To meet the requirements for load, column height, and small column size, this gives the most economical solution. In a large portion of the Memorial Union Building, 27-foot spans are alternated with 14-foot spans. In other words, each joist is a continuous beam composed of a series of unequal spans. In general, the method of solving these problems are based on the theorem of three moments, and with this aid, the bending moments and shears are obtained at critical sections. In continuous-joist systems the maximum bending moment is almost always negative, occurring over a supporting beam. This means that the top of the joist is in tension and the bottom in compression. This is unfortunate since concrete joists made with metal forms are wider at the top than at the bottom. However, by using a special metal form near the end of the span, the concrete joist is widened at the support and thereby the unit compressive stress in the bottom of the joist is reduced at the support. The unit shear of the concrete joist is also reduced by the same process.

In the Alumni Hall—a dance floor—a live load of 100 pounds per square foot was used. In the third floor of the Tripp Commons Building a live load of 40 pounds per square foot was used. These loadings are in accordance with the requirements of the Wisconsin Industrial Commission. Some rooms will have terrazzo floors, others will have wood floors (wood finish on top of the basic concrete construction), while others will have floors covered with linoleum. Thus there will be varying live load and dead load requirement in the different portions of the two buildings.

From the above, it may be seen that live load, floor finish, weight of the construction, span length or combination of span lengths, and the degree of continuity of the joists will have a bearing on the design of concrete-joist floor system.

NEW CARBON MONOXIDE RECORDER AND ALARM

October, 1926

This instrument was developed primarily to protect the lives and health of passengers in vehicular tunnels such as that at Pittsburgh or the new tunnel from New York to Jersey City under the Hudson river. It has been found that anything more than four parts of carbon monoxide in 10,000 parts of air is likely to produce noticeable effects in a person exposed for one hour. The instrument is sensitive to less than one per cent of this concentration.

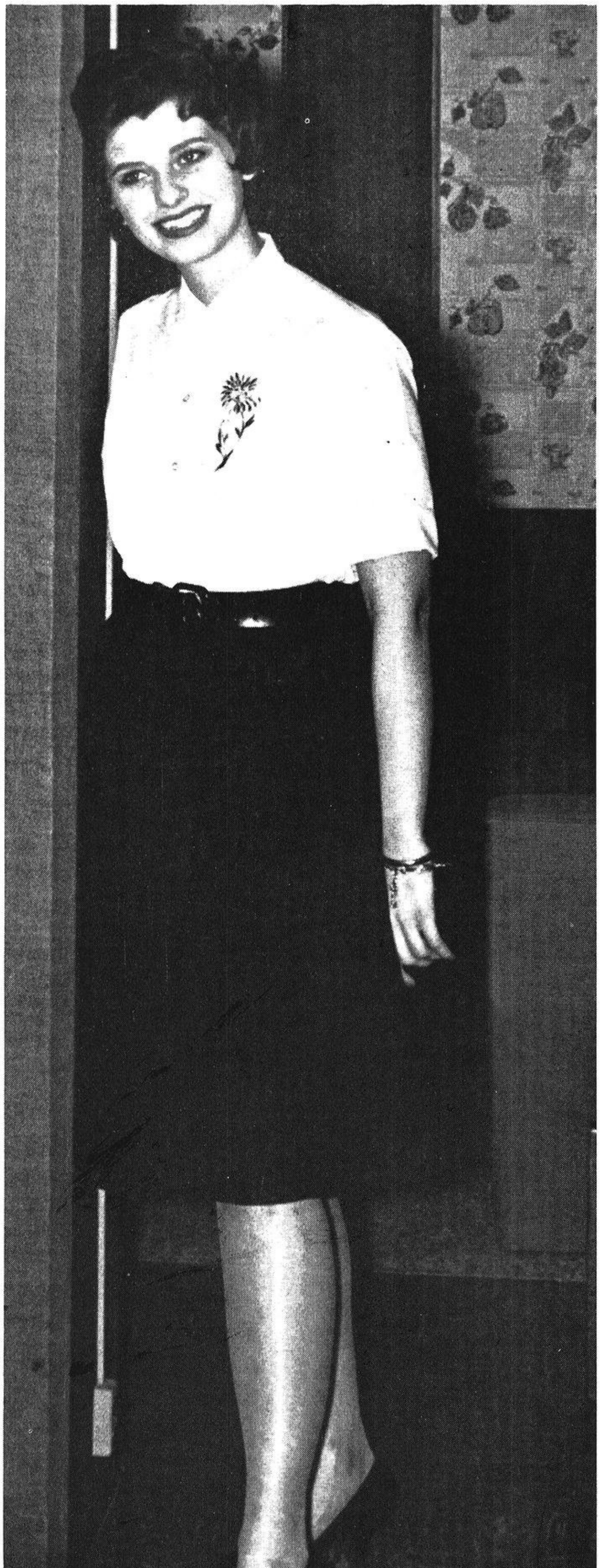
The air to be tested is drawn past the "cold" junction of thermopile buried in granulated hopcalite, —a mixture of manganese dioxide and copper-oxide. This mixture was developed during the World War for use in the canisters of gas masks. When carbon monoxide passes through hopcalite along with oxygen, the oxygen unites with the carbon monoxide to form carbon dioxide. The burning of carbon monoxide to carbon dioxide in this manner produces heat, although the resulting temperature rise is very small by reason of the small concentrations measured. However, the extreme sensitivity of the thermopile makes accurate measurement of the change relatively simple.

THE EFFECT OF SUGAR ON CONCRETE

December, 1926

Two recent cases of failure of concrete in districts in Egypt

(Continued on page 43)

