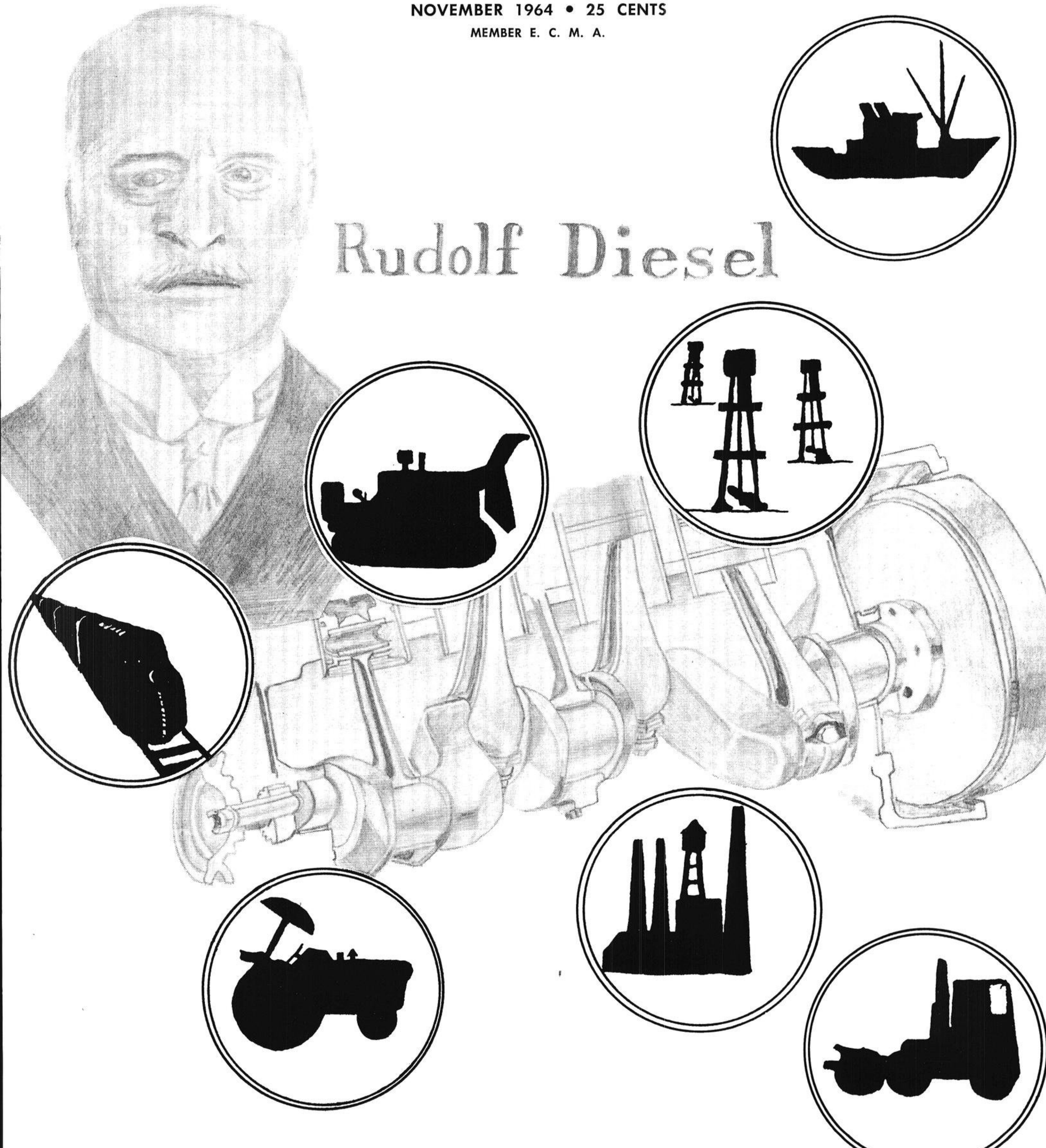
The Wisconsin engineer. Volume 69, Number 2 November 1964

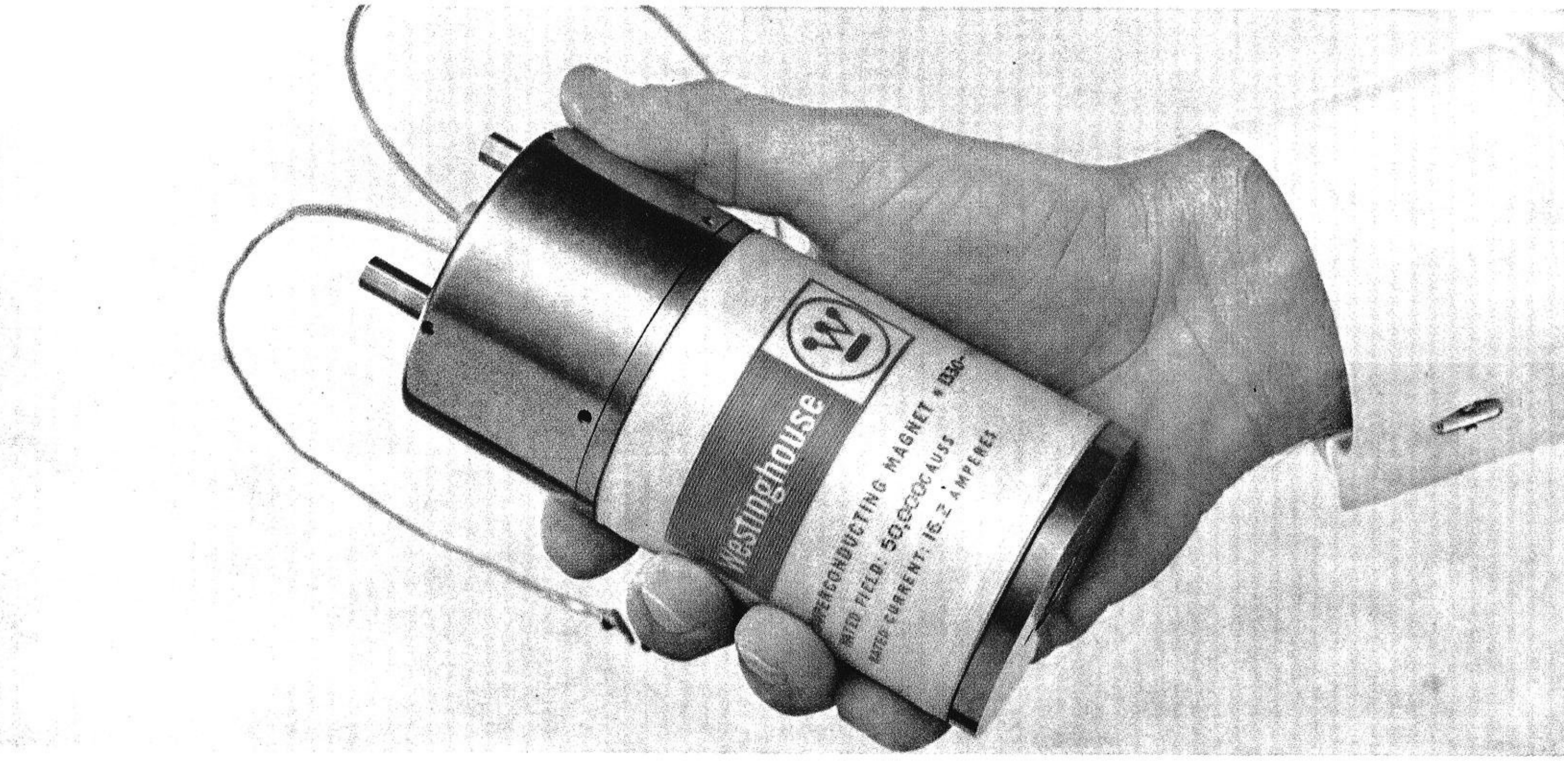
Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

https://digital.library.wisc.edu/1711.dl/7P3DBZ6M5SIJV8I

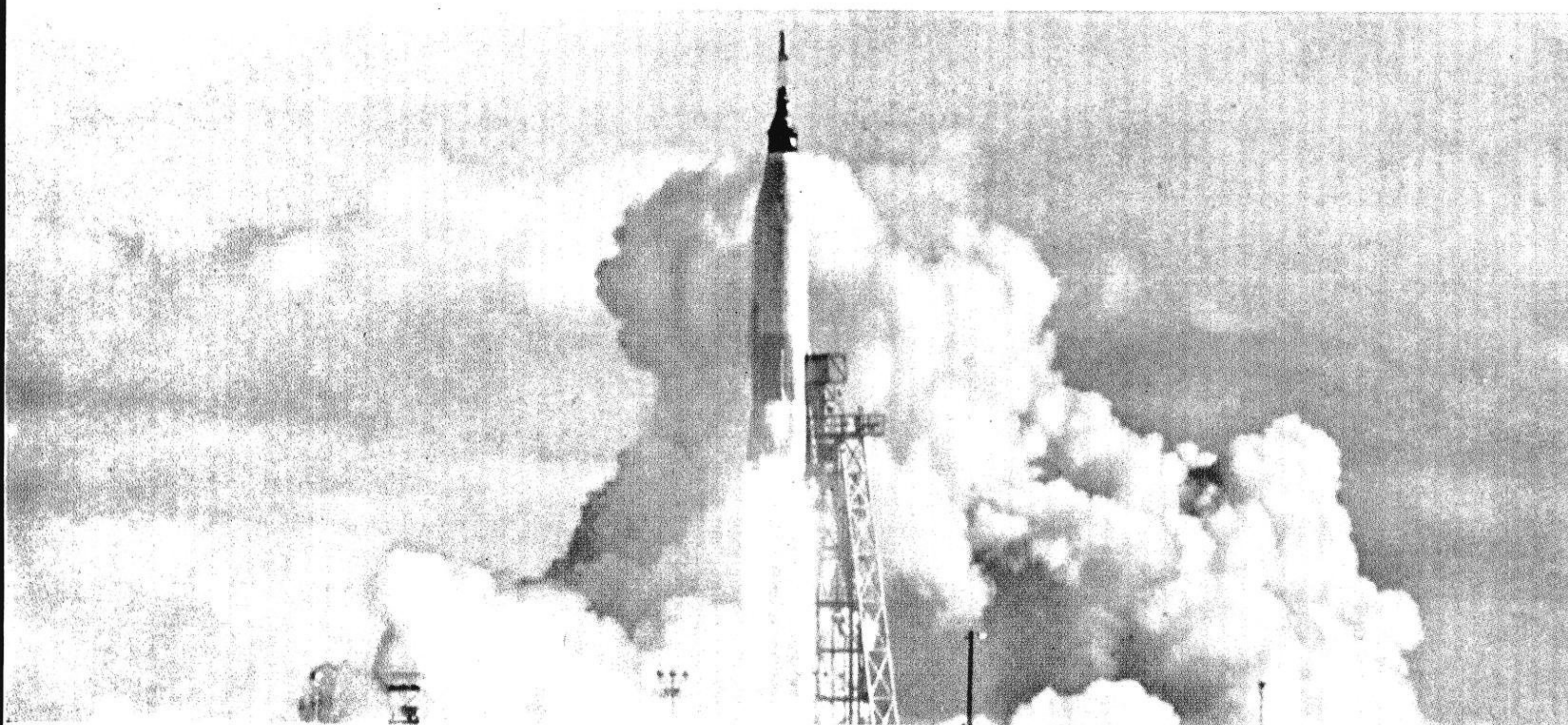
THE WISCONSIN ENGINEER

NOVEMBER 1964 • 25 CENTS
MEMBER E. C. M. A.





Why would a scientist pay $3200 for this little coil of wire from Westinghouse?



Because it is leading to new discoveries in physics, electric power and space travel.

The little coil is made with a most remarkable wire. Cooled to 452°F below zero, it becomes a super-conducting magnet.

In labs all over the country, scientists are using the Westinghouse super-magnet to explore ideas like generating electric power directly from a stream of hot gases; building new kinds of atom smashers; developing power systems for long-distance space travel and communications.

The Westinghouse super conducting magnet operates on less power than an ordinary light bulb. But it has twice the strength of an electro-magnet weighing 20 tons and using 100,000 watts of electricity.

That's why this little Westinghouse magnet is a bargain at $3200.

You can be sure if it's Westinghouse

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

November in Brief

In case you haven't already guessed, our lead article this month is about the Diesel engine. Jim Tyndall depicts Rudolf Diesel and some of the visions he may have had about the future uses of his revolutionary invention.

Beginning on page 12 is "The High-Speed Diesel Engine," by Jaime A. Ricart-Lowe. A bachelor hailing from the Dominican Republic, Jaime is a first year graduate student specializing in internal-combustion engines. He plans to get his PhD in preparation for a teaching and research career. In addition to being active in SAE and ASME, Jaime was Chairman of the Lakeshore Halls Association Film Committee last year. Photography and electronics take up his spare time. We think you'll find his detailed presentation of the development, design, and applications of the engine in question quite interesting.

Howard Berry wrote "Unions For Engineers" (page 18) prior to receiving his BSME last June. A bachelor currently employed by Rex Chainbelt, Inc. in Milwaukee, Howard was active in Tau Beta Pi and ASME while here at UW. His objective discussion of the case for and against engineering unions prompted us to go out on a limb in our editorial, found on page 11. Now that the election is over we feel that the time has come for a new controversy.

As you'll note by reading the Letters to the Editor, our past month's mail was saturated with complaints about the omission of our infamous humor page. Reader pressure has caused us to succumb, even though the professional standing of our publication will suffer. Anyway, enjoy it! Also, watch next month's *Engineer*, out Dec. 15th, for a special Christmas present for your weary eyes—Miss Santa Claus, circa 1964, that girlie feature you all like so well. We'll also have a last-minute shopping guide of gifts that you'd love to get, and may even want to give away. See you then!

Why become an engineer at Garrett-AiResearch? You'll have to work harder and use more of your knowledge than engineers at most other companies.

If you're our kind of engineer, you have some very definite ideas about your career.

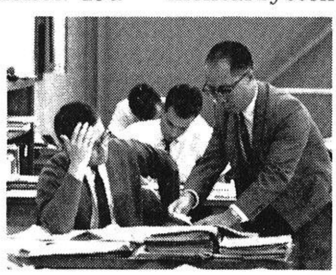
For example:

You've worked hard to get a good education. Now you want to put it to work in the best way possible.

