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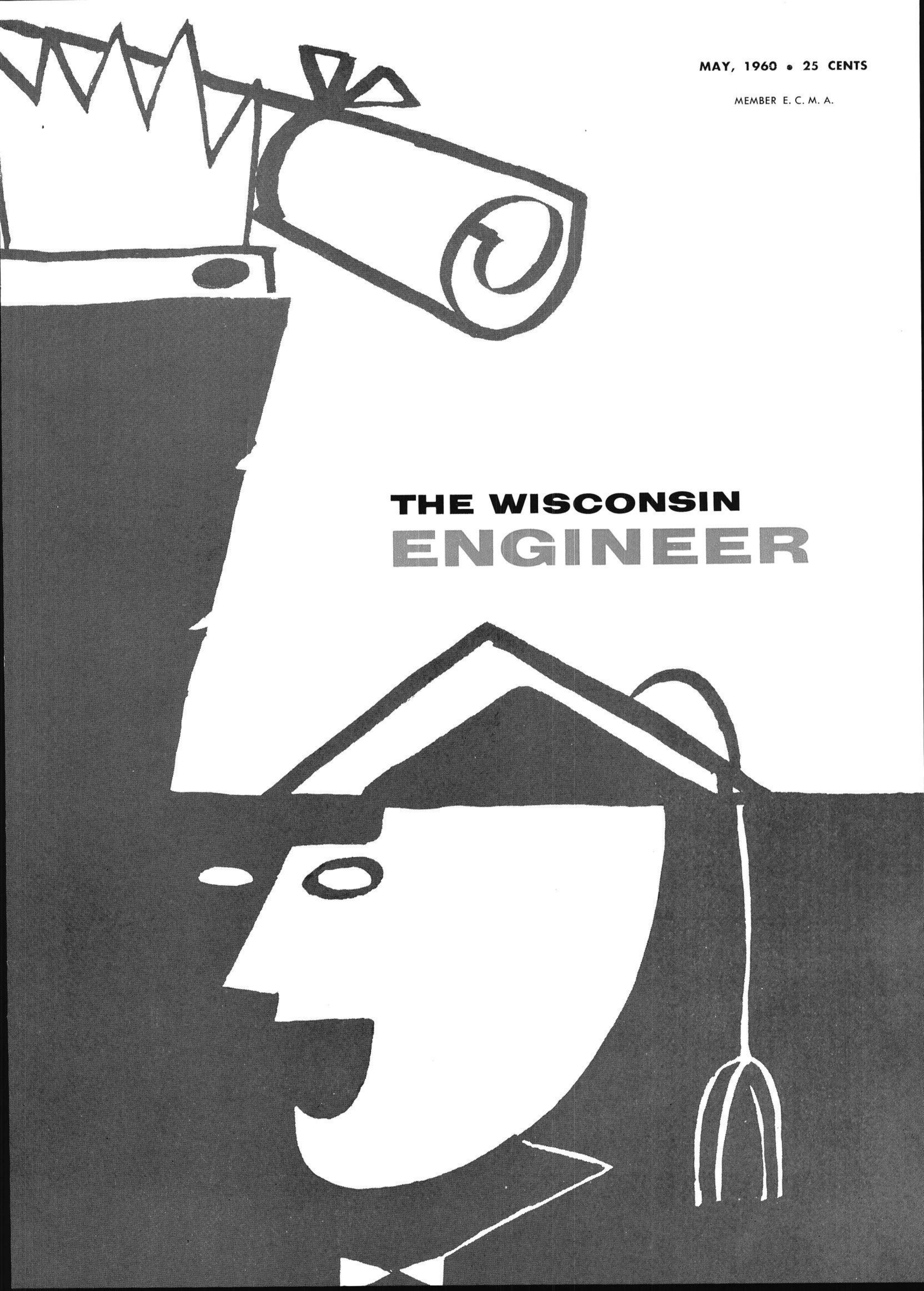
THE WISCONSIN ENGINEER



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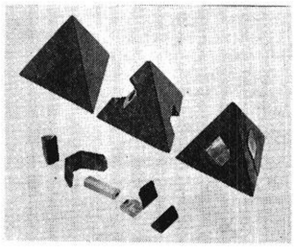

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MAY, 1960

THE WISCONSIN ENGINEER

The Student Engineer's Magazine *Founded 1896*

VOLUME 64, NUMBER 8

THIS MONTH'S COVER was drawn by Jann Fleck, a graduating senior in art education. The diploma serves as a material symbol for the time and effort that has gone into getting a degree in college. Graduation day is looked forward to with anticipation by almost every college student. We of *The Wisconsin Engineer* join with Jann in saluting those who will be graduating this June.

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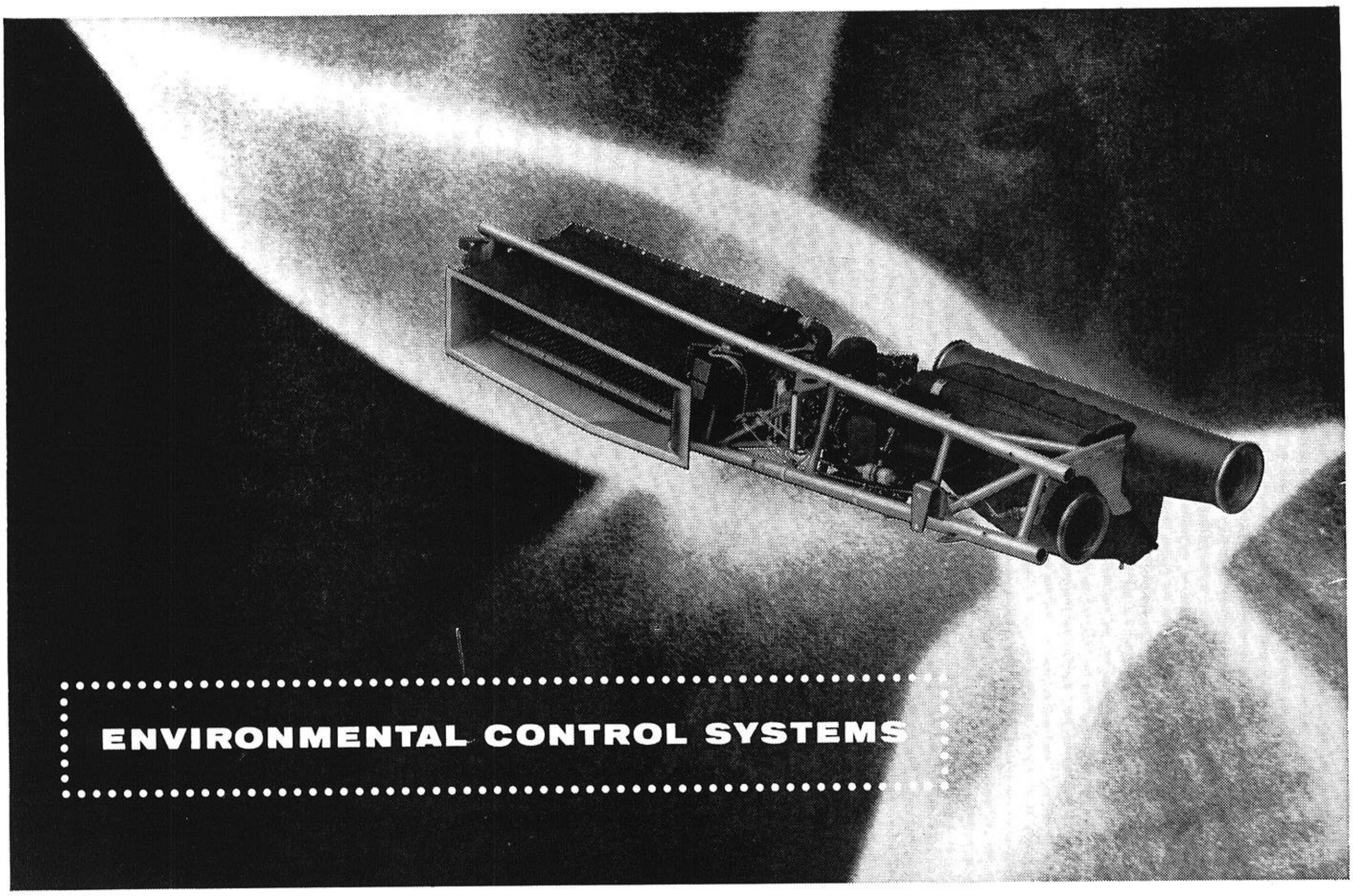

• Shown above is a freon refrigeration system for the Boeing 707. Through its unique design, a 10-ton cooling capacity is provided at one-tenth the weight of commercial equipment. The leading supplier of manned flight environmental control systems, Garrett designs and produces equipment for air-breathing aircraft as well as the latest space vehicles such as Project Mercury and North American's X-15.

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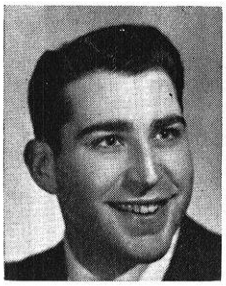
Rambling With The Editor



ON THE opposite page is the mighty arch at the entrance to Camp Randall. Almost every engineer, during his college career at the University of Wisconsin, passes under that commemorative structure. But how much thought does he really give to it? This particular arch was constructed as a tribute to our Civil War heroes, not as a critical structural element, such as a support for a roadway above a river or highway. Yet, the Camp Randall arch still is constructed with the same basic design as any arch. To view an arch, one may look at it from several different points. From one point of view, we see that the unsupported arch is held by the *KEYSTONE.* Without it, the arch could not stand. Some people, then, might say that the *MOST IMPORTANT* part of the arch is the keystone. It is true that without it the arch surely could not exist; without a good foundation, a strong base, or proper design, the arch could not stand either. Then there is *NO–MOST IMPORTANT* part, but just a combination of *RELATIVELY* important parts. Each part is of some importance, some parts being of lesser importance though, since they can be replaced by some other substitute part. Thus the keystone should be considered as a piece of high importance, since it can not be replaced or substituted.

The educational system at the University of Wisconsin is analagous to the arch. Here, the student might be compared to the keystone, and the entire University to the base or foundation. The University offers education in various categories, and each of these categories, or colleges, has its own purpose and facilities. After the base is selected and with the student as the keystone, the arch, or the entire college education, can be constructed. In this construction, we see that the base is already built, as the college has been functioning for several generations and is constantly undergoing continual growth, improvement, and modernization. After the base, consideration must next be given to the exact position of the keystone. If the keystone is set on an angle, the entire appearance of the arch will also be tilted or just plainly—lopsided. At this point, and until further completion, the student is directly responsible for the outcome of his own education. In attaining a final goal, in his formal college studies, the student will have many opportunities to learn much more than what is *EXACTLY* asked for in his examinations. When reading his text, he must be able to understand the ideas and not just the words of the author. But *MORE* important, is the material learned *between* studies. The social and extra curricular life at the entire university is of equal and possibly more importance than the number of grade points attained. The outside life the student leads in the classroom, the life he spends with his roommates, the life he leads with so many different peoples; people from different parts of the state, of the United States, of the World, are of extremely important value. The conduct with his own and opposite sex, and all other personal and business relations can not be learned in the text book. He must be able to learn all this by himself.

The arch that has been built with materials not having the same quality and workmanship on the inside as those on the outside, will not be strong. This type of arch will appear as fine as any other, but *time* will be the deciding criteria. Depending upon the quality, or inferiority of materials, the arch will soon begin to fail the test. The student who has learned the most—in every phase—will stand the test.

The foundation solid, the workmanship of high degree, the keystone properly set in place, will make a fine and solid arch; the foundation solid, the learning of high degree, the student with a well rounded education, will make a fine and worldly person.

Todd S. Deutsch

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A Report on Fuel Cells

by Visvaldis Stepe, me'61

Man is always looking for a better way to make power; fuel cells may end his looking

DEVELOPMENT OF THE FUEL CELL

A FUEL cell is a device which changes chemical energy directly into electrical energy. Theoretically, this direct conversion of energy should approach 100 percent efficiency. In other words, the process should produce no waste materials such as soot, smoke, or ashes. Compared to efficiencies obtainable today, this figure of 100 percent is really startling. Modern power stations produce electricity at an efficiency of 35 to 40 percent. The peak efficiency in internal-combustion engines is 25 to 30 percent. Diesel engines and gas turbines are approaching their limit at 40 percent.

Because the conventional energy converting technology seems to be approaching a dead end, the task of developing the fuel cell into a useful and effective source of power has been seriously undertaken. This work on the fuel cell actually began more than a hundred years ago. In 1839, Sir William Grove described the first hydrogen-oxygen type fuel cell. However, the first fuel cells were not too successful because of relatively low current production and slow reaction rates. Electrochemists continued to work on the problems associated with the fuel cells, but without much progress. Recently, two factors, advances in solid state physics and discovery of new catalysts, helped to create new interest in fuel cells. Advances in solid state physics have helped to solve some of the fuel cell problems by explaining the behavior and movement of particles of a solid. The discovery of new catalysts have helped to increase the reaction rates within the cell, thus solving one of the problems which prevented a more rapid development of the fuel cell in the past.

DESCRIPTION OF THE FUEL CELL

The fuel cell, as earlier defined, is a device which changes chemical energy directly into electrical energy. This electrical energy is in the form of a direct current. In structure the fuel cell resembles the common dry battery because, like the battery, the fuel cell consists essentially of electrodes and an electrolyte. However, unlike the battery, the fuel cell can not store energy within the cell itself and thus the energy has to be led away from the cell as current.

Several types of fuel cells are in existence today, but all of the types operate basically on the same principle and result in production of electric current. Therefore, for the sake of simplicity, the Hydrogen-Oxygen Cell, which is the least complicated type of fuel cell, will be described as a representative cell.

Components

The main constituents of the Hydrogen-Oxygen fuel cell are the electrodes, the electrolyte, and the catalyst. The electrodes, one positive and one negative, are conductors through which current enters and leaves an electrolyte. Electrodes for the fuel cell are made from some porous material, such as carbon, impregnated with catalysts. To prevent the electrolyte from saturating the electrode, the electrodes are water-proofed. The electrode is the heart of the cell, since it is at the electrode that the reactions take place and electric current, or flow of electrons, begins.

The second component of the cell is the electrolyte. An electrolyte is a substance in which the conduction of electricity is accomplished by chemical decomposition. As such, its main function is to serve as the connecting medium between the electrodes. Both solid and liquid electrolytes are used.

The third component of the Hydıogen-Oxygen fuel cell is the catalyst. Because there are so many different catalysts, it is easiest to define a catalyst by its functions. The main functions of the catalyst are to lower the energy barriers and to speed up the reaction. As stated earlier, the electrodes are impregnated with the catalyst.

These three components constitute the basic fuel cell, but such a

—Compliments Allis-Chalmers Co.

Tractor that is powered by fuel cells.

fuel cell will not produce electric current. In order that current be produced a fuel must be introduced into the cell. The cell will operate only as long as the fuel supply lasts.

Fuels

It would be desirable to be able to use coal or hydrocarbon liquids as fuels, because of their low cost. However, the electrochemical properties of these materials are poor. Several gases appear to have the characteristics of an ideal fuel. Of these, hydrogen and carbon monoxide are the most prominent. Hydrogen produces the most energy per pound, but today's commercial hydrogen is too full of impurities to be used in the cell. In its place, pure, specially produced hydrogen is used.

The combinations of two or more fuels are almost unlimited. The only requirement that has to be met is that one of the fuels should be an oxidant and the other a reductant. Oxidants which could be used in a fuel cell are chlorine, oxygen, and air. Examples of reductants are hydrogen, carbon monoxide, zinc, alcohol, natural gas, methane, ethane, coal, and others. Sometimes it is possible for a part of the cell to act as a fuel as well as a basic component of the cell. An example of this would be the electrolyte acting as a reductant.