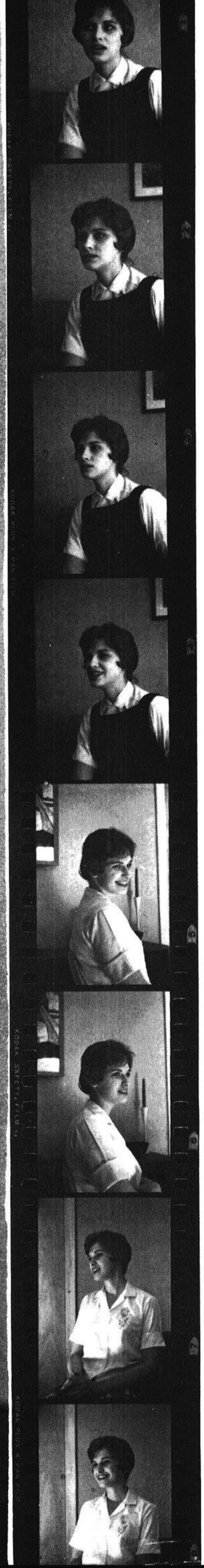


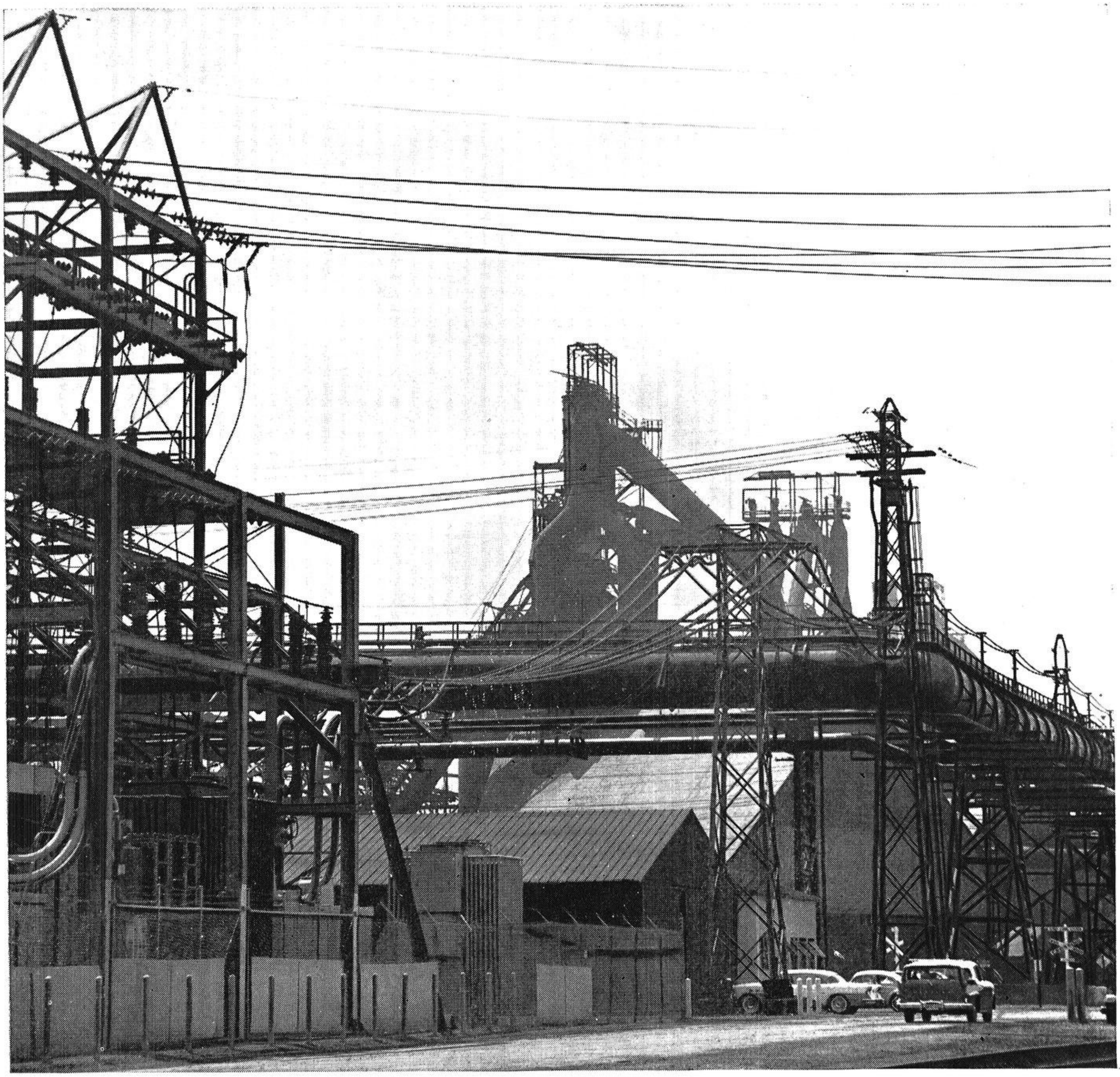
Girl of the Month

BARBARA RYCHLOWSKI

Barbara, the queen of the Cole Hall "Wistful Winterlude" formal, let us in on a secret—she dislikes cold winter weather. However, we are sure an engineer could solve that problem.

We are including a film strip to show that a photographer's work is extremely interesting with a beautiful model.





This steel plant consumes 1/400th of the electric power generated in the United States

Surprising? Not if you realize that steelmaking requires a tremendous amount of electric power.

It takes about 20,000 electric motors to drive the rolling mills and other equipment at our Sparrows Point Plant, near Baltimore, the nation's largest steelmaking plant. Here, at our own steam-electric generating station, we produce enough power for a city of 250,000.

It goes without saying that we need the services of electrical engineers to design, construct, and maintain the vast and complicated array of electrical equipment at our many plants and facilities.

Bethlehem offers excellent career opportunities for men in virtually all engineering curricula: *metallurgical, mechanical, chemical, industrial, civil, mining, ceramic, architectural, and others. We suggest that you discuss Bethlehem with your Placement Officer. And be sure to pick up a copy of our booklet, "Careers with Bethlehem Steel and the Loop Course."*

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SCIENCE HIGHLIGHTS

Dave Cress me'63

MEANS TO MEASURE ULTRA-LOW PRESSURES

A new laboratory tool for the measurement of pressures less than one-thousandth of one-billionth of atmospheric pressure at the earth's surface has been developed by scientists at the Westinghouse research laboratories. The device, known as a photomultiplier ion gauge, was developed by Westinghouse research physicists W. J. Lange, Henry Riemersma and R. E. Fox as part of an ultra-high vacuum research program supported by the U. S. Atomic Energy Commission's Project Sherwood. Project Sherwood is a long-range research program aimed toward achieving controlled nuclear fusion for peacetime uses.

The new instrument has advantages over conventional low-pressure-measuring devices for many critical ultra-high vacuum experiments.

Instruments which measure extremely low pressures, do so by placing electrical charges upon the gas particles remaining in a vacuum system and counting the rate at which these charged particles, or ions, form. Conventionally, these charges come from electrons that are boiled off the surface of a hot tungsten filament that is located inside the vacuum system and in contact with the gas being measured. In many instances, the gas interacts with the hot filament surface, breaking the gas down and converting it to an entirely different substance. Thus the very act of measuring the gas pressure contaminates the gas and upsets the entire experiment.

The new pressure-measuring device overcomes these undesirable effects by doing away with the heated filament completely. Instead of using a hot surface to produce the required ionization of the gas, a beam of ultraviolet light is used. The light is beamed onto a metal surface which has the ability to release electrons under the stimulus of the ultraviolet rays. These electrons are guided onto a series of similar surfaces which multiply the electrons in speed and number. These electrons then are used to form the ions that are collected and counted in the usual fashion. The series of surfaces which releases the electrons and increases their number is called a photomultiplier, from which the name of the new pressure-measuring instrument is derived.

The photomultiplier ion gauge will be useful in a variety of key ultra-high vacuum research experiments, being ideally suited to low-pressure studies of hot filament-gas interactions such as those encountered in the ordinary fluorescent lamp, in electronic tubes and in thermionic energy converters.

The gauge is linear with pressure over the range from one-thousandth (10^{-3}) to one-tenth of one-billionth (10^{-10}) millimeter of mercury. This range of pressures is equal to that encountered in space at distances between 50 and 650 miles above the surface of the earth. In fact, the new device already has found use in pressure measurements and other experiments aimed at understanding the concentration and interactions of the particles found in outer space through duplication of outer space conditions in the laboratory.

REMOTE-CONTROLLED SUBWAY

An electronic computer will run the subway system in Hamburg, Germany, starting in 1962. The computer will handle traffic in the subway by storing timetable data. Special programs will account for unusual conditions such as construction work requiring slowdowns or route switching.

GLASS LIKE STEEL

A Moscow institute claims glass as strong as steel can be made by combining a heat treatment with a chemical bath. Russian researchers increased the bending strength of industrial sheet glass as much as 11 times by first heating it to 200 C., and then immersing it in a hot organosilicon bath.

SUB JET-PROPULSION

The Navy is studying a revolutionary jet method of submarine propulsion, known as the "hole in the nose" system, which may reduce noise made by nuclear subs and make detection more difficult. Sea water is sucked through the bow, condensed, then ejected through the sides to propel the sub through the water.

BALSA WOOD TRAILERS

Highway hauling of refrigerated and frozen food is now being done in trailer bodies made solely of lightweight balsa wood—the kind used in model airplane kits—and two layers of plastic. The trailers weigh 1,500 pounds less than most competitive models.

NEW METHOD DETECTS FILM DISTORTIONS

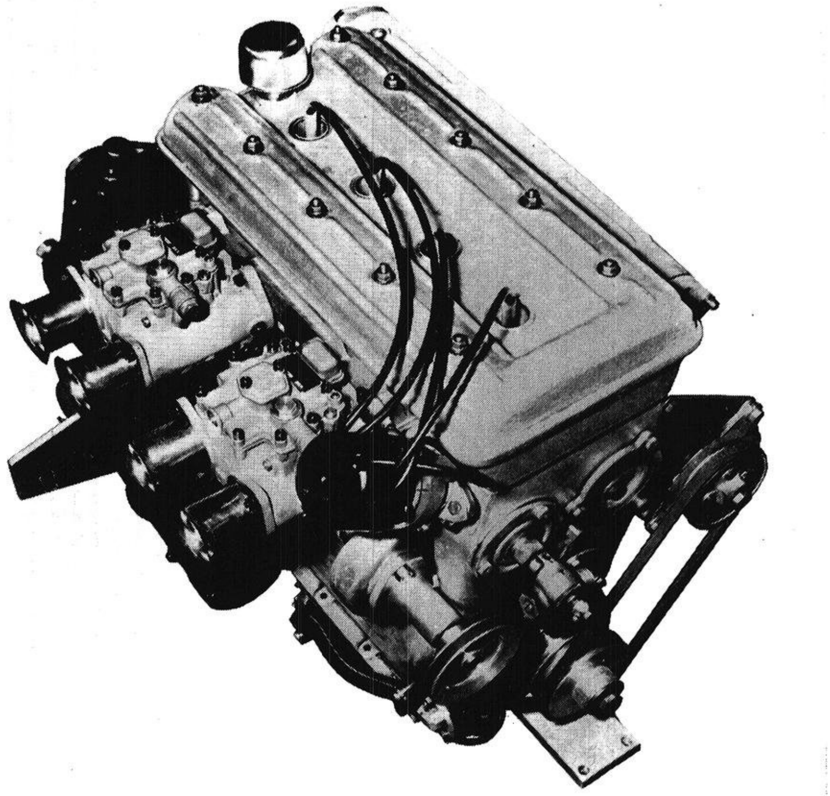
A new method for detecting aerial film distortions as small as 1/5,000 of an inch wide was revealed recently by a team of Kodak scientists. Faults even this small are important when a single 70mm negative pictures up to 10,000 square miles of the earth's surface, they said.

