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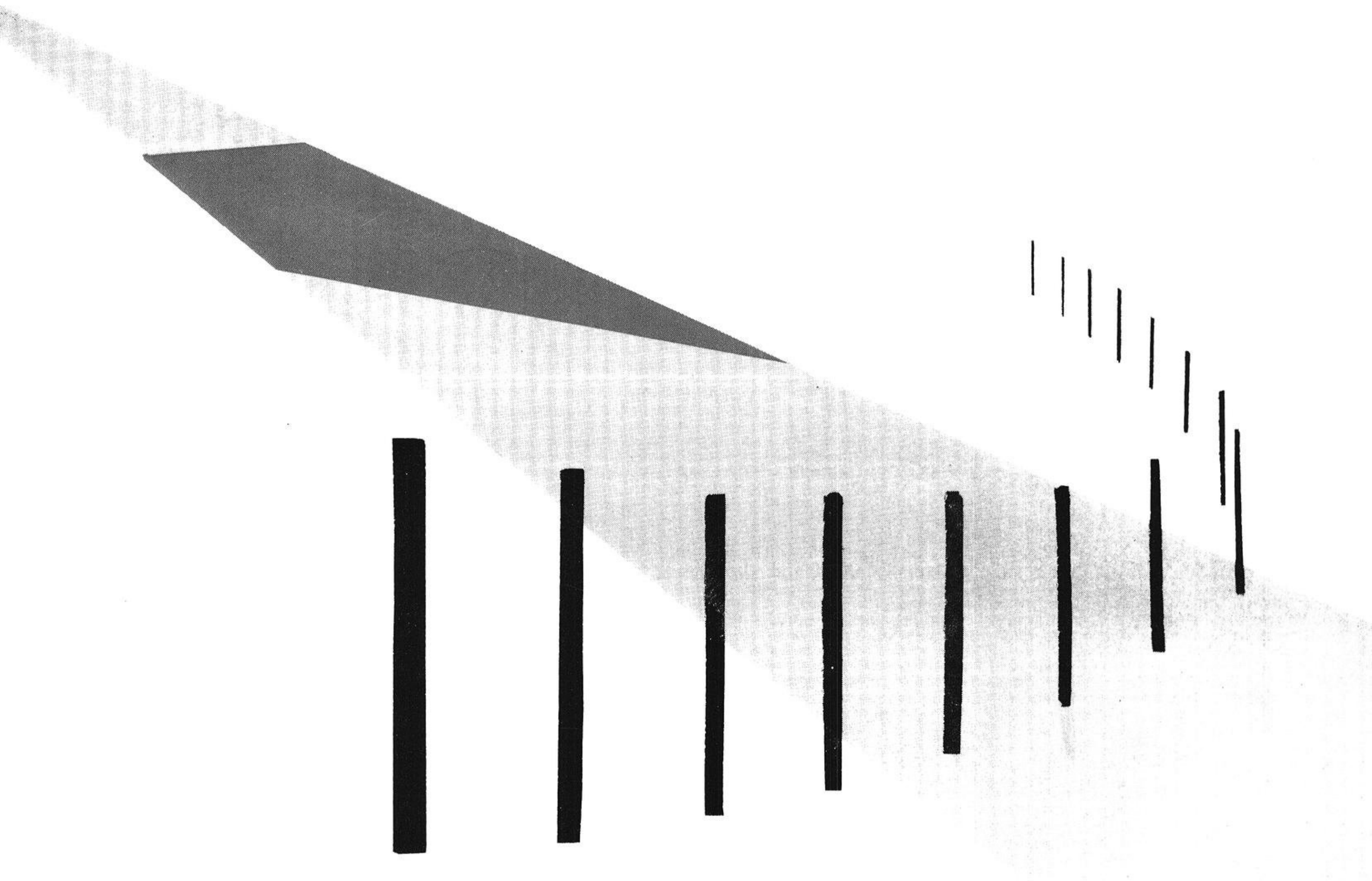
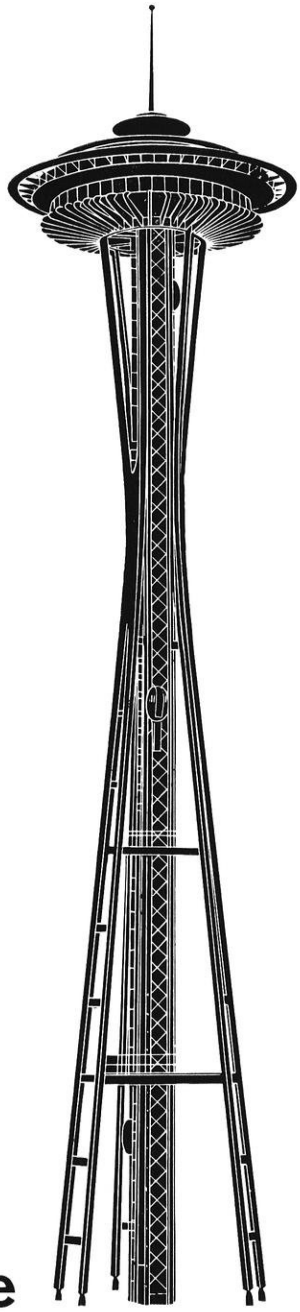


THE WISCONSIN ENGINEER



revolution in space

This amazing structure symbolizes the outer space theme for this year's Century 21 International Exposition in Seattle, Washington. Called the Space Needle, it soars 600 feet into the air on three steel legs, tapers to a slim waist at the 373-ft. mark, then flares out slightly to the 500-ft. level, and is crowned by a mezzanine, observation deck, and a 260-seat restaurant that *revolves* slowly (one complete revolution an hour) while patrons enjoy their meals.

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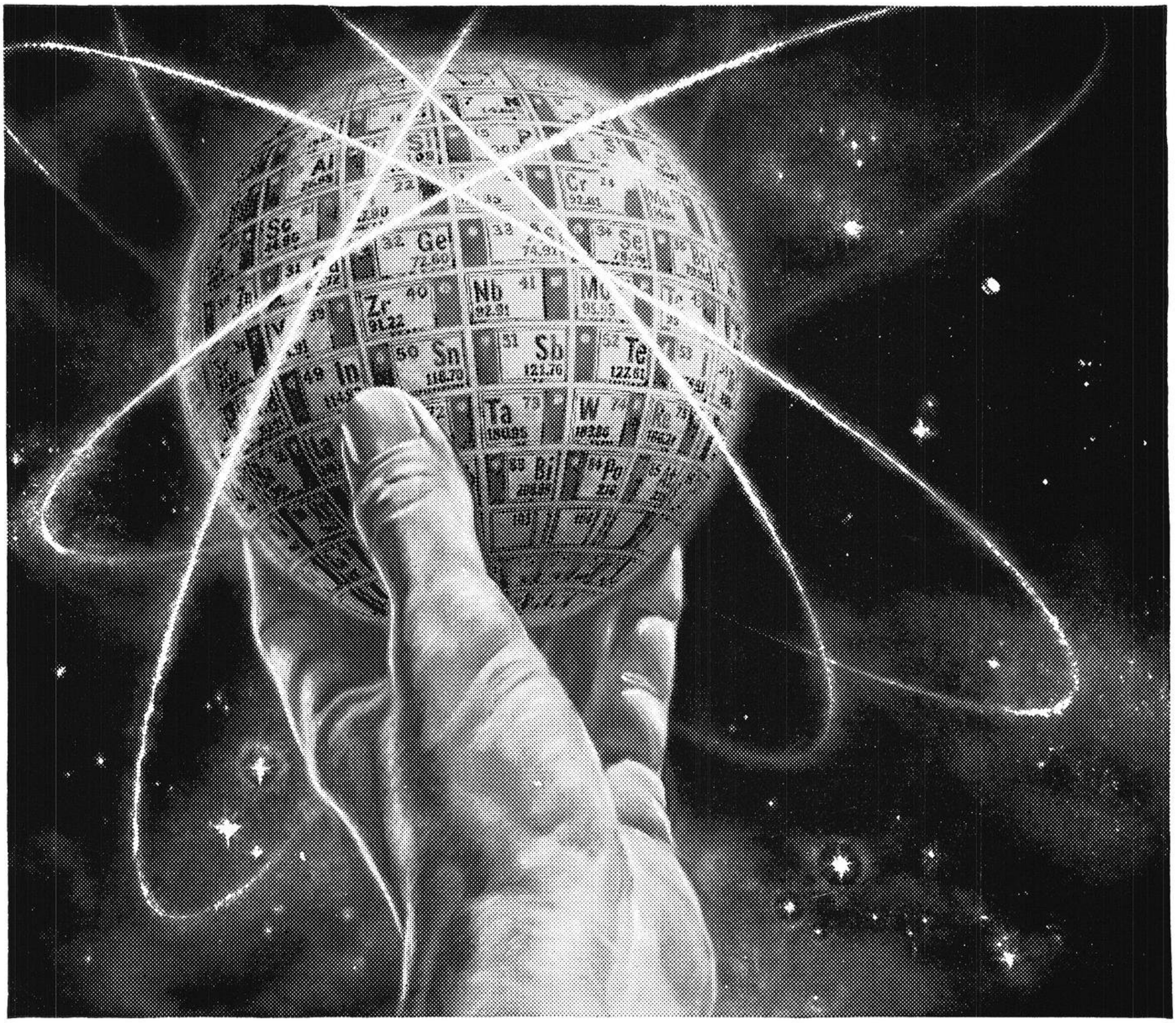

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ARTICLES

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Some straight talk about a career at American Oil

by Roger Fisher

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STANDARD

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A Modern Steam Car

by R. C. Entwistle me'62

THE manufacturing of steam cars ended in 1925 but interterest has lived on through the years. Only enthusiasts have worked and sweated to overcome the problems inherent in the development of a fine steam car. One such enthusiast, who has designed and built several steam-powered automobiles, is Charles F. Keen of Madison, Wisconsin.

In building a new type of car, very few "standard" parts are available. Therefore, the chassis, body, and engine of Mr. Keen's car are all new, with standard brakes and magnesium racing wheels.

BACKGROUND AND HISTORY

Back as early as 1700, steam came to be realized as a source of power. A reciprocating steam engine was developed in which steam was used to push the piston out. Water was then used to condense the steam and cause a vacuum in the cylinder. This vacuum allowed atmospheric pressure to force the piston down. The pressure of the air on top during the downstroke was more a source of power than was the push of the entering steam on the upstroke.

By 1775 a reciprocating steam engine with inlet and exhaust ports was developed that used only the push of the steam.

About 1850 the steam engine had become more fully developed. Multiple stage engines were used in which the exhaust from a first smaller cylinder was used to drive a second and larger cylinder. In this way more of the steam pressure could be used.

Steam engines had been used in railroad locomotives, ships, and factories as well as in steam vehicles. But it was not until 1880, when the four-cycle gasoline engine and the automobile were built, that the steam engine would be put to the test.

At first the steam people had it all their own way. Most of the new horseless carriages were steam driven, with some electric and a few gas powered. These steam carriages of the '80s and '90s were quieter, more dependable, faster, smoother operating, and longer lasting than the gasoline driven ones; which were noisy, smelly, subject to breakdowns, and impossible to start at times.

At the turn of the century, car manufacturers began to pop up and disappear like mushrooms. Right after the 1901 New York Automobile Show, 49 cars were using electric motors—99 were using internal-combustion engines—106 were using steam engines. The electrics were short-lived and the race was between the latter two.