The fuel can be introduced into the cell through hollow, round electrodes or through solid, flat electrodes. Conversion of chemical energy into electrical energy follows the introduction of fuel into the cell. The process is fairly well understood today and is briefly described in the following paragraphs.

(Continued on next page)

Visvaldis Stepe is a junior in Mechanical Engineering. Mr. Stepe was born in Latvia and moved to this country in 1950. He settled in Milwaukee and attended high school there. Mr. Stepe transferred here after attending two years at UW–M. He chose his subject to learn more about it. His present plans are to get into engineering designing after graduation. He is a member of ASME and the Weight Lifting Club.

Fuel Cells

(Continued from last page)

Conversion of Chemical Energy Into Electrical Energy

A Hydrogen-Oxygen fuel cell was developed by Francis T. Bacon of the University of Cambridge. The electrolyte of this cell was held between two thin porous electrodes. The fuel was introduced under pressure and diffused through the electrodes. With the help of the catalyst, the fuel then reacted with the electrolyte.

The basic process of energy conversion can be summarized as follows: hydrogen is fed into the cathode (negative electrode). The gas diffuses through the electrode and is absorbed on the surface of the electrode. The electrolyte produces hydroxyl ions (OH^-). These ions come in contact with the hydrogen atom and form water. In the process, electrons are given up to the electrode and the water is passed into the electrolyte. Meantime at the anode (positive electrode), oxygen is fed in. The oxygen reacts with the electrons from the external circuit and the water from the electrolyte, and forms hydroxyl ions, which will be used up at the cathode. The catalyst helps to push the hydrogen atoms to the surface of the electrode and to unite the atom with the hydroxyl ion. The important product of these reactions is a flow of electrons, or current, through an external circuit.

TYPES OF FUEL CELLS

Besides the popular Hydrogen-Oxygen fuel cell, several other types of fuel cells are now being developed and tested. One of these, the Molten Salt Electrolyte fuel cell, is a cell which would be able to use cheap fuels, but would have to operate at temperatures around 500°C.

Molten Salt Electrolyte Fuel Cell

This high temperature cell must have a solid electrolyte, since at the high operating temperatures the aqueous electrolytes would boil away. The electrolyte is a mixture of alkali carbonates in a ceramic matrix.

The electrodes are made of porous metal disks or screens, tightly pressed against the solid electrolyte.

The fuel is usually not used in its natural form. Instead, it is broken down (by reaction of steam and carbon dioxide) to produce hydrogen and carbon monoxide. These gases diffuse into the negative electrode, where they react with the carbonate ions in the electrolyte. Flow of electrons, water, and carbon dioxide are the products of this reaction. The electrons and the carbon dioxide are sent to the anode where they diffuse, combine with oxygen (from an external source) and form carbonate ions ($CO_3^=$). The cycle repeats and the product, again, is flow of electric current through an external circuit.

There are several disadvantages connected with this type of fuel cell. While simplifying electrode and cell construction, the use of ceramic matrix is certain to result in greater internal resistance in the cell. Also, a screen electrode cannot be expected to yield as high a current density as a true gas diffusion electrode, inasmuch as there is much less active area per unit geometrical area. Presently, the best of the high-temperature cells produce only half the watts per cubic foot as the Hydrogen-Oxygen fuel cell.

One advantage that this cell does have over some of the other fuel cells is that it can use cheap fuels.

A fuel cell which uses a slightly different principle in the conversion of energy, is the Redox fuel cell.

Redox Fuel Cell

Redox fuel cells employ devices called "regenerators" instead of reacting the fuel and oxygen directly. The oxygen and the reductant are fed into the regenerator. Here a chemical intermediate is produced. This intermediate is then sent to a gas diffusion electrode and current is produced in the same manner as in the Hydrogen-Oxygen cell. The draw-back of this cell is the unsatisfactory regenerator reaction efficiency. The process involved in the Redox cell is very similar to the chemical process involved in another type of fuel cell—the Regenerative fuel cell.

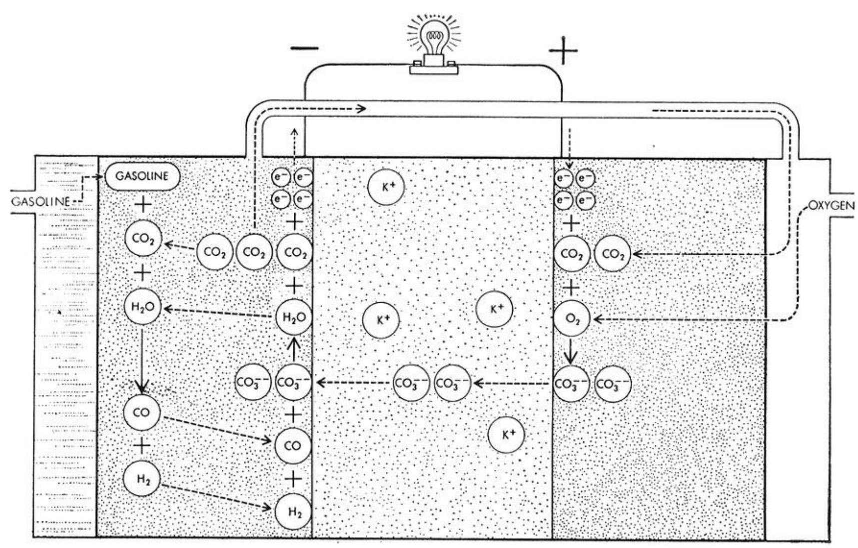
Regenerative Fuel Cell

In a Regenerative fuel cell a cycle is formed in a closed system in which reactants are continuously regenerated from the products of the reaction. Compared to the other cells, the efficiency of the Regenerative cell is low.

Another fuel cell which should be mentioned is the Consumable Electrode fuel cell.

Consumable Electrode Fuel Cell

This type of fuel cell is very much like the Hydrogen-Oxygen cell. A big difference is that the electrodes serve a dual purpose—they act as electrodes and as a source of fuel. Electrode rods are fed continuously into a liquid electrolyte and consumed. The power-weight ratio is high and therefore the consumable electrode principle offers the widest applications, particularly for the transportation industry.



This is an example of a Fuel Cell showing some of the reactions.

General Electric scientists are working on a fuel cell which is different from the previously described fuel cells. This fuel cell is called an Ion Exchange Membrane Fuel Cell.

Ion Exchange Membrane Fuel Cell

The Ion Exchange Membrane fuel cell has a few new ideas employed in its design. It differs from the previously described cells in two respects. An ion exchange membrane is used as the electrolyte, and the electrolyte is acidic. In a cell using acidic electrolyte, the hydrogen ion, rather than the hydroxyl, is the charge carrier. This results in mass transport through the electrolyte from the hydrogen to the oxygen electrode where the product, water, is formed. The formation of the water at the oxygen electrode is advantageous, particularly because the acidic electrolyte permits direct operation on untreated air.

A number of advantages of this cell are listed below:

1. There are no moving parts.
2. The acidic type electrolyte permits operation on gases containing carbon dioxide, e.g. air or diluted hydrogen such as might be obtained by reacting fossil fuels with water.
3. No close tolerances are requried in the construction of the cells nor should they be necessary in the assembly of batteries.

Added to these advantages might be the good power-weight ratio and the absence of liquid electrolyte.

PRESENT WORK DONE WITH FUEL CELLS

Work with the fuel cells is done by several companies today. Each of these companies sees a particular use for the cells in a particular field. Before discussing the uses of the cells, let us first consider the capabilities of the existing cells.

Capabilities

Energy produced by an electrochemical reaction is measured in watt-hours per pound of weight. A car battery has a power rating of 8 to 10 watt-hours per pound. It is interesting to compare with these values the power rating values of some of the better fuel cells. The fuel cells approach the 250 to 300 watt-hour per pound range, Also, it should not be forgotten that the fuel cells are only in the pioneering stage.

Unlike the conventional dry cell, the fuel cell will not disintegrate due to chemical reactions. Lockheed researchers have deliberately tried to 'poison' the fuel cell's electrodes to induce disintegration—and so far, happily, they have failed.

Several industrial concerns have shown interest in the fuel cell after realizing its great capabilities. Small devices of various types have been produced which operate on the power supplied by fuel cells.

Practical Applications of Fuel Cells

Fuel cells are now in existence which produce sufficient electric current to drive small motors and to produce light. Not all the fuel cells are limited to operation of small devices. The Allis-Chalmers Company, for example, is presently testing a tractor which operates on power supplied by fuel cells.

The fuel cell tractor develops 3000 pounds of drawbar pull, more than enough to pull a mulitple-bottom plow in field tests. Power to drive the tractor is obtained from 1008 fuel cells, using a mixture of fuel gases (largely propane) and oxygen. The 1008 individual fuel cells are arranged in 112 units of nine cells each. The 112 units are arranged in four banks and electricity can be taken from any combination of the banks. The electricity supplied to a standard 20 horsepower motor is controlled by a compact controller. The controller permits the tractor driver to regulate speed or reverse the tractor direction by moving two levers. Using the speed control, the operator places the four banks of cells in series or parallel, varying the amount of current going to the motor. To reverse the tractor, the driver moves the second lever, flow to the motor.

The fuel cell, just as any new development, presents a variety of problems which have to be solved before it is perfected.

Problems

The main problem today is that of finding a combination of electrodes, electrolytes, and catalysts which would give the best results. In almost every one of the previously discussed fuel cells, there was some disadvantage associated with that particular type of cell. Many of the problems are presented by the electrodes because an efficient fuel cell must have an electrode which performs efficiently. To do so, the electrodes must meet certain general requirements. Some of the requirements are:

1. High electrical conductivity.
2. Catalytic properties to increase reaction rates.
3. Stable pore size distribution to maintain electrolyte-gas interface at proper position within electrode over wide range of load currents and for long periods of time. In other words, the electrode must neither become "drowned" nor leak gas into the electrolyte.
4. Corrosion resistance.

The size factor of the fuel cell created many problems in the past. However, today this problem has been diminished considerably. Efficiency of the fuel cell is being increased and with increase of efficiency, the size of the cell can be reduced. In theory, a fuel cell can be built in almost any size, depending on the amount of power needed.

Cost, which can be considered as a problem, is not of too great importance. Since the work is in the pioneering stage, high cost is naturally expected. With volume production it can be expected that the cost will decrease.

FUTURE OF THE FUEL CELL

Let us consider the advantages and disadvantages of the fuel cell as some means of measuring the potential of the fuel cell.

Advantages and Disadvantages

The foremost advantage of the fuel cell is its extremely high efficiency. It is expected that once the fuel cells are put in regular operation, they will function at an effi-

(Continued on page 31)

Metal Spraying of Metal to Metal—The Wire Process

by David G. Kumbera me'61

POWDER METHOD

METAL spraying is a comparatively new process of surface finishing. It had its beginning in 1909 when Dr. M. H. Schoop of Zurich, Switzerland devised a method of spraying molten metal. Metal to be sprayed was first made into powder form. It was then fed by gravity into a torch head similar to the type used in oxy-acetylene welding. Within the head the metal was melted, atomized, and forced (by means of compressed air) against the item to be sprayed.

Since the method involved awkward, cumbersome equipment and many separate time-consuming steps, it was necessarily a costly method. Consequently, the powder method was not accepted as a worthwhile manufacturing process. The sprayed surface was, however, recognized as a positive advance in the surface finishing field.

Dr. Schoop continued to search for a better method of applying metal by use of a spray. In 1912 he devised the wire process.

WIRE PROCESS

Upon re-examination of his powder process, Dr. Schoop recognized the following weak points concerning the process:

1. Since powdered metal was expensive and awkward to handle, a major weakness of the process was the powder itself.
2. Since the torch head was an adaptation of the oxy-acetylene welding torch, the temperature at the tip of the inner cone of a neutral flame was nearly 6500° F. Thus enough heat was developed to melt any metal.
3. Since gravity could not be used to feed solid wire a new feed mechanism would have to be designed.

With these ideas in mind, Dr. Schoop first redesigned the torch head to accommodate the wire form. He next designed the feed mechanism to operate in conjunction with the compressed air blower device. By regulating the air flow he could control the wire feed. After three years of effort, Dr. Schoop was ready to test the wire process. The equipment and procedures were a success.

The increased economy of the wire process over the powder method was readily appreciated by industry. In addition, wire spray equipment was far more portable than that used in the powder process. Dr. Schoop's early wire spraying equipment is still the basis of today's modern spraying equipment.

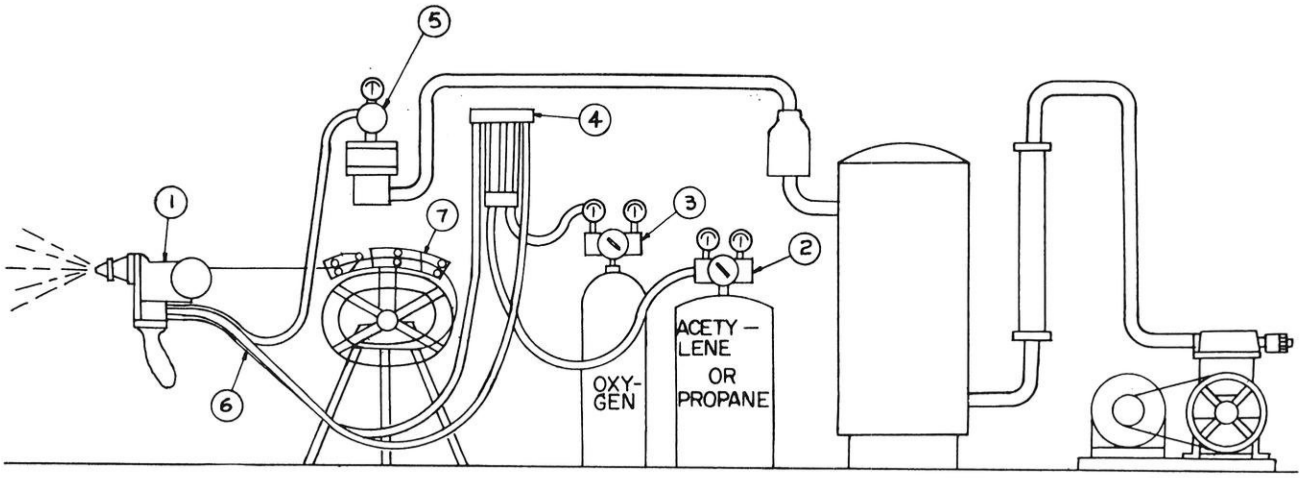
METALLIZING PROCESS

Metallizing Equipment

Modern metallizing equipment consists of the spray gun and a supply of gases—compressed air, oxygen, and a fuel gas.

Though several companies manufacture metallizing guns, they are basically the same. Guns vary in weight from three to six pounds. Most of the guns will adjust to wire sizes ranging from 0.320 to 0.125 inches. The metallizing gun consists essentially of two basic parts:

1. An air-turbine-driven wire-feed mechanism.
2. An oxy-gas flame.



Each part has the necessary controls.

A wire feed consists of knurled rollers between which the wire travels. Feed speeds may be controlled either by throttling the air supply or by use of a friction governor.

The oxy-gas flame is contained in the nozzle of the gun. The tip of the inner cone of the oxy-gas flame is actually beyond the tip of the nozzle. The melting takes place at this point.