A moire pattern, a network of wavy lines, can sometimes be seen on screened windows when light, passing through the window screen, is reflected from the glass, and again passes through the screen in the opposite direction. The interference of the real screen image with the reflected image causes the fuzzy pattern of wavy lines, the scientists explained.

Researchers use moire patterns to locate tiny film distortions by printing a halftone tint on the aerial negative to be studied. A halftone tint, used in making newspaper or magazine illustrations from photographs, is something like a very fine window screen.

From the aerial negative, a print on glass is made and registered with the master halftone that was printed on the original negative. The location and approximate size of distortions become visible as irregularities in the moire pattern formed by the two halftones. The scientists can then calculate the size and extent of the distortion with photographic measuring devices and computers.

Causes of distortion may be water spots left on the film after processing, excessive processing machine tension, or abnormal heating of the film.



New Stainless Steel Engine.

NEW STAINLESS STEEL ENGINE

Auto designers and engineers are taking their first look at a remarkable new engine which features a block made of thin, stainless steel sheet.

The four-cylinder engine is sparking discussion among auto experts by its unique combination of high power, lightness, and durability. For instance, one model of the Tyce/Taylor engine delivers 175 hp, yet weighs only 175 lbs., or one horsepower per pound.

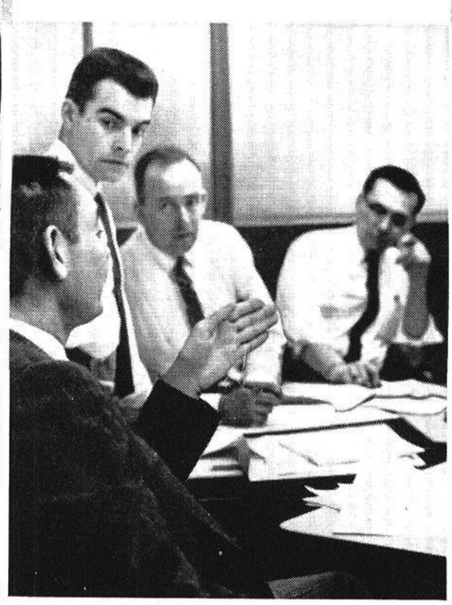
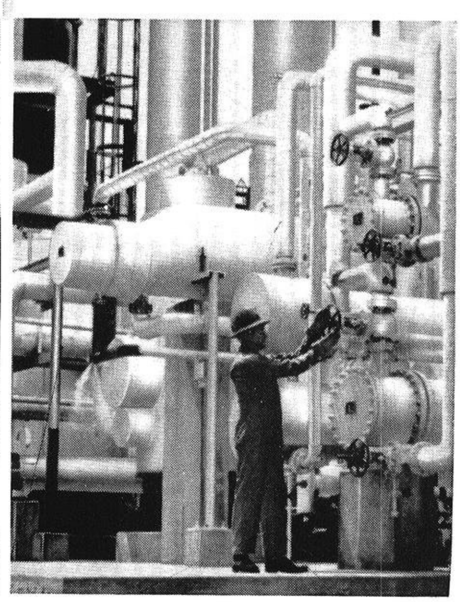
To prove its potential under the toughest conditions, the dual overhead-cam engine has been installed in several boats and is scheduled for early test in sports car and racing car competition. Its high performance design is also expected to be welcomed by the military for airborne and ground support equipment.

The main reason for the new engine's amazing performance is its use of brazed, thin stainless steel sheet for the block assembly, including combustion chambers, cylinders, water jacket, intake and exhaust ports, upper block pan, and spark plug tubes. (Brazing might be simply explained as a sort of "supersoldering" that joins metal parts in a strong mechanical and metallurgical bond.)

Tyce Engineering specified a grade of stainless steel known to the metal trade as Type 302. This is a familiar stainless composition employed in everything from pots and pans, to rocket support stands and building fronts. Besides contributing to the lightness, strength and durability of the Tyce/Taylor Four, the stainless steel construction of the block does away with corrosion worries. Moreover, the thin stainless steel stampings—(in some sections only the thickness of a penny)—dissipate heat several times faster than a cast block. As a bonus, the uniform wall thickness eliminates the troublesome "hot spots" which cause pinging in conventional engines.

The use of stainless steel in the Tyce/Taylor engine involves several unique concepts: Special block design eliminates the head gasket and permits very high compression

(Continued on page 42)

U 235

(Continued from page 15)

since centrifugation and gaseous diffusion had been considered the two most promising methods when the separatory program first started. Both methods were equally simple and certain in theory, and both were equally difficult to put into practice; for this reason, it was not until around 1944 that centrifugation was finally recognized as impractical and gaseous diffusion was finally acclaimed a success.

In the spring of 1945, the full-scale gaseous-diffusion plant at Oak Ridge, Tennessee, went into successful operation for the first time. Of all separatory methods given serious tryouts, this was the last to go into successful operation; however, it was also by far the most successful, and was the first to produce pure fissionable material on a scale which could support large-scale nuclear-energy programs, both military and civilian. It was also the first separatory installation to operate efficiently enough, in relation to its yield, to permit economical peacetime production of fissionable materials, so that they could be sold at rates which rendered civilian nuclear power production economically feasible and competitive with power produced by means of fossil fuels. The original plant at Oak Ridge is still in operation to date, and several similar installations have been built at other locations throughout the country. The gaseous diffusion process is the one currently used by the British; France is currently engaged in building a plant of its own on the same principle.

For the men involved in the development of the Oak Ridge plant, it was a long, hard pull from 1940 to 1945. No pilot plants, as such, were ever built, although several small installations were constructed to test specialized parts of the system. No dramatic intermediate achievements or events were encountered; it was a period of day-by-day struggle with small, vexing, stubborn problems. The process itself is based on Graham's Law of Diffusion, which states that the ratio of the rates of diffusion of two gases is inversely proportional to the ratio of the square roots of their molecular weights. Although this process is actually one of gaseous effusion, rather than diffusion, this principle still holds.

A typical stage of a gaseous-diffusion plant works like this: gaseous UF_6 under pressure is admitted to a chamber, one wall of which consists of a porous barrier containing submicroscopic pores whose diameter is less than 1/10 the mean free path of the gas molecules, and is allowed to effuse through the barrier to the evacuated space beyond until only 50% of the gas remains in the original chamber. With this considered stage assured to be an intermediate one, the remaining gas is returned to a lower stage for recycling while the other half, consisting of gas somewhat enriched in ${}_{92}U^{235}$, is collected by centrifugal pumps for transfer to the next higher stage. The degree of concentration in any one stage is quite small, and 4,000 stages is considered a normal number in a gaseous-diffusion installation. This type of plant is very flexible; any degree of purity, from natural uranium to pure ${}_{92}U^{235}$, can be obtained merely by tapping the installation at the proper stage. As has been mentioned previously, gaseous-diffusion installations are capable of processing tremendous quantities of natural uranium, recovering almost all of its fissionable content, and producing said content in any degree of purity desired. Nevertheless, this type of installation is far from perfect and has many drawbacks. The Oak Ridge plant alone cost five-hundred million dollars, and it has been stated that the installation consumes at least as much electricity as all of New York City. Furthermore, there is the ever-present danger that the gas will liquefy or solidify in one of the higher stages and accumulate until critical mass is attained; continual surveillance must be maintained to prevent such an occurrence. Fluorine and its compounds, by their very nature, provide a multitude of problems. But, in the last analysis, it is the size and cost of gaseous-diffusion installations which are their main drawbacks.

The need for simpler, less expensive, smaller, and separatorily-more-efficient systems and installations is very obvious. The number of nuclear-powered installations would multiply at a much higher rate if the cost of fissionable fuel was significantly cut. Our fast dwindling supplies of fossil fuels would then be conserved or even preserved for uses more valuable than power production. Nevertheless, remarkable progress has been made in the course of a very few short years and, in all probability, is still being made behind the necessary curtain of defense security precautions.

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THE END

The graduate engineer edged his way slyly up to the lingerie counter:

"Yes," cooed the sweet young thing.