Steam was the favorite but it had its disadvantages. The distance that could be traveled between refuelings was less for a steam car. The cost to make a steam car was more; however, it lasted longer. The warm-up time was the big disadvantage because it took as long as half an hour. As the gasoline engine became more reliable, this became even more of a disadvantage.

As the steamers slowly disappeared, the steam car lovers still proclaimed the superiority of the steam engine. Among the last of the steamers to go was the White in 1912, and the famous Stanley in 1925.

THE MODERN STEAMER

The manufacture of the steam car came to an end long ago, but interest has never disappeared. Only the enthusiasts tinker with the old relics or try to design new ones. There is one such enthusiast who has designed a steam car that outperforms all steam cars to date. This man's name is Charles Keen of Madison, Wisconsin. What follows is a presentation of some of the various problems and features of his particular car, the Steamliner.

Engine

The engine in the Steamliner is a 900 V–4, single-acting, poppet valve, unaflow engine. The engine is rear mounted. It is coupled to the rear axle with a 1.6:1 ratio. The connecting rods drive a gear which meshes into the ring gear of the differential. Therefore, there is no driveshaft and no clutch. No transmission is required because it is not necessary to rev up the engine to get power from steam. Only a lever is needed to reverse the engine for forward or reverse motion of the car. An automatically variable compression ratio ranging to 25:1 at high speed is a special feature. Auxiliaries—feedwater pump, cylinder oil pump, and electric generator—are direct driven from the engine.

Boiler

Major improvements have been made on the boiler and burner. It took from 20 to 30 minutes to warm-up the old steamers. In this new Flash-type steam generator or boiler, operating steam is generated in 35 seconds and a full head of 1000 psi in less than one minute. Tested at 6000 psi, this boiler will operate at 1000 to 1200 psi, and consists of stepped sizes of alloy tubing spirally wound in an insulated housing. When the pressure in the boiler drops to 800 psi the atomizing, spark-ignited, blower-fed burner responds automatically to steam demands. It has "high fire" and "low fire" for high and low speeds. Travel through the boiler, from water to steam to vapor and out to the engine, is so fast that the boiler is self-cleaning. Therefore lime will not coat on the inside of the boiler. Exhaust steam from the engine goes to a condensor much like an ordinary car radiator, where it is condensed to water. This water is collected in a supply tank called the hot well, where it is ready to be recycled through the boiler.

Fuel

The fuel burned in the Steamliner is furnace oil. Gasoline, kerosene, or most any liquid that burns can be used. Gasoline is not quite as good as other fuels since its flame is a bit noisy. Coal in liquid suspension will be fine when on the market. The main objective when picking a fuel is economics. The Standard Oil Company gives the following table for fuel prices in the Chicago area, less road taxes:

Considering the table, diesel oil would be the cheapest fuel. Road taxes, however, must be added to the price of gasoline and diesel oil. This added cost makes furnace oil the best buy and is the reason for its choice for the Steamliner.

Atomic energy may also be a future means of producing steam for a steam car. Although atomic energy is used for propelling ships, the atomic reactor is quite large to be fitted to a car. At present, although the core of a reactor need only be 12 inches in diameter, the shielding of concrete, steel, and lead must be about 10 feet thick on all sides. With atomic fuel at approximately $15 per gram, the price is beyond the individual's reach. The future is of course unforeseeable.

Body

The Steamliner is completely brand new from bumper to bumper. The body is an original sports-car design. Its sleek lines were hand molded in fiber-glass and finished in a bright red color. Magnesium racing-type wheels and black and gold upholstery adds to its styling. Bucket seats and the gauge-filled instrument panel gives the appearance of an airplane cockpit. The gauges include:

1. Fuel and water gauge
2. Steam temperature at engine
3. Fuel pressure at burner
4. Boiler pressure
5. Speedometer and odometer
6. Steam pressure at engine
7. Lubrication oil pressure
8. Exhaust pressure
9. Ammeter

PERFORMANCE

Because this car is still in the development stage, performance tests are still in progress. Therefore no graph can be drawn to compare

(Continued on page 24)

TABLE 1.—COST OF STEAM CAR FUELS

Fuel	Btu per gallon	Cost per gallon	Btu per penny of cost
Liquid propane	91,591	18¢	5,088
Gasoline (regular)	124,800	23¢	5,426
Kerosene	134,000	16¢	8,375
Furnace oil (#2)	139,000	16¢	8,687
Diesel oil	137,000	15¢	9,173

Power System Co-ordination

by L. J. Tordoff

THE prime aim of every electric power utility is to provide the best service possible to their customers, the users of electricity. An electrical failure, often referred to as an outage, is the utilities' biggest 'headache' because it causes the loss of revenue, expensive maintenance, and depreciation of the important company-customer relations. The degree of these failures may range from the loss of service to a single home to one which leaves several million people without power, as occurred in New York City several years ago.

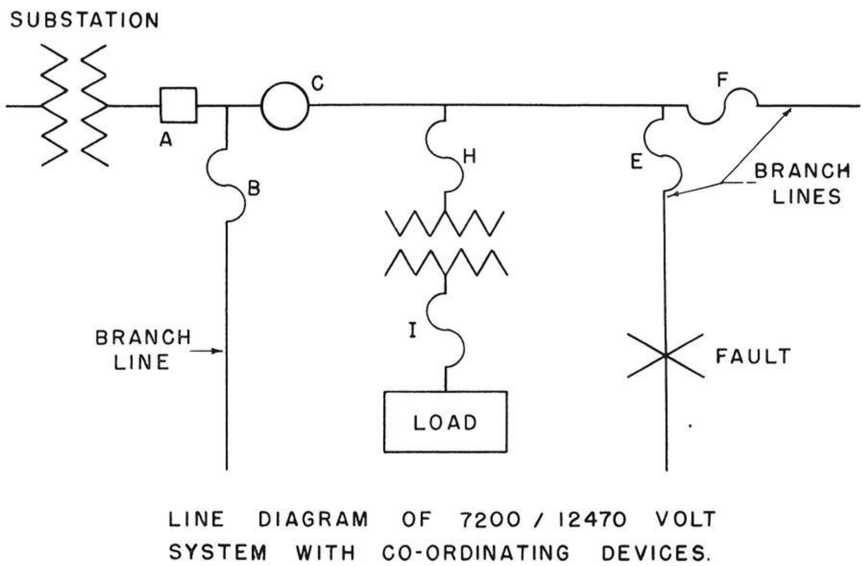
Loss of continuity of service arises from abnormal conditions, often caused by storms, equipment failure, or human error. Among these conditions are line faults, line or equipment overloads, or damaged equipment.

There could be disastrous results if the power system was not protected from the usual overcurrent associated with abnormal conditions. If large currents were allowed to flow for any considerable length of time, valuable equipment would become damaged, fires may start, and service would be lost indefinitely. Fortunately for all concerned, the power company does provide protection in the form of such current interrupting devices as circuit breakers, oil circuit reclosers, fuse cutouts, and fuse links.

Circuit breakers are used to interrupt the higher voltages while the recloser is used largely on distribution lines. Fuse cutouts are also used on the lower voltage distribution system and the fuse link, better known as the common house fuse, protects the individual customer. Most people are familiar with the house fuse which melts ("burns out") and breaks the circuit if, for instance, too many electrical devices are being used in the home. If this did not happen there would be danger of intense heating of the house wiring and a very real fire hazard. A similar protective role is played by other overcurrent apparatus even though fires may not be the main concern.

The device selected for a particular installation depends upon the system characteristics at the point of application. These characteristics are voltage, load current, possible range of fault current, and system parameters. Another consideration in the selection of an overcurrent protective device is the co-ordination of that device with other interrupters in the system. System co-ordination is the teamwork between all the overcurrent protective devices to restrict an outage due to a fault to a minimum section.

System co-ordination can be best understood by observing a simple example. A small part of a power distribution system is shown in Fig. 1 which may represent a rural substation receiving power from a high voltage transmission line and stepping the voltage down to 7200/12470 volts for distribution. This voltage is further reduced to 120/240 for use at the load. The



LINE DIAGRAM OF 7200 / 12470 VOLT SYSTEM WITH CO-ORDINATING DEVICES.

FIG. I

following protective devices are identified by letters: device "A" is at the substation; "C" is in the feeder; "B", "E", and "F" are at the branch taps off the feeder lines; "H" is on the primary side of the transformer and "I" is on the load side. These devices must be of correct size to carry the normal load current yet respond properly to a fault. Two definitions are used when speaking of overcurrent interrupters. The nearest to the fault (on the supply side) is termed the "protecting" device and the next one closer to the supply is known as the "protected" device. Suppose a fault occurs as shown in the figure. Then, by definition, "E" becomes the protector and "C" the protected. If, however, a fault occurred somewhere along the main feeder between "C" and "F", then "C" becomes the protector and "A" the protected. These definitions are explained more clearly in view of the three principles of system co-ordination:

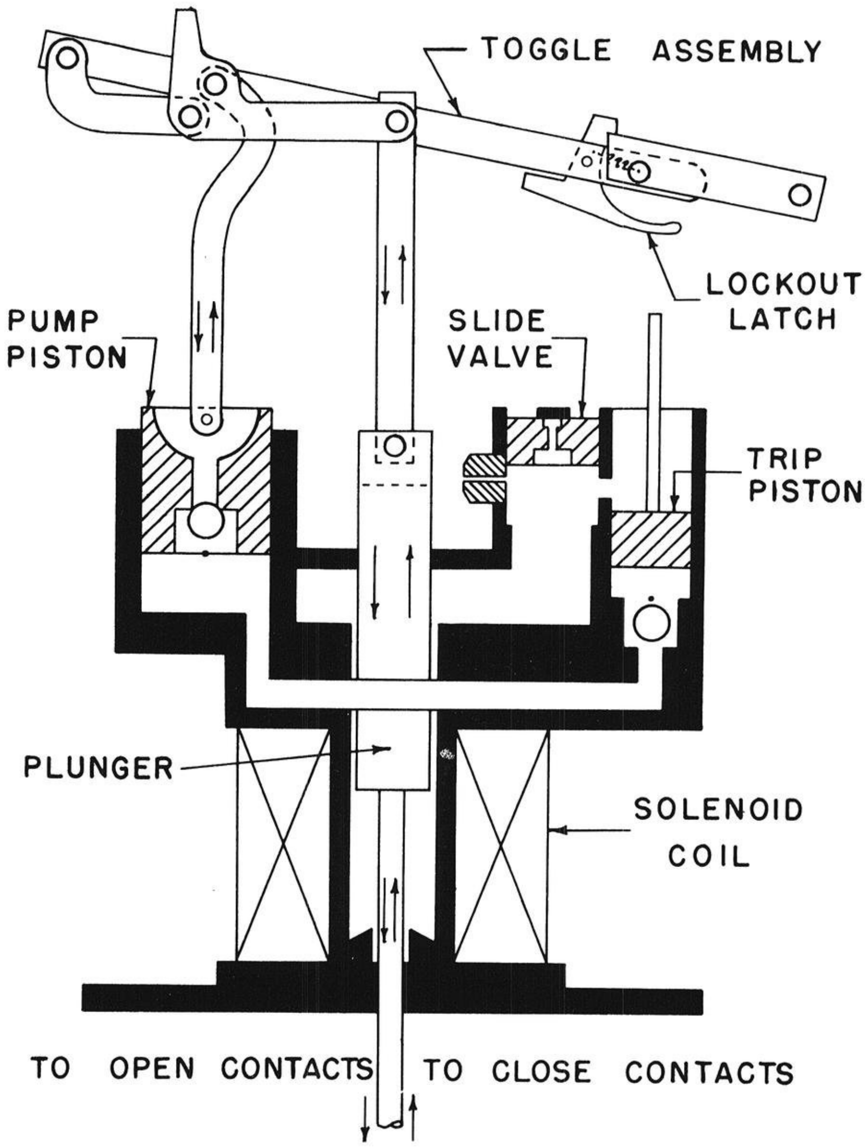
1. Outages caused by temporary faults must be eliminated.
2. An outage must be restricted to the smallest section of the system for the shortest time.
3. The protecting device must clear a permanent fault before the protected device.

