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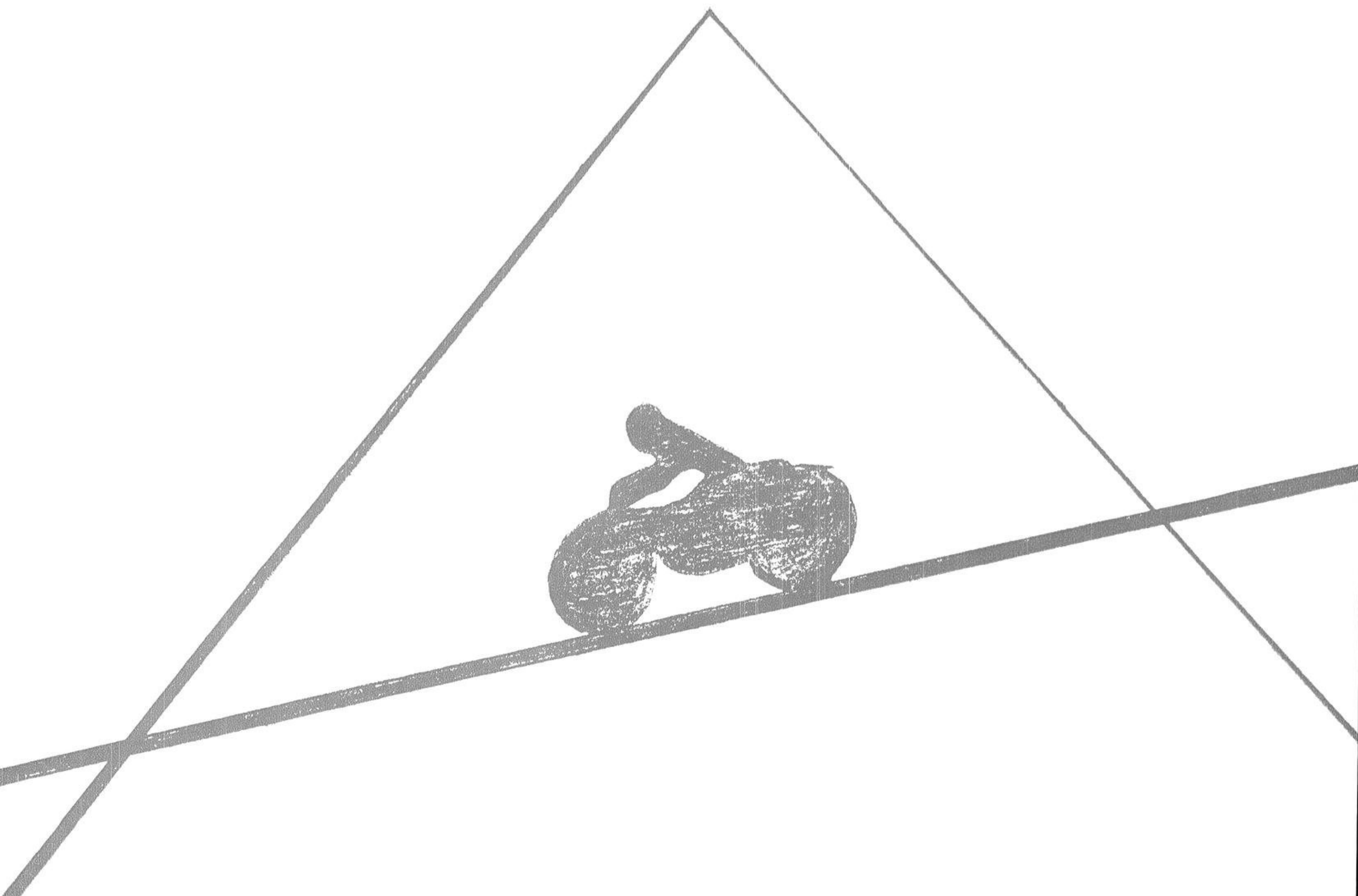
NOVEMBER, 1963

MEMBER E. C. M. A.