"I—I'd l-like to buy a brassiere for my wife."

"Certainly, what bust?"

"Oh, nothin'," said the embarrassed man. "Darn thing just wore out."

Brazing

(*Continued from page 22*)

Induction Brazing

Induction brazing uses the same methods of cleaning, washing, and aligning of the assemblies, as the more common methods of brazing. Induction brazing differs only in the way heat is produced and transferred to the pieces to be joined.

The heat source is entirely from eddy currents induced in the metal by the field of a high-frequency induction coil surrounding all or part of the assembly. The apparatus used to produce the eddy currents are motor-generator sets with frequencies ranging from 1,000 to 12,000 cps and capacities of 50 to 1,000 kw. The higher frequencies heat only the surface and a very thin inner layer of the metal whereas the lower frequencies, though slower to produce the required heat, yield a greater penetration of the metal.

Heat is controlled by auto-electronic controllers employing infrared detectors. This precise method of control is needed to assure that the correct cycles are being used.

An advantage of this type of brazing is the amazingly close control to be had of specific areas and depths by heating as well as excellent heat localization without using a flame. An outstanding disadvantage is the need for high-production rates to pay for the high costs of designing and fabricating the production set-up.

Carbon Resistance Brazing

Again, this method differs from the conventional methods only in the way the heat is produced and transferred. Here the pieces are heated by direct contact with carbon blocks which acquire their heat by their resistance to electricity. An electric current is conducted through one block, through the work, and into the second block, heating the piece to the desired brazing temperature. This method has proved most successful when used to make connections in electrical motor windings.

Block Brazing

This is still another operation which differs from the conventional brazing methods, in that the method of conducting heat is done in a special way. Block brazing makes use of conduction to transmit the brazing heat. Here heated metals dies, which must conform to the general outline of the part to be brazed, are put in contact with the assembly. Since heat transfer is by conduction, surface to surface contact is most desirable. It is for this reason that the dies should conform to the outline of the piece.

The dies may be either electrically heated or gas heated. Block brazing is used principally to braze refrigerator evaporators designed for narrow line contacts.

Mechanized Flame Brazing

Mechanized flame brazing differs little from torch brazing. As the name of the process implies, the pieces are brazed mechanically on a mass production basis.

The process is mechanized in that it involves moving the work past a series of flames on a rotation platform or conveyor. Timing and flame temperatures are critical and must be carefully coordinated. Additional flames may be used to preheat the work, rather than just using those necessary to obtain brazing temperatures. Flames may be directed to make several different joints in different positions on the same piece.

Mechanized flame brazing is inexpensive to install and operate and is well suited to mass production of small parts.

Metal Dip Brazing

Metal dip brazing might be viewed as the reverse of flux dip brazing. In practice, the preheated assemblies are dipped into molten flux, and then dipped into molten filler. Here, the temperature of the molten filler and the immersion are critical since the molten filler acts as a solvent on the assembly. Proper use of a stop-off, previously described on page three, is utilized during this process.

With proper mechanization, metal dip brazing proves to be successful for brazing bundles of hex-end tubes for heat exchangers.

Brazing is a most economical method of joining aluminum. Its use in joining aluminum parts can lead to considerable savings since brazing offers unique freedoms in design and fabrication. As a whole, production costs are lowered and result in savings in time, material, weight, fewer rejects, ease of finishing, and use of practically unskilled labor. Finishing costs are low since the fillets produced are small and smooth. Because temperatures developed in brazing are not as high as those developed in welding, there is also a savings in heat.

Brazing enhances the versatility of aluminum. Since the filler is an aluminum alloy, the parts produced are then 100% aluminum alloy. This is highly desirable because the matching of color, strength, corrosion resistance and ability to be electroplated and anodically coated is assured. The filler alloy diffuses into the parent metal producing a continuous alloy system. The resulting joints have good stress distribution and good fatigue resistance, which afford simplification in design and improvement in appearance.

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THE END

An M.E. was speeding down the highway in his sports car. He stopped to help a farmer, with a Model-T, who was stuck. He pulled the farmer out with a nylon cord and told the farmer to honk when the motor started. Off they went faster and faster. The M.E. was going so fast that he could not hear the farmer honk. They sped through a small town and a few moments later an officer phoned his chief and said he was quitting.

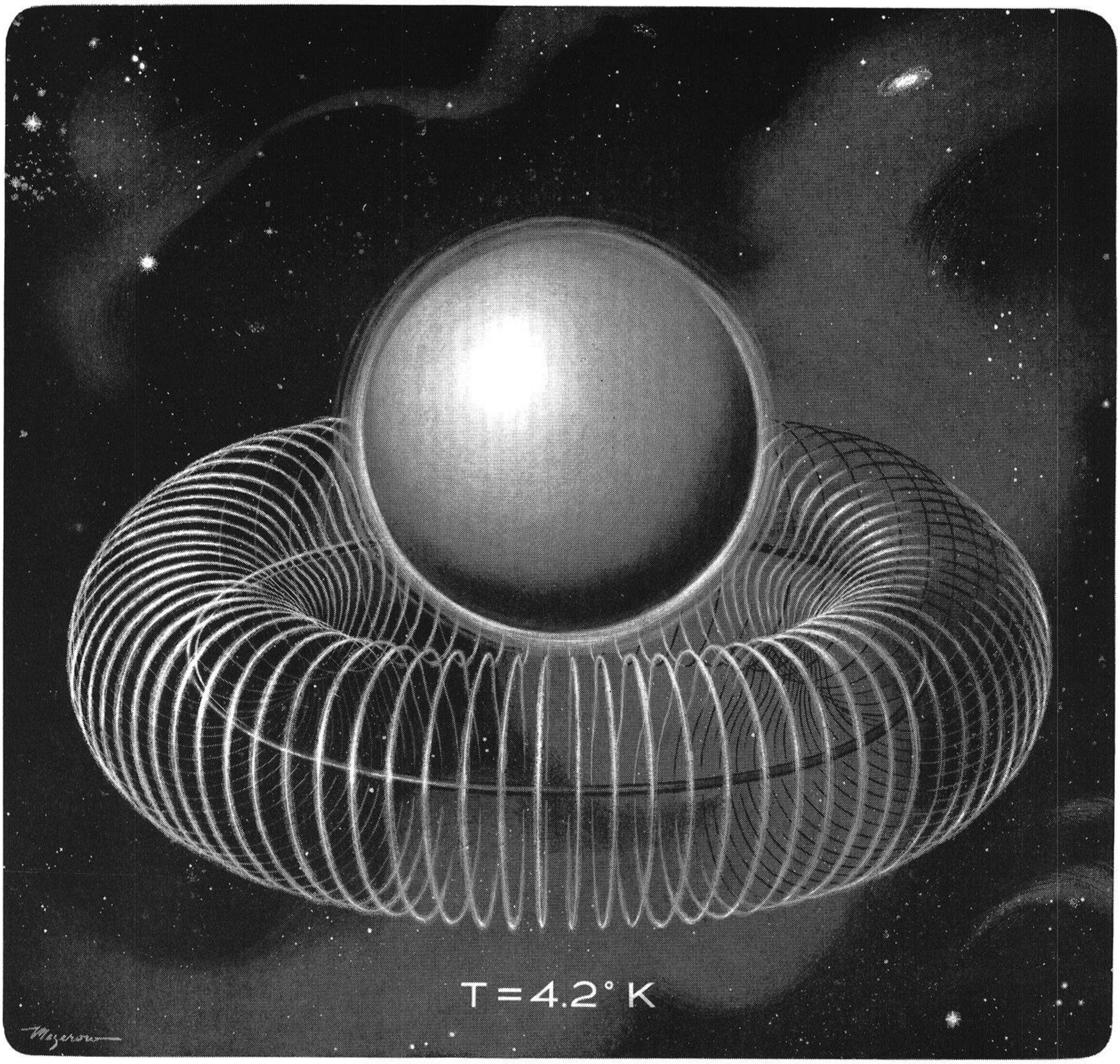
"Why?" said the chief.

"Because," said the officer, "I saw a sports car drive through here at 100 mph."

"That's nothing new," said the chief.

"Yes," said the officer, "but this one had a Model-T behind him honking to pass."

IMPORTANT DEVELOPMENTS AT JPL



THE CRYOGENIC GYRO

A fundamentally new type of gyroscope with the possibility of exceptionally low drift rates is currently under development. The design techniques used in conventional electro-mechanical gyros appear to have been largely exploited. A break-through is needed, and the cryogenic gyro may well provide it.