Most of the commercial gases applicable to welding may be used for metal spraying. A variety of fuel gases—natural gas, propane, hydrogen, acetylene, and manufactured gas—is available for melting. However, hydrogen is usually too expensive for ordinary use. And manufactured gas is limited to spraying metals of low fusion temperatures because of its low Btu content. Acetylene and propane gases are most often used because they are readily available. Also they are relatively inexpensive.

Oxygen, though not a fuel gas will be mentioned here briefly. It, of course, supports the combustion of the fuel gas. Oxygen, as well as the fuel gas, may be obtained from any welding supply house.

Compressed air, however, must be provided by means of an air compressor. Compressed air serves three major purposes:

1. It drives the feed mechanism.
2. It atomizes the melted metal.
3. It provides the force necessary to blow the atomized metal to the part being surfaced.

Surface Preparation of Base Metal

Prior to any spraying, the base metal (surface being sprayed) must be given some type of irregularity or roughness. This roughness gives the spray metal something to cling to. There are five methods commonly used to roughen the base metal. They are:

1. Groove and rotary roughing.
2. Rough threading.
3. Electric bonding.
4. Metallic spray bonding.
5. Grit blasting.

Groove and Rotary Roughing. The groove and rotary roughing method is used primarily on cylindrical surfaces. The part to be resurfaced is placed in a lathe. Using a slow lathe speed in conjunction

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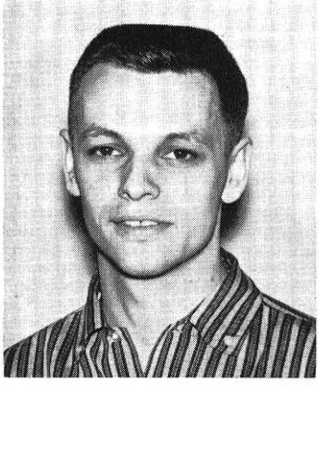

David G. Kumbera is junior in Mechanical Engineering. He attended Wausau High School before coming here. Mr. Kumbera is married and lives in Madison. He wrote on this topic because he became interested in metal spraying in ME 37, a welding course. He has not had any summer work in engineering, but plans to go into industrial engineering after graduation.

Metal Spraying

(Continued from last page)

with a rapid lathe feed, the part is turned against a roughing tool. This tool is similar to a knurling tool.

Rough Threading. The rough threading procedure for roughing a surface is similar to the groove and rotary roughing method. It also produces a ragged, torn surface for cylindrical parts. The major difference between rough threading and rotary grooving is the type tool used for the operation. The tool used here is a single cutting tool with special ground cutting edges.

Electric Bonding. Electric bonding is used to produce irregular surfaces on metals too hard to be machined or effectively grit blasted. In the electric bonding process, electrical resistance heating of an electrode metal as it is applied to the base causes the electrode metal to explode. This exploded electrode metal fuses to the base metal. The explosion "foams" the fused metal, producing a structure like that of soap foam. Over-all surface contour is irregular due to the method of deposition of electrode material. The height of these irregularities can be controlled—ranging from 0.004 to 0.030 inches. Sweeping strokes of the electrode across the base metal produce the desired effect.

Metallic Spray Bonding. Metallic spray bonding makes use of the fact that molybdenum fuses directly to steel. Since steel is the chief material of many parts which are resurfaced, spray metals containing high percentages of molybdenum are important in metallizing. These alloys are sprayed directly on steel parts and take the place of the more elaborate surface preparations such as the groove and rotary roughening method or the rough threading method.

Grit Blasting. Grit blasting is one of the quickest and most economical methods of preparing a base metal for spraying, provided grit blasting equipment is available. A medium grade, clean, sharp sand is used which provides shallow irregularities. Thus, thin coats of spray metal up to about 0.010 inches thick can be applied on grit blasted surfaces. This procedure is readily adaptable to flat surfaces more than to cylindrical surfaces.

Process of Spraying Metal

The actual procedure of applying a metal spray to a base metal is quite simple. And the operation may be likened to paint spraying in the skill required. It is recommended that successive thin coats be applied rather than a single heavy coat. This helps to eliminate irregular stratified build-ups.

Many cylindrical surfaces are sprayed while mounted in an engine lathe. A very uniform coat of sprayed metal is obtained by mounting the spray gun on the tool post and feeding it along the rotating work surface with the lathe feed mechanism.

After spraying has been accomplished, machining may take place immediately.

Some metals give off toxic fumes when they are melted. Though they cause no lasting harm to spray gun operators, the fumes are a nuisance. For example, breathing zinc fumes often gives operators the "zinc shakes"—a weak, dizzy, shaky feeling. Proper ventilation of the spraying area eliminates this problem.

SURFACE BONDING PROPERTIES

Base Metal

Though many studies of the bond between sprayed metal and base metal have been made, the bonding method still cannot be fully explained. The atomized particles are in a molten state at the instant they leave the gun; however, the particles arrive at the base metal in a plastic state. Since the sprayed metal is in a plastic state when it strikes the base metal, fusion does not take place. The bond is purely a mechanical one.

Examination of sprayed metals shows that the metal is made up of a large number of particles that are flattened and mechanically keyed to each other and to the base metal. In order to provide a good bond, the base metal is roughened, using one of the methods cited previously.

Sprayed Metal

All sprayed metal has a high degree of porosity which it obtains when plastic particles are forced against each other or against the base metal. Some properties of the metal sprayed are modified, especially tensile strength.

METALLIZED SURFACE APPLICATIONS

Mechanical Applications

Porosity, once considered a major drawback of many metals, is recognized as the best single advantage of sprayed metal. The minute openings which spraying produces are pockets for retaining oil—the friction reducer. This makes sprayed metal ideal for bearing surfaces.

Often, original shafts and bearing surfaces are left undersize when wrought and brought up to correct size with sprayed metal. If a bearing surface was to be made of a critical metal (a metal that is extremely expensive or difficult to obtain), the bearing could be cast undersize of a cheaper metal. Then, critical metal would be sprayed on the bearing surface making it slightly oversize. Finally, the bearing would be machined to correct size. The saving in time and money is obvious in this case.

Expensive rolls, journals, and shafts may be rebuilt when they become worn. This use alone has probably saved more money and time than all other uses of metallizing combined. Paper mills and rolling mills often have machines that use rolls weighing several tons and costing thousands of dollars. These rolls are rebuilt at a fraction of the cost of replacement.

Sometimes, expensive mismachined parts may be salvaged by metal spraying. The part is again built up oversize and machined to the correct dimensions. However, such an application should be a salvage operation and not a "crutch" for poor workmanship.

Corrosion Resistance

Metal spraying, using such metals as zinc, copper, and stainless steel alloys, is often used to protect surfaces from corrosion.

Barges operating in New York Harbor were required to be hauled out of the water twice a year to check for and replace corroded hull plates. However, since the

(Continued on page 21)

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Chain Conveyors For Materials Handling

Their applications and performance

by Ronald J. Lepak me'61

TODAY, the problems of materials handling are of primary interest in industry. Conveyors are being used more and more frequently to supply machines and workers, to cut transport cost, and to speed production. The chain conveyor family is of particular interest because of the ease of installation, maintenance, and use.

DRAG CHAIN CONVEYOR

Basic Components

A drag or tow conveyor consists of an endless chain supported by trolleys from an overhead track; or it may run in a track above, flush with or under the floor. To this moving chain are attached hooks or other devices which provide means of connecting and thereby moving trucks, dollies, or cars.

Practical Applications

The use of this type of conveyor has changed warehousing methods within recent years. The overhead type is employed where an existing structure or floor space must be used. The in-floor type, developed later, eliminated overhead equipment, but because it is part of the basic structure its use usually is limited to newly constructed buildings.

Besides in warehouses, this conveying system is found in freight terminals, transfer stations, parts depots, car washes, and production lines and other places where freight, packages, boxes, parts, and large units mounted on stands are handled. The types of materials adaptable to this system are restricted by the capacity of the cart. Size is governed by the size of the tow truck.

Variations Possible

The drag chain can be mounted either from above, in the floor, or flush with the floor. With each of these mountings the drive unit can be either a multiple or single speed unit, depending upon how much power is needed. The power requirement is governed by the size and weight of the load handled.

Performance Characteristics

The drag chain conveyor has a practical slope limit of 15 percent. This means that installations of this type of conveyor are primarily run in a horizontal position, but that slight upgrades are possible. It is not practical for downgrades to be used because of the tendency of the dollie or truck to swing about.

Distances of travel range anywhere from 100 to 4000 ft. The load could theoretically run up to the ultimate strength of the chain, but for reasons of safety and wear it is generally held to one-sixth the ultimate strength of the chain. The unit load dimensions are determined as follows:

Height—by the ceiling clearance.
Width—by the aisle width.
Length—by the unit load length.

The curve radius is determined by the unit length, and the drive depends upon the size of the system itself; that is, the drive need be only large enough to handle the loads applied and therefore varies with the load size. Speeds of up to 300 feet per minute are not uncommon, but as a general rule they are held to about 100 feet per minute. Frequency of moves depends upon load size and other factors such as loading and unloading times.

This type of conveyor system has certain advantages. It has high load capacities which make it ideal for applications in a place like an automobile assembly line. It has disadvantages too. The fact that it can be used only on the horizontal or with only a slight upgrade greatly limits its application.

Whenever the drag chain conveyor is used, the following points must be kept in mind:

1. It is limited to a fixed path of travel.
2. It is limited to horizontal movement or a slight upgrade.
3. The loads are limited in size and weight by the tow truck and floor capacities.
4. Aisle space as well as space for other trucking must be provided.
5. The slope limit is 15 percent upgrade because of the danger of load slippage.

TROLLEY CHAIN CONVEYOR

Basic Components

A trolley chain conveyor is composed of a continuous chain which is attached to a tramrail by means of rollers. The chain is driven by a motor mounted on the trolley and through this motor is made to run forward or reversed, automatically or semi-automatically, continuously or sporadically. When attachment devices such as hooks, which are used for individual parts, or baskets, which are used for small parts, are attached to the chain. The chain becomes the medium for conveying the material to any place along the path of travel. It can then be unloaded either by hand or by automobile unloading devices.

Another component which is sometimes, but not always, added is a cleaning device. Through the means of brushes, the chain and rollers are kept free from dirt and grit which, if not removed, would lead to serious wear damage to the chain connections and the roller bearings.

Practical Applications

Because of the great flexibility of this type of chain conveyor, it has been adapted to many varied applications.

It can be used in shipping and receiving. In this application the trolley-chain system is extended to the docks of a plant, and by attaching the material directly to this system, a number of transfer operations can be eliminated.

Another fairly new application is the "live" storage of material. At a large Mengel Company plant in Louisville, Kentucky, large stocks of furniture are kept on an 8000 foot trolley conveyor which serves as a moving and storage system for the plant.

Probably one of the most important features of this conveyor system is that it, like all chain conveyors, can go into places where workers are not allowed. This coupled with the great control of the system makes it excellent for use at dipping points such as those found when bonderizing, degreasing, plating, or dip painting. The same items can then be carried through drying ovens or to other operations without any additional handling.

Specific Variations

This particular chain conveyor is used primarily for the transport of package or part goods. Parts can be attached either individually or in unit loads, the size of which is governed by the total weight of the parts making up the unit load.

As a general rule the upper load limit is taken to be 100 lbs. However, if a special installation is made, the loads could be higher. The overall dimensions of the load depend upon the size of the material being handled. Generally they are limited to zero to six feet high, one-half to ten feet long, and one-half to six feet wide. The minimum curve radius is accepted by materials handling engineers to be four feet, and speeds are held below 300 feet per minute. The drive of any installation is a variable which depends on the size of the installation and the size of the material handled.

Performance Characteristics

The frequency of moves depends upon the size and dimensions of the load.

The slope limit which is the slope through which the conveyor gives best service is summarized in the following table.

This type of conveyor can be used both for horizontal and inclined and declined movement. This is one of the principle advantages of this conveyor system. There is no limit on the effective distances of travel of this conveyor. There are records of installations several thousand feet long.

The trolley chain conveyor is one of the most flexible types in use today. It is adaptable to a wide variety of items and extreme conditions of temperature and atmosphere. At the present time new applications such as "live" storage are being investigated.

Common to all installations of the trolley chain conveyor are the following problems:

1. The chain and drive must be kept clean to stop wear and abrasion.
2. The danger of shear of the pins in the chain is always present, and provision must be made to prevent failure through the use of only safe loads.

SLAT CHAIN CONVEYOR

Basic Components

The slat chain conveyor may be classified as a continuously moving conveyor in which the links of a chain act as the conveying medium. The chain is driven by a motor located anywhere along the path of travel.

Practical Applications

This particular chain conveyor lends itself particularly well to applications in which the flow of materials is more or less continuous, and is composed of a number of

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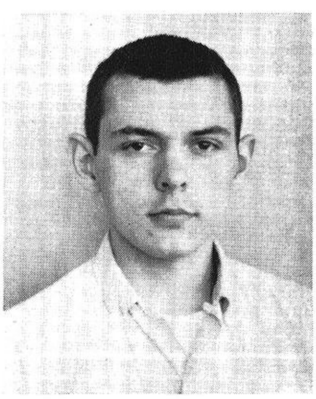


Ronald J. Lepak, a senior from Milwaukee, attended UW–M for three semesters before transferring here. Mr. Lepak chose this topic because of interest developed in ME 120, a materials handling course. His present vocational interest tends toward some phase of industrial engineering. During the summer vacations he has worked for the Wisconsin Electric Power Company and the Allen-Bradley Company. He is a member of ASME and lives in Jones House in the university dorms.

SCIENCE HIGHLIGHTS

by Richard Czaplinski ee'63

THIS month's Science Highlights column features one article. A compact high pressure apparatus has been designed and its applications and performance are discussed.

COMPACT APPARATUS FOR GENERATING HIGH PRESSURES

An extremely compact apparatus for generating high pressures has been designed by E. C. Lloyd, U. O. Hutton, and D. P. Johnson of the National Bureau of Standards. The apparatus produces pressures of 100,000 atm. and above by the application of force against each face of a ½-in. regular tetrahedron of pyrophyllite (hydrous aluminum silicate). The device was made to enable Bureau scientists to study the properties of materials at high pressure so that "fixed points" can be established on the pressure scale, and so that improved pressure measurement techniques can be devised.

Other devices for a similar purpose have been made with 4 independent hydraulic rams to apply forces to the faces of a tetrahedron. The Bureau design, however, consists of an assembly in which external force is applied to only 1 of 4 anvils, with wedge reaction forces acting on the remaining 3 anvils. Because only one external force is needed to operate it, the apparatus can be used in a conventional hydraulic press. The apparatus has a diameter of only 8 in. at its lower bolster.

While a specimen is under high pressure, 4 electrical connections through the anvils permit resistance heating of the specimen and measurement of its temperature, electrical resistance, or other quantities. Other advantages of the apparatus are easy manipulation and alignment of the anvils, and rapid assembly and disassembly.

The instrument consists essentially of 4 anvils having tungsten carbide tips that bear on the faces of a tetrahedron of pressure-transmitting material (pyrophyllite), in which a specimen is embedded. The tip of each anvil is ground to a flat triangular face and transmits pressure to one of the faces of the tetrahedron. The vertical anvil is forced downward by the press, and the remaining anvils transmit reaction forces from a conical retaining ring on which the 3 lower anvils are seated. Thus, forces are applied to the tetrahedron from 4 directions. These forces are very nearly equal, and there is substantially equal motion of each anvil toward the center of the tetrahedron.

The retaining ring and the anvils (excluding the tips) are made of SAE 4340 steel heat-treated to Rockwell 40/41C. Repeated applications of 100-ton loads have resulted in no permanent deformation to either the anvils or the retaining ring.