Applying the principles to the previous example, device "E" must interrupt the branch line circuit to clear the fault from the system. After it has isolated the faulted branch, normal load current flows in the remainder of the network.

A look at the physical operation of two of the pieces of interrupting apparatus and how they work together will provide the necessary insight to system co-ordination and fault clearing. The two that will be discussed are the oil circuit recloser and the fuse cutout.

A cross section view of a standard duty recloser is shown in Fig. 2. The entire mechanism is immersed in oil and all chambers contain oil. The large magnetic force exerted on the plunger when greater than normal currents are passed through the series connected solenoid coil operates the mechanism. The overcurrents accompanying a fault cause the plunger to be drawn into the coil, or downward as shown. A set of contacts (located in a contact assembly not shown) are then opened.

FIG. 2



While the plunger is moving downward, it displaces oil which raises the slide valve and escapes through the port above the trip piston. Concurrently, the pump piston, connected to the plunger by a lever arrangement, forces a charge of oil under the trip piston. This charge is retained in the cylinder of the trip piston by a check valve, displacing the piston one-fourth of the cylinder length.

Opening the contacts and breaking the circuit de-energizes the solenoid coil and a restoring spring connected to the contacts force the plunger back to its original position. With the plunger moving upward, the oil in the slide valve cylinder returns to the plunger cylinder and the slide valve moves down to block the escape port of the trip piston cylinder. Thereafter, oil flows slowly through the small port in the slide valve and this slow flow retards the plunger's return to normal position, causing a delay of about one second before the contacts close.

If the fault still exists then the entire operation is repeated with the only difference being that the oil flow caused by the pump piston moves the trip piston to the midpoint of its cylinder so that upon completion of the cycle the trip piston blocks the escape port.

(Continued on next page)

The third operation, if necessary, differs from the first two only by a greater time delay in opening the contacts. This is achieved by having the escape port blocked so restricting the flow of oil to the small orifice in a plug located in the slide valve cylinder. The trip piston is meanwhile moved up to three-fourths of the cylinder length, still blocking the escape port.

If the fault still persists, a fourth operation similar to the third, takes place. This time the trip piston is forced the remaining distance upward and strikes the lockout latch. Fig. 3 shows the toggle assembly in lockout position during which the contacts are held open. The circuit will remain open until the fault has been cleared and the recloser is manually reset.

If a temporary fault clears before the recloser locks out, all mechanical operations cease and the trip piston settles to the bottom of the cylinder. The recloser again becomes ready for a full four cycle duty upon occurrence of another fault.

The graph of Fig. 4 illustrates the time-current (abbreviated, T-C) curve of a standard duty recloser. The current is expressed as a per-cent of full load rating. This rating may be changed by simply interchanging the solenoid coil used of the particular recloser. Curve A represents the fast interrupting action of operations one and two while curve B represents the retarded action of steps three and four. Curve C is classified as extra retarded and may be used in place of the retarded timing. Various combinations of the three settings are attainable through adjustment of a hydraulic timing mechanism.

The fuse cutout will not be explained in any detail other than to mention it operates, in principle, much like a house fuse. A fuse link of rated current carrying capacity becomes heated when fault currents flow and will melt if subjected to these currents for a specified period of time. Once this has happened that portion of the system remains without service until the cutout is manually refused.

The hypothetical problem illustrated in Fig. 6 will demonstrate

FIG. 3

TOGGLE ASSEMBLY IN LOCKOUT POSITION

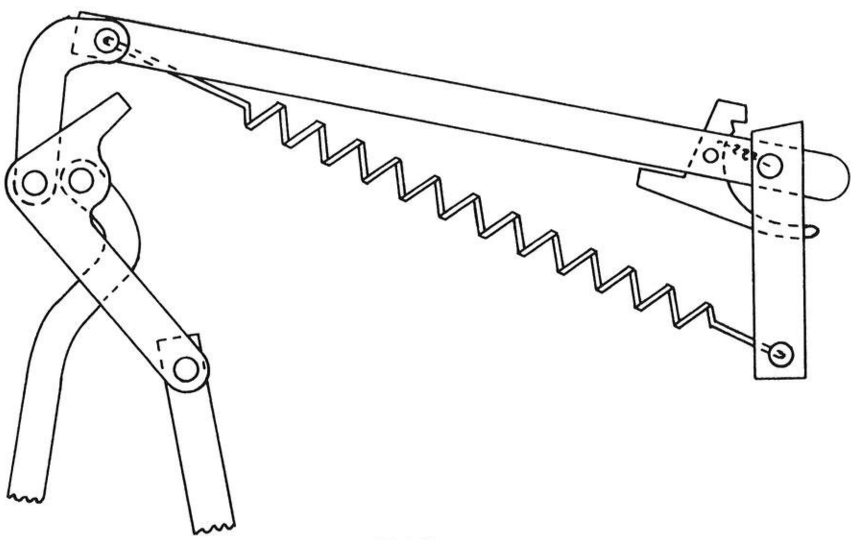
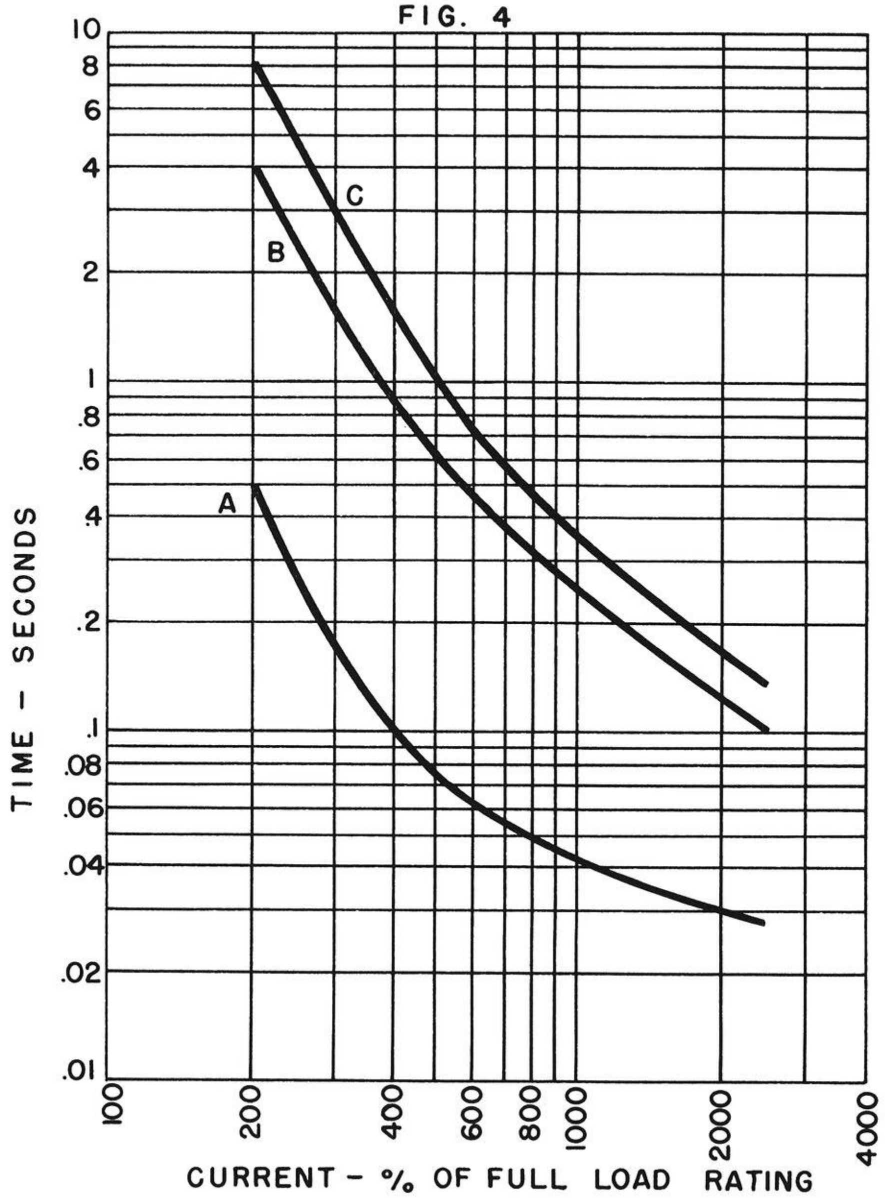


FIG. 4



the co-ordinated action of a recloser and cutout in restricting outages due to various faults. The 35 amp recloser is located on the load side of the distribution transformer. Customer transformers have been omitted for simplification. Each of the four loads is protected by its own fuse cutout. Suppose the normal load current flowing through the recloser is 40 amps with a current of 10 amps flowing to load B. Assume a fault occurs as indicated and the fault current becomes approximately 100 amps. Knowing the fault current permits the use of T-C curves of Fig. 4 and Fig. 5. The recloser has a fast action interrupting time of 0.18 seconds for a current of 300% rated current. The fuse has a clearing time of 0.25 seconds for 100 amps. Thus, the recloser acts first and opens the circuit, clearing the fault. If the fault is momentary, as are about 95%, then upon reclosing, the entire system is back to normal operation with no outage existing. If the fault remains, the recloser completes a second fast operation giving the circuit another chance to clear itself. The fuse cutout will melt and interrupt a permanent fault before the recloser can go through the two retarded cycles and lockout. This is indicated by the recloser clearing time of 1.6 seconds for the retarded cycle, or curve B. Thus, a temporary fault will be cleared with no loss of service and a permanent one will be cleared with the outage restricted to a minimum section.

It is through the use of these interrupting devices that a power utility is able to provide the excellent service customers have come to expect. Each part of the system must be studied and co-ordinated in a similar manner. An electric power failure will then be restricted to the fewest possible users when an unavoidable fault occurs—hence, customer goodwill continues.