The cryogenic (liquid helium temperatures, in the range of 4°K) gyro consists of a superconducting sphere supported by a magnetic field. The resulting configuration is capable of support in this manner as a result of a unique property of a superconductor. Exceptionally low drift rates should be possible. This cryogenic gyro has performance potential unlimited by the constraints of conventional electro-mechanical gyros.

This is just one example of the intriguing solid state concepts which are being pioneered at JPL for meeting the challenge of space exploration. In addition to gyro applications, superconducting elements are providing computer advances and frictionless bearings. The day of the all-solid-state space probe may be nearer than one realizes.

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Reactor

(Continued from page 11)

assembly contains over 2½ tons of natural uranium (about 90 per cent U-238 and 1 per cent U-235) enclosed in aluminum cylinders.

These cylinders are placed in a metal tank four feet in diameter, five feet high, filled with water to act as a moderator and radiation shield. Neutrons from an aluminum cylinder containing plutonium and beryllium are slowed down by the water and then cause fission of uranium-235. Thus, additional neutrons are produced but not in sufficient quantity to cause a chain reaction.

The reactor simulator has controls similar to those used on a regular nuclear reactor, and reactor performance can be simulated by substituting electrical volts for neutrons in the nuclear reactor.

A well-equipped Nuclear Metallurgy Laboratory forms an important part of the facilities of the program. This laboratory is equipped to handle pyrophoric materials and has among others such facilities as vacuum-melting and heat-treating furnaces, a rolling mill, a glove box, machining, grinding, and polishing equipment for preparation of samples for testing and microscopic examination, and autoclaves for corrosion tests.

With this equipment students make, for example, metallic uranium and use this uranium for making fuel element plates. Besides its use in classwork, this equipment is used for research on materials of importance to the nuclear field.

The UW nuclear engineering program is directed by a committee composed of the following faculty members: Profs. Max M. Carbon, chairman, formerly of the AEC's Hanford, Wash., Laboratory; W. Robert Marshall, Jr., chemical engineering and associate dean of the UW College of Engineering; Franz Vitovec, mining and metallurgy; R. Byron Bird, chemical engineering; Thomas J. Higgins, electrical engineering; Raymond J. Roark, engineering mechanics; Gerald W. Lawton, civil engineering; Otto A. Uyehara, mechanical engineering; John C. Weber, electrical engineering; Robert G. Sachs, physics; and John E. Willard, chemistry and dean of the UW Graduate School.

THE END

Science Highlights

(Continued from page 35)

—up to 14:1. A .063-in. steel liner in each cylinder provides exceptional resistance to wear. The two camshafts, and the crankshaft, can be replaced easily with little effort.

The new engine, which is available in four displacement sizes (91, 105, 120, and 135 cubic inches), can be converted from one size to another simply by replacing the crankshaft to change the stroke. All sizes have the same 3.50-in. bore, all develop maximum power at 6500 rpm.

Several standard parts for Detroit cars, were adopted for the Tyce/Taylor engine—Thunderbird intake and Pontiac exhaust valves, Chevrolet Six valve guides, and Ford Six connecting rods. Several transmissions, including the Corvette 4-speed and the Falcon 3-speed units can be used with the new engine. Special adaptor units permit "swapping" the lightweight, high performance engine into such sports cars as the MG, Triumph, and Austin-Healey.

Weight of the four different displacements is about the same—175 lbs. without starter or generator. The 105 cu. in. size will be employed exclusively for midget racing where it will compete with the highly-developed Meyer-Drake engine. The 91 cu. in. size provides increased performance possibilities for inboard racing hulls.

The new Tyce/Taylor four-cylinder engine will be watched closely as it engages in sports and racing car competition and in boats for racing and waterskiing. It already appears to have achieved the long-standing design goal of a lightweight, high performance, practical powerplant for road and marine vehicles.

WASH-AND-WEAR WOOL

Within a year, researchers will have succeeded in making wool a wash-and-wear fiber. The steps being taken involve lessening shrinkage and increasing wrinkle resistance by weaving cloth from yarns in which wool fibers are relatively loosely packed, and then chemically treating the wool fabrics.

INVENTORS' ODDS

The government finds that 40 out of every 1000 proposals submitted by inventors as solutions to its publicized research problems have some merit, ten of the 40 ideas are worth testing, and about 2½ of the ten are finally adopted.

FAIR-WEATHER RADIO

A fair-weather transistor radio, powered by a solar batterly like those used to operate equipment in many space satellites, is being marketed on an experimental basis by a Japanese firm. Though this battery works only when the sun is out, the model is also equipped with an ordinary cell for rainy days.

INKLESS FINGERPRINTS

An electronic optical system that catches and records fingerprints without smearing fingers with ink or other chemicals is now on the market. A gentle touch of the finger on a small glass plate is all that's necessary for the system to produce a clear, distortionless print.

JET-PROPELLED DIRT

The Russians claim the development of the "first Soviet jet earth-digging machine," with capacity of 4,000 tons per hour. The Russians say the blast from a jet engine is used to remove rock to a depth of six feet over a strip six-feet wide and throw it up to 100 feet away.

THE END

The slowest thing in the world is a nudist climbing over a barbed wire fence.

"I hate women, and I'm glad I hate 'em cause if I didn't hate 'em, I'd like 'em, and I hate 'em."

"That girl Bill's dating is spoiled, isn't she?"

"No, that's just the perfume she's wearing!"

Engineer of Yesterday

(Continued from page 29)

where sugar is very plentiful, have led to the investigation of the action of sugar on cement mortar. It was found that in the presence of sugar the concrete set very slowly and produced a mass that was soft, containing dangerous cracks and quite unfit for service. One case of failure was due to the weakness of one small pillar on a large concrete building in a sugar works, in which all other parts were quite sound. Now it is known that sugar combines with lime to form what is known as saccharates and this, doubtless, was responsible for the failure. In another case, which occurred in Copenhagen, certain portions of the structure failed to set, while the main part of the building was excellent. In the cement which had not properly hardened, sugar was found to be present to the extent of 2 parts to 100. This appeared to be due to the fact of the cement having been packed in sugar bags.

PARKING REGULATIONS

April, 1927

Beware, all of you who drive your own car. No more will students be permitted to park their cars back of the Engineering Building, says an official report. Hereafter, only those cars wearing a special insignia, the army engineering castle, attached to the license plate, will be permitted to park at the back door. A special place will be left for visitors.

POSTAL SERVICE IN TIME

April, 1939

In the year 6939 the peoples inhabiting this earth are scheduled to receive an 800-pound metal letter mailed to them in 1938 by this generation. This letter is in the form of a Cupaloy Time Capsule containing a compressed store house of information about today's civilization, and was posed on September 23rd 1938, at the site of the Westinghouse Building on the grounds of the New York World's Fair, 1939. It was sent on its 5,000-year journey into the future by being lowered 50 feet into the ground, where it should remain until it is ready for deliverance. If the archeologists of A.D. 6939 find the missive intact, it will be because of the application of some of the foremost engineering metallurgical talent of our time. The Capsule itself is shaped like a torpedo seven feet six inches long and eight inches in diameter, and is made of a recently developed alloy composed principally of copper and containing small percentages of chromium and silver. The capsule was cast in seven sections and after machining, all segments except the last one were screwed together and sealed with an asphalt compound. The joints were then peened out and burnished, forming a solid unbroken outside shell.

Placed inside this shell was an inner crypt of heat resistant glass which contains the message for posterity sealed in an atmosphere of nitrogen—the inert gas acting as a preservative. The glass envelope was imbedded in waterproof mastic, and the last section of the Capsule capped on by having it shrunk-fit on tapering threads to insure a perfectly water-tight joint.

The materials placed inside the crypt were treated to be resistant to time. The bulk of the information is photographed on acetate microfilm, not only lending it permanence, but concentrating considerable information into little space. About four books the size of "Gone With the Wind" can be condensed into a single 32-millimeter roll of microfilm five inches in diameter. Included will be a small microscope to aid in reading, with instruction for making a larger projecting machine.

The wealth of knowledge contained in the 1100-foot film cyclopedia is staggering. In the ten million words and the thousand illustrations are included books on industry, invention and science, a Sears & Roebuck catalog, the Lord's Prayer in 200 tongues, Walt Disney's Donald Duck, contemporary music, from Sibelius' "Finlandia" to "The Flat-Foot Floogee", scores of magazines, art, great chunks of the Encyclopedia Britannica, and hundreds of other carefully selected fragments of pictorial and printed knowledge.