You will never be satisfied with run-of-the-mill assignments. You demand exciting, challenging projects.

You not only accept individual responsibility – you insist upon it.

Does that sound like you? Then AiResearch is your cup of tea.



Our business is mainly in sophisticated aerospace systems and subsystems.

Here, research, design, and development lead to production of actual hardware. That means you have the opportunity to start with a customer's problem and see it through to a system that will get the job done.

The product lines at AiResearch, Los Angeles Division, are environmental systems, flight information and controls systems, heat transfer systems, secondary power generator systems for missiles and space, electrical systems, and specialized industrial systems.

In each category AiResearch employs three kinds of engineers.

Preliminary design engineers do the analytical and theoretical work, then write proposals.

Design engineers do the layouts; turn an idea into a product.

Developmental engineers are responsible for making hardware out of concepts.

Whichever field fits you best, we can guarantee you this: you can go as far and fast as your talents can carry you. You can make as much money as any engineer in a comparable spot – *anywhere.* And of course, at AiResearch, you'll get all the plus benefits a top company offers.

Our engineering staff is smaller than comparable companies. This spells opportunity. It gives a man who wants to make a mark plenty of elbow room to expand. And while he's doing it he's working with, and learning from, some of the real pros in the field.

If the AiResearch story sounds like opportunity speaking to you—don't fail to contact AiResearch, Los Angeles, or see our representative when he comes to your campus.

We'll be happy to talk to you – about *you* and *your* future.

And put this in the back of your mind:

In a field where meeting challenges pays off in rewards...

AiResearch *is* challenge

An equal opportunity employer

AiResearch Manufacturing Division Los Angeles

Your life at Du Pont...
one of a series for technical graduates

How to join Du Pont closest to the top

Join us right out of school. Few men start higher at Du Pont —or with more promise—than graduating engineers. That's because we fill virtually all important positions from within.

It's a policy that's helped us grow 750% since 1937. Since 1950 our sales have more than doubled from $1 billion to $2.4 billion. Forty thousand new employment opportunities and 50% of our 1962 sales volume came from products created by Du Pont research in the last 28 years!

And because new products continually emerge from our research labs, responsible new career opportunities constantly spring up for our technical men. In fact, there's room for you to actually "change jobs" within Du Pont—to seek out the spot best suited to you without loss of your accrued benefits.

Consider us if you're ready to make your career decision. You may be closer to the top than you think! Write us a letter, or mark and mail our coupon today!

DU PONT
REG. U.S. PAT. OFF.

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

An equal opportunity employer

Technical men we'll especially need from the Class of '65

Chemists	Mechanical Engineers
Chemical Engineers	Industrial Engineers

E. I. du Pont de Nemours & Co. (Inc.)
2531-B Nemours Building
Wilmington, Delaware 19898

When I'm graduated, I'll be a ______________
(List profession)

Please send me more information about how I might fit in at Du Pont.

Name______________

Class________ Major__________ Degree expected__________

College______________

My address______________

City__________ Zone________ State__________

LETTERS

ENGINEER:

Please prepare to cancel my subscription immediately unless you can assure me that they will be included in all subsequent issues. Admittedly they weren't always good (i.e. bad), but they were one of the highlights of each issue.

R. D.
Madison

★

ENGINEER:

What ever happened to the good old days when each issue of the *Wisconsin Engineer* had at least 2 pages of jokes? If this is progress, what a product!

J. M.
Madison

(The response to our omission has been overwhelming. As a result we have obtained a censor of sorts and reinstated our joke page, under the new title of "Printables.")

★

ENGINEER:

We wish to compliment you on the high quality of the editorial content of your October 1964 issue. Keep up the good work of leaving the jokes out!

High School Librarians
Association, WCTU
and others

(Sorry, but we have to please the majority of our (corrupted) readers.)

★

ENGINEER:

Bring back the Girl-of-the Month! Now!

R. T.
Madison

(Anything you say. Wait for our December issue.)

MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman: PROF. J. R. BISSETT, Dept. of Civil Engineering, University of Arkansas, Fayetteville, Arkansas 72701.

Publishers Representatives: LITTELL–MURRAY–BARNHILL, INC., 369 Lexington Avenue, New York, New York 10017.

Second Class Postage Paid at Madison, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at a special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized Oct. 21, 1918.

Published monthly from October to May inclusive by the Wisconsin Engineering Journal Association, 333 Mechanical Engineering Building, Madison, Wisconsin 53706. Editorial Office Hours 2:30–4:30 Tuesday & Thursday. Office Phone (608) 262–3494.

VOLUME 69, NUMBER 2 NOVEMBER 1964

ARTICLES

THE WISCONSIN ENGINEER

The Student Engineer's Magazine Founded in 1896

FEATURES

SUBSCRIPTION PRICE

$4.00 FOR FOUR YEARS $1.25 FOR ONE YEAR

SINGLE COPY 25¢

Work for a bearing and steel company? What's exciting about that?

Nothing—if you're bored by Project Mohole, turbine engines, the world's tallest crane, and biggest strip-mining shovel, a telephone cable-laying ship now crossing the Pacific, space exploration, the Spirit of America race car, the Alweg Monorail, a moveable grandstand for the new District of Columbia Stadium, Atlas missiles and defense work—

They're all recent projects involving The Timken Roller Bearing Company, world's largest manufacturer of tapered roller bearings and a leading producer of fine alloy steel.

The Timken Company is the world's largest because our engineers developed tapered roller bearings that revolutionized our "meat and potatoes" markets in the Automotive, Railroad, Farm and Construction machinery industries.

At the Timken Company you receive up to four years' training in one or more of 22 training programs —80% of which are for young engineers.

Instruction takes place on the job and in the classroom. With pay. And we participate in executive development programs at well-known universities.

If you come with us, you can be an indoor-type working in straight research, testing and production. Or you can be an indoor-outdoor-type and become a sales engineer, helping customers solve *their* design problems, which are also *ours*.

You'll work with one of three products: Bearings, Steel or Rock Bits. Uses for these products number in the growing thousands.

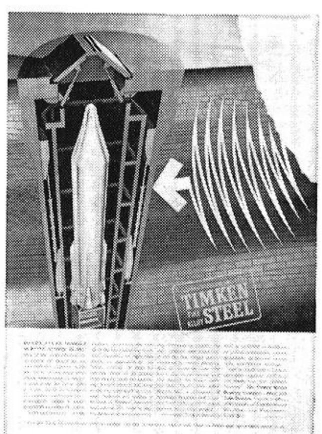
There are 31 Timken Company domestic sales offices in the United States and Canada. Practically every major city has one.

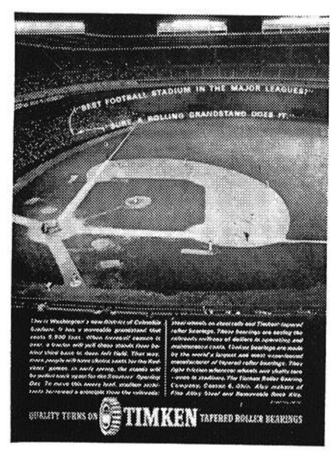
We serve markets in 119 countries from 14 manufacturing plants in England, France, Australia, South Africa, Canada, and the U. S.

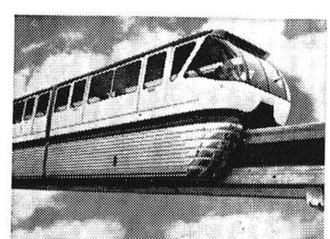
And we're still growing.

So if you're interested in our kind of work, why not get in touch with us? Write Dept. MC for our 12-page career booklet.

The Timken Roller Bearing Company, Canton, Ohio 44706. *An equal opportunity employer.*







Across the Editors Desk

ON UNIONS

We are happy to have the opportunity to print Howard Berry's article "Unions For Engineers" (p. 18) and hope that all of our readers find time to read and digest it.

Professional unions are reality, today, whether we like it or not. Whether they prosper or perish will be decided by each of us as we take our places in the outside world after graduation. A feud is in the making and in a few short years we may all become deeply involved in it, involuntarily or of our own will.

Although we may not necessarily admit it, the salary which we will receive for our services is important to us. Perhaps this was a major reason for our choice of engineering as a career. The unions have existed on this fact from their beginning. We cannot condemn the unions but rather question their validity for professional men. Have the unions overlooked the simple fact that the men they attempt to organize as labor (professional though they may be) are the same men who are constantly sought after by management as trainees in that field.

While we have to at the moment side with the professional societies and their anti-union feelings, this magazine cannot go any further out on the limb, primarily because we feel students are certainly not qualified and experienced enough to make a definite decision on the matter. Nevertheless, there are still many unanswered questions and projections to the future. In light of this, the *Wisconsin Engineer* invites its readers to let their feelings be known through a forum on these pages. Who says all the "sifting and winnowing" at UW must take place on the Hill? Being future graduates of one of the nation's leading Engineering schools, we should be prepared to accept the challenge of professional leadership.

R. J. Smith

The High Speed Diesel Engine

Its Design and Importance

By JAIME A. RICART-LOWE

THE high-speed diesel engine has been in the market for more than thirty years now. However, it was not until the last decade or so that this type of engine started gaining popularity in the U. S. This was due mainly to the improved combustion and injection methods. The combustion of the fuel in the diesel engine is one of the most important considerations when designing a high-speed diesel engine. The combustion methods used in high-speed diesel engines are: the pre-combustion chamber, the turbulence chamber, the air cell chamber, and the direct-injection chamber. As the speed of the high-speed diesel engines increases, so does the importance of the injection system, which must inject minute and accurately measured amounts of fuel into the cylinder at the proper time. The injection systems commonly used today are the individual pump system and the distributor system. High speed diesel engines are preferred over low- and medium-speed diesel engines, because of high-speed diesel engine higher power to weight ratio. Due to the increased cost of lighter fuels — like gasoline — the high-speed diesel engine is bound to become more and more important in the near future.

Before reviewing the design characteristics of the present day diesel engines, it is worthwhile to cover some of the historical and theoretical background of these engines.

HISTORICAL BACKGROUND

Two men are generally credited with the development of the compression-ignition (diesel) engine. Though the English inventor Herbert Ackroyd-Stuart with his improvements of the oil engines of the 1880's can be said to have been an early contributor to the principles of the diesel engine, it was the German scientist Dr. Rudolf Diesel who developed the theory of the compression-ignition engine in 1892, and who was the first one to build a successful engine working on the new cycle, in 1897.

The engines built before the mid 1920's were along the lines of the massive reciprocating steam engines that were used in ships at that time. Diesel engines were restricted to the marine field, because of their large size. As early as 1909, however, Dr. Diesel had built a small engine for experimental purposes. This engine had an output of thirty horsepower at 600 rpm.

It was not until 1919 that serious research work was started in the quest for a high-speed diesel engine. At this point, several definitions are in order. A high-speed diesel engine runs above 1,500 rpm while a slow-speed diesel engine runs below 250 rpm. Medium-speed diesel engines fall between these two extremes.

The development of a high-speed diesel engine was undertaken by Daimler-Benz A. G. of Mannheim, Germany in 1919. This research resulted in an engine that had an output of 50 bhp at 1,500 rpm. Further research by the same company on this crude engine produced an improved engine in 1929. The output of this latter engine was 60 bhp at 1,500 rpm. This Mercedes-Benz (trade mark of Daimler-Benz A. G., Mannheim, Germany) engine became the prototype of the high-speed diesel engines that were used in Europe during the 1930's. Further development of the high-speed diesel engine was stopped by World War II.

In the U. S. the diesel engine was slow to become popular, because of the excess of gasoline available here during those years. It was during the post war years that changes were made in the designs of the early 30's. In the last fifteen years great strides have been made in the improvement of compression-ignition engines. It has been in this last fifteen years that the high-speed diesel engine has started to gain popularity in the U.S. A present research program is designed to yield a very high-speed diesel engine.

THEORETICAL BACKGROUND

The diesel engine cycle as developed by Dr. Diesel can be represented on a pressure-volume diagram in Fig. 1. The processes that take place in the ideal air-standard cycle are as follows:

Process ab — Isentropic compression.

bc — Constant pressure addition of heat.
cd — Isentropic expansion.
da — Constant volume rejection of heat.

Dr. Diesel's original engine used air injection to inject the fuel into the cylinder so his experimental engines closely approximated the ideal cycle.

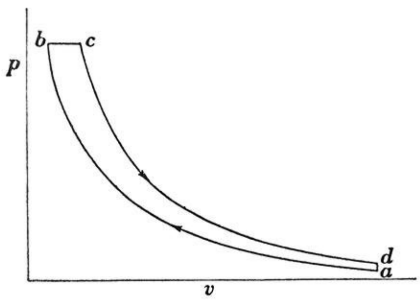


Figure 1.—Air-standard Diesel Cycle.

For reasons to be discussed later, air injection was found unsatisfactory, and solid injection took its place. Solid injection coupled with the high speeds of today's high-speed diesel engines have caused the modern diesel to work on a cycle that resembles the Otto cycle more than it does resemble the Diesel cycle.

The gasoline engine works on the Otto cycle, too. The following question might then pop up in your mind: If both engines work on the same cycle, what, then, is the difference between them? The difference resides mainly in the way the fuel is distributed to the cylinder and the way it is ignited. In a diesel engine the fuel is injected, at high pressure, into the cylinder, just before TDC (top dead center) in the compression stroke, i. e. just before the topmost point of travel of the piston. The injected fuel is then vaporized and ignited, not by a spark—like in the spark-ignition (gasoline) engine—but by the high temperature of the highly compressed air in the cylinder. Since only air is compressed by the piston in its compression stroke, there is no theoretical limit of how much this air can be compressed. In a gasoline engine, however, a mixture of air and fuel is compressed by the cylinder; therefore, the amount of compression is limited by the self-ignition temperature of the combustible mixture. If self-ignition of the mixture were allowed to take place, the so-called "knocking" of the engine would take place. The knocking is due to the sharp pressure rise that takes place when self-ignition occurs. The thermal efficiency of an internal combustion engine working on the Otto cycle is given by

$$N_t = 1 - \left(\frac{1}{r_v}\right) k$$

where, N_t = Thermal efficiency

r_v = Compression ratio = $\frac{\text{initial volume.}}{\text{final volume.}}$

k = Gas constant = $\frac{\text{Specific heat at constant press.}}{\text{Specific heat at constant vol.}}$

Since k is constant for the gas used, which is air in this case, it cannot be changed. Therefore the thermal efficiency of the cycle is a function of the compression ratio. It can be said from the equation that the engine that can achieve the higher compression ratio will be the more efficient one. Therefore, since the diesel engine can achieve higher compression ratios, it follows that it is more efficient than the gasoline engine.