THE WISCONSIN ENGINEER

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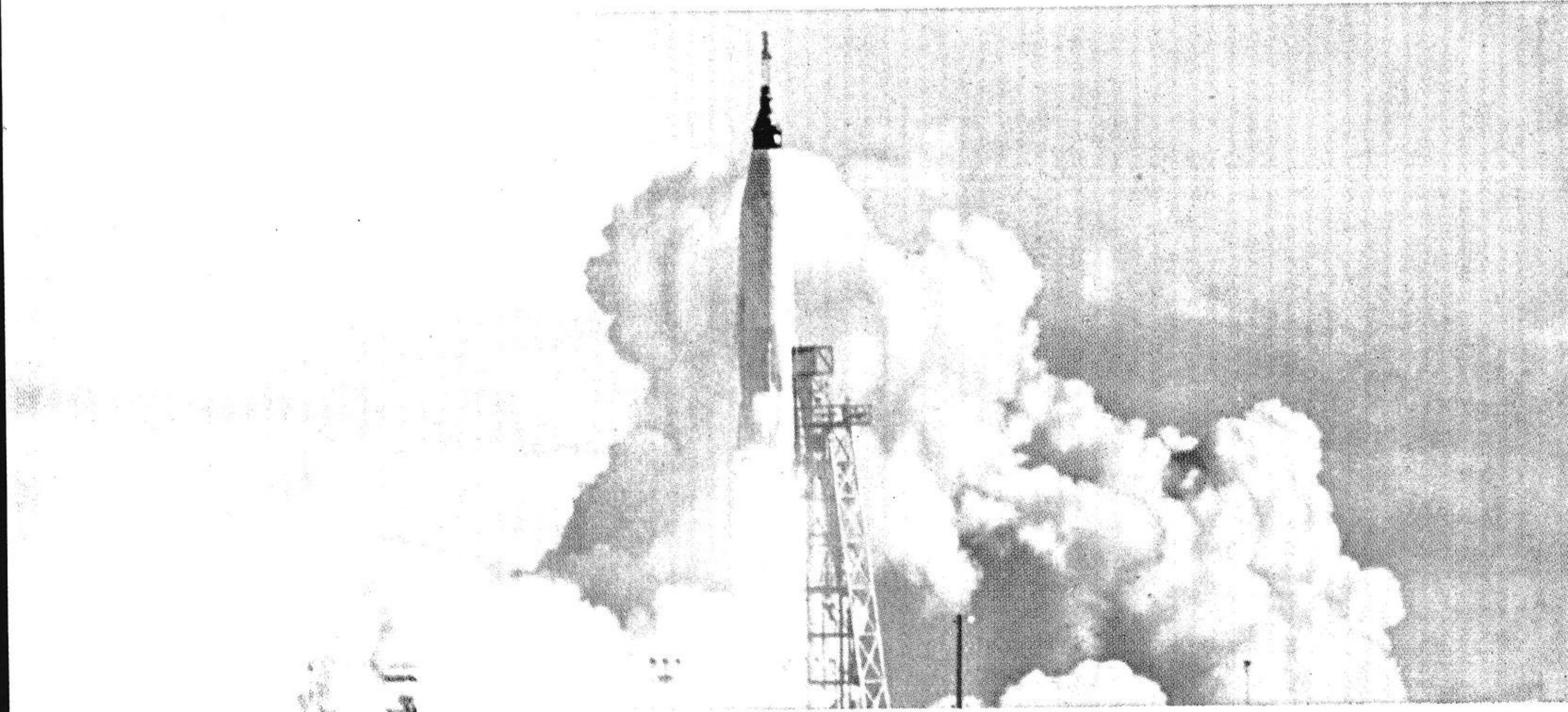