In order that the folks of that distant day may know something of the heft and feel of a few of the implements of modern life, more than 100 solid objects representative of the present day are included. In the collection is found a slide rule, a package of cigarettes, a deck of cards and poker chips, a golf ball, metallic and non-metallic substances, coins, a copy of the Holy Bible, an alarm clock, and—for comic relief—a woman's hat.

Painstaking study has been given to the subject of deliverance of the letter. In over 2,000 key repositories throughout the world, including libraries, museums, universities, monasteries, and shrines, is deposited what is called "The Book of Record of the Time Capsule of Cupaloy", a book describing the Capsule and telling posterity of 5,000 years hence how to find it and understand it. The volume is printed in non-fading ink on permanet rag paper, and though it is believed that some of the original issues might hold out for 50 centuries, those in whose charge the book will be, have been requested to leave word with their successors to reprint the book if it shows sign of deterioration in a few centuries.

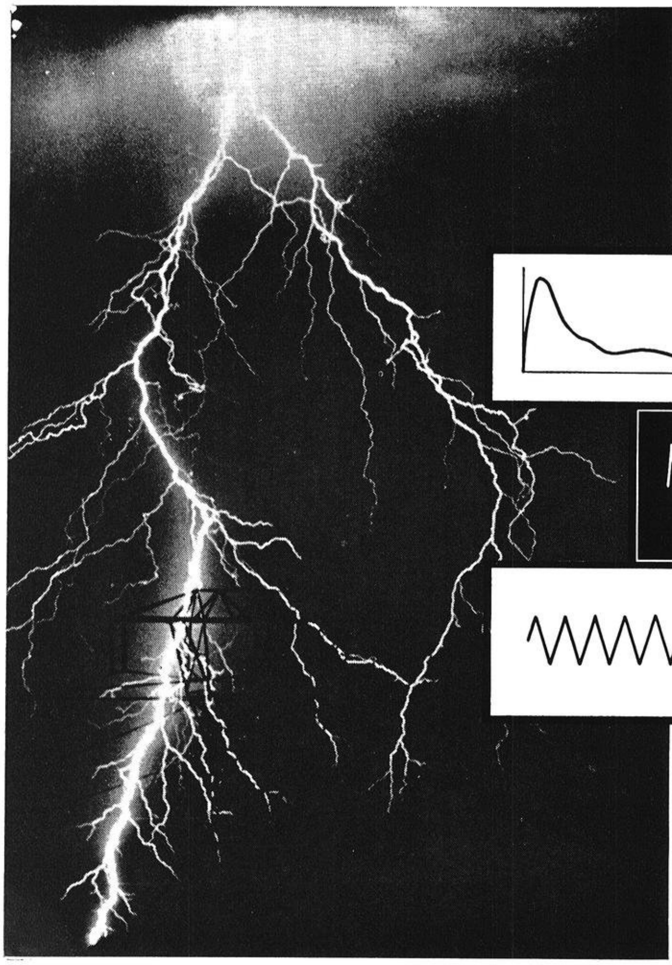
The coordinates surveyed by the United States Coast and Geodetic Survey are given accurately enough to locate an area on the surface of the earth the size of a quarter dollar. The coordinates are as follows: Latitude 40° 44′ 34″.089 north of the equator; longitude 73° 50′° 43″.842 west of Greenwich.

THE END

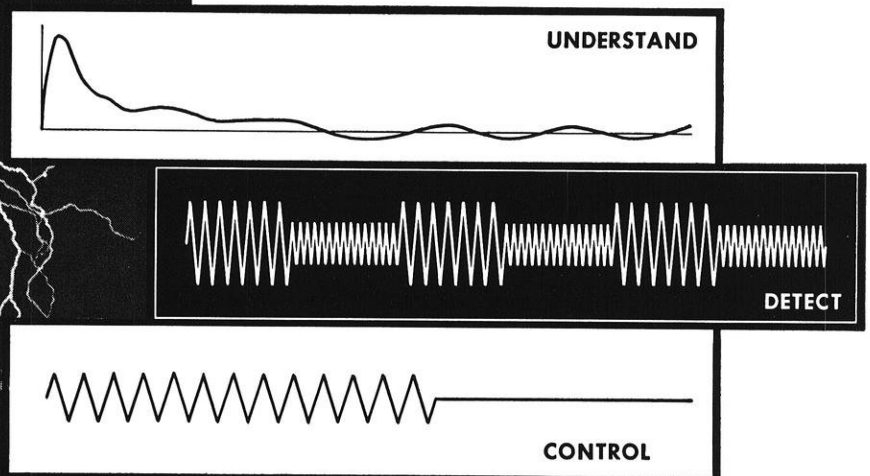
During a fervent revival service at the local church, a lovely young lady seated in the balcony became so wrought up with the spirit of the occasion that she leaned out too far over the rail and fell. The hem of her dress happened to catch on the chandelier and she was held suspended in mid-air.

The thoughtful minister cried out, "Any man who dares look will be stricken blind!"

And a fellow in a front seat said to his friend, "I'm going to chance one eye."



LIGHTNING STRIKES!



TO PROTECT ELECTRIC SYSTEMS, POWER ENGINEERS MUST . . .

UNDERSTAND . . .

by identifying the magnitude of surge, duration and wave shape of lightning. Recently installed devices on Wisconsin Electric Power Company System help do this.

DETECT . . .

by improving the means of discovering electrical faults caused by lightning, through better carrier current (black diagram) and microwave relaying.

CONTROL . . .

by providing better analysis of electrical faults caused by lightning. Power engineers are working to improve fault interruption and prevention devices.

LIGHTNING is one of the oldest known electrical phenomena, yet it is one of the least understood. In the rapidly growing power network of Wisconsin Electric Power Company, engineers are constantly working to provide better system operation through improved methods of lightning protection and faster interruption of lightning caused faults.

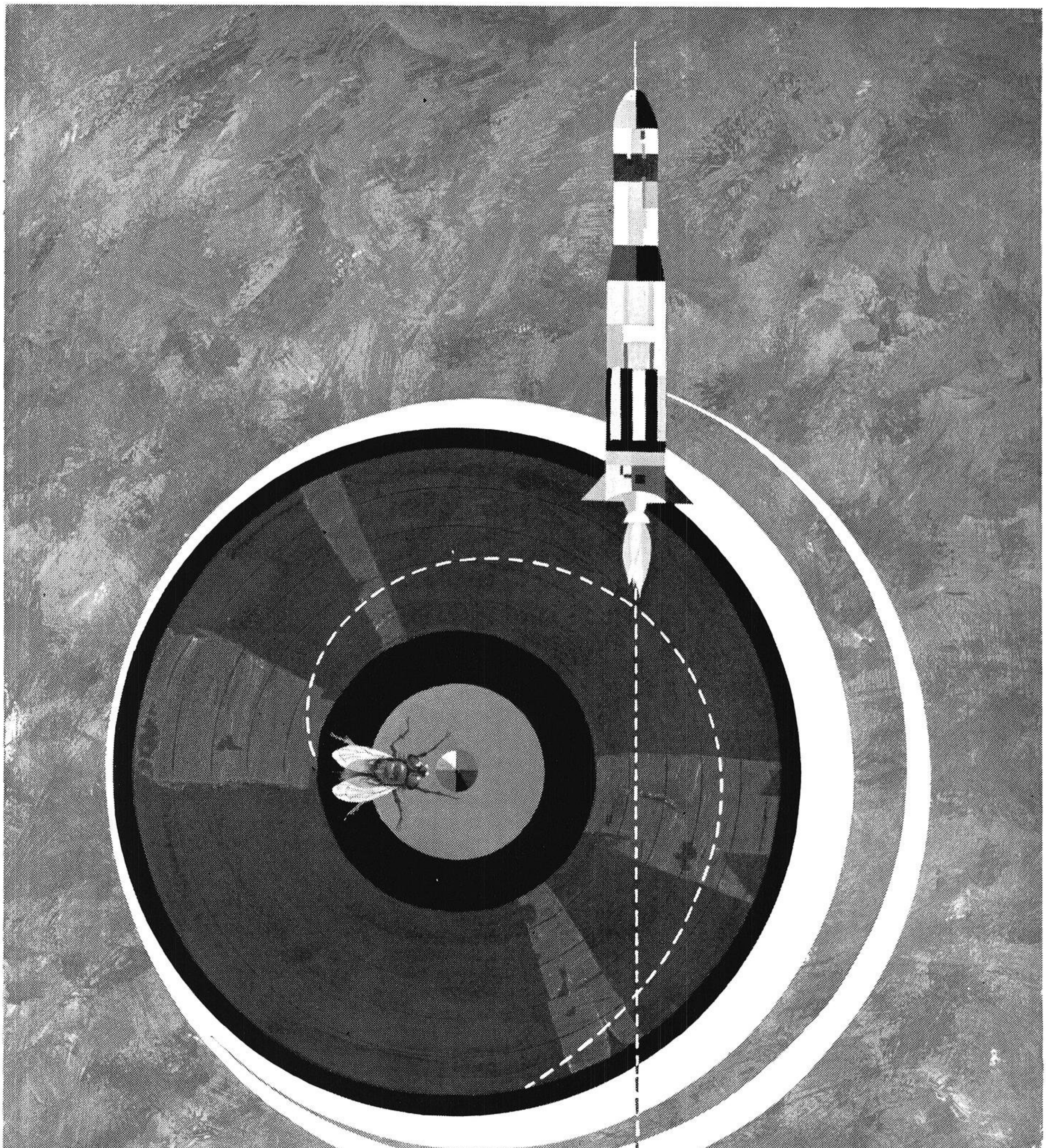
This is just one of many challenging possibilities in electrical engineering at Wisconsin Electric Power Company. Openings in other fields of engineering, too, offer bright futures in electric power. Ask our representatives.