With the theory in mind, we can now proceed to discuss the design characteristics of the combustion chamber of the high-speed diesel engine.

DESIGN CHARACTERISTICS OF COMBUSTION CHAMBERS

The design of the combustion chamber is one of the most important facets in today's high-speed diesel engines. Because the fuel is not introduced until the end of the compression stroke, the fuel has a short time to vaporize and form a combustible mixture with the air in the cylinder. In the slow- and medium-speed diesel engines, this is not a difficult proposition, because the fuel can be injected directly into the cylinder and it still has enough time to mix with the air before the piston reaches TDC. However, in a high-speed diesel engine, the amount of time available between the start of injection and the end of the compression stroke is very small so the combustion methods used in low- and medium-speed engines would be very wasteful. However, this problem has been solved by creating a very turbulent atmosphere in the cylinder just prior to injection. Several very ingenous ways have been used to achieve this end.

The Precombustion Chamber

The pre-combustion chamber is by far the oldest of the combustion methods in use. It was developed by Daimler-Benz A. G. of Mannheim, Germany, in 1928.

A cross-section of the pre-combustion chamber is shown in Fig. 2. The action is as follows: when the air is compressed in the cylinder a large amount of it is in the pre-combustion chamber, A; when the injection starts, a small amount of the injected fuel ignites. The amount of fuel that burns inside of the pre-combustion chamber is limited by the air present in the latter. This combustion process increases the pressure in the pre-combustion chamber. Due to this increase in pressure, the remaining fuel, together with the hot gases present in the chamber, is expelled at high speeds through the orifice B. This high-speed jet creates a turbulent atmosphere in the cylinder and, thus, the fuel is mixed intimately with air present in the cylinder. A glow plug, C, is provided for starting the engine in cold climates. The pre-combustion chamber is at present being used in engines whose speeds range up to 3,-500 rpm.

The advantages of the pre-combustion chamber are as the following:

1. Low injection pressures as compared with other types of combustion chambers, e.g. 1,-000 lb. per sq. in.
2. Maximum economy is obtained both under full and part load conditions.

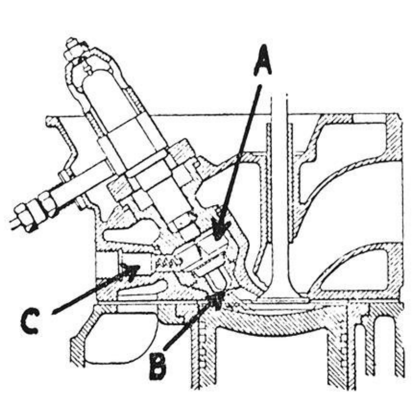


Figure 2.—Mercedes-Benz pre-combustion chamber.

3. Simple, single-orifice, nozzles can be used, because the fuel does not have to be atomized to any great extent.
4. Low-grade fuels can be used without harming performance.

The main disadvantage of the pre-combustion chamber is the fact that a large amount of heat transfer from the mixture to the surroundings takes place at orifice B. This results in higher fuel consumption than for other types of combustion chambers.

The performance of the pre-combustion chamber proved the advantages of a turbulent atmosphere. Further research resulted in the development of the next type of combustion chamber that will be reviewed.

The Turbulence Chamber

The turbulence chamber is actually a modification of the pre-combustion chamber. The action of the turbulence chamber combines effectively characteristics from both the pre-combustion chamber and the open or direct injection chamber (to be discussed later). The turbulence chamber is used very extensively and there are several good designs in the market. Here, two of the representative designs of the turbulence chamber will be reviewed—the Perkins chamber (British), and the Hercules Motor Co. (U. S. A.) chamber.

Perkins Combustion Chamber

The way that it works is as follows: the injection nozzle is of a special design that gives two streams of fuel: A small one directed towards the combustion chamber, and a large one directed towards the cylinder. The object of the small spray is to ensure an intimate mixing of the fuel and air, this mixing is achieved by means of a mass of swirling air in the chamber. This swirl is obtained by compression of the air in the cylinder as the piston approaches top dead center. Then the mixture in chamber ignites, and the burning mixture rushes out of the chamber. As the mixture rushes out it ignites the fuel that has already been injected into the cylinder by the nozzle.

The advantages of this type of chamber are:

1. Easy starting—no need for glow plugs.
2. Complete absence of "diesel knock", which results in very smooth running.
3. Very low injection pressures —850 psi.

The main disadvantage of the Perkins chamber is the need for a relatively expensive double-orifice nozzle.

The Perkins combustion chamber is used in all the engines manufactured by Perkins Motors. Speeds as high as 4,000 rpm have been achieved with it.

Hercules Combustion Chamber

In the Hercules combustion chamber, the manufacturers claim, the air charge receives a high rotational speed of fifty times the crankshaft rpm. The Hercules chamber was designed with the purpose of producing a very efficient combustion of the fuel. Experimental results show that up to 95% of the fuel supplied to the cylinder can be burned by this chamber. In the commercial engines 90% usage is claimed. This latter value is much higher than those for other types of combustion chambers in the market.

The way the Hercules combustion chamber works is basically the same as the Perkins chamber. The main difference lies in the method of producing the swirl. In the Hercules chamber, the swirl speed of the air is produced not only by compression of the air in the cylinder as the piston approaches top dead center, but by the fact that the piston itself reduces the effective area of the orifice as it approaches TDC.

The advantages of the Hercules chamber are the following:

1. Easy starting—no glow plugs needed.
2. Almost complete combustion of the fuel—complete lack of exhaust smoke and fumes.
3. Very easy to assemble the chamber in the engine block.

The disadvantages of the Hercules chamber are:

1. High injection pressure—1,650 psi.
2. Expensive pintle nozzle is needed.
3. Need for high grade fuel for smooth operation.

The next type of combustion chamber to be discussed is the type that uses a chamber or cell as a reservoir of air to produce a turbulent atmosphere.

The Air Cell Chamber

The air cell chamber, unlike the pre-combustion chamber and the turbulence chamber, uses a chamber or cell in which no fuel is injected at any time. The main purpose of the air cell is to insure a thorough mixing of the air and the fuel throughout the combustion process.

The best representative of the air cell chamber is that used in the engines manufactured by M. A. N. of Germany. The M. A. N. chamber is shown in Fig. 3. This chamber uses an atomizing nozzle to inject the fuel. Part of the fuel burns immediately in the area designated as combustion space. The purpose of the air cell, in which air has been compressed at very high pressures, is to initiate secondary turbulence in the combustion chamber by means of a stream of air. This turbulence is called secondary, because it does not become important until the last moments of the combustion process when its main purpose is to assure the combustion of any remaining fuel. Before injection starts there is a definite amount of turbulence in the combustion chamber due to com-

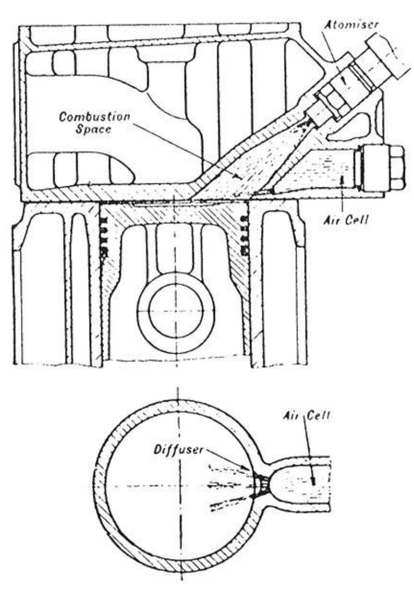


Figure 3.—M.A.N. Combustion Chamber.

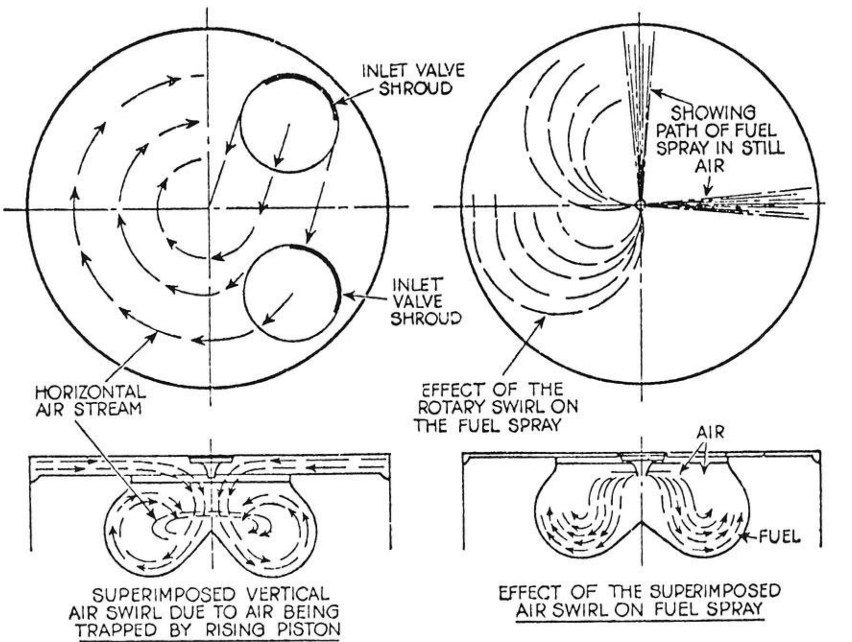


Figure 4.—Sauer dual-turbulence cylinder head.

pression of the air as the piston approaches top dead center. The turbulence caused by the escaping stream of air is superimposed on the turbulence caused by the piston or primary turbulence.

The advantages of the air cell chamber are:

1. Very smooth running.
2. Exhaust completely free of smoke and bad odor.
3. Easy starting—no need for glow plugs.

The disadvantages of the air cell chamber are:

1. Expensive atomizer is needed.
2. High injection pressures—2,000 psi.

The last chamber to be discussed is the direct injection combustion chamber which contrasts with those previously discussed involving an additional chamber.

It was stated at the beginning of this section on combustion chamber designs, that the early designers of high-speed diesel engines found direct-injection unsuitable for high speed operation. To a certain point this was right; however, today through ingenious design, the direct-injection chamber is perfectly fit for high-speed diesel engines.

The forerunner of the direct-injection chambers used today was the chamber designed by Saurer and Co. of Switzerland and introduced in 1934. Since most of the combustion chambers of this type in the market today are nothing but modifications of the original design, it will be reviewed here. The chamber and the air currents formed in it are shown in Fig. 4.

As it can be seen in Fig. 4, the intake valves have shrouds in them so as to direct the entering air in one direction. A note of explanation must be given here; the original design had four valves: two for intake and two for exhaust. However, modern combustion chambers of this design only have two valves. The piston head (crown) has a toroidal cavity in it, this cavity causes further turbulence to be given to the air, because of compression of the air as the piston approaches top dead center. The nozzle used with this chamber is a multi-hole one. As it is shown in Fig. 4, these holes are located every 90 degrees.

The main advantage of the direct-injection chamber is its economy. This economy is due to a reduced area presented to the burning charge and, thus, reduced heat losses.

The disadvantages of the direct-injection chamber are the following:

1. Speed is limited to around 2,400 rpm.
2. Operation tends to be rough, if low grade fuels are used.
3. Comparatively expensive nozzle and piston.
4. Shrouded intake valves might decrease the volumetric efficiency of the engine, if they are not properly designed.

Even with all these disadvantages, the direct-injection chamber is becoming more popular, because of its outstanding economy characteristics. This is mainly true in European countries, where fuel consumption is the most important consideration.

DESIGN CHARACTERISTICS INJECTION SYSTEMS

The injection system of the high-speed diesel engine is, by far, one of the most important parts of the engine, because the injection system must inject into the cylinder, at the proper time, accurately-measured minute amounts of fuel. In high-speed diesel engines the problem is complicated further by the fact that the fuel is compressible and the tubing is expandable. These properties cause severe problems, because when the pump pumps the fuel at high pressure this disturbance travels through the tubing as a high pressure region. In slow-speed engines this is no problem; however, in high-speed engines this pressure wave causes problems, because of the delay existing between the time that the fuel leaves the pump and the time that an equal amount of fuel is injected into the cylinder. It is this problem that has limited the speed of diesel engines to a maximum of 3,500 rpm. However, at least two companies have licked the problem and have built engines that can run as high as 10,000 rpm. Nothing more can be said about these engines and their injection systems, because the companies concerned have not released information about them to the public.

Three general types of injection systems are in use today. These systems are: the common rail system, the distributor system, and the individual-pump system. Of these the common rail is the oldest one in use. The distributor system is the newest one. The principle of each of these systems is shown in Fig. 5.

The Common Rail System

The common rail injection system was the first solid injection system to be used and to this day

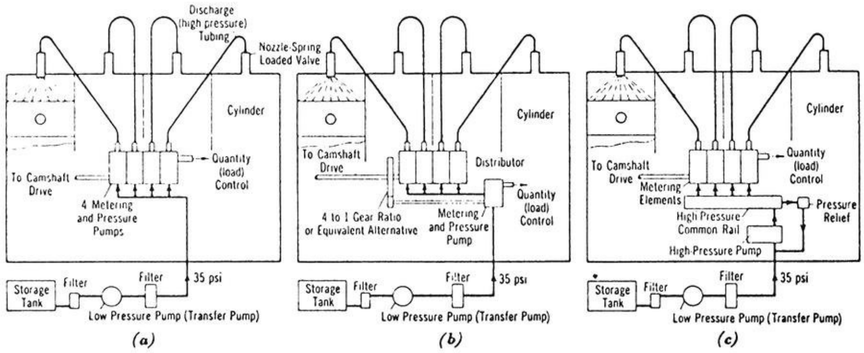


Figure 5.—Basic solid injection systems. (a) individual-pump, (b) distributor, (c) common-rail.

it is still used in slow- and medium-speed marine engines. As shown in Fig. 5-c, it consists of a low pressure pump connected to the fuel tank. This pump feeds the high-pressure pump which connects with the common rail to which individual injectors are connected by means of a valve. This valve is actuated at the proper time by a cam in a camshaft connected to the engine crankshaft. The original common rail system is shown in Fig. 6. In this system the amount of fuel injected was governed by the position of the wedge in the pushrod mechanism. The main fault with the original system was that if the valve did not seat well, there would be a continuous dribbling of fuel into the cylinder, causing large amounts of exhaust smoke and fouling of the engine.