The inner surface of the retaining ring makes an angle with the horizontal that is nearly the same as the angle between the faces of the tetrahedron (70.528 degrees). This surface is inclined approximately one degree more, however, to compensate for the friction (coefficient of friction approximately 0.01 with Teflon lubricant) between the butt ends of the anvils and the conical surface. This friction is held to a minimum for satisfactory operation.

Several materials have a low coefficient of friction under heavy loading and appear suitable for use as lubricants between these surfaces. Sheet Teflon, 0.003-in. thick, was found to be satisfactory. It also provides the electrical insulation that is needed between the anvils and the ring when studies are made of changes in electrical resistance with pressure.

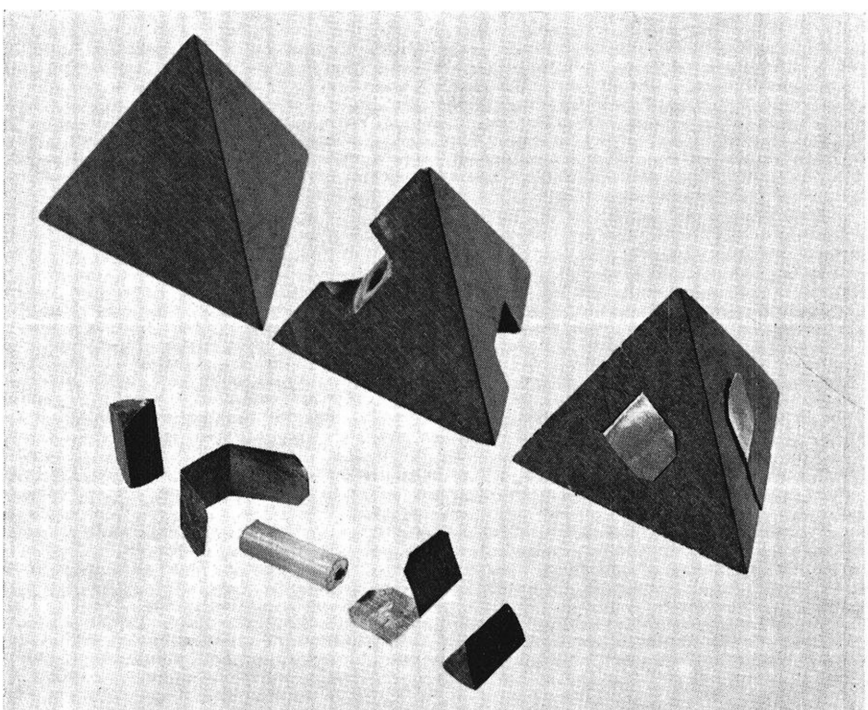
When the apparatus is used to study resistance changes with pressure, a specimen is first inserted in a hole (up to 1/8-in. diameter) drilled from edge to edge of the tetrahedron. Pieces of silver foil are placed in contact with each end of the specimen, and bent to give an exposed surface to each of the anvil faces. Thus, one end of each foil is in position to make electrical contact with one anvil. The remaining notches in the edges of the tetrahedron are then filled with prisms of pyrophyllite, and the tetrahedral assembly is ready for an experiment. This arrangement makes available an electrical lead via each of the 4 anvils. Thus, a 4-lead circuit can be used for resistance measurements during studies of changes in electrical resistance with increasing pressure.

Measurements of relative resistance with pressure have been made with specimens of antimony, barium and bismuth. The results have shown good agreement with the work of other investigators. Values of ram forces required to reach the first resistance transitions of barium and bismuth have indicated that approximately 10 percent of the total applied force is lost to gasket forces and to the internal friction of pyrophyllite.

It appears desirable to investigate other pressure-transmitting materials for use as tetrahedral pressure cells. Also, certain combinations of tetrahedron material and specimen sheath material may have more nearly optimum properties and may improve the uniformity of pressure applied to a specimen.

If a larger tetrahedron were used for a given specimen size, more uniform pressure would result, and the proportion of force taken by the gasket should be reduced. Recently, a larger apparatus of the same general design has been built so that the advantages of larger size may be investigated. The new apparatus is designed to apply forces up to 600 tons to tetrahedrons of about 1-in. edge length. Success in operating the larger apparatus would indicate the feasibility of a 2-stage device, in which a small tetrahedron would be embedded in a tetrahedron of, say, 3 in. on a side. The forces needed to support the second-stage anvil would be supplied by the pressure in the large tetrahedron.

It is hoped that further work will enable the National Bureau of Standards to determine more accurately the pressures at which there are changes in electrical resistance, changes of state, and polymorphic crystalline transitions in certain materials. The properties of these materials could then be used to define fixed pressure points useful in pressure calibrations, in much the same way that freezing points of certain materials are used to define the International Temperature Scale. **THE END**



—Courtesy of National Bureau of Standards

Assembly of the Tetrahedron used in the new highpressure apparatus.

Metal Spraying

(Continued from page 16)

barges were sprayed with zinc, the New York Port Authorities require a check only once every two years.

Relatively cheap protection may be afforded storage tanks used for mild alkalis or mild acids by spraying with a resistant metal. There is, however, one limitation of sprayed metals in tanks. Due to the high porosity of sprayed metal, liquids under extreme pressures will "leak" through the sprayed surface. Corrosion may take place and not be observed until serious damage to tanks has been done.

Foundry Applications

Many castings having minor shrinkage cavities, blow holes, and similar defects used to be scrapped. Now they are made usable by a metal spraying application. For example, much material and many hours of labor are required to make one large turbine rotor. Scrapping of one such casting due to minor defects can be extremely costly. Companies save these castings by use of metal spraying.

Expensive metal patterns in foundries have long been a problem of maintenance. In plants where sand slingers are used the metal patterns become eroded. The sand slinger acts on the metal pattern in the same way that grit blasting does. Savings, here too, are realized by rebuilding and remachining again at a fraction of the cost of replacement.

Electrical Applications

When motors and generator shafts become worn and need rebuilding to restore them to proper working order, metal spraying is the answer. Since the sprayed metal particles are in a plastic state when they strike the base metal, the temperature of this surface remains low. Thus, motor and generator windings are not shorted by heat. Then, too, heat distortion may be completely disregarded.

(Continued on page 27)

ENGINE EARS

by Larry Hyde ce'62

FLYING CLUB

Bucky Badger may have some new trophies to add to his collection, won in the latest intercollegiate sport, flying. The University of Wisconsin Flying Club is making plans for the 1960 National Intercollegiate Flying Association spring flying meet at Ohio State on May 12–14. Club members are brushing up on their spot-landing and bomb-dropping technique (2 lb flour bag bombs), plus their navigation proficiency, hoping to win some of the individual and team contests at the meet.

At the 1959 meet held at the University of Illinois, the first such meet attended by U. W. Flying Club members, Wisconsin's best effort was a fourth in the navigation event by Stan Schwantes. Since the 1959 meet, the club has grown to a two plane "air force" and active membership has increased to 38. With the experience gained in last year's meet and more members and planes attending this year, the Badger team should make a strong bid at Columbus this May. Since mechanical bombsights are not allowed, the Wisconsin bomb-drop team of Dave Hotchkiss and Stan Schwantes is rumored to have perfected a new "eyeball" technique after their fruitless attempt last year to hit the target (a barrel from an altitude of 200 feet.

The Wisconsin pilots will be competing against flying clubs from such schools as Purdue, Minnesota, Iowa State, Texas A & M, and Oklahoma State, some of the 19 schools which attended last year's meet at Champaign and brought over 200 students and 42 aircraft.

Last year's meet was sponsored by 49 aviation-minded individuals and organizations such as Bendix Aviation Corp., Cessna Aircraft Corp., and Capital, TWA, and United air lines, just to name a few. Shell Oil Company donated 500 gallons of aviation gas for the contestants' airplanes.

While guests of the Illinois flying club members had a chance to see the facilities of the University of Illinois Institute of Aviation, which includes a complete airport with three 5000 ft. concrete runways, large shops, hangers, and classroom and administration space. Ozark Airlines has 12 daily flights to the airport, which serves the city of Champaign. The University

Eugene Hinte inspecting the Flying Club's "Aerona Champ."

—Aerial Photo

Stan Schwantes, Secretary of the Flying Club, in their "Cessna 120."

owns over 40 aircraft and has complete aircraft and engine mechanic training facilities, including a jet engine test cell. Illinois also offers a degree in aeronautical engineering.

Illinois students in Letters and Science are allowed several credits for pilot training courses, which include basic flight training, acrobatics, and instrument flight instruction. University and state officials may use the University aircraft, which include a DC–3, for business trips. Students may rent aircraft for training or pleasure at rates less than charged by commercial airport operators.

Of course, U. W. Flying Club members would like Wisconsin to start such an aviation program but this may not be possible for quite some time. In the meantime, the U. W. Flying Club, Inc., which is a chartered non-profit corporation for University students, faculty, and employees, is the only campus organization for the student who wants to fly or learn to fly. For information about the flying club, attend one of the meetings, usually the second Tuesday of each month in the Union, or call Dave Hotchkiss, Al 5–6438 or Stan Schwantes, Al 6–0786.

KHK NEWS

The house at 204 North Murray is vibrating with the usual high spirits of Kappa Eta Kappa's busy spring social schedule. Spring activities commenced on March 12 with a banquet at Thallers Steak House preceding the St. Pat's Dance. Although the weather bore no resemblance to spring, the spirits of the participants were not dampened. On March 26th, the Chapter House was converted into a casino for a gambling party. Fifty and one hundred dollar bills flowed as freely as the refreshments. Lucky couple of the evening was Jim and Marlene Smedema while booby prize winners, Lee and Joyce Eichenseer, went home in a barrel. Running the gaming tables were Dick Cary at the Roulette Wheel and Howie Abraham dealing Black Jack. The dice game, alhough open to all, was dominated by John (Shaky Jake) Kruse. After an enjoyable evening the money was returned to the monopoly set.

Also on the spring docket are the pledge party, a fraternity spring formal and a fraternity picnic.

Intramural sports are upon us and KHK is participating, under the leadership of "Coach" Beetle Bailey, in softball, golf and tennis. This is in addition to our own gruelling ping pong tournament in which Nootan Parekh leads the pack.

Since this is the last issue of the school year, we wish to congratulate in advance Ralph Hintze, Don Laughlin, and Jim Ably who intend to take brides this summer. All Kappa Eta Kappas are invited to the weddings.

ALPHA CHI SIGMA

Alpha of Alpha Chi Sigma has taken part in a variety of activities this year. During the first semester five professional meetings were held. At each one a guest addressed the membership. Speakers and topics were: Dr. E. Cameron, "Role of Geochemistry"; Dr. J. Conway, "Some Aspects of the Law"; Dr. D. G. Byrd, "Contemporary Art"; Mr. T. Wisniewski, "Water Pollution Problems"; Mr. R. Rosen, "TV Production and Direction."

(Continued on next page)

Engine Ears

(Continued from last page)

Under the chairmanship of Thomas Grace, the safety committee of the chapter has also continued its program of supplying safety pamphlets for the freshman chemistry laboratories.

On May 14 the chapter held the annual picnic at Devils Lake. The feature attraction of the outing was the traditional chemistry vs. chemical engineering baseball game. This year was no different—the engineers won.

Another of the chief social functions of the chapter, the annual formal, was held April 30. The theme for this years dance was "Southern Belle". The dance was held at the Holiday Inn and a good time was had by all.

In addition to participating in a varied social and professional program, the members of Alpha Chi Sigma have financially "adopted" Kostantinos Kalotihos, a 15 year old Greek boy. This program is carried on through the Foster Parents Plan, Inc., New York City. The Foster Parents have promised to contribute $15.00 a month toward the childs support for at least a year. To encourage a warm personal relationship between the Foster Parents and "his child" the fraternity has received a history of the child and a photograph, and correspondence through the Plan office is translated both ways. The letters received are posted for the benefit of all members.

MINING AND METALLURGY CLUB

The last meeting of Mining and Metallurgy Club was called to order by President Huff. Mr. Richard Stoll of U. S. Steel South Works gave a talk on "Modern Trends in Steelmaking."

James Knabe, our representative on Polygon, asked the members of the club if they were interested in buying books at cost through the Polygon board. Nearly all members present were in favor of the proposal.

The next meeting will feature Dr. Allen Grey, editor of Metals Progress, who will give a talk on Powder Metallurgy.

A.S.C.E.

The highlight of the March meeting of the A.S.C.E. was a talk given by Mr. F. W. Schooley of Chicago Bridge and Iron Co. He spoke on the development and testing of T–1 steel and supplemented his speech by showing an interesting film called "Tanks Tested to Destruction". The group also discussed plans for the annual picnic to be held in May, all members of A.S.C.E. were encouraged to attend. Beer and chips were served after the meeting.

The A.S.C.E. invited Mr. Karl Roesser, a structural engineer from the Portland Cement Co., to speak at their March 30th meeting. He gave an interesting talk entitled "What's New in Concrete Cement". A short business meeting followed and refreshments were served.

AIEE–IRE

A non-technical talk by Mr. Robert E. Barnhart started and highlighted the evening for the members at the March meeting. The meeting was held in the Wisconsin Center with Dan Donohoo vice-president taking over for Bill Dachelet who, because of an important engagement, came late. But Bill came in time to enjoy the business part of the meeting from an unaccustomed seat with the crowd, and also to partake of the coffee and donuts, served thru the services of the Center's catering service. Incidentally, we would like to give due credit to the people who have arranged and run this service in the past. We have always received excellent response.

Jim Vanderhagen gave a report on the very successful membership drive and later presented the chapter with a thorough breakdown of the PHT (Putting Hubby Thru) Dance and Dinner (instead of Banquet as in the past) for May 18. This year the Al Mack Band will perform at the Chanticleer in Middleton for the students and Madison section members and their best girls. Corsages will be issued at the door for the women. This entire event has the indications of being the big event of the year and undoubtedly will be an annual affair.

Don Sanford, Mike Noth, Duane Ritche, and Bob Daugherty as our polygon board representatives did a bang-up job on the St. Pat's Day festivities. Along with Bob Moe, buttons and tickets chairman, and his workers, these men should be recognized as having done a commendable bit of work.

S.A.E.

On March 30, Mr. Bob Benzinger gave a talk on the Chevrolet Corvair. Primary emphasis was placed the radically new engine with its many aluminum parts and rear position in the Corvair. Slides were presented to supplement the lecture and a movie highlighted the meeting. Mr. Benzinger conducted a question and answer period which gave the members a chance to learn further of specific items. Beer and cheese were served as usual.

The May meeting of SAE will consist of a picnic at Olbrich Park. The date is tentatively set for May 14, and very little change can be made or is expected to be made. This will be a joint picnic with ASME. Beer will be served and a drunken baseball game will be played most of the afternoon. Boat rides will be provided with Prof. Eastons boat, and a demonstrator Corvair will be available for the participants to take demonstration rides. Wives and girl friends of the members of SAE and ASME are cordially invited to attend.

AFS

Mr. Donald Spence of Pelton Steel Castings Company gave a very interesting talk at the last meeting of the American Foundrymen's Society. His topic was the feeding and solidification of steel castings. Refreshments were served after the meeting.

The next meeting will feature Mr. Robert Eck of Eck Foundries, Manitowoc.

A.I.Ch.E.