WISCONSIN ELECTRIC POWER COMPANY SYSTEM

Wisconsin Electric Power Co.
MILWAUKEE, WIS.

Wisconsin Michigan Power Co.
APPLETON, WIS.

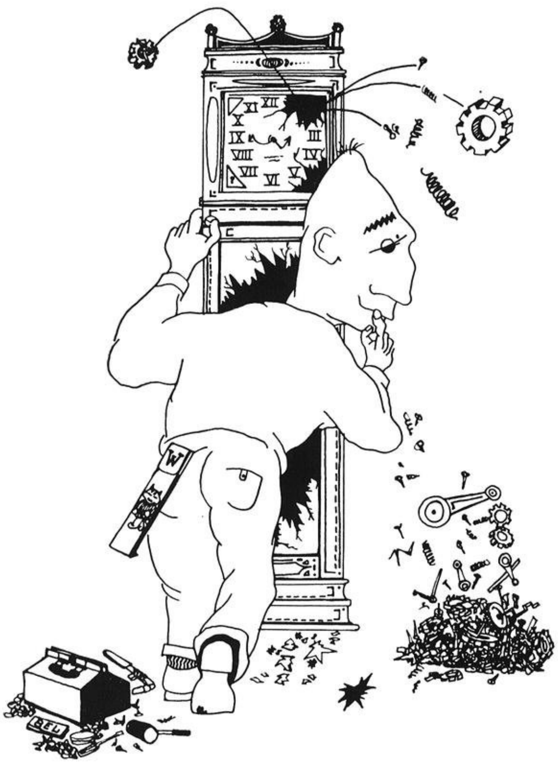
Wisconsin Natural Gas Co.
RACINE, WIS.



THANKS, MONSIEUR CORIOLIS, BUT WE PLAY IT STRAIGHT!

Your theory is a little complicated for us. Rather than work in rotating coordinates and compensate for your famous acceleration, we avoid the problem. Our guidance system platforms are stabilized in inertial space instead of rotating Earth space. The result is simpler guidance system computations for missiles like Titan. If you would like to be trained to work in this challenging atmosphere, please contact your college placement office, or write to Mr. R. E. Allen, Director of Scientific and Professional Employment, 7929 S. Howell, Milwaukee 1, Wisconsin.

AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS



STRIPPED GEARS

edited William S. Huebner

Lawyer: "I want a ticket to New York."

Agent: "By Buffalo?"

Lawyer: "That's okay if the saddle's comfortable.

* * *

If George Washington was so honest, why on his birthday do all the banks close?

* * *

Love is like a fried egg. Looks good at first, but the moment you take a stab at it, it becomes a big mess.

* * *

Life is one thing after another. Love is two things after each other.

* * *

Two of Uncle Sam's sailors, retiring from the sea, purchased a small saloon in a country town. They immediately closed the place up and began painting it inside and out.

The villagers, after a few days, gathered outside the place and one of them knocked at the door. A window opened, and one of the former sailors inquired the reason for the gathering outside.

"We want to know when you are going to open up," was the reply.

"Open up?" retorted the man at the window. "We bought this place for ourselves."

"Where did you get that cute blonde, Neil?"

"I don't know. I just opened my wallet and there she was."

* * *

A kiss is a mouth full of nothing that tastes like heaven and sounds like a cow pulling her foot out of the mud.

* * *

Little Girl: "Mother are there skyscrapers in heaven?"

Mother: "No dear, it takes engineers to build skyscrapers."

* * *

Bus Driver: "All right back there?"

Feminine Voice: "No, wait till I get my clothes on."

Then the driver led a stampede to the rear and watched the girl get on with a basket of laundry.

* * *

Mother: "Now, Evelyn, what did you do when the E.E. kissed you last night?"

Daughter: "Well, when I wanted to scream, I couldn't; and then when I could, I didn't want to."

* * *

There was the mother who took her son to the doctor and said,

"Doctor, I don't know what to do. My son insists on emptying ash trays."

"Why, that's not unusual," said the Doctor.

"Yeah, but in his mouth?"

Senior (at a basketball game: "See that big substitute down there playing forward? I think he's going to be our best man next year."

Coed: "Oh, darling, this is so sudden."

* * *

Sitting in class on Saturday morning recently were three night owls in tux and tails. The professor, a rather narrowminded individual, viewed the group scornfully and commented: "I would rather commit adultery than attend class in evening clothes."

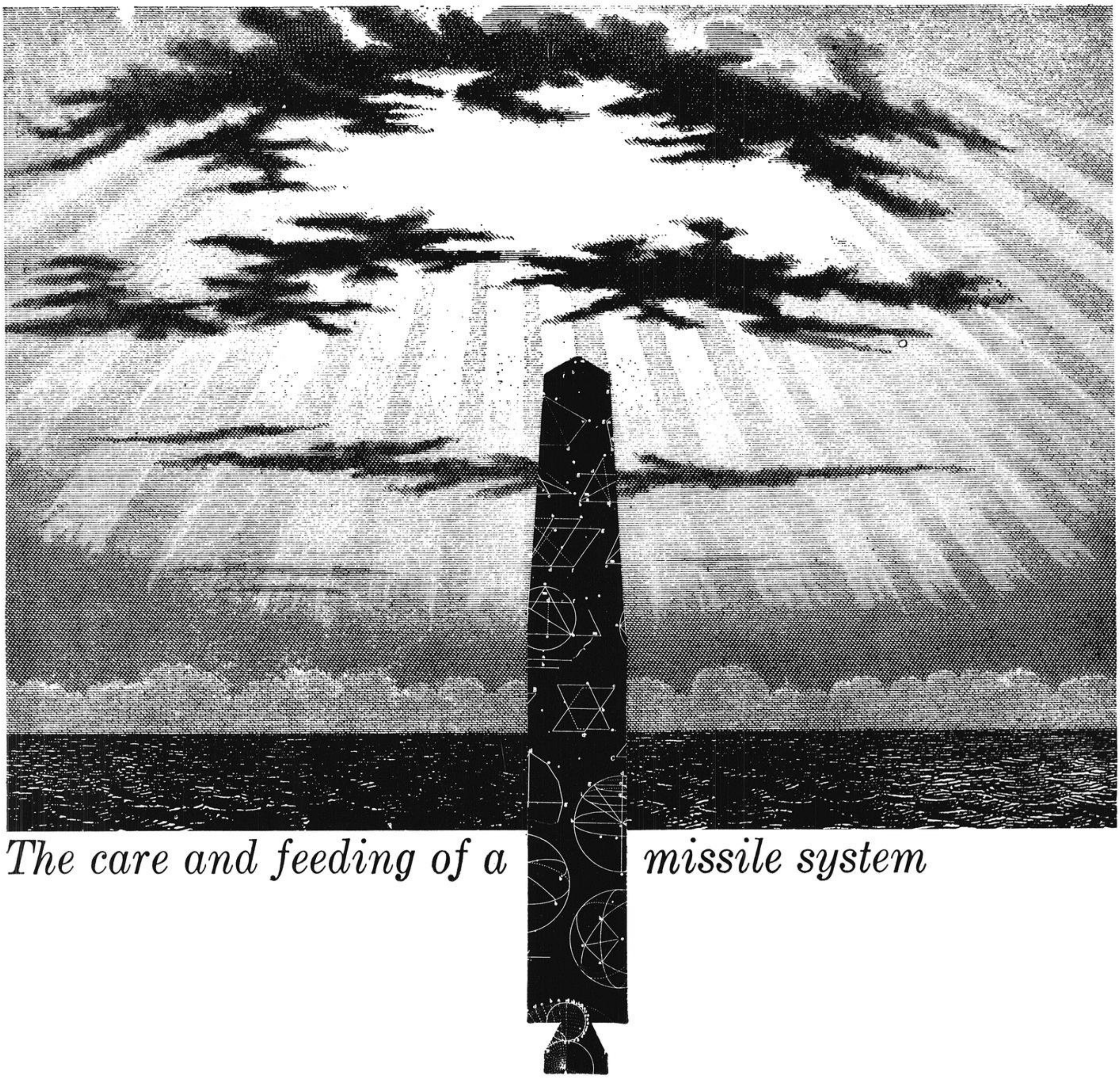
From the back of the room a muffled voice replied: "Who wouldn't?"