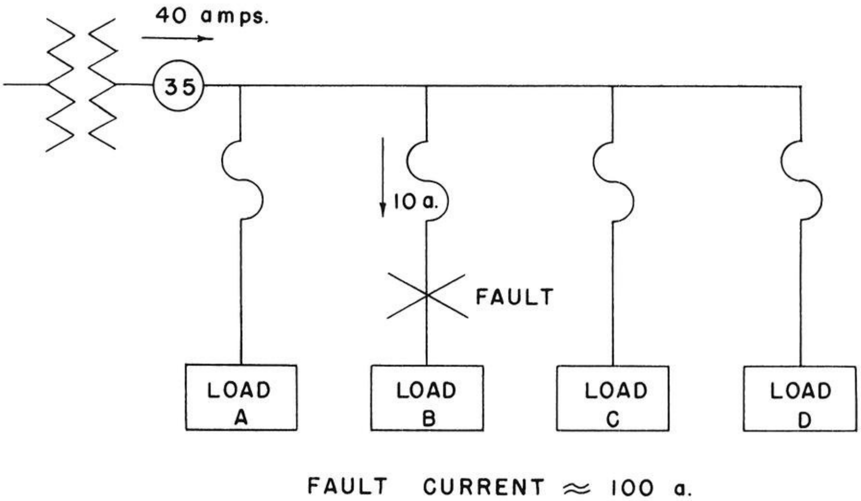
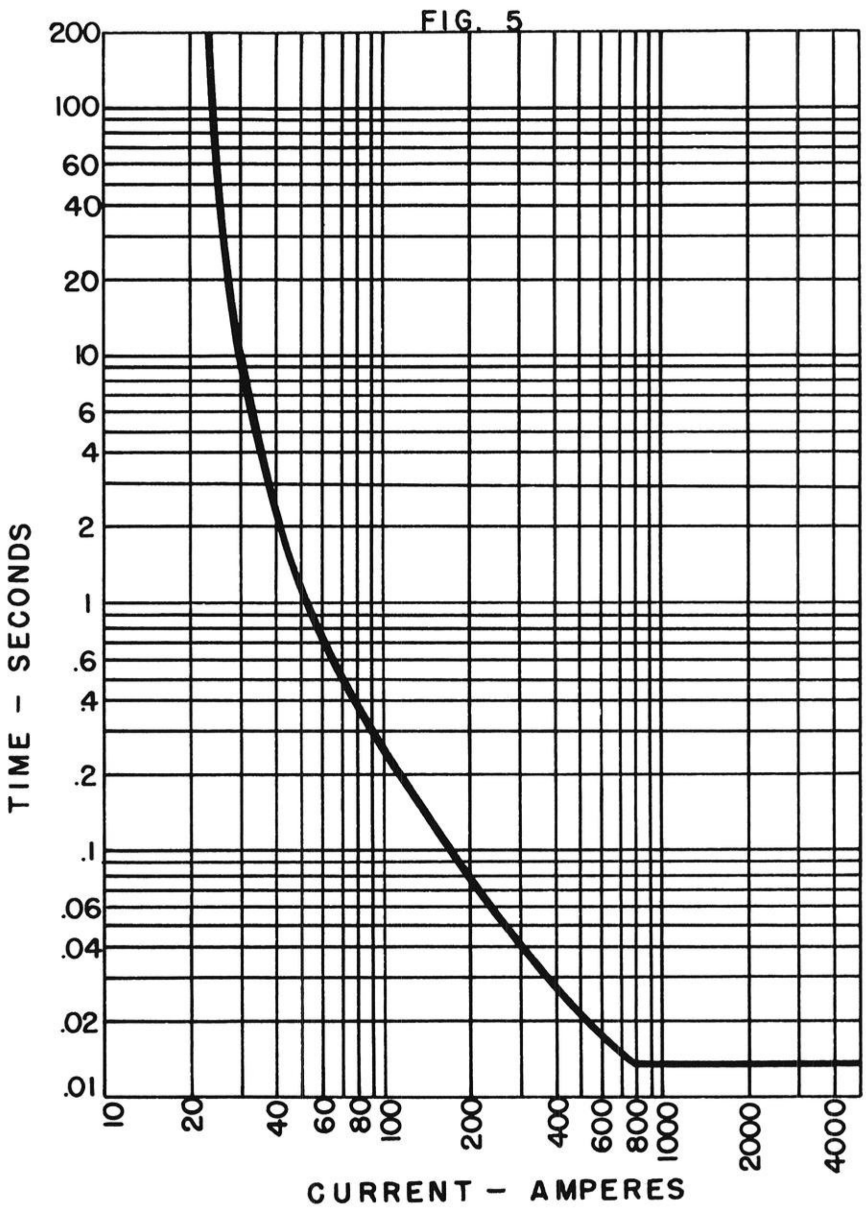


FIG. 6

FIG. 5



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Auxiliary Power Systems for Space Vehicles

by R. C. Molander me'63

As SPACE vehicles grow ever larger and space missions become increasingly ambitious, compact, lightweight, and reliable power systems will become a critical factor in the successful development of space technology. The manned space station, space probe, ion propulsion system, and the planetary base of the more distant future will all require extensive quantities of electrical power. How will this power be generated in an environment of space?

During the present formative stage of space technology, one cannot find a clear cut answer to such a question. It is possible, however, to sketch much of the space power picture. That is the purpose of this report. It summarizes the viewpoints and proposals of many of the leaders in the space power field as set forth in national space and missile publications. It is a composite picture of the present level of development in the space power field—avoiding the highly technical aspects to make comprehensible reading for persons in any engineering field.

REQUIREMENTS OF A SUITABLE AUXILIARY POWER SYSTEM

Basically, electrical power in a space craft can come from any of three fundamental energy sources:

1. Solar energy.
2. Chemical energy.
3. Nuclear energy.

All are significant enough to warrant a detailed investigation of each. But before such an investigation can be made, it would be advisable to delve into the general characteristics of a suitable power system.

Mission

The choice between auxiliary power systems must of necessity be based on a detailed consideration of the specific mission and the limitations imposed by the vehicle and operational environment. The mission provides the most important criteria in the selection of the type of system that will be used:

Where will the vehicle operate?
Will it be manned?
Must it operate while shadowed from the sun?
Will it reenter?

These are the first questions to which the vehicle designer will seek answers.

Space Environment

Outer space is a rigorous environment with intense fluxes of electromagnetic quanta, subatomic particles, and meteoroids. The space vehicle power supply will be eroded, punctured, heated by the sun, and otherwise degraded. Certain systems are less affected by these attacks than others; this becomes a prime factor.

Power systems which employ working fluids will also encounter new problems in the zero gravity of the space environment. Of particular concern are the liquid and vapor regions of the Rankine power cycle, the thermodynamic cycle which will probably be used. In this area scientists are hindered extensively in their development by their inability to produce zero-gravity conditions for extended periods of time.

Heat Rejection

The designer must also keep in mind that the energy delivered by his system will eventually be converted into waste heat within the vehicle. Radiation is the only feasible way that this heat can be dissipated in the vacuum of space. The radiator should operate at the highest possible temperature since its effectiveness varies with fourth power of the absolute temperature. Consequently, the higher the temperature of rejection the smaller the radiator. But this higher heat rejection temperature reduces the carnot efficiency of the heat conversion system if it employs a working fluid. The designer is thus faced with striking a compromise between these two factors.

Specific Weight

Probably the most significant power source parameter is the specific weight or weight per unit power since this determines to a large extent the performance of a system.

Along this line, the effect of mechanical power systems with rotating or reciprocating parts cannot be neglected. All improperly balanced equipment will lead to a weight penalty due to the need for a more complicated orientation system. In this respect, static power generating systems look quite attractive.

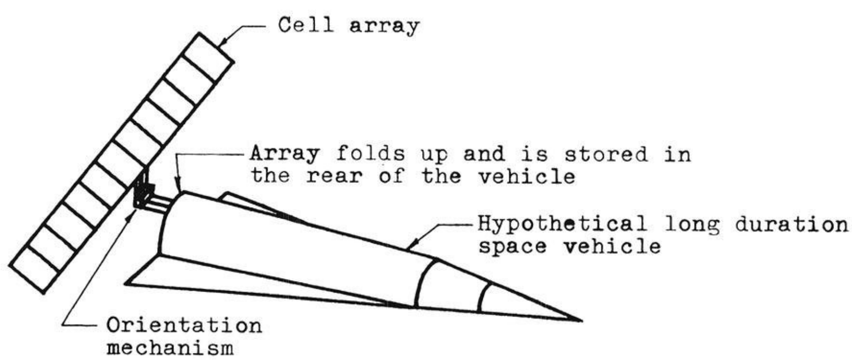

Figure 1. Model of silicon cell solar collector in fully deployed position.

SOLAR ENERGY SOURCES

Fundamentally, the energy which is used to provide electrical power can come from either an external source or be carried aboard the vehicle. The sun provides the most obvious source of external energy in the form of solar radiation. This radiation can be converted directly into electricity by photovoltaic cells or can be converted into heat which can in turn be converted into electricity by a variety of means.

Photovoltaic Cells

The conversion of solar radiant energy to electric power by photovoltaic cells is one of the most attractive sources of power being considered for long duration space vehicles. These devices will be able to provide the power to handle operating equipment loads and, if necessary, charge storage batteries for dark side operation.

The photovoltaic process employs a semiconductor device—such as silicon—which releases electrons within the material when bombarded by photons from solar radiation. These electrons produce a flow of electric current.

Theory indicates that the maximum conversion efficiency of silicon cells is about 23%; but, until recently, the maximum that could be obtained in production was only about 10%. This low efficiency is due to the internal voltage losses which occur when the size of the cells is increased. Thus, with incident energy of solar radiation being about 0.15 watts per sq cm at the earth's average distance from the sun, it may require as many as 60,000 individual cells to produce a single KW of power.

In an effort to increase this low cell efficiency, several companies are under contract to the government to develop new and improved cells. GE is experimenting with the rolling, forging, and extruding of silicon to give large area cells with a minimum of induced voltage losses. They are also working on thin films of silicon which hold promise of reducing the cost per watt to one-fiftieth of the present value of $420,000. Air Force sponsored research with cells made of thin films of cadmium sulfide also offers potential weight and cost reduction. Films, however, have not to date exhibited high efficiencies.

The actual cell array will consist of a large rectangular plate as shown in Figure 1.

The arrangement shown is one proposed by E. T. Raymond of Boeing. The collector cell array would consist of eleven plates of silicon cells oriented to the sun by a mechanism as indicated. During launch and reentry the plates would fold up and be stored in the rear of the vehicle. With present methods such an array with an area of 400 sq. ft. would provide 4.4 KW with a system weight of 600–700 pounds.

Photovoltaic cells will certainly play an integral part in the advance of space technology. They are now being used successfully in space satellites and are thus the only proved long-operating time power equipment now available.

Thermionic Conversion

A solar thermionic system presently under development is expected to be ready for flight testing by 1963. STEPS (Solar Thermionic Electric Power System) is being developed by GE's Missile and Space Vehicle Department under a contract with the Air Force's Aeronautical Systems Division.

STEPS generates power through the use of a parabolic reflector which focuses the sun's rays on a generator made up of many thermionic converters and several subsystems. The schematic is shown in Figure 2.

The thermionic converter operates in principle like the convential vacuum tube diode. Electrons are boiled off a hot cathode by the concentrated radiation and are collected at a relatively cool anode. From here, the electrons, as an electric current, flow through a load where they perform work and then return to the cathode. Within the power range of 3 to 10 KW, the specific weight of such a system using thermal energy storage is

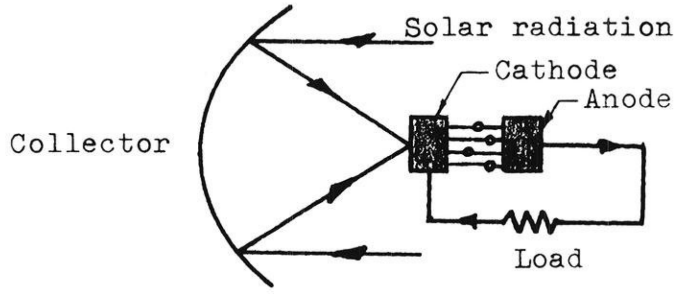

Figure 2. Solar Thermionic Electric Power System

estimated to be between 150 and 200 lb per KW.