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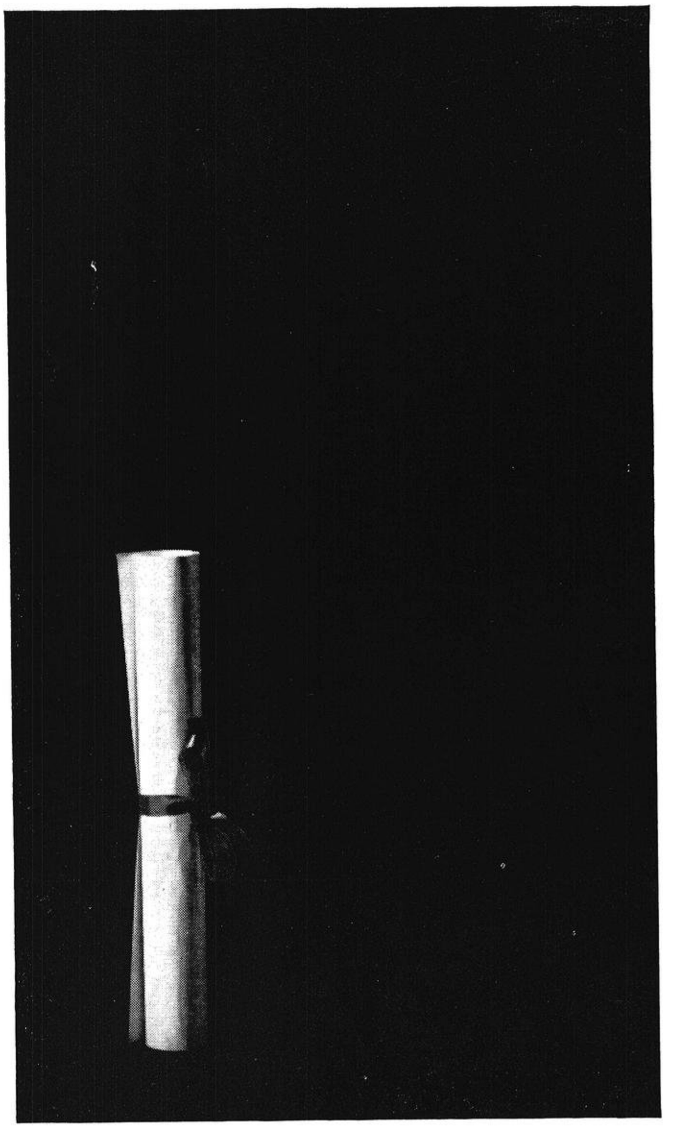