The Individual Pump System

The individual pump system, shown in Fig. 5-a, is used in two manners—either as an individual pump in each cylinder and driven by a timing camshaft or as an *en-bloc* construction. The individual pump system was developed by a German inventor, Robert Bosch, in the 1920's. It was Bosch who put forth the idea of a high-pressure pump to each cylinder. He also founded a company, Bosch A. G. of Stuttgart, Germany, to build the pumps. To this day Bosch A. G. jointly with its American subsidiary, American-Bosch Corporation, remains the leader in the field of manufacturing individual pump systems. Due to this fact, the Bosch *en-bloc* injection pump will be discussed here.

In the Bosch pump, fuel is forced into it by means of a low pressure (25 psi) pump and through a fine filter. This low-pressure fuel enters into a sump which is connected through the ports to the plunger and barrel assembly. As the plunger compresses the fuel, the delivery valve opens and the fuel flows through the discharge tubing to the injector nozzle. The discharge of the fuel from the nozzle takes place through the orifice which is closed by a spring load valve and is opened by the pressure of the fuel in the discharge tubing. The plungers in the pump are driven by cams on a camshaft that is driven by the engine through gears. The way the pump meters and pumps the fuel is shown in Fig. 7.

When the plunger is at the bottom both ports, A and B, are uncovered, and fuel is forced into the barrel by the pressure existing in the fuel feed line. When the plunger rises it closes both ports, and the compressed fuel lifts the delivery valve. This action begins the injection period. As the plunger continues to rise, the helical grooves in it will uncover port B. This action is shown in Fig. 7. The uncovering of port B will occur at some point of the travel of the plunger. This point will be determined by the load that is placed on the engine at that particular time. The uncovering of the port B will cause the high-pressure fuel above the plunger to escape through slot S back into the sump, ending the injection period.

The metering of the fuel is accomplished by the position of the helical groove with respect to relief port B. This relative position is altered by means of a rack, and pinion system which rotates the plunger acting as a throttle.

From what has been said before, it is apparent that the full load position will occur when the plunger travels the most before uncovering port B. For other load conditions the duration of the injection period is decreased. For shut down of the engine, the effective pumping travel of the plunger is down to a minimum.

The advantage of the individual pump injection system lies in its compactness, because all the functions are combined in a separate pump for each cylinder. However, since the plungers, barrels and other parts of the pump in a multicylinder engine must be carefully machined to very close tolerances for smooth operation of the engine, the individual pump injection system tends to be very expensive.

The unit injection system, i.e. each cylinder with an individual pump located nearby and the latter being a unit completely independent from the pumps for the other cylinders, is not as popular as the *en-bloc* assembly. The unit injection mode of the individual pump injection system has been used very extensively and successfully by General Motors Corp. in this country, however.

The Distributor System

The first successful distributor system, the principle of which is shown in Fig. 5-b, was designed and manufactured by Cummings Engine Corporation in this country. Since the Cummings system is a good representative of the systems available in the market, it is the system that will be discussed

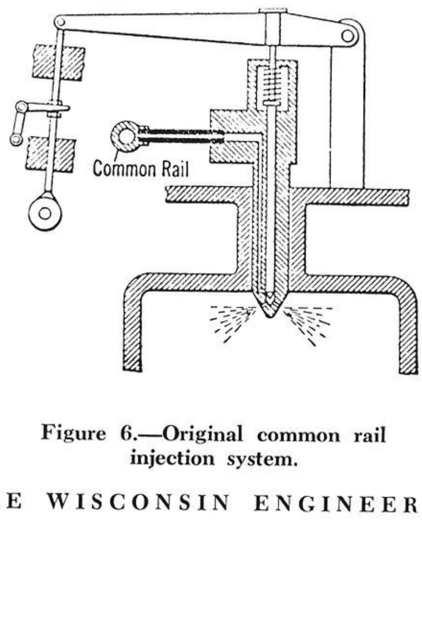


Figure 6.—Original common rail injection system.

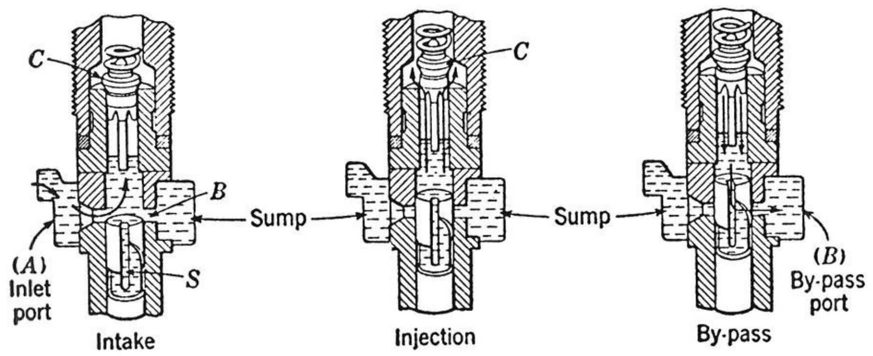


Figure 7.—Cross section of fuel-pump barrel.

here. A diagramatic sketch of the Cummings system is shown in Fig. 8.

The Cummings distributor injection system works as follows: fuel at medium pressure (120 psi) is supplied by a transfer pump, which is not shown, to a metering pump. This metering pump is a plunger, barrel and rack arrangement as used in the individual pump system. The fuel so metered is then directed to the proper cylinder by a distributor with drilled passageways, rotated by the camshaft. At this point the metered fuel has not been compressed to the high pressure necessary for injection. The fuel is compressed to high pressures by means of a pump integral with the injector nozzle. This pump-injector unit is shown in detail in Fig. 8-b. The plunger A of this high pressure pump is operated by the camshaft of the engine and it works as follows: during the intake stroke of the engine the plunger rises gradually while the metered fuel is entering the plunger chamber B through check valve C. On the compression stroke of the engine, hot compressed air enters the plunger chamber. This action heats and vaporizes the fuel. Just prior to top dead center, the plunger A is forced downward compressing and discharging the hot fuel through six small orifices in the spray tip.

The main purposes of the design of the distributor injection system are to meter the fuel at relatively low pressures, to avoid high-pressure delivery lines, and to use only one measuring pump for all cylinders.

It must be mentioned once again that the diagrams of Fig. 8 are merely schematic diagrams. The actual system differs from these diagrams, but the functioning is identical.

THE ADVANTAGES OF THE HIGH-SPEED DIESEL ENGINES OVER MEDIUM- AND SLOW-SPEED DIESELS

From mechanics, it is known that the horsepower available in a moving shaft is given by

$$HP = \frac{2\pi T N}{33{,}000} \quad (1)$$

where,

HP = Horsepower,
T = Torque, in Foot-pounds,
N = Shaft rpm.

Thus the shaft horsepower is directly proportional to shaft speed and the torque exerted on the shaft. If the horsepower output is to be kept constant, the applied torque must increase as the shaft rpm are decreased.

For an internal combustion engine the torque exerted on the output shaft is given by,

$$T = \frac{\text{bmep} \times D}{12 \times (X)} \quad (2)$$

where, T = Torque in foot-pounds,
bmep = Brake mean effective pressure, psia,
X = 1 for a two-cycle, 2 for a four-cycle engine, 2 for a four-cycle engine.
D = Displacement of the engine, cubic inches.

If equation (2) is substituted into equation (1), then:

$$HP = \frac{2 \times \pi \times \text{bmep} \times D \times N}{33{,}000 \times 12 \times (X)} \quad (3)$$

It is then apparent from equation (3) that if the speed of the engine and the number of cycles of the engine are fixed, either the mean effective pressure or the displacement must be increased in order to produce a higher horsepower output. In actual engines both of these characteristics are not simple functions. However, it is worthwhile to notice, that as the displacement of the engine increases so does the size of the piston. This in turn limits the maximum speed of the engine, because of the inertial problems presented by the larger piston. As the mean effective pressure is increased, which means that the cylinder must experience higher pressures, the engine has to be built sturdier. These two characteristics cause the slow- and medium-speed engines to be very heavy. Slow-speed diesel engines in common use today are as much as four times as heavy per output horsepower as their high-speed counterparts.

(Continued on page 22)

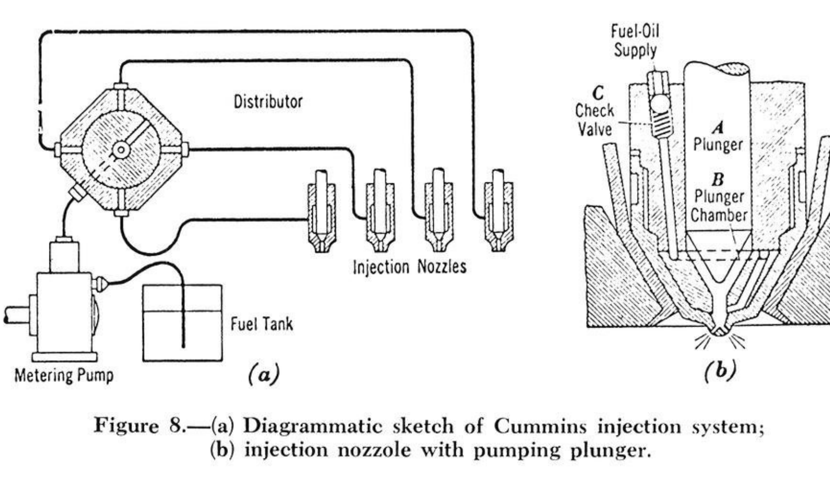


Figure 8.—(a) Diagrammatic sketch of Cummins injection system; (b) injection nozzole with pumping plunger.

Unions for Engineers

By HOWARD R. BERRY

ON JULY 8, 1958, pickets paraded around the RCA plant at Camden, New Jersey. Similar groups marched around other RCA plants at Moorestown and Cherry Hill, New Jersey, and outside the RCA Building in New York City, proclaiming that management was unfair to labor. Eighteen hundred RCA employees were on strike after collective bargaining did not yield the demanded 19.5% pay increase. On a whole the strikers were orderly, but there were some acts of vandalism as several hundred members of the striking union crossed picket lines and reported for work. The strikers had a neat trick of standing near the plant entrance with arms down at their side—an extended key concealed in their hand. As a car passed, an ugly, expensive scratch appeared along its full length.

This was not just an ordinary strike. The strikers were not common laborers; they were not men who must earn their living with skilled hands or a strong back and could only improve their position through collective bargaining. These were professional men; men who earned their living with their intelligence and creativity. They were college graduates whose jobs involve the consistent exercise of discretion and judgment; men of the type such that the output produced or the result accomplished by them cannot be standardized in relation to a given period of time. These men were RCA engineers; all involved in research and development. They were members of The Association of Professional Engineering Personnel—an engineering union.

Engineering unions are fact—they exist today. Although they are not growing as rapidly or causing as much alarm and controversy as they did five years ago, professional and technical unions have a firm footing in some American companies, principally in California and New York. The young graduate engineer just entering industry may not be aware that a condition of employment in some companies is membership in a labor or trade union.

Four years of higher education in preparation for a professional career just to be classified as a worker or member of the labor force is a rather dismaying thought, a thought worth investigation.

How the Door to Professional Unions Was Opened

The Wagner Act, coming in the middle of the depression, guaranteed the right of collective bargaining, but the Act provided no distinction between professionals and other employees. Engineers found themselves becoming minority groups in unions that did not represent them. To rectify the situation, engineers formed their own unions and negotiated for interpretations from the National Labor Relations Board.

While NLRB had the power to recognize engineering groups as separate bargaining units, it was slow in doing so. The board admitted the professional nature of engineering, but it did not deem professionalism a sufficient reason to distinguish engineers from other employees.

After World War II much of the friction had subsided and the labor laws were reviewed. Professional societies beseiged Congress with distinctions between professionals and nonprofessionals and pressured for legislation to protect engineers' collective-bargaining rights. The result—incorporated in the Taft-Hartley Act—was a fundamental change in labor law that affected subsequent developments in the engineering-union movement. While professional unions had originally been formed for defensive reasons, they now began to think aggressively.

Who Are the Unions?

In 1960 thirty unions, located principally in California and New York, represented technical personnel; they bargain for some 65,000 members, but only 41,000 or 63% are professionals. Since reliable sources seem to agree that about a million professionals work in the United States, the number of unionized professionals appears small.

The unions may be classified as follows: 1) Engineers and Scientists of America; 2) Engineers and Scientists Guild; 3) American Federation of Technical Employees; 4) five small unions associated with AFL-CIO; and 5) eight independent unions.

Largest and most highly professional of the union groups is the Engineers and Scientists of America—representing 54 percent of all the unionized professionals. Formed in 1952 with eight member unions, the ESA has failed to attract many new unions; membership, at a high of 50,000 in 1956, has now dropped to half that number. The major cause for the decline was a controversy over the relative merits of professionalism and unionism. Tighter eligibility requirements resulted and several member unions withdrew to form their own federation—the Engineers and Scientists Guild.

Organized in 1957, ESG said that the shift to a rigid definition of the professional requirements for membership and the de-emphasis on the function of collective-bargaining by the ESA had forced them to secede. The ESG, however, has never developed to the point where it could effectively conduct collective bargaining. The primary problem, other than the usual organizational difficulties, has been the fear of the small unions in ESG for the power of the one large member, the Engineer's and Architect's Association, representing 55% of the total membership.

Unions Must Organize the White-Collar Workers

Developments in our economy are shifting large numbers of workers from both skilled and unskilled trades to highly trained technical and professional duties. It has been predicted that by 1965 the white-collar workers will outnumber the blue-collar workers by over a million. The census figures reflect this critical change in the composition of the labor force. Between 1952 and 1959, the number of semi-skilled industrial workers declined by 5% and non-skilled workers by 12% of their strength; the number of professional and technical employees in industry, however, increased by over 60%.

The major labor organizations are well aware that their future growth and influence must come from these technical and professional or white-collar groups. They must look to other than the production ranks if they wish to increase membership, collect more 10 on 11 Cal. 13 ems mag. 1 italic dues, and gain wider control over industry. However, the union recognizes that there are differences between these two types of workers and calls for shifts in union organization and policy to meet them.