Like other solar energy systems employing reflectors, the chief drawback of the thermionic converter is that reasonable system efficiency demands unusually high accuracy in reflector surface orientation with respect to the sun.

Solar Mechanical Engines

The Sundstrand Company, under an Air Force contract, is currently undertaking the design and development of a flight prototype of a 5 KW solar mechanical power unit capable of one year of continuous operation. The contemplated system would have a specific weight of less than 60 lb per KW and operate as shown in Figure 3.

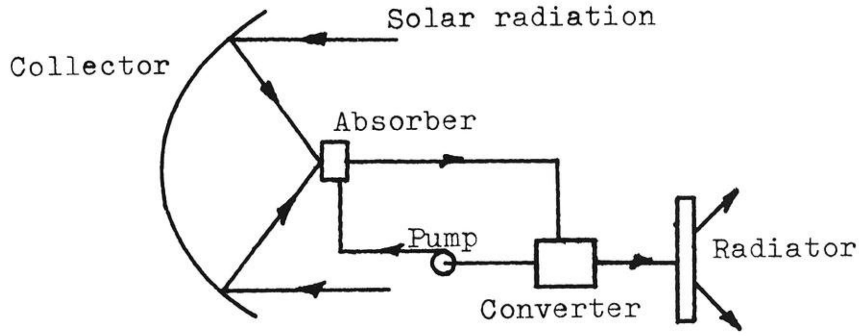

Figure 3. Solar mechanical conversion system

The reflector concentrator will direct solar rays into a cavity absorber where heat will be transferred to the working fluid which powers the turbogenerator. The latter will supply operating power and charge batteries for shadow phase operations. Essentially this will be a closed Rankine cycle power system using rubidium as the working fluid.

The power system when deployed will use a 40 foot mirror concentrator. The big paraboloid will be folded during transit and must be opened and oriented as soon as the vehicle is in space. Orientation will be by a sun seeker accurate to 0.1 degree.

There are many problems to be surmounted in developing a system of this type. Foremost among these are the unknown properties of rubidium and the design and materials for the solar concentrator. Nevertheless, such a system has tremendous potential and will without a doubt contribute significantly to the space power field.

Solar Concentration Cell

A new two-stage device known as a solar concentration cell has shown promise of producing power and efficiencies comparable with current photovoltaic devices. A sketch of the operation, a solar to chemical to electrical conversion, is shown in Figure 4.

In the first stage, solar energy is converted to chemical energy by the photochemical isomerization of trans to cis organic acids. (Trans and cis are two forms of geometric isomers.) The next stage converts chemical to electrical energy by means of electrochemical concentration cells. In such cells, solutions containing the same ion at different concentrations produce a potential difference. Such systems are still in the development stages and not expected to be competitive for a number of years.

General Comments on Solar Energy Sources

To perform efficiently, the collector of any solar power system must, of course, face the sun. Solar cell arrays offer the advantage of being able to operate adequately with an orientation accuracy of 15 degrees while competitive mirrors require accuracies as close as 0.1 degrees.

Solar mechanical systems offer a distinct advantage over the other systems; it may be possible to use the same power generating unit during all flight phases by substituting another energy source for the solar collector during launch and reentry.

Concentrator development offers many unknowns. Meteorite puncture effects can probably be made negligible; however, sublimation in a space environment could be disastrous.

Solar thermionic systems hold promise of someday having a specific weight about one-third that of other solar power systems. However, a considerable amount of work remains to be accomplished before such a system can be demonstrated to have achieved satisfactory performance.

Thus it can be seen that there are many possible applications for solar energy in the space power systems of the future.

CHEMICAL ENERGY SOURCES

Of the three main sources of energy previously mentioned, chemical sources are the most advanced technically since they have been in use for such a long time. Their applicability to space vehicles centers around batteries, combustible fuels, and noncombustible fuels which produce energy through electrolysis.

Fuel Cells

The fuel cell is basically a chemically fueled device that converts

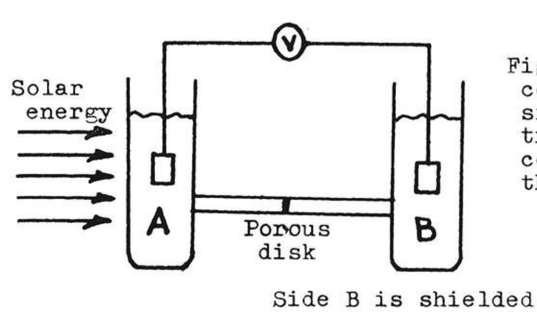

Figure 4. Proposed solar concentration cell. Both sides contain saturated trans acid with side A containing an excess of the solid acid.

chemical energy directly to electrical energy through the process of electrolysis. The most advanced is the open cycle type in which hydrogen combines with oxygen to produce water and electrical power. Hydrogen-oxygen cells can also be operated in a closed cycle in which the water by-product from the cell is converted back to hydrogen and oxygen through electrolysis. There are hopes that research will make it possible to use solar radiation or direct heat to break down the water into its constituent parts. If this is not possible, whatever fuel is taken aloft must suffice.

The maximum theoretical efficiency of fuel cells is about 80% with some having already been constructed with actual efficiencies greater than 60%. This compares with an efficiency of about 40% for most conventional steam turbines. High specific weight in the present models is one of the drawbacks for fuel cells. However, a significant breakthrough was announced this past summer by Ionics, Incorporated. Working under an Air Force systems contract, they have developed a fuel cell with a specific weight of 25 lb/KW—a highly significant decrease from previous levels.

Fuel cells will find their greatest applicability for space missions lasting over three days with power demands in the range of one to five likowatts. Lunar flights and space probes come under this heading.

Batteries

Battery powered accessory power units have been the most common form of nonpropulsive power in this country's earth satellite and other space systems. Their storage life is excellent and so is their reliability. Quite important for present space programs is that a system of practically any size can be put together from available or readily produced parts.

A shortcoming of batteries is that, as power needs and operating times increase, the specific weight of the battery power units soon exceeds that of competing equipment.

The applications for which the battery power systems look promising are: (1) Medium power and short time, as in emergency escape capsules and ICBM's; (2) Low power and medium time as in non-orbiting space probes. It has also been proposed that batteries supplement the solar cell power system for launch and reentry of the Ranger vehicle to be employed in lunar landings.

Liquid Fuels

There are two main systems that are classed under liquid fuel power sources. In the first, the hot decomposition or combustion of a monopropellant is used to drive an expansion engine which in turn drives a generator. Such systems can be used for missions up to three days in length at expected power demands of as much as 50 KW. Because of excellent storage characteristics such fuels could provide launch and reentry power for long duration space vehicles that depend on solar or nuclear sources for most of their flight.

In the second system, a bipropellant combination of hydrogen and oxygen is used to drive an expansion engine. The fuel consumption is low, making such a system applicable to longer space flights.

Solid Fuels

Solid fuel, nonpropulsive power systems are now in use in some rockets and missiles. In their operation hot gases from the combustion of a solid fuel are used to drive a piston which runs a reciprocating or turbine heat engine.

Solid fuels do, however, burn at a fixed rate. Therefore fuel grain must be sized for peak power which produces the problem of eliminating the excess gas during periods of low consumption. As a result, fuel consumption is high.

General Comments on Chemical Energy Sources

Liquid fuel systems will suffer from the problem of zero gravity with a need for a positive means of delivering the fuel from the tanks to the combustion or decomposition chambers. However, both solid and liquid fuels offer the advantage of being able to supply power in a variety of forms—AC, DC, or hydraulic—while offering a substantial weight reduction over other chemical systems.

The fuel cell, with its high efficiency, will most likely be the competitor among the chemical power systems. However, the proven capabilities of the other chemically fueled systems will make them applicable for a number of years to come.

NUCLEAR POWER SOURCES

The use of nuclear sources for spacecraft auxiliary power will largely depend upon the mutual compatibility of the nuclear sources with the various space missions and the corresponding vehicles. Two sources of nuclear energy can presently be considered: radioisotope and fission. A third source, fusion, has not been developed to the point where it can be compared in terms of operation with the other two.

SNAP Program

The development of nuclear power systems for space vehicles has progressed more rapidly than any other space power program. This can be attributed to Project SNAP (Systems for Nuclear Auxiliary Power), the NASA/AEC program for developing electrical power generating systems using radioisotope and fission sources.

Under this program, the Nuclear Division of the Martin Company was awarded a contract to develop radioisotope power sources for space use. Similarly Atomics International, a division of North American Aviation, Incorporated won a competition to develop a compact core for a nuclear fission power system. Each company began work in 1955. Almost all of the developments discussed can be attributed to these efforts.

Radioisotopes

In June of 1961, the United States put into orbit Transit IVA, an airborne navigational signal station for ships and aircraft. The electricity that powers this satellite comes from a radioisotope powered heat to electricity generator. The

(Continued on page 34)

JT3D

DIRECT ENERGY CONVERSION

TURBOJET

ROCKET

LIQUID HYDROGEN

LR-115

THERE'S CHALLENGE TODAY FOR VIRTUALLY

FUEL CELLS

MACH 3

MAGNETOHYDRODYNAMICS

SATURN

NUCLEAR

Modern Steam Car

(Continued from page 11)

the steam car and its engine to the internal-combustion gasoline-engine. However, some of the known facts are presented to give some idea of the performance that can be expected from the Steamliner.

Thermal Efficiency

Most gasoline-burning internal-combustion-powered automobiles have over-all thermal efficiencies between 16 and 20% at 60 mph on a level road. The 1959 Mercedes-Benz 190–D diesel powered car was reported to have an efficiency of 27% at 60 mph and 19% at 30 mph. The Steamliner, however, has a thermal efficiency of only about 15%. This low efficiency is due to the large amount of heat that is rejected in the condensor.

Speed

The speed that can be attained by the Steamliner is 70 mph at about ¾ throttle. Though not tested, it is believed that the maximum speed would be a little over 100 mph.

Fuel Consumption

The amount of fuel burned per mile in the Steamliner is about the same as in conventional gasoline cars, but the furnace oil burned in the Steamliner is cheaper than gasoline. This gives the steam car a lower operating cost than gasoline powered cars.

One might think that because of the lower thermal efficiency of a steam car, the fuel rate would increase. Table 1 (see page 8) shows that furnace oil gives 139,000 Btu/gallon and gasoline gives only 124,-800 Btu/gallon. This increase in heat per gallon offsets the decrease in thermal efficiency and gives the two cars equal mileage.

ADVANTAGES AND DISADVANTAGES

When comparing two or more objects it is hard to find a balance that will weigh each component justly. The decisions expressed by

(Continued on page 26)

WHAT? MECHANICAL ENGINEERS IN A CHEMICAL COMPANY?

True, we do employ a number of chemists and chemical engineers at Du Pont. But our need for mechanical engineers is just as urgent. In fact, the ratio of MEs to CHEs at Du Pont is 10:17.

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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Modern Steam Car

(Continued from page 24)

an observer are relative to the importance he places on each item of the comparison. Comfort and economy are two such items.

Economy

As mentioned above, the steam car is more economical to run. However, at such early stages of development, Mr. Keen is afraid to guess what the cost of purchasing a similar car would be. Steam engines, on the other hand, last longer than a gasoline engine because the fuel is burned outside of the cylinder. Wear is reduced because the ash of combustion is not inside the cylinder to multiply to the otherwise slight function wear. Also, there is no friction at all in a boiler. Another point is that steam is expansive rather than explosive and therefore smoother.