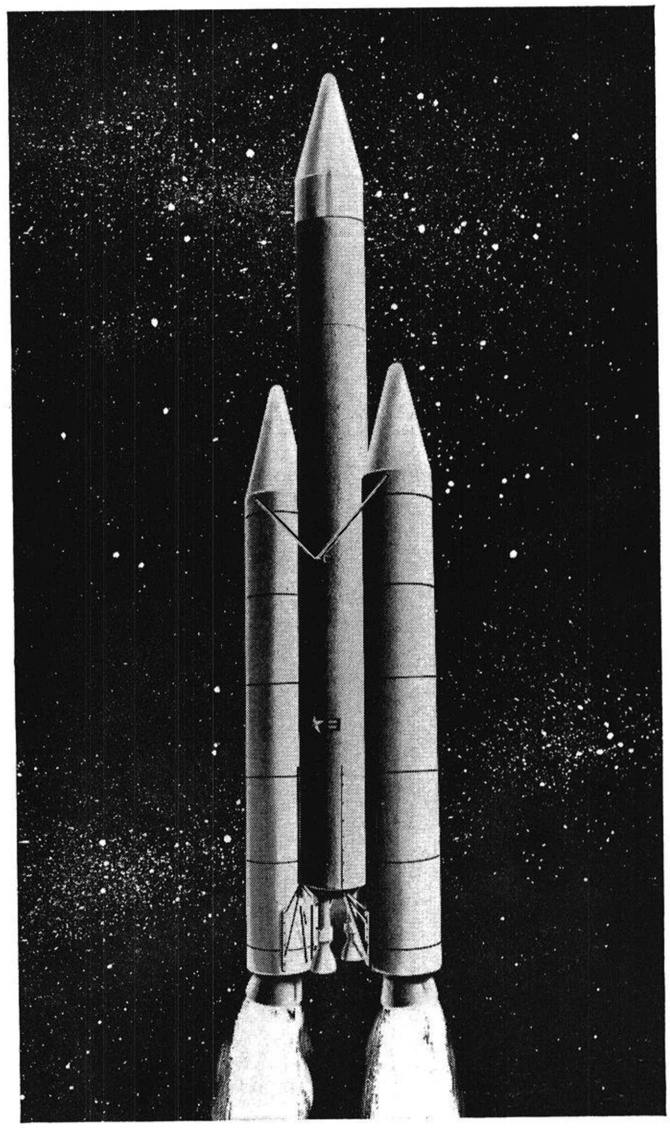

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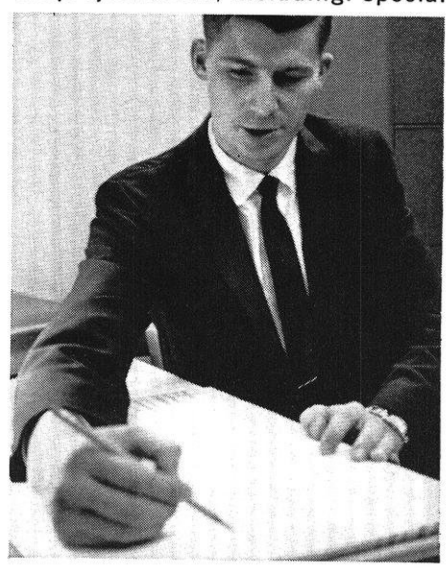
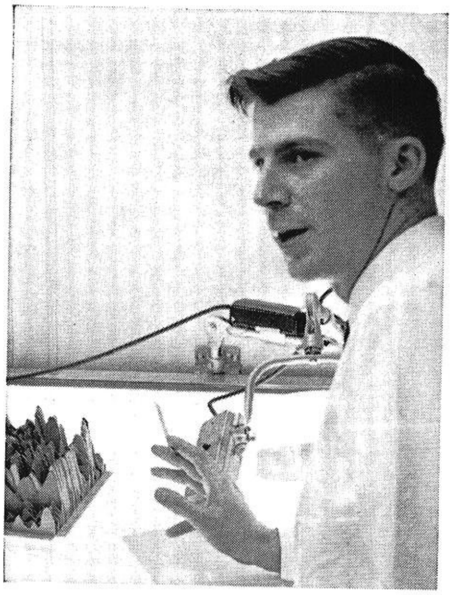


initiative...



transistor circuits, cryogenic development, experimental studies on voice output from computers. He is now being recognized for his success in developing a new method of compressing speech by which time might be saved in voice transmission of data.

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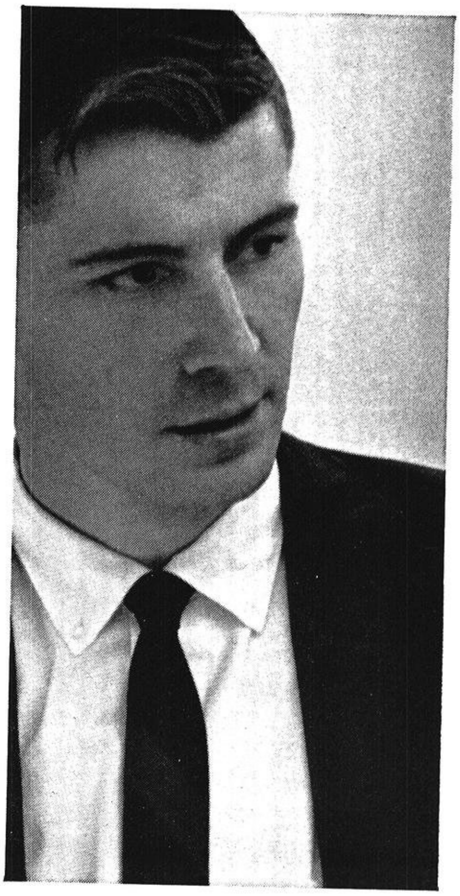