During this school year, A.I. Ch.E. has tried to present speakers representing the various phases of Chemical Engineering Men

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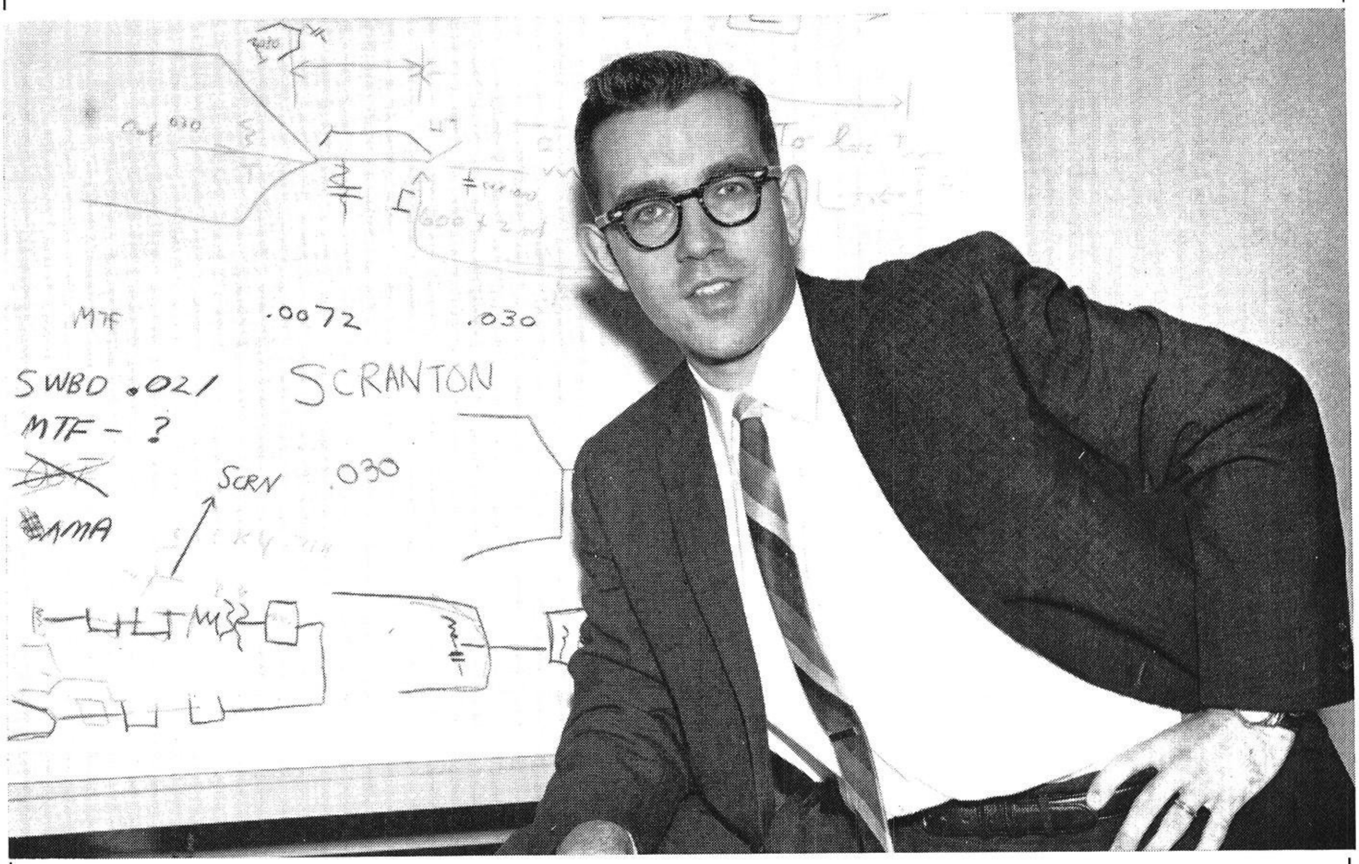
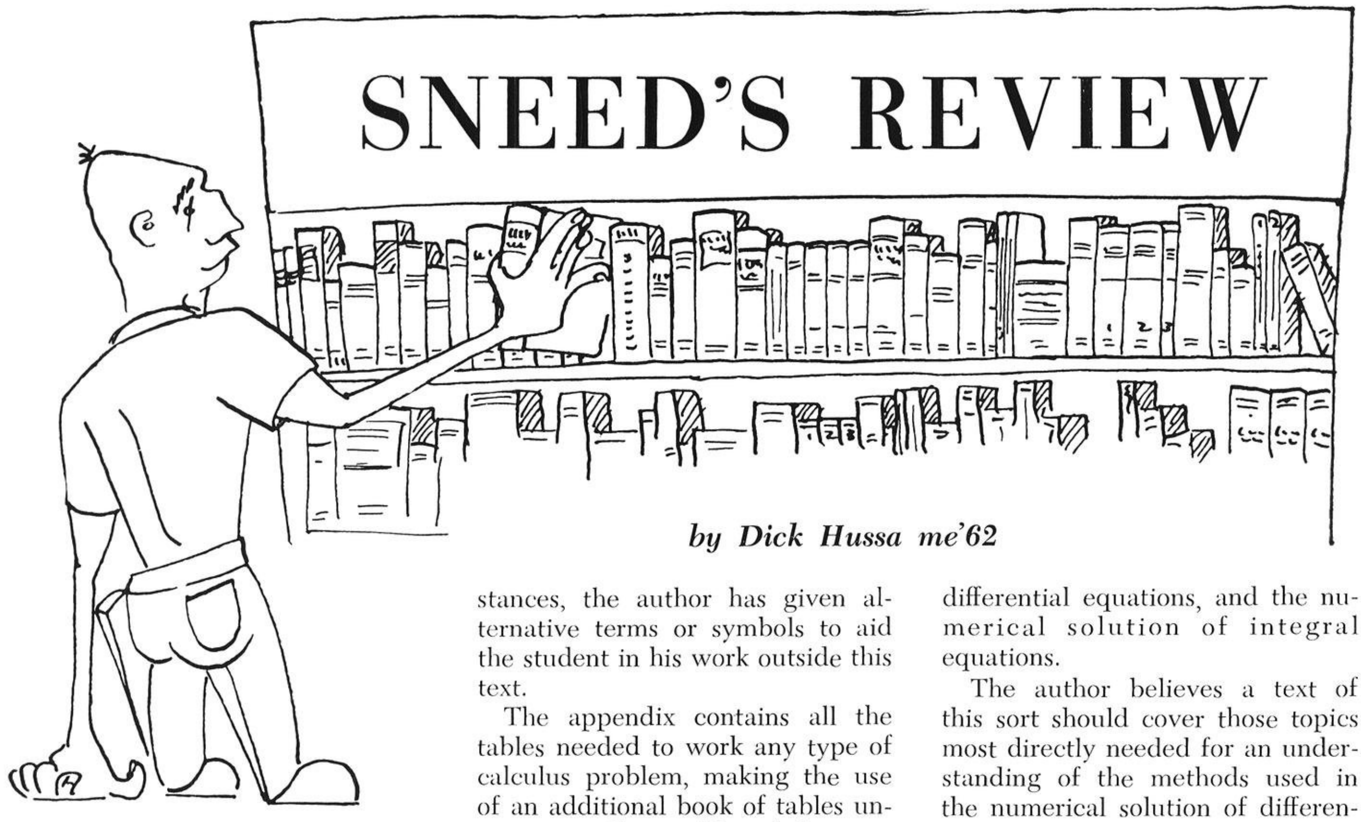

SCRANTON

SNEED'S REVIEW



by Dick Hussa me'62

CALCULUS FOR ELECTRONICS

By A. E. Richmond
407 pages. $8.25

Here is a complete text for those in the field of electronics who require a knowledge of calculus in their work. It presents simultaneously the processes of calculus and their application to problems in electrical and electronic circuits. This combination gives the reader a firm grasp of the basic science of his applied field and motivates him to go on to more advanced work.

Beginning with fundamental concepts of calculus, the book develops the basic operations of differential and integral calculus and advances to such special topics as the complex exponential representation of a physical sinusoid; Taylor's expansions of functions of two independent variables; Fourier's series; and an introduction to differential equations.

Application of calculus methods to television, radar, loran, and transistors are also included in the text. This book can be used as an introductory text in conjunction with courses in circuit analyses. As each topic is discussed, it is illustrated by examples taken directly from electricity and electronics. All symbols used were chosen with regard to published standards. In many instances, the author has given alternative terms or symbols to aid the student in his work outside this text.

The appendix contains all the tables needed to work any type of calculus problem, making the use of an additional book of tables unnecessary. Short tables of the most frequently used derivatives and integrals have been printed inside the back cover where they can be found quickly.

The book has over 450 problems relating directly to electronics. Answers for most of the odd-numbered problems are included in the back of the book.

This book was written to be used as a mathematics text in engineering colleges, technical institutes, training-in-industry programs and in courses conducted by the Armed Services. Practicing engineers should find this work of use in reviewing calculus procedures.

NUMERICAL ANALYSIS

By Kaiser S. Kunz
381 pages. $8.00

Numerical Analysis is written by Kaiser S. Kunz, Research Physicist, Schlumberger Well Surveying Corporation, Ridgefield Research Laboratory in Connecticut.

This book develops a fundamental understanding of the use of finite difference methods in obtaining numerical solutions to problems in applied mathematics. Beginning with a study of numerical solutions of algebraic equations, methods of interpolation, and numerical integration, it proceeds to an application of the finite difference techniques to ordinary and partial differential equations, and the numerical solution of integral equations.

The author believes a text of this sort should cover those topics most directly needed for an understanding of the methods used in the numerical solution of differential equations—both ordinary and partial, and in the solution of integral equations. Consequently, considerable time is devoted to finite difference tables and notation, and to numerical differentiation and integration. In preparation for the study of partial differential equations, the book treats rather thoroughly the solution of simultaneous linear equations and multivariate interpolation.

Highlights and Strong Points

It gives a unified treatment of the finite difference methods leading up to a study of ordinary partial differential equations, and integral equations.

Special consideration is given to the relationship between the various methods used in obtaining a numerical solution.

Many methods heretofore found only in the literature are given; e.g., the use of the lozenge diagram for the numerical differentiation and integration, and the treatment of multivariate interpolation, integral equations, and error analysis.

The methods are directly applicable to either electronic calculators or desk machines.

A great many worked-out examples are given and exercises for the students are provided for each chapter.

HOW TO GET THAT PART TIME JOB

By Dr. Norman Feingold and Harold List
92 pages. $1.50

In their new book, "How To Get That Part Time Job," two leading vocational advisors, Dr. Norman Feingold and Harold List, have compiled an invaluable store of information for students, for employed adults who need to add to their income, for the unemployed and for retired people who wish to continue to be useful. "How To Get That Part Time Job" is published in paper at $1.50 and cloth at $2.50. Orders may be sent directly to Arco Publishing Company, 480 Lexington Avenue, New York 17, N. Y.

This invaluable book tells you clearly and concisely when and where to look for a part time job in both industry and government, giving complete listings of part time jobs, including a glossary of little known and unusual part time jobs and businesses. It tells you how to look for a part time job, with a thorough explanation of all the tried and tested ways available today. If you're a little shakey about resumes, interviews and applications, you will find everything you need to know to reduce your nervousness. Did you know that there were special laws to protect part time workers? They're all summarized in this book. The book concludes with an important bonus section listing 1005 free publications relating to part time jobs.

ENGINEERING ANALYSIS

By Stephen H. Crandall
417 pages. $9.50

Concerned with the analysis of highly complex engineering problems whose solution is being made possibly by high-speed automatic computing machines, this book is of unique interest to engineers or engineering mathematicians. It considers briefly the formulation of mathematical models and, more thoroughly, the construction of computational programs for solving these with automatic or hand computing machines.

The material is arranged according to a natural classification of the basic *types of problems* in engineering analysis. The author believes that the selection of appropriate numerical procedures cannot be made intelligently without giving due consideration to the intrinsic *structures of the physical systems* involved.

Features to Note

1. Three broad classifications of problems are recognized: equilibrium, eigen-value, and propagation. Emphasizing this particular breakdown is original with the author.
2. Several physical examples are given in each chapter to identify clearly the class of problem being treated. These examples are drawn from the fields of elasticity, heat transfer, fluid mechanics, and electric circuits. The classical mathematical behavior of such systems is then briefly outlined before attacking the numerical procedures.
3. Procedures suitable for hand computation and for automatic machine computation include iteration, relaxation, perturbation, variational and finite difference methods.
4. Three items frequently omitted in engineering mathematics courses are developed: matrix notation, the calculus of variations, and the theory of characteristics of partial differential equations.

Stephen Crandall, the author, is an associate professor of Mechanical Engineering, Massachusetts Institute of Technology. THE END

Metal Spraying

(Continued from page 21)

Metallizing is also used in printed circuits. Here, however, the metal is sprayed on bakelite, plastics or similar non-conductors. Ridges of the non-conductor are left between the "wires" and the circuit base is roughened, usually by sand blasting. Then, the entire circuit base is sprayed with a conducting metal. Finally, the sprayed metal surface is sanded until the ridges of the non-conducting material are exposed. This process is superior to other methods of circuit printing in one respect—vibration does not cause the circuit to chip or peel as in other processes.

NEW DEVELOPMENTS

Gang Spraying

Gang spraying (using several spray guns) is used mostly on long cylindrical surfaces which are mounted in lathes. Several spray guns are mounted on multiple tool posts, each spray overlapping the previous one. Thus, several coats of spray are applied in one operation.

A new innovation of "gang" spraying is used in production machines. Several spray guns are mounted in fixed positions and the work moves past these guns. In some production machines, particularly those which handle long flat surfaces, a cleaning device (such as a grit blast) is mounted ahead of the spray mechanism. This provides rapid cleaning and metallizing.

Rocket Spraying

"Rocket" spraying is the term given to one of the latest advances in metallizing. Rocket spraying makes use of only one principle of a rocket—the exiting gas which has a high temperature and a high velocity. This gas melts and atomizes a metal wire which is fed through the rocket nozzle. The gas also blows the metal particles against the base metal. Its inventors claim three major advantages over the gun method:

1. No air compressor is needed; consequently, initial equipment cost is lower.
2. Propane gas, which is cheaper than acetylene gas, may be used.
3. Smaller atomized particles are obtained; therefore, there is less porosity in sprayed metals.

This method has not been applied commercially as yet and is still in the experimental stage.

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A very familiar sight in the M.E. building is Miss Judy Kennedy, secretary of the Air Force ROTC, who is seen working at her desk in the picture at the right.

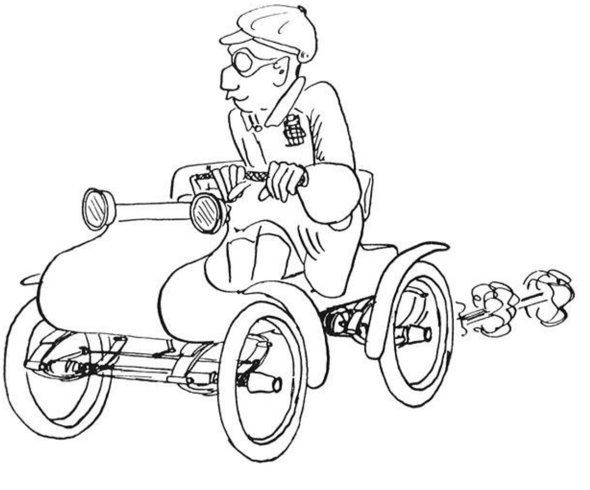
GIRL OF THE MONTH

Judy Kennedy

Judy, who is from California, has her home in Madison decorated in an Oriental motif. The symbols on the wall in the picture above represent Happiness and Good Luck.

One of her interests is traveling, and she has been in various parts of the United States and Hawaii. Her interests in sports are mainly swimming and golf.