Comfort

Because the engine is smooth-running, the car rides very smoothly. For this reason the steam car is very quiet; only an occasional hiss of steam can be heard. The center of gravity of the Steamliner is now and, therefore, the car handles with ease.

Simplicity

The Steamliner has fewer parts than an ordinary car. The Steamliner does not have any transmission or clutch. With the engine in the rear, no drive-shaft is needed. However, the internal-combustion gasoline-engine does not need a boiler and the other associated apparatus required by the steam engine.

ASPECTS OF THE FUTURE

The future for the Steamliner is hard to forecast—the road to perfection has many pitfalls. When Mr. Keen is thoroughly satisfied with the performance of his car, he hopes to interest manufacturers in the possibility of its production. This will be the greatest test of the Steamliner.

No one can expect the steam car to replace the gasoline car. Records show that 99½% of all unorthodox vehicles never go into production. However, can anyone help but enjoy the silent and smooth ride, the absence of gear-shifting, the great power at low speeds, the greater economy, or simply the pure fascination and fun of owning the Steamliner—steam car of tomorrow?

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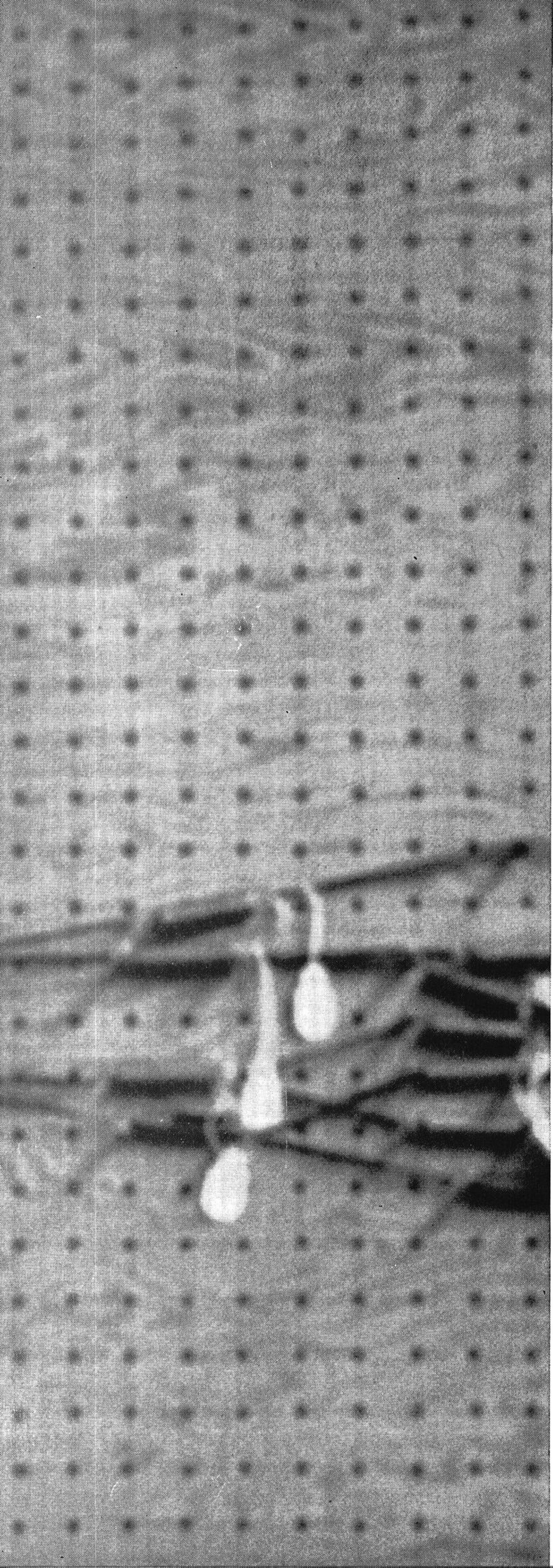
"It's quite simple," explained one of the seniors in EE, "to hook up an electric power circuit. We merely fasten leads to the terminals and pull the switch. If the motor runs, we take our readings. If it smokes, we sneak it back and get another one."



Edward H. Sussenguth, Jr. (B.A., Harvard '54; M.S. in E.E., MIT '59) has investigated the theoretical requirements of an automated design system for advanced cryotron-circuit computers.

HE WORKS WITH A NEW DIMENSION IN COMPUTER DESIGN

Thin film cryotrons may make possible computers of small size and truly prodigious speeds.

The speeds of today's computers are limited mainly by device switching times. Speeds of cryotron computers would be limited mainly by signal propagation times between devices.

Automation of Logical Circuits. Edward Sussenguth has studied methods of design which will reduce the distance between devices to a minimum. He hopes that these will contribute to a completely automatic design system.

Ultimately, then, the systems designer would specify his needs in terms of Boolean equations and feed them into a computer. The computer would (a) design the logical circuits specified by the equations, (b) translate the logical circuits into statements describing the interconnections, (c) from the interconnections, position the devices in an optimal fashion, (d) from this configuration, print out the masks to be used in the evaporation process by which these circuits are made.

This is a big order, but Edward Sussenguth and his colleagues have already made significant progress. Their work may well have a profound effect on computer systems in the coming years.

Orientation: the future. One of the exciting things about computer development is this orientation towards the future. If a man wants to match his personal growth with the growth of computer systems, his future can be virtually unlimited. This is true of all the fields associated with computer systems — research, development, manufacturing, programming, marketing. The IBM representative will be glad to discuss any one of these fields with you. Your placement office can make an appointment. All qualified applicants will be considered for employment without regard to race, creed, color or national origin. You may write, outlining your background and interests, to:

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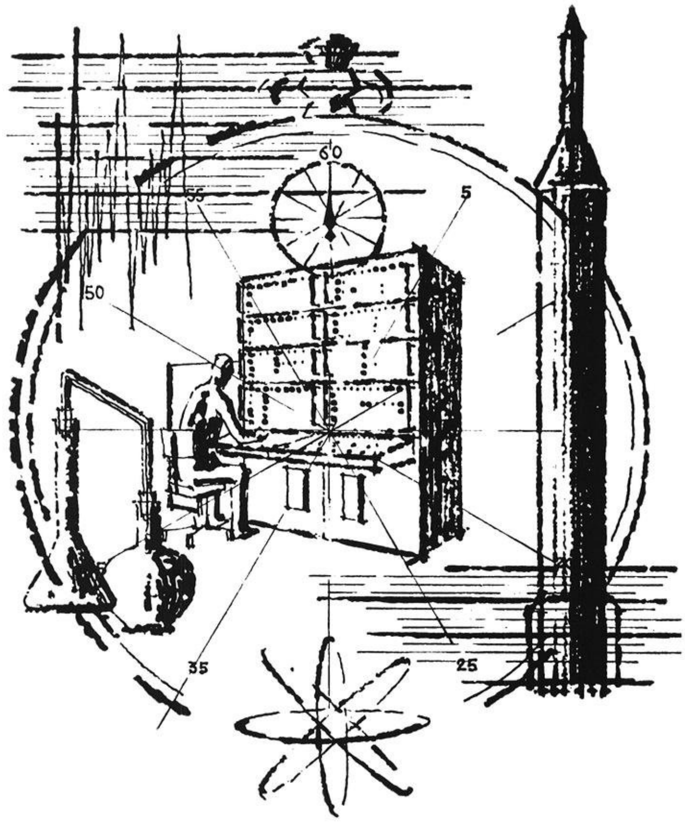

SCIENCE HIGHLIGHTS

by John C. Ebsen 3A'64

ANOTHER TRY AT USING SEA WATER

A pilot plant to demonstrate a new freezing process for converting sea water to fresh water will be placed in check-out operation near Oxnard, Calif., next week by Rocketdyne, a division of North American Aviation, Inc.

In its first phase, the pilot plant will be operated to develop performance characteristics of its new equipment before a series of tests is begun to demonstrate conversion efficiency.

The pilot plant will be operated by a Rocketdyne crew which moved to the site this week to prepare for activation.

The freezing process to be demonstrated by the plant eliminates conventional heat exchangers in all principal sections of the freezing cycle. It is based on concepts originated some years ago by Drs. Ludwig Rosenstein and Manuel Gorin, chemical consultant of San Francisco.

In the North American process, incoming sea water first is cooled, then frozen to form crystals of fresh water. The freshwater crystals then are separated from brine surrounding them, washed, and melted to obtain water for domestic and industrial uses.

The pilot plant was designed as a development tool to gather engineering data and operating experience applicable to large-scale saline water conversion plants. It was built as part of a program by North American Aviation expected to reach $1 million in cost, for research and development in the saline water conversion field.

The Rocketdyne facility is located at Mandalay Beach on land leased from the So. Calif. Edison Co.

NUCLEAR ROCKET COULD INCREASE PAYLOAD CAPABILITY 2–3 TIMES, WESTINGHOUSE EXECUTIVE SAYS

Development of a nuclear rocket to operate in conjuction with already planned space programs could increase United States payload capability two to three times, John W. Simpson, Westinghouse Electric Corporation vice president told members of a congressional committee on March 1.

Testifying before the House Science and Astronautics Committe, the executive in charge of the company's atomic power department and astronuclear laboratory added that adding a nuclear upper stage to Saturn would double or triple the payloads we can put into orbit prior to 1970. This early capability is not only impcrtant during this critcal decade in our international affairs but it will also build the base for the period after 1970, when nuclear rockets will dominate space propulsion.

The United States could conduct a test flight of its first nuclear rocket in 1965, Mr. Simpson said while pointing out that this flight test program could involve research and development expenditures of "hundreds of millions of dollars."

The nuclear rocket engine is the key to greater outer space capabilities, he said, and represents the biggest single improvement in our rocket capability in this decade. The Westinghouse vice president cited several technical areas where development of the nuclear rocket will be challenging, but added that much work has already been done at Los Alamos Scientific Laboratories. The feasibility of the project has been established and the development program required can now be determined.

"It will be necessary to have a thorough understanding of the safety requirement that will be involved in preflight testing and the ultimate launching of the rocket," he told committee members."This program will require money and people and the solution of extremly difficult technical problems, but we believe that one day nuclear rockets will be launched with complete safety and will carry great payloads into outer space."

LIARS, BEWARE

Pocket-size-lie detectors exported by Japan soon will be on the market, International Management McGraw–Hill publication, reveals. The transistorized battery powered detectors will measure the change in a person's pulse, breathing and blood pressure caused by the "mental commotion" of telling a lie.

SUPERCONDUCTIVITY MAINTAINED UNDER HIGH MAGNETIC FIELD

Extremely high magnetic fields are required in a large number of scientific applications, including deflectors in particle accelerators, solid state masters, adiabatic demagnetization experiments, and many others. Recent work[1] by the Cryogenic Engineering Laboratory of the National Bureau of Standards, Boulder, Colo., in cooperation with the Department of Physics, University of Colorado, may lead to the development of superconducting magnets having field strengths higher than any previously known. In a project sponsored by the Atomic Energy Commission, V. D. Arp, R. H. Kropschot, and J. H. Wilson of the Bureau, and W. F. Love and R. Phelan of the University have shown that niobium-tin (Nb_3Sn) wire remains superconducting in pulsed fields of up to 185 kguass When extrapolated to zero measuring current, the critical field appears to be about 188 kgauss at 1.6 °K.