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ARTICLES

THE WISCONSIN ENGINEER

The Student Engineer's Magazine Founded in 1896

FEATURES

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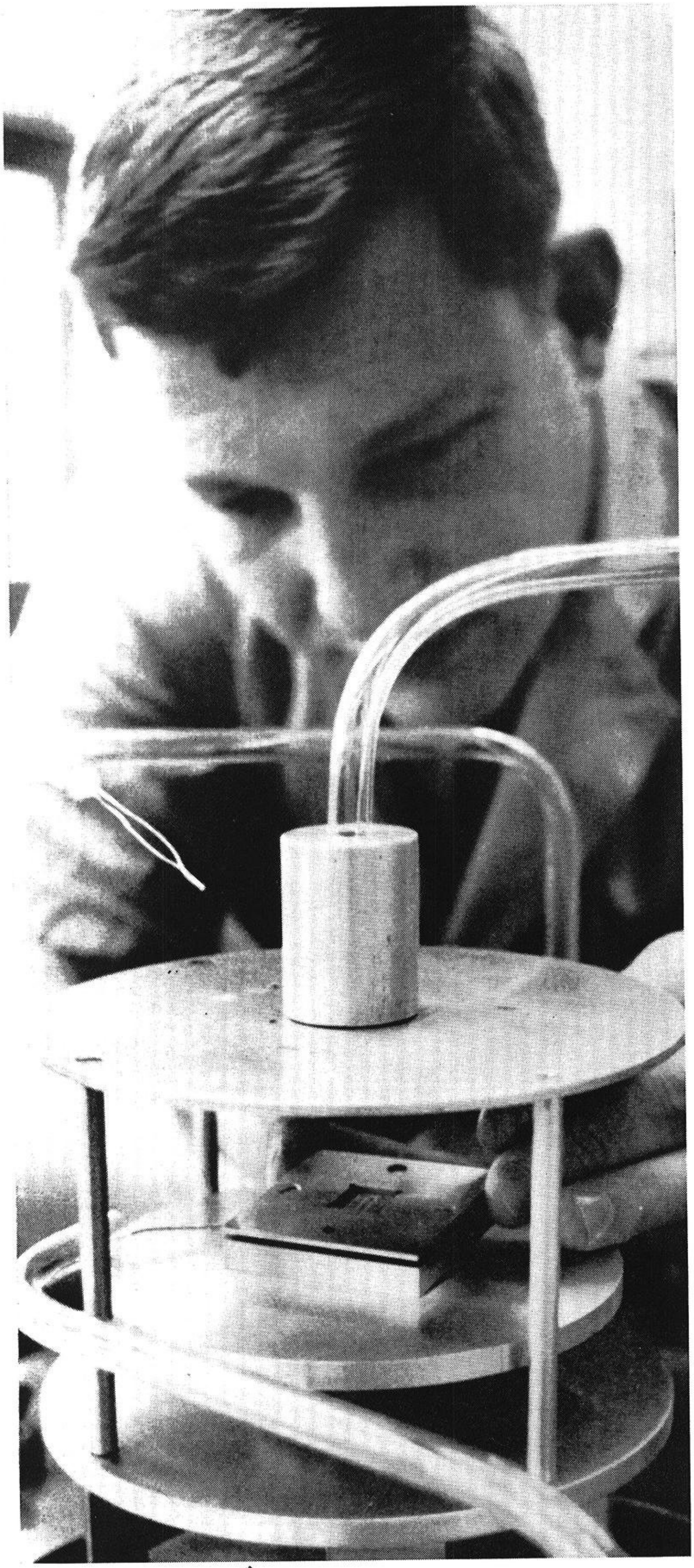

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■ Edward G. Whittaker, III received his BS Degree in Engineering Physics from Colorado University in January of 1963. Shortly thereafter he joined the Research and Advanced Development Group at Delco as a Physicist.