—Photos by Walter Ronn



THE ENGINEER OF YESTERYEAR

by Floyd Gelhaus, ee'61

THE SIGNIFICANCE OF RADAR CONTACT WITH THE MOON

November, 1946

We have all read about how on January 10, 1946 a group of scientists supervised and directed by the U. S. Army Signal Corps succeeded in radar contact with the moon. To the average reader this means very little, but to the men working on the project this was the first step in the opening of a new field. Through past experiences radar specialists knew that the highly electrified outer areas of the earth's atmosphere had deleterious effects on radio waves. This outer area is termed the inonosphere and extends from 38 to 250 miles above the earth's surface, forming a shield through which radio waves emitted by ordinary radar sets are unable to pass. Leading radar men doubted whether sets powerful enough to penetrate this shield could be built to operate satisfactorily.

In order to make an analysis of the effect of the ionosphere on radion waves, it was deemed by the specialists that first there must be proof positive that radar signals could pass through this shield and into the space beyond. Secondly, it was necessary to strike an object such as the moon from which an echo could be received. Then a study could be made of the differences in the strengths of the broadcast impulse and of the return impulse or echo for the purpose of getting the complete details of the effect of the ionosphere on radio waves. The use of long-range radar sets during the war for warning against air attacks and for submarine warfare played no small part in the allied victory. With the cessation of hostilities radar continues its outstanding work, but now for peaceful purposes in scientific research.

A planet which warrants an exhaustive study is the moon. It is known that the moon has a great effect on our daily lives, since it holds sway over the tides and the weather to such an extent that it affects the crops and indirectly the health of the inhabitants of this planet. Now it may be possible to dispel some of the age-old mystery that cloaks the moon, the action of which is bound by formulas much too complicated for lay understanding. With the best radar equipment, it could be possible to measure the moon with an electronic ruler for the purpose of getting practical data, which should prove much more enlightening than the abstract data produced by the complicated calculations.

It is also predicted that space ships from earth should be able to roam thousands of miles into the heavens to report astronomical data, electronically computed aboard such vessels. A further proposal includes radar control of jet of rocket-propelled vessels circling above the earth.

SOUND SEARCHES FOR FLAWS

October, 1946

One of the great aids in mass production is the development of non-destructive methods of testing materials and products. What good is a large volume of production if a large percentage of the finished products are imperfect? There are quite a few nondestructive methods of testing which have been developed in the last few years. Among these are radiographic, spectrographic, magnetic, and supersonic methods of analyses.

Supersonic flaw detection operates on the principle of sending high frequency (inaudible sound waves of 0.5 to 12 megacycles) sound waves into the material and observing the reflection of these waves. It is necessary that the frequency of the sound waves is high, because, in order to get an appreciable indication of a flaw, the wave length of the sound wave must be less than the smallest lateral division of the material being inspected. Unlike radio waves, supersonic sound waves are dissipated very rapidly in air and travel best in materials such as metals, liquids, plastics and wood. The velocity of these longitudinal sound waves depends on two properties of the material: the density and the elastic properties. Thus it can be seen that a change in speed will take place when a sound wave strikes a flaw, such as a crack, separation, or an air space. The time for a supersonic sound wave to reflect from a certain material can be measured and used as an indication of the internal qualities of the piece tested.

The machine which uses sound waves to detect flaws is called a "supersonic refectroscope." In this apparatus, a quartz crystal makes contact with the material to be tested through a thin film of oil. When an oscillatory voltage is applied to the crystal, the latter grows thicker and thinner in synchronism with the electrical oscillations. The crystal puts a pressure on the material causing sound waves to be transmitted through it. The crystal is made to vibrate only a very short time—such as one-millionth of a second—then the pulse goes through the piece and reflects from the other side and also from any flaw. The reflected wave is picked up by the same crystal that initiated the first wave, and a voltage is generated in the crystal. This voltage is amplified and indicated on a cathode-ray oscilloscope in such a way that the over-all time can be measured. These short oscillations are sent out at intervals of sixty times per second.

THE END

Engine Ears

(Continued from page 24)

working in sales, research, production and development have discussed their various branches of engineering at the monthly A.I.Ch.E. meetings. This was done in an effort to familiarize the undergraduate engineer with the various branches and perhaps help him decide which one to enter upon graduation. At our April meeting, Mr. Richard Tomlin, a former Wisconsin student now working for The Chemstrand Corporation, told which branch he chose and why in a talk entitled "My First Year in Industry."

At the last meeting of the year, to be held this month, chapter officers will be elected for the 1960–'61 school year.

THE END

Fuel Cells

(Continued from page 13)

ciency of 60 to 80 percent. Other advantages of the fuel cell can be listed as follows:

1. No noise.
2. No fumes.
3. Simple design.
4. Low maintenance cost because of lack of, or limited number of, moving parts.
5. Rapid acceleration.

Among the limitations of the fuel cell can be listed such things as the present high cost of pure gas fuels, such as hydrogen. Electrical leakage can also be listed as a disadvantage.

The advantages of the fuel cell far exceed its limitations, thus indicating that uses for the cell will be found in the future.

Probable Uses of the Fuel Cell

It can be expected that the cell will become extremely important in three fields. These are industry, transportation, and space travel.

In industry the cell may become a source of power. Aluminum producers, in particular, would benefit through the usage of fuel cell power. In the production of aluminum, large quantities of low voltage direct current are needed.

In transportation, the fuel cell would be an ideal source of power for trucks and locomotives. There is also the possibility of the small passenger car propelled by the power of the fuel cell.

This is the space age, so undoubtedly the fuel cell with all its advantages, will be important in space exploration.

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FINAGLE FACTORS

(Continued from April 1960)

Multiply	*By*	*To Get*
kilogram-calories	3.968	British thermal units
kilogram-calories	3086	foot-pounds
kilogram-calories	1.558×10^{-3}	horsepower-hours
kilogram-calories	4183	joules
kilogram-calories	426.6	kilogram-meters
kilometers per min	60	kilometers per hour
kilowatts	56.92	Btu per min
kilowatts	4.425×10^{4}	foot-pounds per min
kilowatts	737.6	foot-pounds per sec
kilowatts	1.341	horsepower
kilowatts	14.34	kg-calories per min
kilowatts	10^{3}	watts
kilowatt-hours	3415	British thermal units
kilowatt-hours	2.655×10^{6}	foot-pounds
kilowatt-hours	1.341	horsepower-hours
kilowatt-hours	3.6×10^{6}	joules
kilowatt-hours	860.5	kilogram-calories
kilowatt-hours	3.67×10^{5}	kilogram-meters
knots	6080	feet per hr
knots	1.853	kilometers per hr
knots	1.152	miles per hr
knots	2027	yards per hr
Lines per square cm	1	gaus
lines per square inch	0.1550	gaus
links (engineer's)	12	inches
links (surveyor's)	7.92	inches
liters	10^{3}	cubic centimeters
liters	0.03531	cubic feet
liters	61.02	cubic inches
liters	10^{-3}	cubic meters
liters	1.308×10^{-3}	cubic yards
liters	0.2642	gallons
liters	2.113	pints (liq)
liters	1.057	quarts (liq)
liters per minute	5.855×10^{-4}	cubic feet per second
liters per minute	4.403×10^{-3}	gallons per second
$\log_{10} N$	2.303	log. $_{10}N$
$\log_e N$ or ln N	0.4343	log. $_e N$ or ln N
lumens per sq ft	1	foot-candles
maxwells	10^{-3}	kilolines
megalines	10^{6}	maxwells
megmhos per cm cube	10^{-3}	abmhos per cm cube
megmhos per cm cube	2.540	megmhos per in. cube
megmhos per cm cube	0.1662	mhos per mil foot
megmhos per inch cube	0.3937	megmhos per cm cube
megohms	10^{6}	ohms
meters	100	centimeters
meters	3.2808	feet
meters	39.37	inches
meters	10^{-3}	kilometers
meters	10^{3}	millimeters
meters	1.0936	yards
meter-kilograms	9.807×10^{7}	centimeter-dynes
meter-kilograms	10^{5}	centimeter-grams
meter-kilograms	7.233	pound feet
meters per minute	1.667	centimeters per sec
meters per minute	3.281	feet per minute
meters per minute	0.05468	feet per second
meters per minute	0.06	kilometers per hour
meters per minute	0.03728	miles per hour
meters per second	1968	feet per minute
meters per second	3.284	feet per second
meters per second	6.0	kilometers per hour
meters per second	0.06	kilometers per min
meters per second	2.237	miles per hour
meters per second	0.03728	miles per min
meters per sec per sec	3.281	feet per sec per sec
meters per sec per sec	3.6	km per hour per sec
meters per sec per sec	2.237	miles per hr per sec
mhos per mil foot	6.015×10^{-3}	abmhos per cm cube
mhos per mil foot	6.015	megmhos per cm cube
mhos per mil foot	15.28	megmhos per in. cube
microfarads	10^{-15}	abfarads
microfarads	10^{-6}	farads
microfarads	9×10^{5}	statfarads
micrograms	10^{-6}	grams
microliters	10^{-6}	liters
microhms	10^{3}	abohms
microhms	10^{-12}	megohms
microhms	10^{-6}	ohms
microhms	$1/9 \times 10^{-17}$	statohms
microhms per cm cube	10^{3}	abohms per cm cube
microhms per cm cube	0.3937	microhms per in. cube
microhms per cm cube	6.015	ohms per mil foot
microhms per inch cube	2.540	microhms per cm cube
microns	10^{-6}	meters
miles	1.609×10^{5}	centimeters
miles	5280	feet
miles	1.6093	kilometers
miles	1760	yards
miles	1900.8	varas
miles per hour	44.70	feet per minute
miles per hour	88	centimeters per sec
miles per hour	1.467	feet per second
miles per hour	1.6093	kilometers per hour
miles per hour	0.8684	knots
miles per hour	26.82	meters per minute
miles per hour per sec	44.70	cm per sec per sec
miles per hour per sec	1.467	feet per sec per sec
miles per hour per sec	1.6093	km per hour per sec
miles per hour per sec	0.4470	M per sec per sec
miles per minute	2682	centimeters per sec
miles per minute	88	feet per second
miles per minute	1.6093	kilometers per min
miles per minute	60	miles per hour
milligrams	10^{-3}	grams
millihenries	10^{6}	abhenries
millihenries	10^{-3}	henries
millihenries	$1/9 \times 10^{-14}$	stathenries
milliliters	10^{-3}	liters
millimeters	0.1	centimeters
millimeters	0.03937	inches
millimeters	39.37	mils
mils	0.002540	centimeters
mils	10^{-3}	inches
miner's inches	1.5	cubic feet per min
minutes (angle)	2.909×10^{-4}	radian
minutes (angle)	60	seconds (angle)
months	30.42	days
months	730	hours
months	43.800	minutes
months	2.628×10^{6}	seconds
myriagrams	10	kilograms
myriameters	10	kilometers
myriawatts	10	kilowatts
Ohms	10^{9}	abohms
Ohms	10^{-6}	megohms
Ohms	10^{6}	microhms
Ohms	$1/9 \times 10^{-11}$	statohms
ohms per mil foot	166.2	abohms per cm cube
ohms per mil foot	0.1662	microhms per cm cube
ohms per mil foot	0.06524	microhms per in. cube
ounces	8	drams
ounces	437.5	grains
ounces	28.35	grams
ounces	0.0625	pounds
ounces (fluid)	1.805	cubic inches
ounces (fluid)	0.02957	liters
ounces (troy)	480	grains (troy)
ounces (troy)	31.10	grams
ounces (troy)	20	pennyweights (troy)
ounces (troy)	0.08333	pounds (troy)
ounces per square inch	0.0625	pounds per sq inch
Pennyweights (troy)	24	grains (troy)
Pennyweights (troy)	1.555	grams
Pennyweights (troy)	0.05	ounces (troy)
perches (masonry)	24.75	cubic feet
pints (dry)	33.60	cubic inches
pints (liquid)	28.87	cubic inches