The electromagnets commonly used to provide high magnetic fields require tremendous power for their operation. By utilizing the phenomenon of super-conductivity—the disappearance of electrical resistance in certain metals at very low temperatures—magnets having high fields and low power requirements can be constructed. Unfortunately, most metals lose their superconducting properties when exposed to a small magnetic field above a certain critical value. However, the development of new alloys, such as Nb_3Sn has resulted in wires that remain superconducting even under very high field conditions.

The Nb_3Sn wire used in this investigation was prepared in the Bureau's metallurgy laboratories following the procedure outlined by others[2] (who previously had produced Nb_3Sn wire which had remained superconducting in their highest available field of 88 kguass), except that the wire was swaged rather than drawn to its final diameter of 0.50 mm. In brief, the preparation consisted of packing a niobium tube with a powdered Nb-Sn mixture, drawing or swaging the tube into wire, after which individual specimens, 12 cm long, were heat treated at 1000 °C for 16 hours. The ends acid-etched and tinned in a bath of molten indium after heat treatment. Current and potential leads were attached to the wire with indium solder.

Measurements were made with the wire oriented parallel to the field of a pulsed magnet 6.4 cm long and 1.4 cm I.D., leaving the current and potential leads outside of the magnet. The wire was immersed in a liquid helium bath, and the magnet was placed in a surrounding bath of liquid nitrogen. The maximum current applied to the sample was 23 amp; 1100 amp could be applied to the magnet. Oscilloscope traces of both magnetic field and the voltage across the wire provided a means of determining the critical field.

An estimate has been made of the eddy current heating of the sample during the field pulse. The results show that above the lambda point (2.17 °k) the sample might warm by as much as 1 deg k; below this temperature the rise should be less than 0.5 deg K. Also, the attenuation of the pulsed field through the sheath was calculated and found to be negligible.[3]

The use of Nb_3Sn wire in superconducting magnets requires knowledge of the critical field transverse to the current flow, rather than parallel as in these experiments. Therefore, the investigation will be continued in order to observe transverse critical fields. In addition, materials other than Nb_3Sn, such as solid solutions of NbZr, are being studied for possible use as superconducting magnets.

Stopping at the first farmhouse on his famous midnight ride, Paul Revere cried, "Is your husband at home?"

"Yes!" came the reply.

"Tell him to get up and defend himself; the British are coming."

At the second, third and fourth houses the same conversation ensued, but at the fifth house it went something like this:

"Is your husband at home?"

"No!" came the reply.

"Whoa!"

A lighted fluorescent panel lamp is shown here with two of General Electric's lamp development engineers—Richard S. Christy and Edward V. Parillo—who helped create the revolutionary light source. The waffle configuration of the face plate helps make the lamp strong but light in weight, and attractive either lighted or unlighted. The unique new fluorescent lamp adds a square form to the point, linear and circular light sources which have been available in the past.

New xenon bulb developed by Duro-Test Corporation, North Bergen, N. J., in cooperation with U. S. Army Engineer Research and Development laboratories. Built for military use, search lights, projectors and space applications, it is an intensely powerful light source which can project its rays for 50 miles.


If it isn't fun, don't do it!
There are those who will tell you that the world beyond the academic walls is (a) highly competitive, (b) full of opportunity, and (c) above all, serious business. Although we are keenly aware of the serious implications of the advanced propulsion work we're doing, at UTC we take a somewhat different view.
We believe that the right man in the right job will *enjoy* what he's doing. He'll find the competition stimulating, the challenge exciting. He'll be eager to get to work in the morning, simply because his work is *fun*. And this enthusiasm is bound to rub off on the paycheck, make no mistake about that.
Now, while you're giving serious thought to your future, we invite you to check out the possibilities here at UTC. For more information, write Jay Waste, Dept. 11
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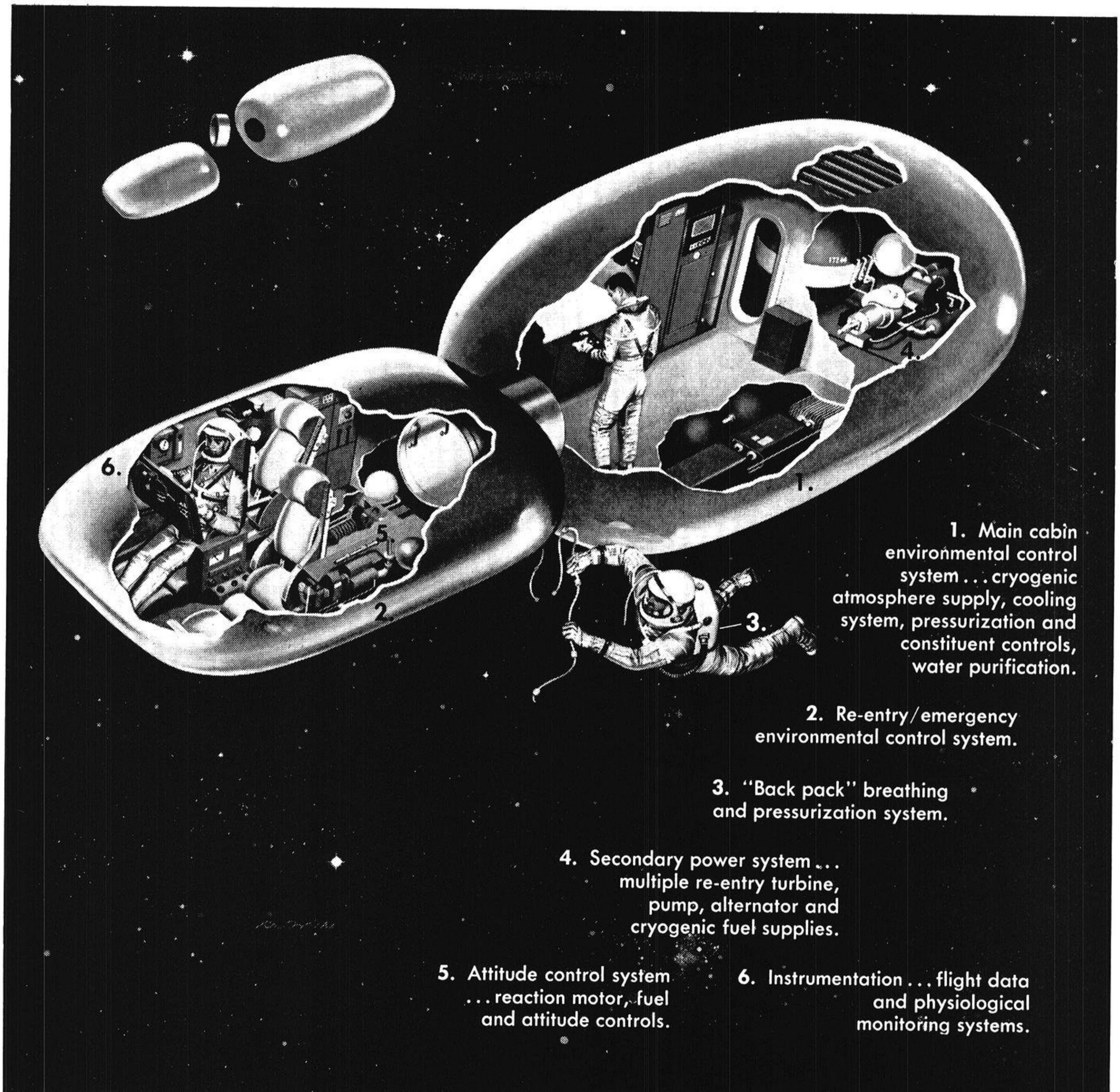

Manned space flight requires reliable and efficient thermal and atmospheric systems plus secondary power equipment. Complete, integrated systems (such as those pictured above) are under study at Garrett's AiResearch Manufacturing Divisions. Their design reflects 20 years of leadership in airborne and space systems, including NASA's Project Mercury life support system.

Other project areas at Garrett include: solar and nuclear power systems for space applications; electronic systems, including centralized flight data computer systems; and small gas turbines for both military and industrial use.

An orientation program lasting several months in diversified areas is available to every newly-graduated engineer to aid in his placement. It includes working on assignment with experienced engineers in laboratory, preliminary design and development projects.

For further information about a career with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

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Auxiliary Power Systems for Space Vehicles

(Continued from page 19)

4½ pound generator is very rugged, with an estimated operational lifetime of at least five years. As a followup, Transit VI A with a similar radioisotope generator was put into orbit in November of this year.

Radioisotope systems have thus been shown as appropriate for long-lived space satellites. Improved versions at higher power levels could power space probes and more ambitious scientific payloads. At present, however, their applicability seems limited to power levels below 500 watts.

Unfortunately, isotopes which have a high energy output also have very short half lives. This, of course, limits their use. All isotopes do, however, possess the advantage of not requiring a critical mass or special fuel geometry. However, the power source cannot be shut off; thus coolant failure will cause system meltdown.

Fission

Compared to radioisotopes which are limited by their availability to low power ranges, the fission reactor shows the most promise at the higher power levels. Consideration of the SNAP 2 power system gives the best insight to the working of these fission reactors.

The SNAP 2 system employs the same concept as ordinary steam power generating units with the exception that mercury vapor is used instead of steam and the cycle heat is rejected by a radiator to outer space instead of to cooling water. The Rankine cycle to be used takes advantage of the latent heat gained from phase changes, the lower flow rates, and the isothermal heat transfer to obtain high efficiency, light weight, and good reliability. A sketch of the operation is shown in Figure 5.

The nuclear reactor that takes place within the reactor core delivers thermal energy to a sodium potassium eutectic liquid metal (NaK) that is pumped along the interstitial passages between the fuel elements. Heat exchange occurs in the boiler where the NaK converts the mercury working fluid into a vapor which in turn drives a miniature turbogenerator. The The mercury vapor then flows through a condenser radiator and is pumped back into the boiler. All rotating components are mounted on a common shaft, the only moving part in the SNAP 2 system.

SNAP 2 will be capable of generating 3 KW of useful energy continuously for one year when flight type systems are available in 1963 or 1964. The reactor alone is about the size of a fuel can and weighs only 220 lbs. With a complete auxiliary power unit and the necessary shielding, the total system weight would be 900 lbs. for an unmanned vehicle and 2400 lbs. for a manned vehicle.

Potential missions that can use SNAP 2 systems are surveillance satellites, communication satellites, space station power systems, lunar station power systems, and solar system probes.

The AEC will extend the SNAP 2 reactor concept to provide a thermal capacity to run one or two 30 KW combined rotating units. In many respects this system, designated SNAP 8, is a scaled up version of SNAP 2. It will use higher operating temperatures, pressures, and flow rates while employing a reactor quite similar to that used in SNAP 2.

The planned uses of the first SNAP 8 include supplying the power for the first ion propulsion system to be tested in orbit. However, SNAP 8 will not be ready for flight testing for another three or four years.

Also under development is SNAP 10, to be used in competition with solar sources in the low power ranges. It employs a conduction cooled thermoelectric conversion system. Such a unit would be truly static and produce about 300 watts in a 350 lb. package with no moving parts. This fits the power and weight requirements of several satellite missions planned in the next few years.