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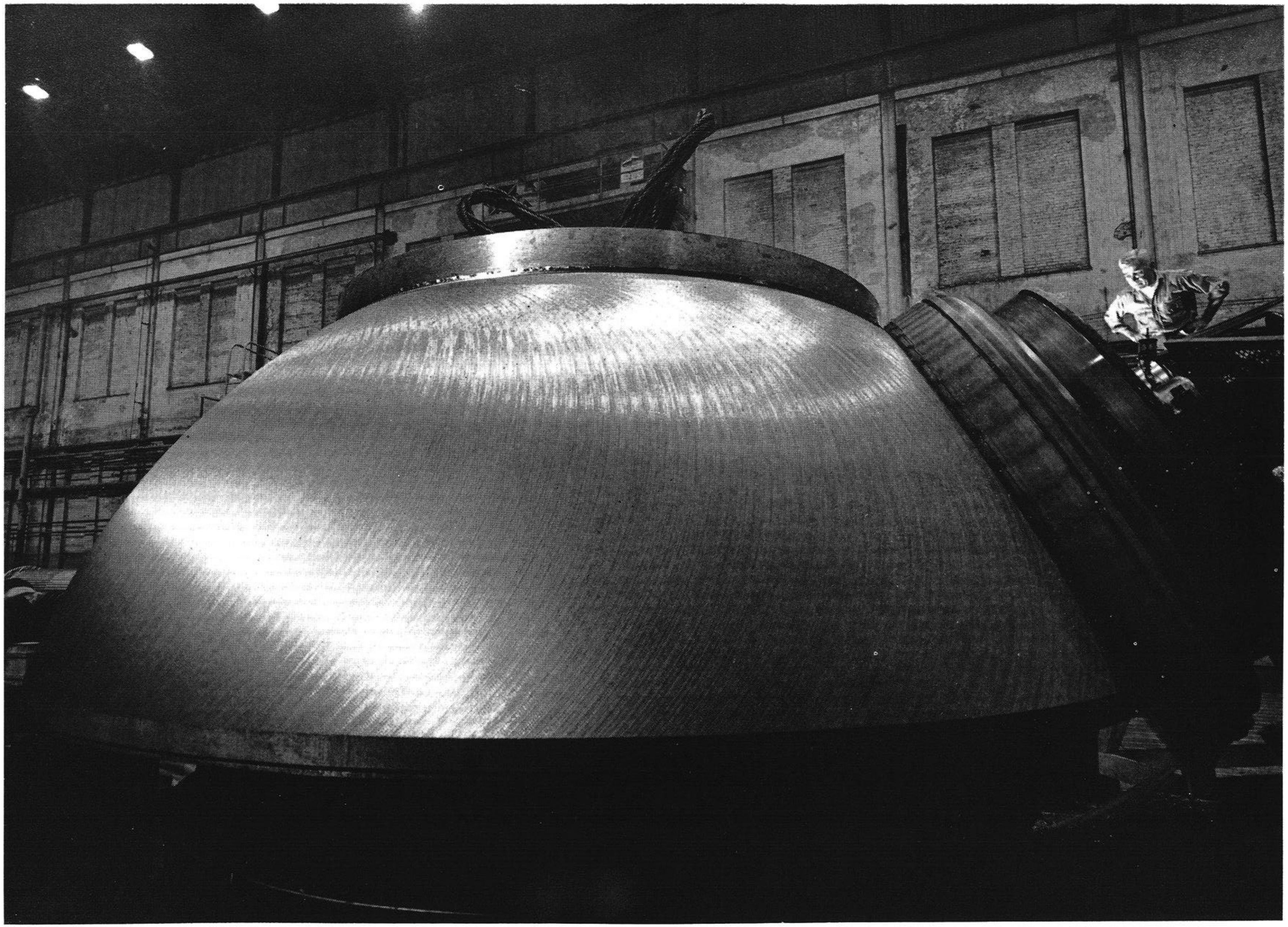