Union Officials Set the Stage for Future Action

Engineers as a group show little affection for unions. Labor organizations must work to improve their image and at the same time modify their organizational structure to better meet the needs of the technical and professional worker. Several engineering unions, notably the Engineers and Scientists of America, stress status in collective-bargaining agreements; these unions frequently request a contract requiring the employer to pay professional society dues for the engineer-employee. Other contract clauses often include leave of absence with pay for engineers wishing to attend professional society meetings, tuition refunds for engineers taking university courses connected with their work, leave of absence without loss of seniority to engineers wishing to further their education on a full time basis, and provisions covering the signing of patent agreements.

The union believes that occupational problems facing professional and technical employees are, in some cases, similar to those of the typical production and maintenance worker. There is little difference seen in the pension needs of the two groups, though professional workers seem to take more interest in the technical details and mathematics of pension and welfare plans. Unions realize that both their strongest bargaining point and their greatest need for a shift in thinking lie in the wage area. While the production-maintenance worker expects to be paid on the basis of the job he holds, the professional expects to be paid as much for his knowledge, training, and ability as for his actual duties. Unions feel that professional and technical employees are as much interested in getting pay raises, by any means feasible, as are production and maintenance workers.

Traditional union attitudes on seniority require considerable revision for acceptance by professionals. The nature of the work performed by professionals, and their high regard for excellence of performance, is felt to minimize the importance of seniority in promotion and as far as layoffs are concerned, professionals' attitudes are thought to be more in line with traditional union policy.

Unions Try to Improve Their Image

According to AFL-CIO thinking, the engineer is deeply poisoned by management in evil partnership with the engineering schools, owned body and soul by the corporations and by the technical societies working within the schools. To counteract this poisoning process, AFL-CIO is undertaking major programs to reach young people in the schools before the societies can get to them. These programs include growing unionization of teachers and the use of them to spread organization philosophy among their students, and publishing of material on benefits of professional and technical employees from collective bargaining without detriment to their professional status.

Union Attiude Toward Engineers

The stand taken by the American Federation of Technical Employees is that engineers are workers. Mr. M. F. Lunch, an official of the AFTE says, "In elevating engineers to the elite status of doctors and lawyers, the Defense Production Act is applying an obsolete and superficial criterion. In modern industrial management the engineer is more closely akin to the machinist at his lathe and the production worker on the line. Engineers and employers of engineers know this to be true."

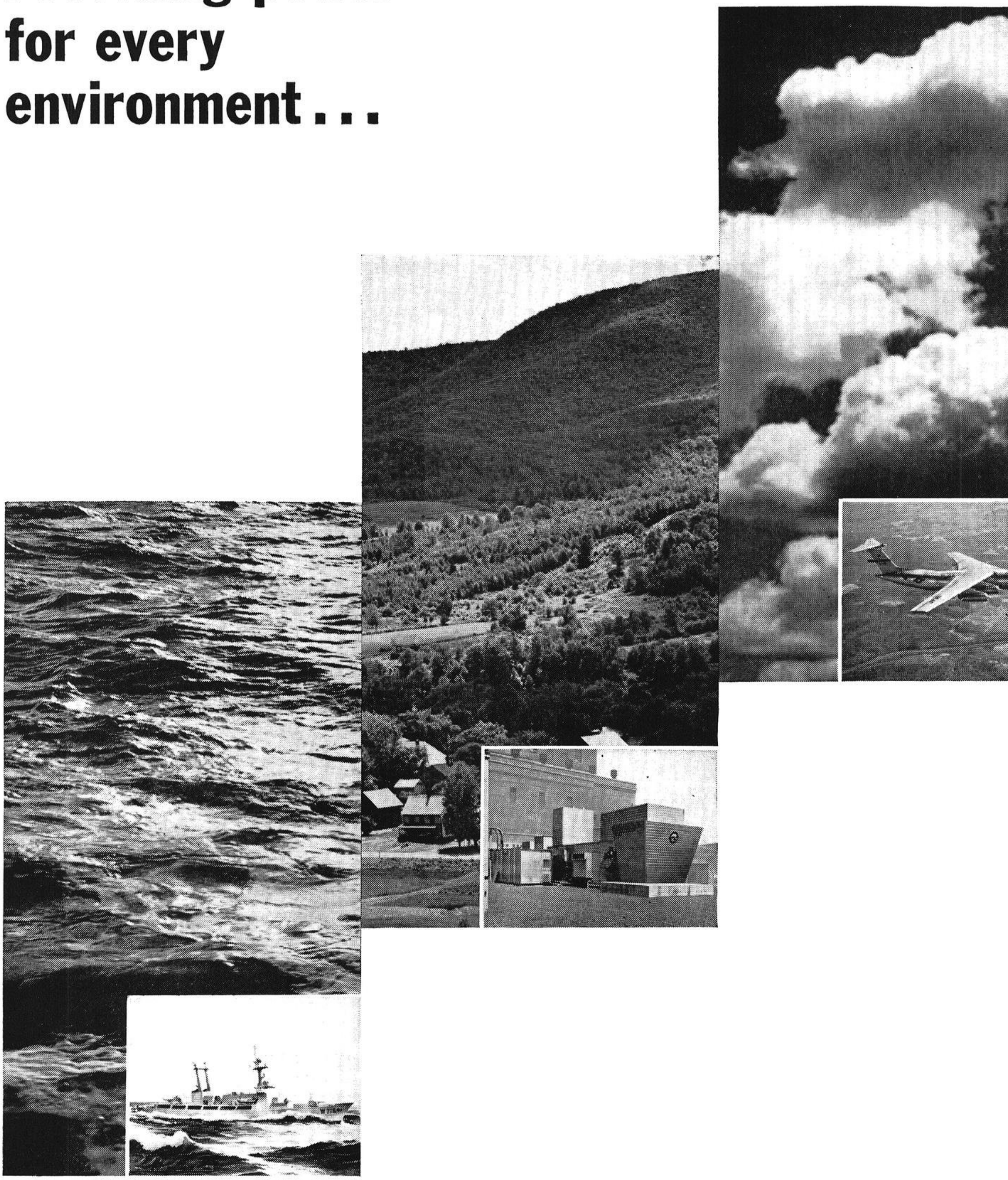
Attitude of Professional Societies

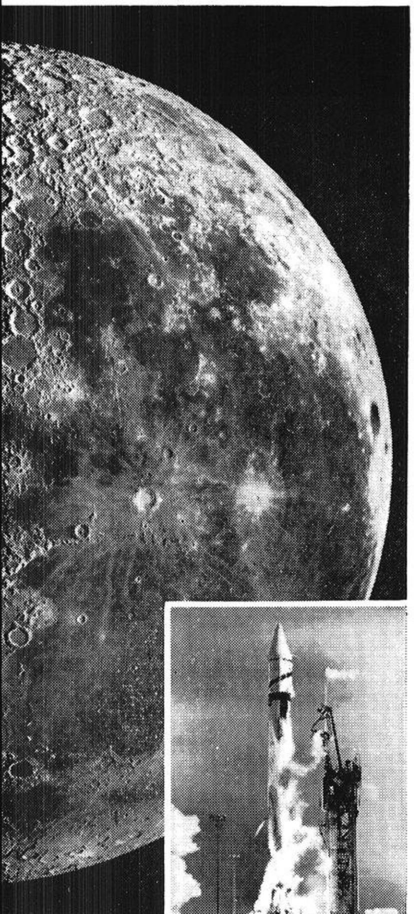
The technical and professional societies are openly anti-union. They are doing everything in their power to convince the engineer that, as a professional, he should resolve differences with his employer without calling for a union. They claim the engineer must choose the professional values of dedication, independence, and contribution to society. The primary consideration is betterment of mankind, regardless of tangible rewards. Judged in this light, collective bargaining, says the societies, places primary importance on material benefits and restricts, rather than enhances, freedom and satisfaction.

Professional societies find it difficult to directly oppose the unions because of certain legal restrictions as well as the tax restrictions. Since many members of professional societies are also employers, active antiunionism by the societies is therefore limited under the Taft-Hartley Act.

(Continued on page 27)

Providing power for every environment...





provides challenge for virtually every technical talent at Pratt & Whitney Aircraft

Being a technically trained man . . . we assume you are looking ahead to a career of exciting growth and accomplishment and that you are looking for a company possessing these same qualities.

If our assumption is correct, we would like you to take a close look at us. For this Company, while solving the problems of the day, thrives on a sort of creative restlessness which anticipates the challenges of tomorrow. And more important to you, it recognizes its engineers and scientists as the master key to its present success and future progress.

From a solid foundation of basic and applied research, our Company has gained a firm foothold in the land, sea, air, and space programs that are helping to shape our nation's future. Our engineers and scientists are exploring ever-broadening avenues of *energy conversion for every environment.* Should you join them, you'll be assigned early responsibility . . . to apply your engineering talents to such areas as advanced gas turbines . . . rocket engines . . . fuel cells and nuclear power.

Such trail-blazing projects command the best of varied talent. That's why you'll find at Pratt & Whitney Aircraft men with college training as diverse as their responsibilities. You will also find that opportunities for professional growth are further enhanced by our corporation-financed Graduate Education Program. Your degree? It can be a B.S., M.S. or Ph.D. in: **MECHANICAL • AERONAUTICAL • ELECTRICAL • CHEMICAL and NUCLEAR ENGINEERING • PHYSICS • CHEMISTRY • METALLURGY • CERAMICS • MATHEMATICS • ENGINEERING SCIENCE or APPLIED MECHANICS.**

For further information concerning a career with Pratt & Whitney Aircraft, consult your college placement officer—or—write to Mr. William L. Stoner, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.

SPECIALISTS IN POWER . . . POWER FOR PROPULSION—POWER FOR AUXILIARY SYSTEMS. CURRENT UTILIZATIONS INCLUDE AIRCRAFT, MISSILES, SPACE VEHICLES, MARINE AND INDUSTRIAL APPLICATIONS.

Pratt & Whitney Aircraft

DIVISION OF UNITED AIRCRAFT CORP.

CONNECTICUT OPERATIONS EAST HARTFORD, CONNECTICUT
FLORIDA OPERATIONS WEST PALM BEACH, FLORIDA

An Equal Opportunity Employer

Diesel Engine

(Continued from page 17)

Slow-speed engines, due to the larger amount of time available for combustion, can burn very heavy and cheap fuels. The high-speed diesel engine needs much lighter fuels to work well. These fuels are, of course, more expensive than the heavy ones. The advantage of the slow-speed diesel engine over the high-speed diesel engine is outweighed by the fact that heavy fuels tend to have very large percentages of sulphur and ashes. The high content of impurities causes the heavy fuels to be more detrimental to the engines.

Of course, high-speed diesel engines are the only diesel engines that are suitable for use in the automotive field, but there are many advantages in using them in situations where the slow- and medium-speed diesel engines had been dominant before. These situations include marine and railroad transportation. It has been found unpractical to build high-speed diesel engines whose outputs exceed 1,500 brake horsepower.

Use in the Automotive Field

High-speed diesel engines have found a great deal of application in that segment of automotive transportation that requires a constant power output and, therefore, a constant speed. This segment includes buses and trucks.

At constant power the high-speed diesel engine (for that matter all diesel engines) exhibits its highest efficiency and therefore, its highest economy. The diesel engines used in trucks and buses usually exhibit very poor acceleration characteristics as compared with the gasoline engine. But, since acceleration is not particularly important in trucks and buses, the popularity of high-speed diesel engines is not hampered in these fields.

The design characteristics of diesel engines for automotive uses do, however, follow either one of two very different trends: relatively high speed (3500 rpm) with lower economy as compared to relatively low speed (2000 rpm) and very high economy. The first trend is more apparent in the United States, where the second is more apparent in Europe. This is, of course, due to the high cost of fuels in Europe.

Among the interesting designs used in the field is the horizontal engine used in the coaches (buses) made by General Motors Corp. in this country. This is a two-cycle, six cylinder engine designed for an output of 165 hp at 2,000 rpm. It also exhibits a forced air scavenging system. The weight per horsepower of this G. M. horizontal diesel compares very well with that of an equivalent gasoline engine.

High-speed diesel engines have never been very popular in the field of family cars, because of their poor acceleration, high level of noise, large weight to horsepower ratios, and relatively low speeds as compared to equivalent gasoline engines. Furthermore, high-speed diesel engines require frequent changes of the fuel filters, because of the accurately machined fuel pump. Also high-speed diesel engines require very high-grade lubricating oil which must be changed often, because of the high pressures encountered in these engines. It is apparent that the average car driver would not go for all these disadvantages when all he is going to get out of it is fuel economy and more dependability. For those drivers that are willing to do away with acceleration and high speed performance for the sake of economy, Mercedes-Benz of Germany, Citröen of France and Fiat of Italy market high-speed diesel engines that can be fitted to their standard sedans. For an example of the performance characteristics, the Mercedes-Benz 170 D sedan has a fuel consumption of 35 mpg. and a maximum speed of 62 mph. It must be added that a sedan fitted with a high-speed diesel engine costs as much as $400 more than the car fitted with the standard gas engine. To quote Professor Phillip S. Myers,

> "I do not foresee, at this time, any chance for the diesel engine as a power source for family cars. They are too noisy and too expensive. The gasoline engine is here to stay in the family car business."

Use in the Marine Field

Until not long ago the marine field was strictly the domain of slow and medium-speed diesel engines. However, now the high-speed diesel engine is starting to make strong headway in the field. made possible by the application of modern theories to the construction of power plants for vessels.

The slow- and medium-speed diesels were perfect for marine use. because they could drive the propeller shaft directly without the need of a reducing gearbox and without the danger of damaging the propeller by inducing cavitation. However, it is now thought that if a vessel needs 10,000 horsepower for propulsion and 500 horsepower for auxiliary power, it is better to have something like twenty-five 500-h.p. high-speed diesels driving electric generators. Twenty of these would be used for propulsion and one for auxiliary power. The remaining four sets would be used for emergency purposes. It is claimed that this system gives the best flexibility and dependability, because the shutting down of one unit does not affect the other units, while for example in a vessel powered by a large slow-speed diesel, if something goes wrong with it, all the propulsive power is lost. The whole high-speed diesel power plant is much lighter than an equivalent slow-speed diesel power plant.