General Comments on Nuclear Energy Sources

It is the nuclear heat source that causes the most difficult problem associated with nuclear systems because of its effect on launch and reentry into the earth's atmosphere. If the reactor were operated during these phases the crew would have to be completely shielded from the dangers of air scattered radiation. Thus it appears desirable to start the nuclear reactor after injection into orbit and shut down before entry. This would not necessitate the extensive shielding which might otherwise be required.

The advent of the Saturn booster with its tremendous thrust appears to be the earliest time at which the use of nuclear fission reactors becomes advantageous. As with the radioisotope generator, the fission reactor systems appear particularly attractive for landing missions involving operation during the night portion of the cycle.

These nuclear auxiliary power units will soon be with us if the present rate of progress is any measure. It was less than five years from the start of the SNAP program in 1955 until the first compact reactor began operating. By 1965 we are being promised SNAP 2, 8 and 10. It would be a pessimistic engineer indeed who discounted the prospects of nuclear-derived power for use in advanced space programs.

COMPARISON OF PROPOSED AND AVAILABLE SYSTEMS

Now that the various systems have been discussed it would be advisable to compare them as to limitations and applicability and then make a few concluding remarks about the space power picture in general.

Operation Limitations

Solar energy sources have the obvious limitation of not being able to operate in the absence of the sun's radiation. For cyclic operations in which only part of the time is spent in darkness, energy storage equipment can solve this problem. There is, however, the additional requirement for storing and protecting the solar collectors from the aerodynamic launch and reentry loads. Similarly the nuclear power systems cannot operate during these phases as previously discussed. This necessitates the carrying of extra power equipment to handle the high power demands during these phases.

Reentry weight may also penalize certain power systems. Equipment that uses expendable fuel will enter at a much lower weight than the fixed mass systems like the solar, nuclear, and battery types. Reduced weight means lower aerodynamic control forces during reentry and lower structural temperatures.

Though nuclear sources have the advantage of high continuous power flow, they encounter competition due to their severe radiation hazard. The designer is also faced with ground handling problems and political considerations.

As used in many systems the handling of boiling and condensing fluids at zero gravity is a difficult one that can only lead to complicated problems. Here, as in many other areas, designers face one of the biggest problems in the space power field; that of not being able to test under actual operation conditions.

B. Applicability

Chemical energy will be the prime candidate in most short space missions requiring powers up to 500 watts. The liquid fueled chemical sources do not in fact face too much competition from solar and nuclear designs in the range from three hours to three days.

For longer missions in the power range of 0.7 to 5.0 KW, solar energy is currently the preferred system, but the chemical fuel cell has real potential here, too. It should be pointed out that solar energy systems would have little value for probes in the direction of Mars and Jupiter since their already low energy output decreases with the radiation intensity as they move away from the sun.

Up to ten KW, solar energy sources will be in competition with nuclear sources. Above this level, nuclear energy is the only available long-duration high-power energy source. For space stations, lunar bases, and interplanetary vehicles for which power levels of 10 KW and more will be needed for months, nuclear power systems are the obvious answer.

It is now possible to build static or dynamic heat engines with specific weights under 10 lbs. per KW for power levels over 200 KW. Nuclear heat sources operating at 1700 F. to 2000 F. with exotic working fluids such as potassium and rubidium should bring this down to about 6 or 7 lbs. per KW within the next ten years. However, the size of the system necessary to obtain such specific weights makes their use impossible until boosters are developed which are capable of taking the vehicles employing them away from the earth's gravitational field.

CONCLUSIONS

The relationship between the vehicle characteristics on the one hand and the non-propulsive power system on the other are so complex that it is really impossible to pick a definite power system as being the *best possible* without an exhaustive analysis of the problem. There is only one exception to this rule: For the vehicle that needs large amounts of power for long periods of time, a nuclear system is the obvious answer. Otherwise, all that the designer can be sure of today is:

—Batteries, liquid and solid fueled, solar photovoltaic and nuclear systems will be used over the next few years.

—Fuel cells, concentration cells, solar thermionic and solar mechanical systems show promise but are not yet competitive.

The general consensus is that all types of space power systems are needed—and the "who'll be the first" attitude among industries and nations may best serve to spur more rapid development of these systems.

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

Pictured above are the Winners of the Beard Awards and the Badger Beauties, left to right, First Row: Bruce Pfister, William Thisius, Ronald LaBlanc. Second Row: Carol Bradley, Nancy Goodman, Mary Alice Schull, Marcia Lawton. Third Row: Ray Haviland, Roger Jensen, John Dueringer, Larry Dodge, Richard Clarkowski.

St. Pat Was an Engineer

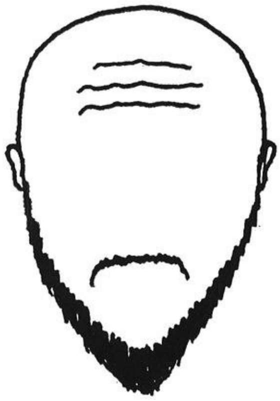
This year's festivities were held the second week in March. The Beard judging was done by the Badger Beauties on Thursday and the awards were presented at the St. Pat's Dance on Saturday evening.

St. Pat this year was Ronald Pember, ASCE. (Pictured next page, left, center, with his wife) Ron is a Junior in Civil Engineering and hails from Sheldon, Wisconsin.

WINNERS OF THE BEARD AWARDS

Most Colorful	Bruce Pfister	ASCE
Longest (1–7/16″)	William Thisius	IRE
Most Devilish	Ronald LaBlanc	IRE
Ideal Beard	Ray Haviland	ASME
Curliest	Roger Jensen	AIEE
Bushiest	John Dueringer	SAE
Most Distinguished	Larry Dodge	AICHE
Most Lincoln-Like	Richard Clarkowski	ASCE


ST. PAT



BRAIN BUSTER

by L. L. Chambers

Two rockets start at the same instant from their launching pads on Earth and Planet Z respectively. They travel in a straight line between the planets, which remain stationary with respect to each other; each travels at a constant speed, but one is faster than the other. They pass at a point 10,000,000 miles from one planet. Each rocket lands, unloads and refuels, then starts back two hours after having landed. On the return trip they meet 2,000,000 miles from the other planet. How far is Earth from Planet Z?

* * *

A hunter walks one mile south, turns and walks one mile east, and then turns and walks one mile north. He is now back where he started. He shoots a bear What color was the bear? The answer generally given is that the bear must be white because the hunter started at the North Pole. Suppose the problem is reversed. (The hunter walks north, east, and then south one mile in each direction, thus returning to his starting point.) What point or points in the NORTHERN hemisphere fulfill the requirements of the problem now? (Forget about the color of the bear.)

* * *

There once existed two neighboring countries, A and B; each country had the dollar its unit of currency. An agreement between the countries specified that each would treat the A and B dollars as equivalent. However, relations between the countries grew strained, and A announced that B dollars would henceforth be worth only 90 cents in A. In retaliation, the B government declared that A dollars would be worth only 90 cents in B.

There happened to be a poor college student living near the border between the two countries who was reduced to his last bit of money—one A dollar. He was very hungry for some breakfast. Accordingly, he went to a shop in A and bought two doughnuts costing five cents each. He proffered his A dollar in payment, and received a B dollar in change. Then he went to a nearby diner in B and bought a cup of coffee, costing ten cents. He paid for it with his B dollar, and got an A dollar in change.

Thus the student had both his A dollar and his breakfast. Who had paid for the coffee and doughnuts?

1. The ABC literary society had a big crowd at the hayride. Nine hundred people started on the hayride in 100 wagons, 9 to a wagon, (one was the driver in case you wondered).

2. At first sight it would seem that the state of the bag, after the operation, is necessarily identical with its state before it, the chance being just what it was, $\frac{1}{2}$. This, however, is an error. The correct answer is that the chances of drawing a white bean after the operation is 2/3.

Since Jim's wife got home 20 minutes earlier she must have met Jim 10 minutes earlier at 5:50. Therefore Jim walked 50 minutes.

The sneaky C. E.'s must have found a pot of 1021 gold pieces.

As a moment's reflection will show, there are two possible solutions to this problem. The ladder will either reach 28 feet or 21 feet on the wall.

A diagram and a little trig showed that the flagpole was on the base, 4.94 feet from the center of the tower.

The correct matching of matches is that the M.E., Ch.E., and E.E. were married to the Purdue girl, OSU girl, and Wisconsin girl respectively.

The chances of forming a triangle are 1 in 4.

Any sphere through which a 6 inch hole can be drilled will have 36π cubic inches remaining. It is interesting to note that if the earth were considered to be a sphere and a 6 inch long hole drilled through it, 36π cubic inches of material would be left—hardly enough to fill a flower pot.

Fill in your Own Lines

by Ronald Neder

Then there was the time the good looking blonde drove down University Avenue when the rear tire went flat near the M.E. building. As she got out of her T-bird, she saw a few M.E.'s walk by and she asked, "Wonder if you'd help a girl in trouble?" One of them replied, "Sure we can. Just what type of trouble do you want to get into?"

* * *

A young man-about-town took a glamorous girl out on a date. They were driving down a moonlit country lane when the engine suddenly coughed and the car came to a halt.

"That's funny," said the young man. "I wonder what that knocking was?"

"Well I can tell you one thing for sure," the girl answered icily, "It wasn't opportunity."

* * *

In a thermo class the students were being orally tested.

The professor asked several questions, and then it was one of the "hep cats" turn to answer.

"You . . ." said the professor pointing to this fellow, "what is steam?"

"Steam? Why Professor, that's water that's crazy with the heat."

* * *

Wife: Do you have a good memory for faces?"

C.E.: "Of course I have."

Wife: "That's good. I just dropped your shaving mirror."

The Kinsey Report proves just one thing: women like to talk.

* * *

Home from the Capitol, a businessman looked out of the window and saw a big log floating down the river. He pointed it out to his engineering friend and said, "That reminds me of Washington. There are about 10,000 ants on it and each one think he's steering it."

* * *

Then there was chemical engineer who wouldn't let his wife feed their kid milk before it went to sleep because he reasoned that the kid would toss from side to side; that milk turns to cheese, cheese turns to butter, butter to fat, fat turns to sugar, sugar turns to alcohol; therefore, the kid would wake up with a hangover.

* * *

A college student arrived at the pearly gates where St. Peter asked him who he was. After replying that he was a liberal arts major, St. Peter said, "Go to the devil."

Some time later a political science major arrived and upon being asked who he was, was told to go to Hades.

Then another student arrived with his slide rule in hand and was asked the same question. He replied, "I'm an engineer," and St. Peter replied, "Come on in son, you've been through Hell already!"

The day after finals, a disheveled Ch.E. walked into a psychiatrist's office, tore open a cigarette, and stuffed tobacco up his nose.

"I see that you need some help," remarked the startled doctor.

"Yeah," agreed the student. "Do you have a match?"

* * *

"Here, here, don't spit on the floor."

"Why, does it leak?"

* * *

The efficiency professor died after many years of faithful service, and the university arranged an elaborate funeral. The pallbearers were carrying the casket when suddenly the coffin lid popped up and the expert sat up and said, "If you'd put this thing on rollers, you can cut your time by 37.3%."

* * *

A Boston spinster was shocked at the language used by workmen repairing telephone wires near her home, so she wrote to the Telephone Company. The manager immediately asked the foreman on the job to make a report and here's what the foreman said:

"Spike Williams and me were on this job. I was upon the pole and accidentally let the hot lead fall on Spike—and it went down his neck. Then Spike looked up at me and said: "Really, Harry, you must be more careful."