Bob: I beg your pardon, Miss, but this would have never happened if you had not stepped between me and the cuspidor.

* * *

A boy and a girl were out driving. They came to a quiet spot on the country lane and the car stopped. "Out of gas," said the boy. The girl, carefully opened her purse and rolled out a bottle. "Wow!" exclaimed the boy, "You've got a whole pint—what kind is it?"

"Gasoline," replied the girl.



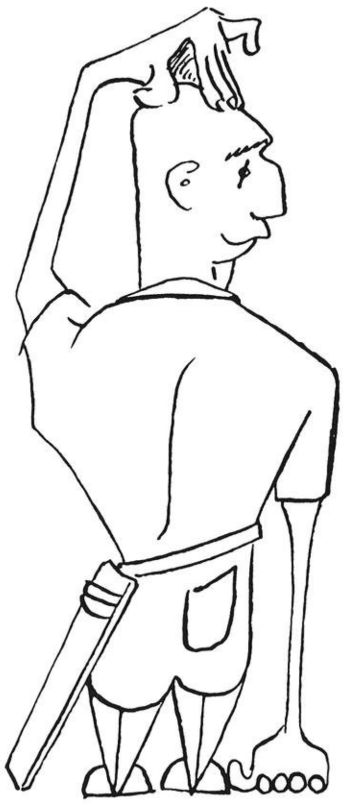
The care and feeding of a missile system

It takes more than pressing a button to send a giant rocket on its way. Actually, almost as many man-hours go into the design and construction of the support equipment as into the missile itself. A leading factor in the reliability of Douglas missile systems is the company's practice of including all the necessary ground handling units, plus detailed procedures for system utilization and crew training. This complete job allows Douglas missiles like THOR, Nike HERCULES, Nike AJAX and others to move quickly from test to operational status and perform with outstanding dependability. Douglas is seeking qualified engineers and scientists for the design of missiles, space systems and their supporting equipment. Write to C. C. LaVene, Box P-600, Douglas Aircraft Company, Santa Monica, California.

Alfred J. Carah, Chief Design Engineer, discusses the ground installation requirements for a series of THOR-boosted space probes with Donald W. Douglas, Jr., President of

DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB® ■ GROUND SUPPORT EQUIPMENT



So You Think You're SMART!

by Sneedly, Law'66

HERE we are at the end of another semester already. We engineers seem to let things slide before Christmas vacation and plan on doing them during vacation. When we embark after vacation it seems that not too much has been accomplished in the line of school work. With only two weeks of classes left and a multitude of tests we must then burn the midnight oil to get caught up and to study for the last hour exams. Then immediately after this rat race, final exams are here again. This is always a bad week irregardless of the schedule of your exams.

After finals are over you are given a much needed vacation. After this vacation you return to register for the second semester and then all h— breaks loose again.

This is a sample of what an engineering student goes through. We may appear as not to like this life on the surface but deeper down we do, and will miss this life when we finish with school. If we ever finish, that is.

Solutions to December's problems and puzzles:

1. 8.8 MPH relative to zero velocity.
2. Since the missiles home on each other, the velocity of each one is always directed along one side of the shrinking square toward the missile located at the next vertex. Thus, the rate at which the sides of the square shrink is equal to the velocity of the missiles (one mile per second), and since the missiles were originally twenty miles apart, it will take twenty seconds for them to collide.
3. 15/128

Here are this month's problems that require a little logic and mathematics. Do not fear. The only math required is a little advanced arithmetic.

Problem #1

It is 25,000 miles around the earth. A rope manufacturer receives the contract to manufacture a rope to stretch snugly around the earth at the equator, but he makes the rope a yard too long. If this rope were used, assuming the earth to be a smooth sphere, would there be any detectable error?

Problem #2

If 5 were one-half of 3, what would a third of 10 be?

Problem #3

In a room 30 feet long, 12 feet wide, and 12 feet high, there is a spider in the center of one of the smaller walls, 1 foot from the ceiling. There is a fly in the middle of the opposite wall, 1 foot from the floor. What is the shotest distance which the spider may crawl to get to the fly?

Send your answers with your own name and address to:

SNEEDLY
% The Wisconsin Engineer
333 Mechanical Engineering Building
Madison 6, Wisconsin

All answers must be sent in the mail and only letters with the correct answers having the earliest postmark will be considered the winner(s). THE END

One of a series

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

Technical Training Programs at General Electric

Q. Why does your company have training programs, Mr. Abbott?

A. Tomorrow's many positions of major responsibility will necessarily be filled by young men who have developed their potentials early in their careers. General Electric training programs simply help speed up this development process.

In addition, training programs provide graduates with the blocks of broad experience on which later success in a specialization can be built.

Furthermore, career opportunities and interests are brought into sharp focus after intensive working exposures to several fields. General Electric then gains the valuable contributions of men who have made early, well-considered decisions on career goals and who are confidently working toward those objectives.

Q. What kinds of technical training programs does your company conduct?

A. General Electric conducts a number of training programs. The G-E programs which attract the great majority of engineering graduates are Engineering and Science, Manufacturing, and Technical Marketing.

Q. How long does the Engineering and Science Program last?

A. That depends on which of several avenues you decide to take. Many graduates complete the training program during their first year with General Electric. Each Program member has three or four responsible work assignments at one or more of 61 different plant locations.

Some graduates elect to take the Advanced Engineering Program, supplementing their work assignments with challenging Company-conducted study courses which cover the application of engineering, science, and mathematics to industrial problems. If the Program member has an analytical bent coupled with a deep interest in mathematics and physics, he may continue through a second and third year of the Advanced Engineering Program.

Then there is the two-year Creative Engineering Program for those graduates who have completed their first-year assignments and who are interested in learning creative techniques for solving engineering problems.

Another avenue of training for the qualified graduate is the Honors Program, which enables a man to earn his Master's degree within three or four semesters at selected colleges and universities. The Company pays for his tuition and books, and his work schedule allows him to earn 75 percent of full salary while he is going to school. This program is similar to a research assistantship at a college or university.

Q. Just how will the Manufacturing Training Program help prepare me for a career in manufacturing?

A. The three-year Manufacturing Program consists of three orientation assignments and three development assignments in the areas of manufacturing engineering, quality control, materials management, plant engineering, and manufacturing operations. These assignments provide you with broad, fundamental manufacturing knowledge and with specialized knowledge in your particular field of interest.

The practical, on-the-job experience offered by this rotational program is supplemented by participation in a manufacturing studies curriculum covering all phases of manufacturing.

Q. What kind of training would I get on your Technical Marketing Program?

A. The one-year Technical Marketing Program is conducted for those graduates who want to use their engineering knowledge in dealing with customers. After completing orientation assignments in engineering, manufacturing, and marketing, the Program member may specialize in one of the four marketing areas: application engineering, headquarters marketing, sales engineering, or installation and service engineering.

In addition to on-the-job assignments, related courses of study help the Program member prepare for early assumption of major responsibility.

Q. How can I decide which training program I would like best, Mr. Abbott?

A. Well, selecting a training program is a decision which you alone can make. You made a similar decision when you selected your college major, and now you are focusing your interests only a little more sharply. The beauty of training programs is that they enable you to keep your career selection relatively broad until you have examined at first hand a number of specializations.

Furthermore, transfers from one General Electric training program to another are possible for the Program member whose interests clearly develop in one of the other fields.

Personalized Career Planning is General Electric's term for the selection, placement, and professional development of engineers and scientists. If you would like a Personalized Career Planning folder which describes in more detail the Company's training programs for technical graduates, write to Mr. Abbott at Section 959-13, General Electric Company, Schenectady 5, N. Y.

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