Several ships have been built with this new concept in Germany. So far the results are most encouraging. The only disadvantage of this type of a set up is the need for better quality fuel and, therefore more expensive fuel. But this is not too high of a price to pay for increased reliability and reduced dead weight.

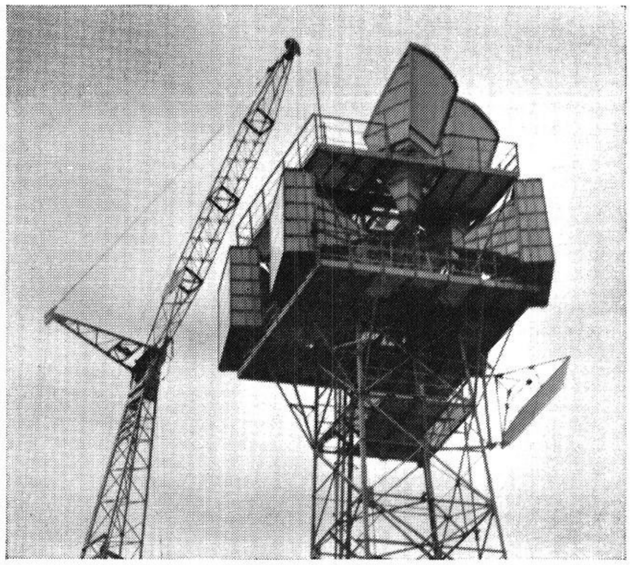
Use in the Railroad Field

In the field of railroad power plants, the slow- and medium-speed engines were masters after they had displaced the steam locomotive. However, for the last ten years, the high-speed diesel engine has been the leader, having displaced its slower relatives.

Most locomotives in the field today use diesel-electric drives. For such type of drive the higher the speed of the prime mover, the higher the efficiency, because with higher speeds lighter electric generators may be used. Also high-

(Continued on page 27)

Find a career expanding and improving the Bell System



Microwave relay towers assure reliable land transmission of telephone, radio, television and data traffic—with complete flexibility.

To serve a growing America, we are steadily enlarging our communications system . . . opening new route-miles of cable and microwave . . . bringing more customers into the network . . . adding new services.

As a result, the Bell System offers unique career opportunities to ambitious young engineers who want to work on projects commensurate with their talents.

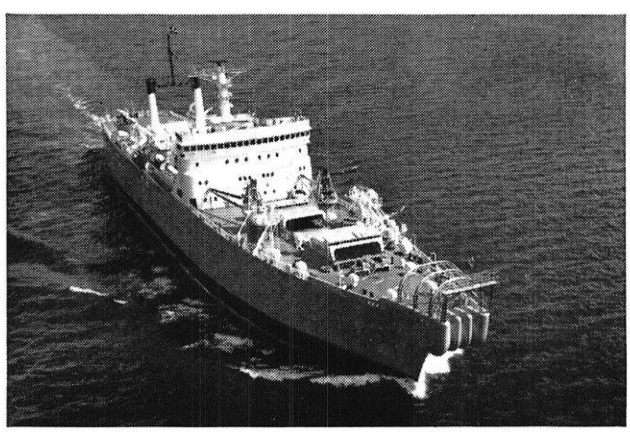
In the Bell System there are literally hundreds of intriguing engineering assignments ranging from the planning of telephone service for large communities to the development of miniaturized components for equipment. A Bell System career can bring an engineer an exciting variety of tasks, every one important, with everything needed to carry them out.

The Bell System companies are equal opportunity employers that match the benefits, salaries and working conditions of other companies. Few can match them, however, for work that is interesting and important.

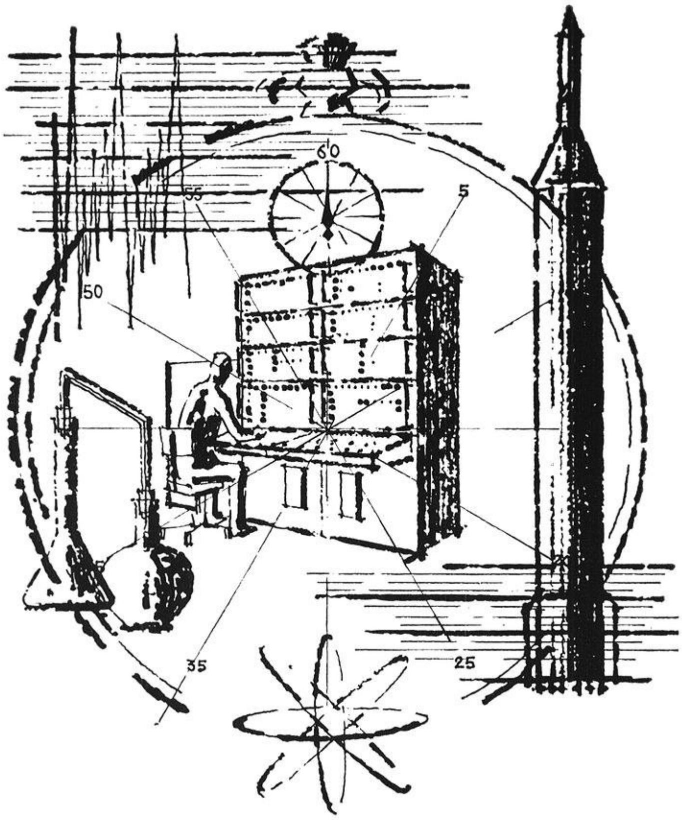
You owe it to yourself to investigate your career possibilities in the Bell System. Have your Placement Office arrange a date with our interviewing team, or get in touch with a local Bell operating company. Either way, we'll welcome a chance to talk with you.

BELL SYSTEM

American Telephone & Telegraph Co.
and Associated Companies



C. S. LONG LINES lays and maintains Bell System undersea telephone cables that provide dependable overseas transmission.



SCIENCE HIGHLIGHTS

By HAROLD WEBER, me'66

THE STRATOSCOPE II TELESCOPE SYSTEM

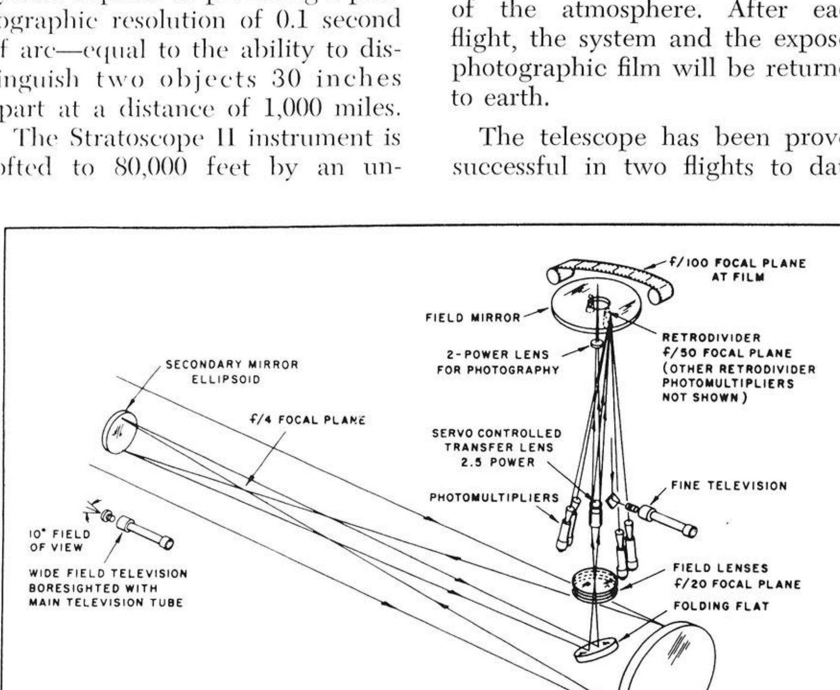
Project Stratoscope II telescope is a 3-ton, 36-inch aperture optical system capable of providing a photographic resolution of 0.1 second of arc—equal to the ability to distinguish two objects 30 inches apart at a distance of 1,000 miles.

The Stratoscope II instrument is lofted to 80,000 feet by an unmanned balloon. The primary mission of the telescope system is to photograph planets, nebulae and other celestial objects above the dust and water vapor interferences of the atmosphere. After each flight, the system and the exposed photographic film will be returned to earth.

The telescope has been proved successful in two flights to date. Both flights involved a modification of the optical systems to employ a spectrophotometer for infrared analyses of celestial objects. The first, in March 1963, gathered infrared data on the atmosphere of Mars; the second, in November 1963, was directed at ten objects including Jupiter and certain cool red giant stars. The first photographic flight is scheduled for late in 1964.

Project Stratoscope is directed by Professor Martin Schwarzschild of Princeton University Observatory. It is sponsored by the National Science Foundation, the Office of Naval Research and the National Aeronautics and Space Administration.

Key elements of the Stratoscope II telescope system are: a precise optical system, with a 400-pound, 36-inch diameter primary mirror which has been fabricated to an accuracy of 1/2,500,000th of an inch; a command system capable of controlling more than 80 actions and a 64-channel telemetry system which provide a high degree of remote control; a guidance tracking system with an accuracy of 0.02 second of arc; and a suspension



Optical system of Stratoscope II Telescope.

The Verrazano Narrows Bridge Opened November 21.

system which permits the telescope to be moved about multiple axes.

WELDING STRENGTHENS ROADWAY OF LONGEST SUSPENDED BRIDGE SPAN

More than 2¼ miles of welded steel flooring will carry traffic on the double-decked Verrazano-Narrows Bridge. The bridge, whose 4,260-ft. suspended main span is the world's longest, will soon connect New York's Staten Island with Brooklyn.

The floor system consists of connected sections made from openwork constructional carbon steel. These sections were shop-fabricated of light, rolled I-beams and intersecting reinforcing bars.

Roadway sections are welded to the floor beams of the suspended structure and to the contact points of the reinforcing bars. Concrete is then poured through and over the floor system to a total depth of 6 in.

To weld the complex floor system, American Bridge Division of United States Steel Corporation used a high-tensile-strength low-hydrogen, iron-powder electrode.

Designed for the Triborough Bridge and Tunnel Authority, the giant bridge is a record-breaker on many counts. Its twin suspension towers, rising 690 ft. out of New York Harbor, are taller than any building outside of New York.

Wire used in the four 7,205-ft. cables could encircle the earth nearly six times, and took more than three years to make and spin. Enough steel is contained in the structure to build three Empire State Buildings, and enough concrete to form a four-lane highway from the bridge to Washington, D. C.

Diesel Engine

(Continued from page 22)

speed diesels have a better power to weight ration than slow- and medium-speed diesels. These two factors result in reduced weight and reduced length, both of which are important to railroads for economy and maneuverability. These advantages have caused most locomotives in the U. S. and Europe to be driven by high-speed diesel engines.

CONCLUSION

One might look forward to a world in which all heavy transportation vehicles—buses and trucks—are going to be powered with high-speed diesel engines. Also all auxiliary construction equipment will use high-speed diesel engines. Even today, one only has to pick a magazine covering these trades and read about the companies that have switched to diesel power. Furthermore, at the present time several companies are carrying very extensive research programs aimed at reducing the noise produced by diesel engines. When these programs yield results, one can look forward to complete taxicab fleets powered by high-speed diesel engines.

Most of these opinions have been put forth keeping in mind the present state of the art. However, at this time, it is impossible to make any solid predictions, mainly because of the fast pace at which present technology is advancing.

Unions for Engineers

(Continued from page 19)

To improve the engineer's position, technical societies are fostering better understanding and cooperation between engineers and management. They are conducting educational campaigns and encouraging formation of informal sounding boards.

In spite of these activities, some authorities feel that professional societies cannot possibly provide for all the needs of engineers. Even though they are broadening their programs, the societies have no direct way of controlling the environment provided by managers; they can only attempt to influence the managers.

(Continued on page 30)

BOOK PARADE

Mathematical Bafflers, By Angela Dunn, McGraw-Hill, $6.50.

"The first expedition to Mars found only the ruins of a civilization. The explorers were able to translate a Martian equation as follows: $5x^2 - 50x + 125 = 0$: $x = 5, 8$. This was very strange mathematics. The value $x = 5$ seemed legitimate enough but $x = 8$ required some explanation. If the Martian number system developed in a manner similar to ours, how many fingers would you say the Martians had?"*

This is only one of over 150 mathematical gems compiled by chic, vivacious puzzle buff and university lecturer Angela Dunn in her book, "Mathematical Bafflers: A collection of the best puzzles from the famous 'Problematical Recreations' series of Litton Industries, together with dozens of provocative posers created especially for this volume."

The problems, selected for originality, elegance of solution, and imaginative appeal, range from the very simple — those requiring no mathematical background—to those which would challenge the ingenuity of a professional mathematician. Clever illustrations throughout the book give subtle clues to solutions and add a humorous touch.

Miss Dunn says her primary object in writing this book is to entertain, therefore she has avoided tedious solutions, well-known problems, duplication of theme from problem to problem, and extremely difficult problems. The problems she has chosen combine the unusual, the unexpected, and the nonobvious for those who "take pleasure in the process of reasoning, who enjoy exercising their inventive facilities, who delight in the pursuit of an elusive proof."

Among the types of problems in "Mathematical Bafflers" are: a number of exercises in algebraic reasoning; a variety of geometry problems; problems for those who like Diophantine equations; a large variety of logic and deduction puzzles; probability posers; a collection of intriguing puzzles requiring only a flash of inspiration to reach a solution; and assorted number theory problems.

* We shall assume that the base of the number system is equal to the number of fingers. If b is the base then we can write the equation as follows:

$$5x^2 - 5bx + (b^2 + 2b + 5) = 0$$

Thus $b = 5 + 8 = 13$ and the Martians had 13 fingers.

The Making, Shaping and Treating of Steel. U. S. Steel Corp., $5.00.

The most complete one-volume reference work relating to the iron and steel industry has been published in its eighth edition. Completely revised since its seventh edition was issued in 1957, the new volume offers users and makers of steel a comprehensive summary of present-day theory and practice covering all phases of iron and steel production from raw materials to finished products.

Recent developments in steelmaking and processing that are reviewed include basic oxygen steelmaking processes, vacuum degassing and continuous casting methods. Four new chapters cover the manufacture of tonnage oxygen for steel plant use, direct-reduction processes, manufacture of heavy press forgings, and water requirements for steelmaking. A fifth new chapter presents the fundamental principles of the physical chemistry of iron and steelmaking.