Multiply	*By*	*To Get*
poundals	13,826	dynes
poundals	14.10	grams
poundals	0.03108	pounds
pounds	444,823	dynes
pounds	7000	grains
pounds	453.6	grams
pounds	16	ounces
pounds	32.17	poundals
pounds (troy)	0.8229	pounds (av)
pounds per cubic foot	1.356×10^{7}	centimeter-dynes
pound-feet	13,825	centimeter-grams
pound-feet	0.1383	meter-kilograms
pound-feet	421.3	kg-cm squared
pounds-feet squared	144	pounds-in. squared
pounds-feet squared	2.926	kg-cm squared
pounds-inches squared	6.945×10^{-3}	pounds-feet squared
pounds-inches squared	0.01602	cubic feet
pounds of water	27.68	cubic inches
pounds of water	0.1198	gallons
pounds of water	2.660×10^{-4}	cubic feet per sec
pounds of water per min	0.01602	grams per cubic cm
pounds per cubic foot	16.02	kg per cubic meter
pounds per cubic foot	5.787×10^{-4}	pounds per cubic inch
pounds per cubic foot	5.456×10^{-9}	pounds per mil foot
pounds per cubic inch	27.68	grams per cubic cm
pounds per cubic inch	2.768×10^{4}	kg per cubic meter
pounds per cubic inch	1728	pounds per cubic foot
pounds per cubic inch	9.425×10^{-6}	pounds per mil foot
pounds per foot	1.488	kg per meter
pounds per inch	178.6	gram per cm
pounds per mil foot	2.306×10^{6}	grams per cubic cm
pounds per square foot	0.01602	feet of water
pounds per square foot	4.882	kg per square meter
pounds per square foot	6.944×10^{-3}	pounds per sq inch
pounds per square inch	0.06804	atmospheres
pounds per square inch	2.307	feet of water
pounds per square inch	2.036	inches of mercury
pounds per square inch	703.1	kg per square meter
pounds per square inch	144	pounds per sq foot
Quadrants (angle)	90	degrees
Quadrants (angle)	5400	minutes
Quadrants (angle)	1.571	radians
quarts (dry)	67.20	cubic inches
quarts (liq)	57.75	cubic inches
quintals	100	pounds
quires	25	sheets
Radians	57.30	degrees
Radians	3438	minutes
Radians	0.637	quadrants
radians per second	57.30	degrees per second
radians per second	0.1592	revolutions per second
radians per second	9.549	revolutions per min
radians per sec per sec	573.0	revs per min per min
radians per sec per sec	9.549	revs per min per sec
radians per sec per sec	0.1592	revs per sec per sec
reams	500	sheets
revolutions	360	degrees
revolutions	4	quadrants
revolutions	6.283	radians
revolutions per minute	6	degrees per second
revolutions per minute	0.1047	radians per second
revolutions per minute	0.01667	revolutions per sec
revs per min per min	1.745×10^{-3}	rads per sec per sec
revs per min per min	0.01667	revs per min per sec
revs per min per min	2.778×10^{-4}	revs per sec per sec
revolutions per second	360	degrees per second
revolutions per second	6.283	radians per second
revolutions per second	60	revs per min
revs per sec per sec	6.283	rads per sec per sec
revs per sec per sec	3600	revs per min per min
revs per sec per sec	60	revs per min per sec
rods	16.5	feet
Seconds (angle)	4.848×10^{-6}	radians
spheres (solid angle)	12.57	steradians
spherical right angles	0.25	hemispheres
spherical right angles	0.125	spheres
spherical right angles	1.571	steradians
square centimeters	1.973×10^{5}	circular mils
square centimeters	1.076×10^{-3}	square feet
square centimeters	0.1550	square inches
square centimeters	10^{-6}	square meters
square centimeters	100	square millimeters
sq cm (cm sqd)	0.02402	sq inches (inches sqd)
square feet	2.296×10^{-5}	acres
square feet	929.0	square centimeters
square feet	144	square inches
square feet	0.09290	square meters
square feet	3.587×10^{-8}	square miles
square feet	.1296	square varas
square feet	1/9	square yards
sq feet (feed sqd)	2.074×10^{4}	sq inches (inches sqd)
square inches	1.273×10^{6}	circular mils
square inches	6.452	square centimeters
square inches	6.944×10^{-3}	square feet
square inches	10^{6}	square mils
square inches	645.2	square millimeters
sq inches (inches sqd)	41.62	sq cm (cm sqd)
sq inches (inches sqd)	4.823×10^{-5}	sq ft (feet sqd)
square kilometers	247.1	acres
square kilometers	10.76×10^{6}	square feet
square kilometers	10^{6}	square meters
square kilometers	0.3861	square miles
square kilometers	1.196×10^{6}	square yards
square meters	2.471×10^{-4}	acres
square meters	10.764	square feet
square meters	3.861×10^{-7}	square miles
square meters	1.196	square yards
square miles	640	acres
square miles	27.88×10^{6}	square feet
square miles	2.590	square kilometers
square miles	3,613,040.45	square varas
square miles	3.098×10^{6}	square yards
square millimeters	1.973×10^{3}	circular mils
square millimeters	0.01	square centimeters
square millimeters	1.550×10^{-3}	square inches
square mils	1.273	circular mils
square mils	6.452×10^{-6}	square centimeters
square mils	10^{-6}	square inches
square varas	.0001771	acres
square varas	7.716049	square feet
square varas	.0000002765	square miles
square varas	.857339	square yards
square yards	2.066×10^{-4}	acres
square yards	9	square feet
square yards	0.8361	square meters
square yards	3.228×10^{-7}	square miles
square yards	1.1664	square varas
statamperes	$1/3 \times 10^{-10}$	abamperes
statamperes	$1/3 \times 10^{-9}$	amperes
statcoulombs	$1/3 \times 10^{-10}$	abcoulombs
statcoulombs	$1/3 \times 10^{-9}$	coulombs
statfarads	$1/9 \times 10^{-20}$	abfarads
statfarads	$1/9 \times 10^{-11}$	farads
statfarads	$1/9 \times 10^{-5}$	microfarads
stathenries	9×10^{20}	abhenries
stathenries	9×10^{11}	henries
stathenries	9×10^{14}	millihenries
statohms	9×10^{20}	abohms
statohms	9×10^{5}	megohms
statohms	9×10^{17}	microhms
statohms	9×10^{11}	ohms
statvolts	3×10^{10}	abvolts
statvolts	300	volts
steradians	0.1592	hemispheres
steradians	0.07958	spheres
steradians	0.6366	spherical right angles
steres	10^{3}	liters
Temp (degs C) + 273	1	abs temp (degs C)
Temp (degs C) + 17.8	1.8	temp (degs Fahr)
temp (degs F) + 460	1	abs temp (deg F)
temp (degs F) − 32	5/9	temp (degs Cent)
tons (long)	1016	kilograms
tons (long)	2240	pounds
tons (metric)	10^{3}	kilograms
tons (metric)	2205	pounds
tons (short)	907.2	kilograms
tons (short)	2000	pounds
tons (short) per sq ft	9765	kg per square meter
tons (short) per sq ft	13.89	pounds per sq inch
tons (short) per sq in	1.406×10^{6}	kg per square meter
tons (short) per sq in	2000	pounds per sq inch
Varas	2.777	feet
Varas	33.3333	inches
Varas	.000526	miles
Varas	.9259	yards
volts	10^{8}	abvolts
volts	1/300	statvolts
volts per inch	3.937×10^{7}	abvolts per cm
volts per inch	1.312×10^{-3}	statvolts per cm
Watts	0.05692	Btu per min
Watts	10^{7}	ergs per second
Watts	44.26	foot-pounds per min
Watts	0.7376	foot-pounds per sec
Watts	1.341×10^{-3}	horsepower
Watts	0.01434	kg-calories per min
Watts	10^{-3}	kilowatts
watt-hours	3.415	British thermal units
watt-hours	2655	foot-pounds
watt-hours	1.341×10^{-3}	horsepower-hours
watt-hours	0.8605	kilogram-calories
watt-hours	367.1	kilogram-meters
watt-hours	10^{-3}	kilowatt-hours
webers	10^{8}	maxwells
weeks	168	hours
weeks	10,080	minutes
weeks	604,800	seconds
Yards	91.44	centimeters
Yards	3	feet
Yards	36	inches
Yards	0.9144	meters
Yards	1.08	varas
years (common)	365	days
years (common)	8760	hours
years (leap)	366	days
years (leap)	8784	hours

THE END

. . .THE EXPLORATION OF SPACE

Since its inception nearly 23 years ago, the Jet Propulsion Laboratory has given the free world its first tactical guided missile system, its first earth satellite, and its first lunar probe.

In the future, under the direction of the National Aeronautics and Space Administration, pioneering on the space frontier will advance at an accelerated rate.

The preliminary instrument explorations that have already been made only seem to define how much there is yet to be learned. During the next few years, payloads will become larger, trajectories will become more precise, and distances covered will become greater. Inspections will be made of the moon and the planets and of the vast distances of interplanetary space; hard and soft landings will be made in preparation for the time when man at last sets foot on new worlds.

In this program, the task of JPL is to gather new information for a better understanding of the World and Universe.

"We do these things because of the unquenchable curiosity of Man. The scientist is continually asking himself questions and then setting out to find the answers. In the course of getting these answers, he has provided practical benefits to man that have sometimes surprised even the scientist.

"Who can tell what we will find when we get to the planets? Who, at this present time, can predict what potential benefits to man exist in this enterprise? No one can say with any accuracy what we will find as we fly farther away from the earth, first with instruments, then with man. It seems to me that we are obligated to do these things, as human beings."

DR. W. H. PICKERING, *Director, JPL*

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CALIFORNIA INSTITUTE OF TECHNOLOGY

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A Research Facility operated for the National Aeronautics and Space Administration

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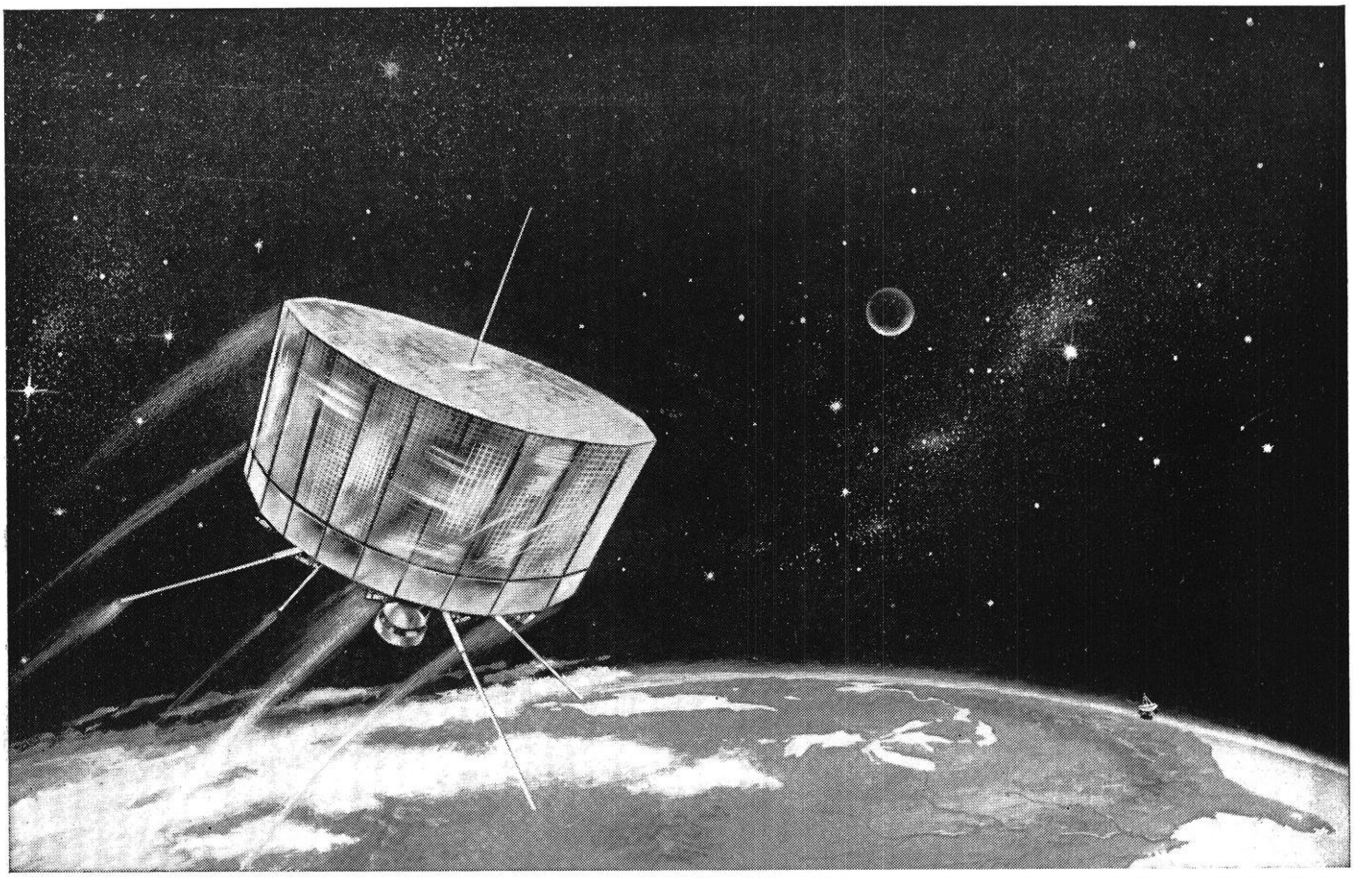

TIROS satellite orbiting towards ground station in Eastern United States.

RCA-BUILT "TIROS" SATELLITE REPORTS WORLD'S WEATHER FROM OUTER SPACE

As you read these lines, the most remarkable "weather reporter" the world has ever known hurtles around our globe many times a day, hundreds of miles up in outer space.

The TIROS satellite is an orbiting television system. Its mission is to televise cloud formations within a belt several thousand miles wide around the earth and transmit a series of pictures back to special ground stations. Weather forecasters can then locate storms in the making . . . to help make tomorrow's weather forecast more accurate than ever.

The success of experimental Project TIROS opens the door to a new era in weather forecasting—with benefits to people of all lands. This experiment may lead to advanced weather satellites which can provide weathermen with hour-by-hour reports of cloud cover prevailing over the entire world. Weather forecasts, based on these observations, may then give ample time to prepare for floods, hurricanes, tornadoes, typhoons and blizzards—time which can be used to minimize damage and save lives.

Many extremely "sophisticated" techniques and devices were required to make *Project TIROS* a success—two lightweight satellite television cameras, an infra-red horizon-locating system, complex receiving and transmitting equipment, and a solar power supply that collects its energy from the sun itself. In addition to the design and development of the actual satellite, scientists and engineers at RCA's "Space Center" were responsible for the development and construction of a vast array of equipment for the earth-based data processing and command stations.

Project TIROS was sponsored by the National Aeronautics and Space Administration. The satellite payload and ground station equipment were developed and built by the Astro-Electronic Products Division of RCA, under the technical direction of the U. S. Army Signal Research and Development Laboratory.

The same electronic skills which made possible the success of man's most advanced weather satellite are embodied in all RCA products—RCA Victor black & white and color television sets, radio and high-fidelity systems enjoyed in millions of American homes.

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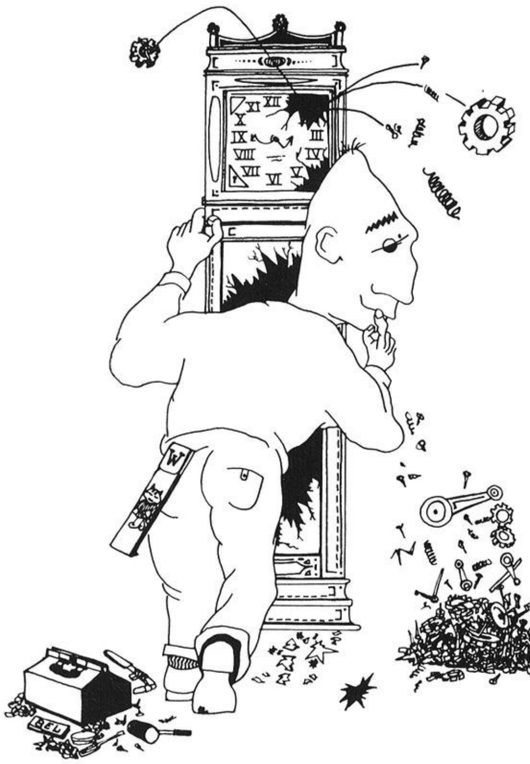


STRIPPED GEARS

by Todd S. Deutsch

"A sense of humor is the oil of life's engine. Without it the machinery creaks, squeaks, and groans. No lot is so hard, no aspect of things so grim, but that it relaxes before a hearty laugh."—TSD

Betcha Didn't Know

1. *That an angel is just a pedestrian who jumped too late.*
2. *The most delightful is the one that keeps you from going some where you didn't want to go.*
3. *It's practically impossible to tell where an orderly woman will put things.*
4. *My friends laughed at these jokes not because I'm funny, because they are.*
5. *I got a lot of birthday presents that were just what I needed to exchange for exactly what I wanted.*

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 the 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."

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."

Thought of the Month

The shortest way to do many things is to do only one thing at a time.

—Richard Ceck

Little Boy: "May I come in your yard and get my arrow?"

Neighbor: "Yes, where did it fall?"

Boy: "I think it's stuck in your cat."

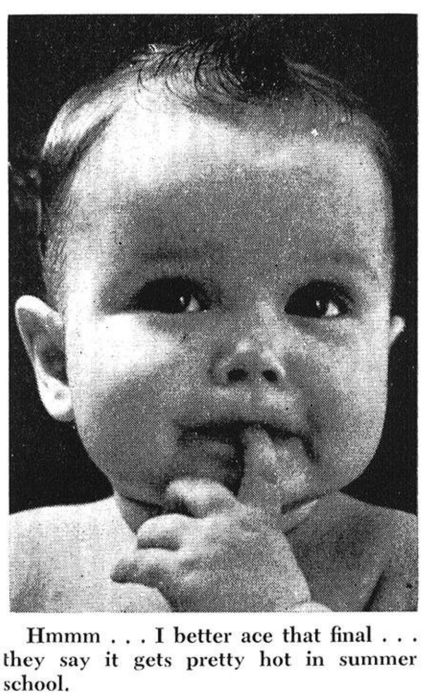
Art Student: "I've got a splinter in my finger."

Engineer: "Been scratching your head again."

According to math majors, golf is a game in which one ball 1½ inches in diameter is placed on another ball 8,000 miles in diameter. The object is to hit the small ball, but not the large one.

The young lady eyed her escort with disapproval. "That's the fourth time you've gone back for more punch, Horace," she said coldly. "Doesn't it embarrass you at all?" "Why should it?" the engineer shrugged. "I keep telling them I'm getting it for you."

Sneedly, Jr.



Hmmm . . . I better ace that final . . . they say it gets pretty hot in summer school.

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!"

A quiet little freshman co-ed from the country was on her first college date, and thrilled beyond words. She didn't want to appear "countrified", so she put on her prettiest dress, got a sophisticated hair-do, and was all prepared to talk understandingly about music, art, or politics.

Her date took her to a movie and then to the favorite college bar.

"Two beers," he told the waiter.

She, not to be outdone, murmured, "The same for me."

History Prof: "What is a monarchy?"