The book, which contains 1,198 pages of text, 982 illustrations and 150 tables, is divided into 48 chapters, which are subdivided into sections. Each chapter and section is made as nearly independent of others as possible. An extensive index simplifies use of the book for reference work.

In addition to the subjects mentioned above, the book deals with refractories; iron ores; fluxes and slag; addition agents; steel scrap; early iron and steelmaking methods; modern blast furnace practices; the modern pneumatic, open hearth, electric furnace, duplex and triplex steelmaking processes; steel and iron castings, including roll manufacture; heating methods; rolling mills; rolling and forging practices; steel conditioning; protective coatings; heat treatment; mechanical testing and gages.

Extensive discussions are devoted to the manufacture and properties of carbon and alloy steels, and the products made from them. These include blooms, slabs and billets; heavy forgings; rails and structural sections; plates, merchant bars, and hot strip mill products; cold reduction mill products; galvanized products; tin plate and terne plates; circular shapes; axles; shafts; wire; tubular products; electrical sheets; and corrosion-resistant and heat-resistant products.

Copies of the volume, priced at $10.00 each, may be obtained from United States Steel, Office Service-Stores, 1509 Muriel Street, Pittsburgh, Pa. 15203. Students of accredited educational institutions may obtain the book for $5.00 per copy, providing each order is countersigned by a faculty member.

Construction Company Organization and Management. By George E. Deatherage, McGraw-Hill, $12.00.

"I have observed, during my more than 50 years in engineering and construction, that many contractors fail to use the basic proven methods of organization and management," writes George E. Deatherage in the preface of his book, "Construction Company Organization and Management," published last month by McGraw-Hill.

"In a recent comprehensive survey covering an entire metropolitan area," he continues, "it developed that most contractors had not even thought of formal organization until they were asked about it in the interview. Less than 25 percent had organization charts, and these primarily were in the larger firms. This is enlightening when considered along with the fact that, according to each yearly analysis of business failures in the construction business, 85 per cent of such failures were due to lack of management knowledge and experience. Fully one-third of all contractors are in the loss column at the year's end, and an equal number only barely escape closing the books with a loss to their creditors."

Mr. Deatherage has written his book with a view towards correcting this situation by providing a comprehensive volume on the subject of construction company organization and management. His purpose is to present not only the basic fundamentals of construction organization in the light of the type and extent of the work to be done as expressed in the contract document requirements, but to express this in such detail that it will be truly informative and immediately useful. In addition, he has always kept in mind that "whatever information is imparted, it must be helpful in furthering the 'core' function of the contracting business, that of preparing realistic cost estimates which give the maximum assurance that a profit can be made."

"Construction Company Organization and Management" is divided into 15 chapters. Chapter 1 explains the function of a general contractor, and Chapter 2 describes the manner of creating the structural framework of construction organizations, illustrating that regardless of size the functions remain basically the same.

Chapter 3 covers the historical transition of organizations from the traditional military or line type to the modern line and staff or functional type. The next chapter is devoted to the various departmental components which constitute the over-all organizational structure. Methods of developing a field organization are explained in Chapter 5, while basic leadership guidelines for conducting a successful organization are presented in Chapter 6.

Chapter 7 explains the necessary preliminary functions a construction manager needs to perform personally before obtaining a fully staffed field organization. In Chapter 8 the author discusses the various forms of contracts and asserts that an organization is shaped by contractual arrangements. There follows a chapter on the general provisions contained in a contract which establish and define the relationship between the owner, architect, and contractor.

The various functions and operations which can be transferred from the prime contractor's organization to that of his subcontractor are presented in Chapter 10, while Chapters 11 through 15 discuss the commonly used and recognized standard contracts including details on lump sum and cost plus agreements, engineering construction contracts, federal contracts, and highway contracts.

McGraw-Hill is publishing three additional books by Mr. Deatherage during the next six months: "Construction Office Administration," "Estimating and Job Preplanning," and "Construction Scheduling" (tentative title).

Further information on Deatherage's "Construction Company Organization and Management" may be obtained from the McGraw-Hill Book Information Service, 327 West 41st Street, New York, N. Y. 10036.

Interview Dates

Wednesday, November 18

Alleghany Ballistics (1 of 2)
Allis Chalmers (1 of 2)
American Can (Canco Div.)
Continental Oil
Eastman Kodak (2 of 2)
Harnischfeger
North American Aviation (3 of 3) (PhD's only) Autonetics A.M.
Atomics International A.M.
Rocketdyne A.M.
Space & Information A.M.
Sherwin Williams
State of Indiana Highway Com. P.M.
Bureau of Ships

Thursday, November 19

Aerospace (1 of 2)
Alcoa
Alleghany Ballistics (2 of 2)
Allis Chalmers (2 of 2)
Ceco Steel Co. P.M. (ME & IE's) (1 of 2)
Minnesota Mining & Mfg. (3 of 4)
National Distillers Co.
Procter & Gamble (Charmin Paper Div.) (1 of 2)
Kimberly Clark
Wisconsin State Highway
Zenith Radio Corp.
Dept. of Health Education & Welfare A.M.

Friday, November 20

Aerospace (2 of 2) if needed
Ceco Steel Co. (CE's) (2 of 2)
Hallmark Cards
Marathon Electric
Minnesota Mining & Mfg. (4 of 4)
National Cash Register Co. P.M.
A. E. Staley
Univac
Washington State Highway
N.A.S.A. (Ohio) Lewis Res. Ctr.
U. S. Geological Survey
N.A.S.A.—Southern Prof. Staffing
Procter & Gamble—Charmin Paper (2 of 2)

November 23 thru November 30—

No interviews

Tuesday, December 1 P.M.

American Agric. Chemicals P.M.
Chrysler Corp.
Hughes Aircraft Co.
Ingersoll Milling
Mitre Corp. A.M.
Nalco Chemicals
Rockwell Standard A.M.
Texas Instruments
Wisconsin Electric Power Corp.
Youngstown Sheet & Tube Co.
Mason & Hanger

Wednesday, December 2

Lawrence Radiation Labs (Livermore)
Los Alamos Scientific Labs
Minnesota State Highway
Union Oil Co.
U. S. Gypsum Co.
U. S. Weather Bureau P.M.

Thursday, December 3

Joseph Bancroft & Sons A.M.
Factory Mutual
Hercules Powder
Outboard Marine
Sangamo Electric Co.

Monday, December 7

Wyandotte Chemicals

Wednesday, December 9

U. S. Marines
Eaton Mfg. A.M.

Thursday, December 10

General Electric (1 of 2) PhD's

Friday, December 11

General Electric (2 of 2) PhD's

Unions for Engineers

(Continued from page 27)

Managements' Position

Managers, shaken by the threat, are moving fast to counteract union arguments with plans to improve engineer-administrator relations; their program gets at the heart of two secondary problems, as well, employee turnover and effective utilization of manpower. The main effort, however, is aimed at bridging gaps in communication channels, giving the engineer-employee more chance to freely discuss his dissatisfactions.

Mr. J. H. Smith, President of Canadian General Electric, says that to prevent unionization, management must provide five specific needs of the professional engineer:

1. He must have professional work.
2. He must have opportunity for promotion as a professional employee and as an individual contributor.
3. He must have financial incentives as rewards for improved performance and greater contribution as an individual.
4. His job must be supervised from a professional viewpoint.
5. He must have professional recognition both within an enterprise and in the surrounding community.

Management is Not Meeting the Needs of the Engineer

Engineers have many complaints about the treatment they receive from management. A recent opinion survey conducted by Standard Oil Company of California showed that great quantities of red tape and little encouragement by management for the engineer to improve himself were the major causes for dissatisfaction. This dissatisfaction stimulates the desire for engineers to have unions.

Why Do Engineers Join Unions

If most engineers look at unions with such strong disfavor, how do technical and professional unions thrive and why do some engineers choose to join a labor organization? Psychologists say people join unions for security and recognition, which they do not get from their employers. *Machine Design Magazine* in its survey of September, 1958, asked 1,000 engineers, "What conditions do you think cause engineers or scientists to join unions?" Most of the answers were aimed straight at management. Some 18 different reasons were listed. Of these, money led the parade—low salaries or wages, poor salary administration, lack of compensation for overtime, and so on.

The second biggest condition favoring unionism was a poor engineer-management relationship—lack of recognition, little appreciation or consideration and indifference—which all help to alienate the engineer from his management.

The union inclined engineer is pictured as a lazy, mediocre performer, who can't stand on his own two feet but who is never satisfied. It should be noted that the survey did not ask union members why they joined a union but rather asked engineers (only 24 of whom were union members) what conditions caused engineers and scientists to join; consequently there are bound to be some criticisms of union members.

In Summation

Because of the change in composition of the labor force, there must be a vigorous effort to unionize the white collar workers if the unions are to remain strong and influential. Because many engineers are dissatisfied with the treatment they receive from management, they are very susceptible to the persuasion of labor unions. Professional societies and management both have forceful plans of action to halt the trend toward unionsim. Some engineers are repelled by the thought of regimentation and the leveling effect so characteristic of mass organizations. Others feel the effect of unionization on the employees has been to better their working conditions, raise their wage scale, and better their understanding of the problems of management in its dealings with employees.

ST. PAT'S

1965 DANCE CHAIRMANSHIP

Polygon is now taking applications for a 1965 St. Pat's dance chairman. If you'd like a CHALLENGE and think you can make next year's dance a SUCCESS, put your name, address and telephone number on a sheet of paper and place it in one of the suggestion boxes located in the M.E. and E.E. lobby, or contact your Polygon representative.

SUBSCRIBE NOW

DON'T MISS A COPY OF THE 1964-65 WISCONSIN ENGINEER

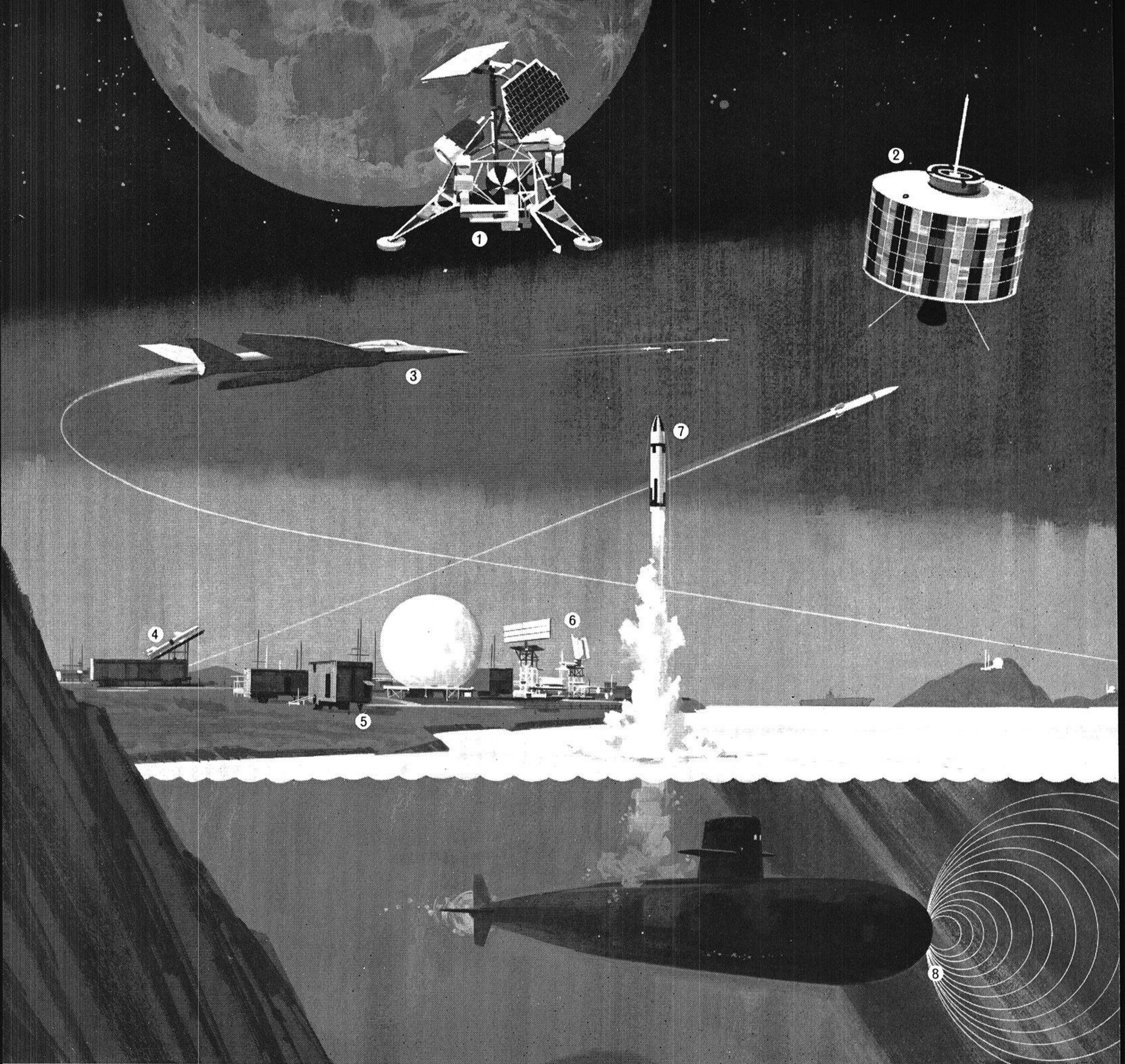
The Wisconsin Engineer
333 Mechanical Engineering Bldg.
Madison, Wisconsin 53706

Name ______________________________

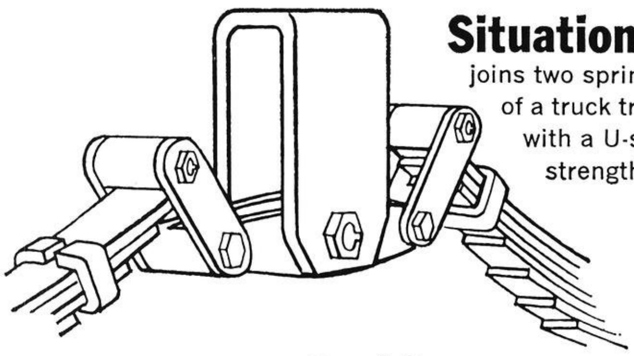
Street ______________________________

City, State and Zip Code ______________________

1 year $1.25 ☐
4 years $4.00 ☐



How Would You Solve This Design-Material Problem?



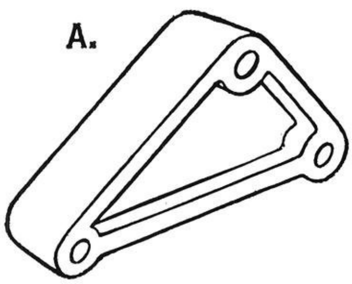
Situation: The equalizer bar shown here joins two spring assemblies to the undercarriage of a truck trailer. It is a Malleable iron casting with a U-shaped cross section. It has high strength and weighs only 3.8 pounds.

Problem:

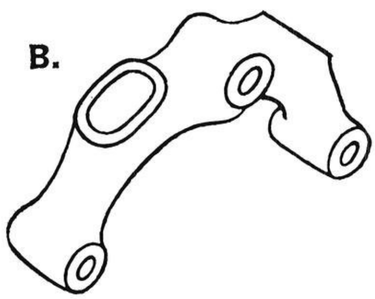
To raise the center hole 3 inches so that the unit can be adapted for use on house trailers. Costs must be kept to the absolute minimum to be successful in this highly competitive field.

Which design would you use?

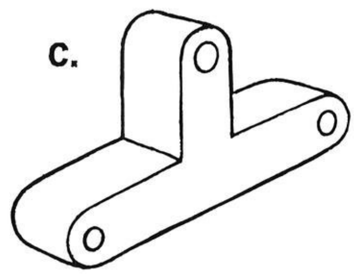
A.



B.



C.



Solution:

Illustration B, the curved tubular shape, has the best stress distribution characteristics because metal is placed where the load occurs—at the outer edges of the part. In this situation a solid cross section isn't indicated because very little of the load occurs at the center line. The material selected was again Malleable iron, combining high strength with design freedom.

Is this the solution you would have chosen? If not, it may be to your advantage to learn more about Malleable castings. Their many unique abilities are described in a new digest called "Design Criteria for Malleable Iron Castings". Send for your free copy today.

MALLEABLE FOUNDERS SOCIETY

MALLEABLE FOUNDERS SOCIETY · UNION COMMERCE BUILDING · CLEVELAND, OHIO 44114

"PRINTABLES"

A car pulled up along side a couple seated in a car.

"What's the matter," asked the intended helper, "out of gas?"

"Nope," came the answer from the inside.

"Engine trouble?"

"Nope."

"Tire down?"

"Didn't have to."

* * *

A farmer was phoning a veterinarian. "Say, Doc," he said, "I've got a sick cat. He just lays around and licks his paws. He has no appetite. What shall I do for him?"

"Give him a pint of castor oil," said the vet.

Somewhat dubious, the farmer forced the cat to take a pint of castor oil. A couple days later he met the vet in town.

"How's your sick calf?" inquired the vet.

"Sick calf! That was a sick cat I had."

"My Gawd, did you give him that pint of castor oil?"

"Sure did."

"Well what did he do?" asked the vet.

"Last time I seen him," said the farmer, "he was going over the hill with five other cats. Two were digging, two were covering up, and one was scouting for new territory."

* * *

Student: "What shall we do tonight?"

Friend: "I'll toss a coin. If it's heads, we go to the movies; if its tails, we go bowling; if it stands on end, we study."

* * *

Every man is free to choose his own form of government—blond, brunette or redhead.

* * *

Then there was the groom who finished his wife's first breakfast, muttering, "Can't cook either."

A young man contemplating matrimony wanted to propose and didn't know how, so he went to his dad for advice.

"Well, son," said the old man, "I don't know that I can help you much. With me and your Maw it happened one Sunday evening, when yer Maw and me was asittin' on the sofa. We was just a talkin' along and purty soon yer Maw leaned over and whispered in my ear and I said, "The hell you are," and the next day we were married.

* * *

It's a fact: If you drink a gallon of milk a month for 1200 months, you'll live to be a hundred years old.

* * *

And then there was the inebriated E.E. who was arrested for feeding the squirrels in the park. He was feeding them to the lions.

* * *

Overheard in a parked car near the campus "Slow down, Columbus, you've discovered enough for tonight."

* * *

Be thankful life isn't as tragic as portrayed in TV serials.

* * *

They call blondes dizzy but it's the men's heads that turn.

* * *

The little boy wanted $100 so badly he decided to pray for it. He prayed several weeks with no results. So he wrote God. The post office finally forwarded the letter to the White House. The President chuckled and ordered $5 sent to the boy. The lad, delighted that his prayers had been answered, in part at least, wrote a thank-you note to God but added this P.S.: "I notice you routed my letter through Washington and as usual the bureaucrats deducted 95 per cent."

With a bushel of apples you can have a hell of a time with the doctor's wife.

* * *

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

* * *

Young man to draft board: "But you can't turn me down! I've proposed to three girls, told my instructor what I think of him, and sold my car.

* * *

Jack: "I'll bet you think twice before you leave your wife alone evenings."

Mack: "I'll say. First I have to think up a reason for going out—then I have to think up why she can't go with me!"

* * *

Soph.: "I failed my Physics exam."

Jr. "But I thought you had the answers written on your cuff."

Soph.: "Yeah, but by mistake I put on my calculus shirt."

* * *

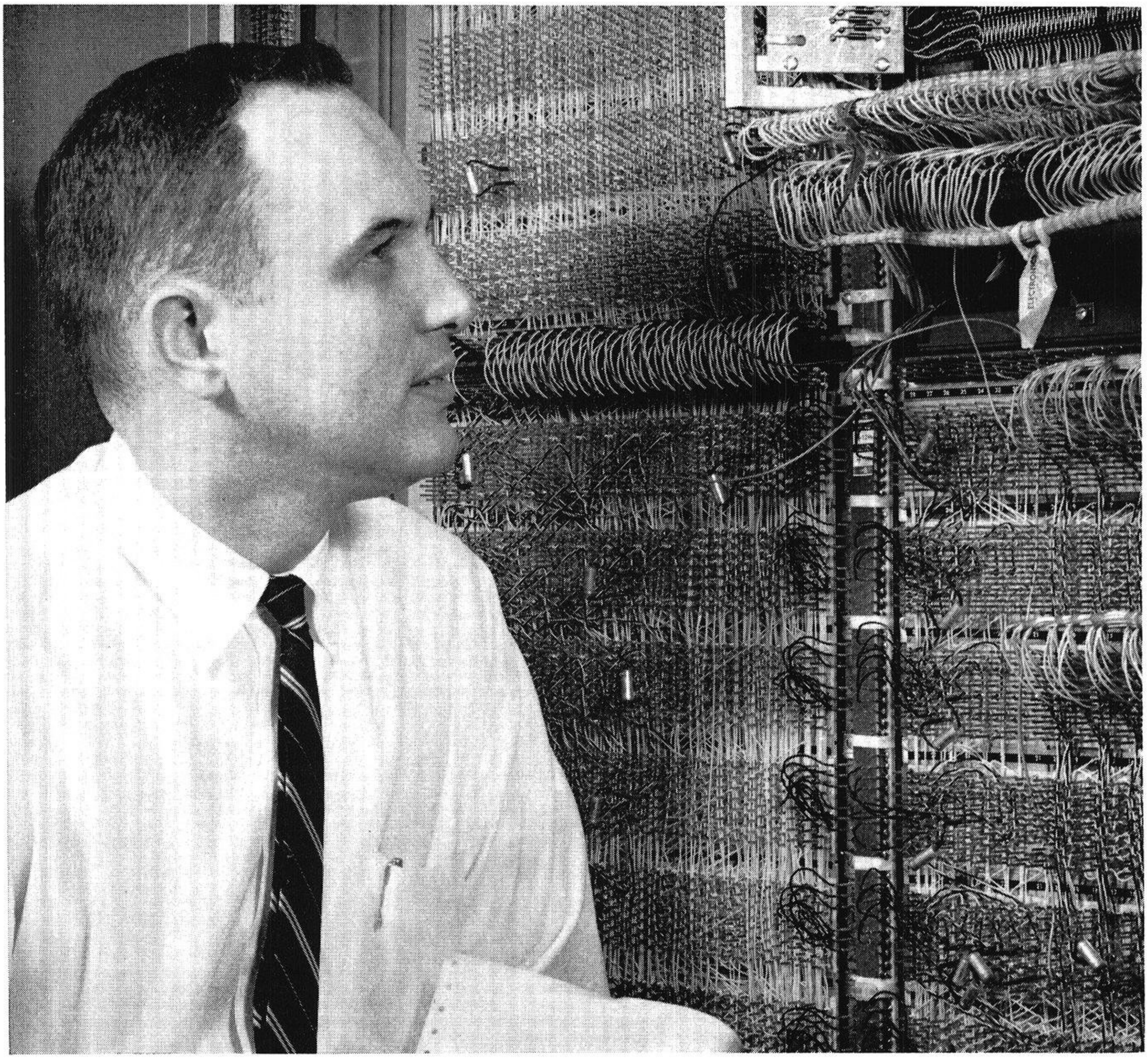
Voice on Phone: "John Smith is sick and can't come to class today. He requested me to notify you."

Professor: "All right. Who is this speaking?"

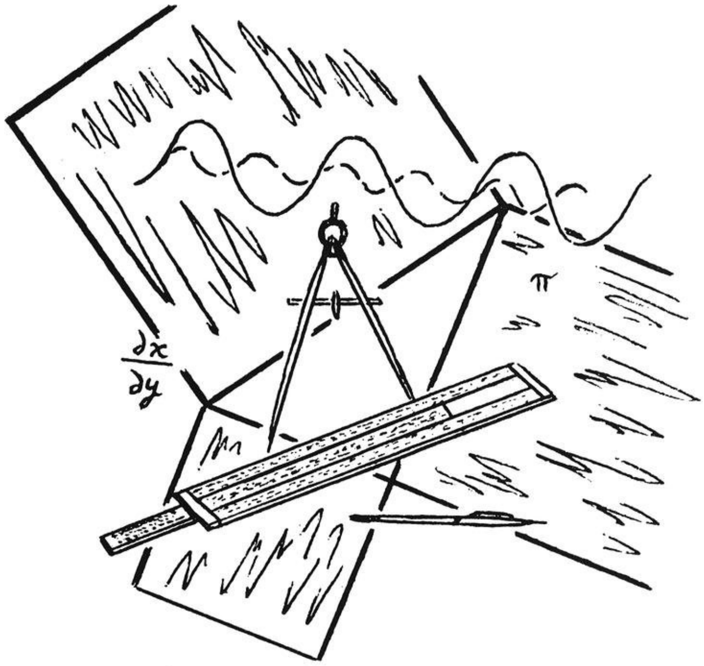
Voice: "This is my roommate."

* * *

An English lady, self-appointed supervisor of village morals, accused a workman of having reverted to drink because "with her own eyes" she had seen his wheelbarrow standing outside a public house. The accused made no defense, but that evening placed his wheelbarrow outside her door and left it there all night.



THE MENTAL MAZE



By CLIFTON FONSTAD, JR. ee4

TO QUOTE Sitting Bull after doing Custer and the boys in—Our faces are red. It seems that the examples of x = 3, y = 5 that were given in problem 3 last month don't work. Just to convince yourself that there are many x and y with $x \neq y$ and satisfiying the equation, though, try 3 and 5, 1 and 7, or 15 and −7. There are many more.

Before we start this month's Mental Maze here is a short poem—our thought for the day!

If your nose is close
to the grindstone rough
And you keep it down
there long enough
In time you'll think
there's no such thing
As brooks that babble
and birds that sing.
These three will all
your world compose
Just you, the stone,
and your dern old nose.

Since you are reading the Wisconsin Engineer we don't have to worry about the poem appling to you but keep it in mind. And now, enough of this, let's get started on the first puzzle the first turn in this month's Mental Maze.

1. To start off, try this problem. It's a good one to spend time on.

Mrs. Brown and Mrs. Black bought cloth at a cost in cents per yard equal to the number of yards that each brought. Mrs. Green and Mrs. White bought groceries. Mrs. Green spent one cent more than the excess of twice Mrs. Brown's payment over 7/9 of Mrs. Black's. Mrs. White spent an amount equal to 2/3 of Mrs. Black's plus 1/2 of Mrs. Green's. Mrs. Brown spent an amount equal to 5/6 of Mrs. Green's plus 1/3 of Mrs. White's. The total was greater than $1.00 but less than $10,000. Each spent a whole number of cents but exactly how much?

2. Solving that last one should have taken you awhile so let's try a quicky for a change of pace.

In a certain town 200 people voted on two issues in a referendum, and 150 ballots were cast in favor of the first issue and 120 votes were cast for the second issue. If there were exactly 30 people who voted against both issues, how many people voted for both issues?

3. That was easy so don't stop now; here comes another quicky.

The engineering societies on the Tioga Tech. campus were running a joint membership booth this fall and they got 7 volunteers—one from each society—to man the booth. Each day two of these guys would try to work together selling society memberships but by the end of the day they would be fighting too much over which engineering was best to sell many memberships. Still the drive continued, each day with a different pair of societies represented. How many days could the drive last without a rematch?

4. This problem can be quickly stated: In how many zeros does 10,000! (factorial) end? Can you you solve it as quickly?

Hint: the right answer is not simply "A Helluva Big Number." We want the number.

5. We're almost out of this months' maze. There are just five small puzzles to solve before reaching the end.

Thinking of two-digit numbers:

a. What number is twice the product of its digits?
b. What number is three times the product of its digits?
c. What number is the square of its units digit
d. What number exceeds its reversal by 20%?
e. What numbers plus their reversals sum to perfect squares?

ANSWERS: The answers to last month's Mental Maze were:

1. n = 1, 2, 3, 8, 9, 10,—e.i. All n but 4, 5, 6, 7.
2. 4, 3 just touches
4. 48
5. Kathy was Steve's date.

Don't forget, each month we give five dollars to the first person who sends the correct answers for the Mental Maze to "The Mental Maze", Wisconsin Engineer, 333 Mechanical Engineering Bldg., University of Wisconsin, Madison, Wisconsin 53706. You don't have to have all the answers right to win, but entries will be judged first on the number of correct answers, then on the earliest postmark.