M.E.: "A people governed by a king."

History Prof: "Who would reign if the king would die?"

M.E.: "The queen."

History Prof: "And if the queen should die?"

M.E.: "The Jack."

If all the freshmen in the world were placed in a line holding hands, they would reach more than halfway across the ocean.

A lot of seniors would be in favor of this scheme.

It seems that a co-ed on the hill was in the habit of sending notes to her professors and signing them appropriately. Thus to her english prof, "Literally yours." To her math prof, "Mathematically yours," and to her history prof, "Historically yours." And this semester she took anatomy.

C.E.: "Have you heard about the girl they call turnpike because there isn't a curve in sight?"

"Where's my slide rule, Glouster?!!"

Grandmother was a diabetic patient and, although put on a strict diet, she would not conform to all of the Doctor's orders and was "cheating" all the time. After numerous violations, she was sent to the hospital.

Owing to the crowded condition of the hospital, the only available room was in the maternity ward. After she had been there a few days her little granddaughter paid her a visit. As the little girl was lolling in front of her grandmother's room, some visitors walked past. "What are you doing here?"

"I'm visiting my grandmother."

"Grandmother!" said one of the visitors in astonishment. "What is she doing here?"

"Oh," said the youngster, "She's been cheating again."

Professor: If I talk too long, it's because I forgot my watch and there's no clock in this hall.

Ci.E.: "There's a calendar behind you."

During mock maneuvers the army commander ordered a sign to be displayed on a bridge stating: "This bridge has been destroyed by air attack." But to his chagrin, he noticed through his field glasses that a foot regiment was crossing the bridge despite his orders. He sent his adjutant to the officer in charge to find out how he dared to defy his orders. An hour later the adjutant was back. "It's all right, sir," he reported. "The troops are wearing signs saying, "We are swimming!"

"Junior, I saw you kick your little next-door neighbor. Why?"

"I was tired of playing with him and I wanted him to go home!"

"Why didn't you just ask him to go home?"

"Why, Daddy! That wouldn't have been polite."

••••

Heard any good jokes lately? Send them to "Stripped Gears" c/o Wisconsin Engineer, 333 M.E. Bldg. One dollar will be awarded for each joke used.

Chain Conveyors

(Continued from page 14)

similar pieces. They are commonly found in bottling plants, along assembly lines of small unit items, and in foundries handling a large number of castings.

Recently a modification of this conveyor has been adapted to the handling of bulk material. The movement is accomplished by forming a chain of H-shaped links. The bulk material to be handled is then placed upon the conveyor and is carried away. Such an installation is likely to be found in a sawmill or papermill as a refuse conveyor or in a similar application.

As with all conveyors there are limitations to this type of installation. Because the material being handled is carried above or directly on the conveyor, special precautions must be taken to guard against dust, corrosion, and wear. Failure is likely to occur if the material being handled happens to drop into the working mechanism. Temperature also becomes an important factor in this conveyor's operation. The Link-Belt Company suggests that a special investigation of the installation be made if operating temperatures are above 500°F.

Variations Possible

This mechanism can be mounted in such a way as to carry material from one operation or machine to another. It can be either unidirectional or bi-directional depending upon the type of drive unit installed. This equipment is used primarily for horizontal movement. It can be adapted to inclines or declines if certain refinements, such as a push or cross bar, are added to prevent slippage.

Performance Characteristics

The slat conveyor gives continuous service, with the frequency of moves depending on the weight and size of the material being handled. It can handle very heavy loads, a weight of 2500 lbs. not being uncommon. Distances serviced by the heavy load conveyor are usually held to below 300 feet. The drives of the installation depend on the variables such as weight, load size, frequency of moves, and length of haul. The drive must therefore be selected individually for each installation.

By its very nature, the slat chain conveyor is limited to flat bottomed packaged material. However, with the new developments and modifications it can be used to handle bulk material, irregularly shaped units, and packaged goods and parts. It remains a flexible member of the conveyor family and continues to be widely used throughout industry.

FLIGHT CHAIN CONVEYOR

Basic Components

The flight chain conveyor, the most recent development in the chain conveyor family, is used for the movement of bulk material. This movement is accomplished by moving the material through troughs and passages in which a chain with attached scoops is run.

Practical Applications

The flight chain has found wide application in the handling of bulk animal feed, coffee, corn, flour, and grain. Because it handles this type of material, outdoor installations are very common. Its application is limited by such things as:

1. The moisture content of the material.
2. The weight of the material handled.
3. The drive efficiency of the motor over a varied set of operating conditions.
4. The danger of "dust" explosions.

Performance Characteristics

Since this type of equipment is a fairly recent development, there is no standard data available which pertains to drives, serviceable distances, and speeds.

It is known however that the movement is continuous, that upgrades and downgrades are possible, and that it can be run in either direction. This last characteristic means that it can be run both as a loader and unloader of material.

Because this is a recent development, there is as yet no set standard for rating this type of conveyor. Each manufacturer has his own method of computing the variables. For these reasons it is recommended that each contemplated installation be studied individually by someone who is completely familiar with this type of equipment.

It must be remembered that each conveyor discussed in this report is a separate mechanism. Although there may be a few factors common to all of them, there are limitations and problems which are peculiar to each one. For this very reason, the fact that each is really basically different from the others, no general statement concerning chain conveyors can be made.

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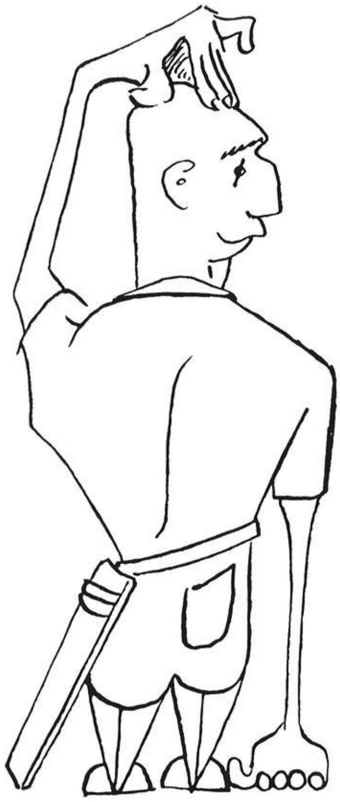


So You Think You're SMART!

by Sneedly, Law'65

WHAT is the hardest month of the school year to be an engineer? May, of course. This month only the most ambitious and most motivated engineers are getting their reports in on time. And those reports certainly have a horrible, mysterious way of piling up about now.

How should you arouse yourself from your annual spring stupor? I have no positive suggestions, but here are a few negative ones.

1. Don't even think of, much less go near, Picnic Point.

2. Stay away from all piers and beaches. Don't rationalize and tell yourself that your'e only going out in the sun to study.

3. Always remember that tennis, sailing, and golfing are reserved exclusively for English students and Home Ec majors.

If you do succumb to any of the pleasures, relax and think of my theme song, "Mañana".

The answers to April's problems are:

1. The length of CD is 9.2 inches.

2. Trial and error for this one. A fairly recent year must be in the 1940's or 1950's. In this recent year my son was married, so it is possible that he was then in his early twenties and my father in his sixties. This condition suggests 26 and 62 but their product is 1612 and surely my son was not married then. So my father might be in his seventies. Try 27 and 72. This gives 1944 when multiplied, and is the only possible solution. I must be 54.

3. He divides the group into three parts of three, three and two. He then weighs the three against the three. If they balance, the bad coin is one of the remaining two, which another weighing will quickly reveal. If they do not balance, he weighs two of the group of three that was heaiver on the first weighing. If these two balance, the bad coin is the one left out. If they do not balance, the bad coin is the heavier of the two.

Now for this month's problems and your last chance to pick up an easy ten dollars for sending in the first set of correct answers.

1. Connect all the dots in the pattern below with four *continuous* straight line segments.

• • •
• • •
• • •

2. Can you make 1000, using only eight 8's? You may use any process in arithmetic to solve the problems. To illustrate: in order to make 100 with four 9's we could write 99 9/9 or to make 5 with three 5's we could write 5/5 x 5.

3. For all the clock watchers in the crowd. Jack and Ed were to meet at the railroad station to make the eight o'clock train. Jack thinks his watch is twenty-five minutes fast, while in fact it is ten minutes slow. Ed thinks his watch is ten minutes slow, while in reality it has gained five minutes. What is going to happen if both, relying on their watches, try to be at the station five minutes before the train leaves.

In response to a few comments by some "on the ball" engineers, I will make it a habit to print the name of the winner from the previous month each time, so those concerned may be duly consoled. The winner from last month (April 1960) was Jerome Hanson, 716½ W. Dayton St.

Send your answers with your own name and address to:

SNEEDLY
c/o 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).

LAST YEAR'S WINNERS

P. C. Owzarski
March '60

Joel Barlow
February '60

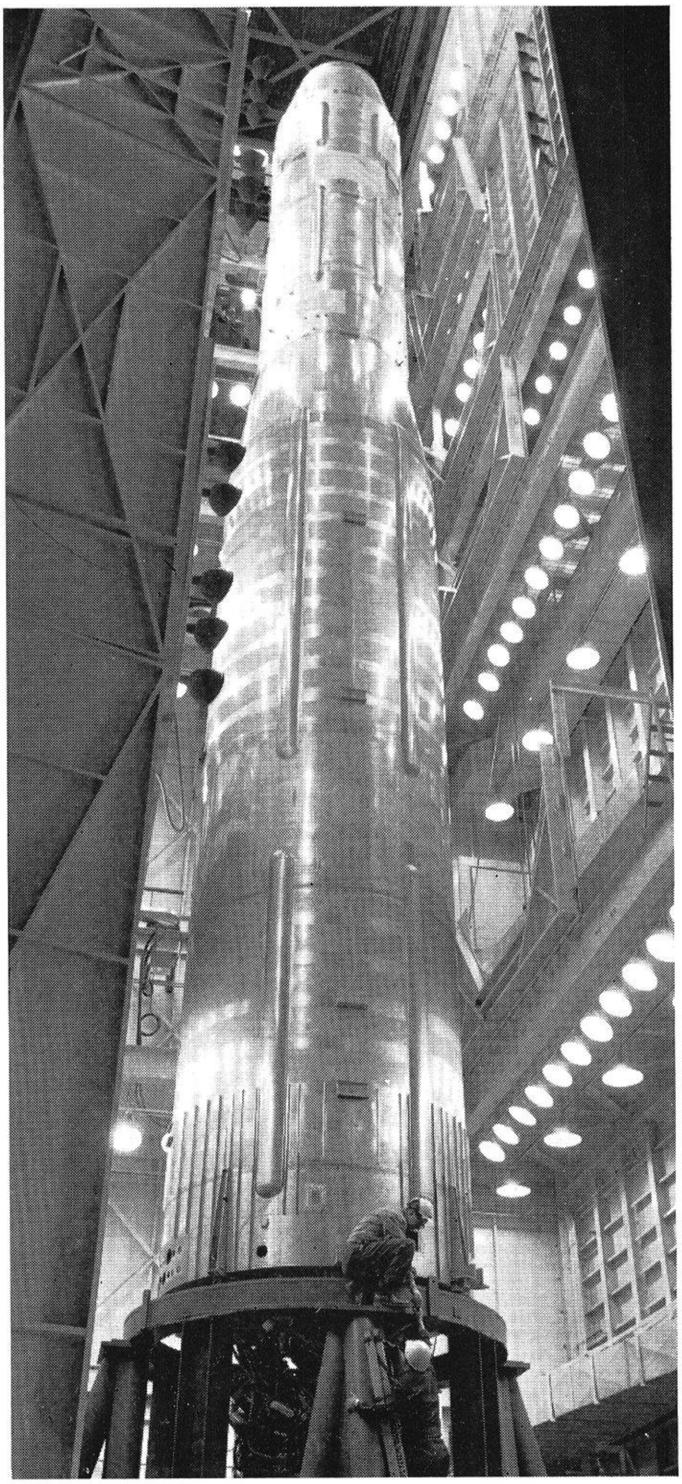
Joseph C. Kopeck
January '60

Kenneth Gasper
December '59

Joseph C. Kopeck
October '59

If your sights are set 

on outer space–



U.S. Air Force I.C.B.M. "Titan" shown in the vertical test laboratory at the Martin Company, Denver, Colorado.

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TRADEMARK

One of a series

Interview with
General Electric's Byron A. Case
Manager—Employee Compensation Service

Your Salary at General Electric

Several surveys indicate that salary is not the primary contributor to job satisfaction. Nevertheless, salary considerations will certainly play a big part in your evaluation of career opportunities. Perhaps an insight into the salary policies of a large employer of engineers like General Electric will help you focus your personal salary objectives.

Salary—a most individual and personal aspect of your job—is difficult to discuss in general terms. While recognizing this, Mr. Case has tried answering as directly as possible some of your questions concerning salary:

Q Mr. Case, what starting salary does your company pay graduate engineers?

A Well, you know as well as I that graduates' starting salaries are greatly influenced by the current demand for engineering talent. This demand establishes a range of "going rates" for engineering graduates which is no doubt widely known on your campus. Because General Electric seeks outstanding men, G-E starting salaries for these candidates lie in the upper part of the range of "going rates." And within General Electric's range of starting salaries, each candidate's ability and potential are carefully evaluated to determine his individual starting salary.

Q How do you go about evaluating my ability and potential value to your company?

A We evaluate each individual in the light of information available to us: type of degree; demonstrated scholarship; extra-curricular contributions; work experience; and personal qualities as appraised by interviewers and faculty members. These considerations determine where within G.E.'s current salary range the engineer's starting salary will be established.

Q When could I expect my first salary increase from General Electric and how much would it be?

A Whether a man is recruited for a specific job or for one of the principal training programs for engineers—the Engineering and Science Program, the Manufacturing Training Program, or the Technical Marketing Program—his individual performance and salary are reviewed at least once a year.

For engineers one year out of college, our recent experience indicates a first-year salary increase between 6 and 15 percent. This percentage spread reflects the individual's job performance and his demonstrated capacity to do more difficult work. So you see, salary adjustments reflect individual performance even at the earliest stages of professional development. And this emphasis on performance increases as experience and general competence increase.

Q How much can I expect to be making after five years with General Electric?

A As I just mentioned, ability has a sharply increasing influence on your salary, so you have a great deal of personal control over the answer to your question.

It may be helpful to look at the current salaries of all General Electric technical-college graduates who received their bachelor's degrees in 1954 (and now have five years' experience). Their current median salary, reflecting both merit and economic changes, is about 70 percent above the 1954 median starting rate. Current salaries for outstanding engineers from this class are more than double the 1954 median starting rates and, in some cases, are three or four times as great.

Q What kinds of benefit programs does your company offer, Mr. Case?

A Since I must be brief, I shall merely outline the many General Electric employee benefit programs. These include a liberal pension plan, insurance plans, an emergency aid plan, employee discounts, and educational assistance programs.

The General Electric Insurance Plan has been widely hailed as a "pace setter" in American industry. In addition to helping employees and their families meet ordinary medical expenses, the Plan also affords protection against the expenses of "catastrophic" accidents and illnesses which can wipe out personal savings and put a family deeply in debt. Additional coverages include life insurance, accidental death insurance, and maternity benefits.

Our newest plan is the Savings and Security Program which permits employees to invest up to six percent of their earnings in U.S. Savings Bonds or in combinations of Bonds and General Electric stock. These savings are supplemented by a Company Proportionate Payment equal to *50 percent* of the employee's investment, subject to a prescribed holding period.

If you would like a reprint of an informative article entitled, "How to Evaluate Job Offers" by Dr. L. E. Saline, write to Section 959-14, General Electric Co., Schenectady 5, New York.

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