LOST YOUR BEARING? TRY THIS ONE

There is not much chance of anyone ever losing this bearing—it weighs a mere one hundred sixty-seven tons. This huge chunk of steel, seventeen feet in diameter, is being machined at the East Pittsburgh Plant of Westinghouse Electric Corporation. It will be installed as part of a radio telescope at The National Radio Astronomy Observation at Green Bank, West Virginia. The large radio telescope at the Observation moves around and points toward sound or radio signals, necessitating a large, low-friction bearing to support the weight of the operating telescope.

Rambling With The Editor

"The man of science appears to be the only man who has something to say, and the only man who does not learn how to say it."—Sir James M. Barrie, *English novelist.*

How many times today will an engineer or scientist fail to express his thoughts satisfactory to his employer, his co-workers, the men he is supervising, the public, or even to himself? Or closer to home, how many times today will we, as students, ask a question or discuss a problem with an instructor in a manner which will call for additional explanation because of misunderstanding.

In industry this inability to express yourself clearly means money, time, effort and maybe a promotion lost. In school it means incomplete understanding of some problem and reduced grades.

How do we overcome this handicap? Simple, by listening, reading and writing. The first two go hand in hand. By listening and reading we can develop a useful vocabulary while exposing ourselves to many effective styles of expression.

Writing is the hardest of the three to conquer. Fortunately a technical writing course is a requirement at the university but this one course is not enough to make us accomplished writers. We should look upon the many laboratory reports which we have to turn in as an opportunity to improve the writing techniques obtained in the technical writing course.

Then, we should look for other opportunities to practice our writing for a different kind of communication. *The Wisconsin Engineer* offers an excellent outlet for technical and non-technical articles which may be modifications of material you may have already prepared for laboratory experiments or special projects.

In addition to the pride of accomplishment in producing a good article, you also may benefit financially. For example, *The Wisconsin Engineer* gives three awards each year for the best articles. The technical societies often have cash awards; there are a number of national handling paper awards each year; and the Lincoln Welding Foundation has an award. Of course, companies are always interested in students who have produced publishable material.

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R. N.

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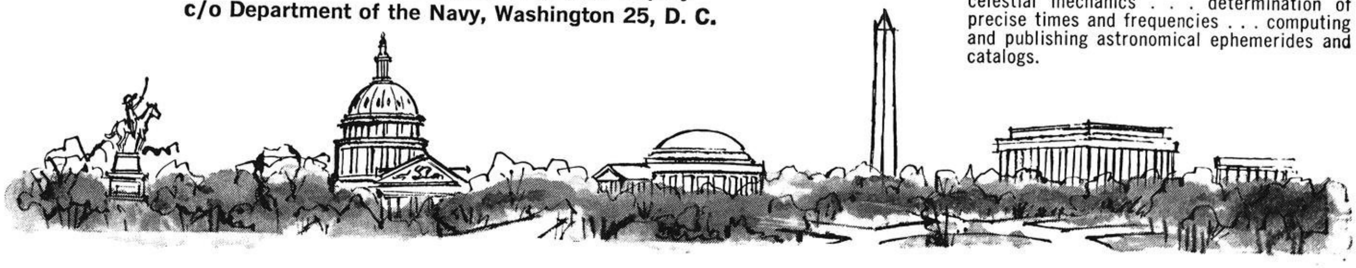
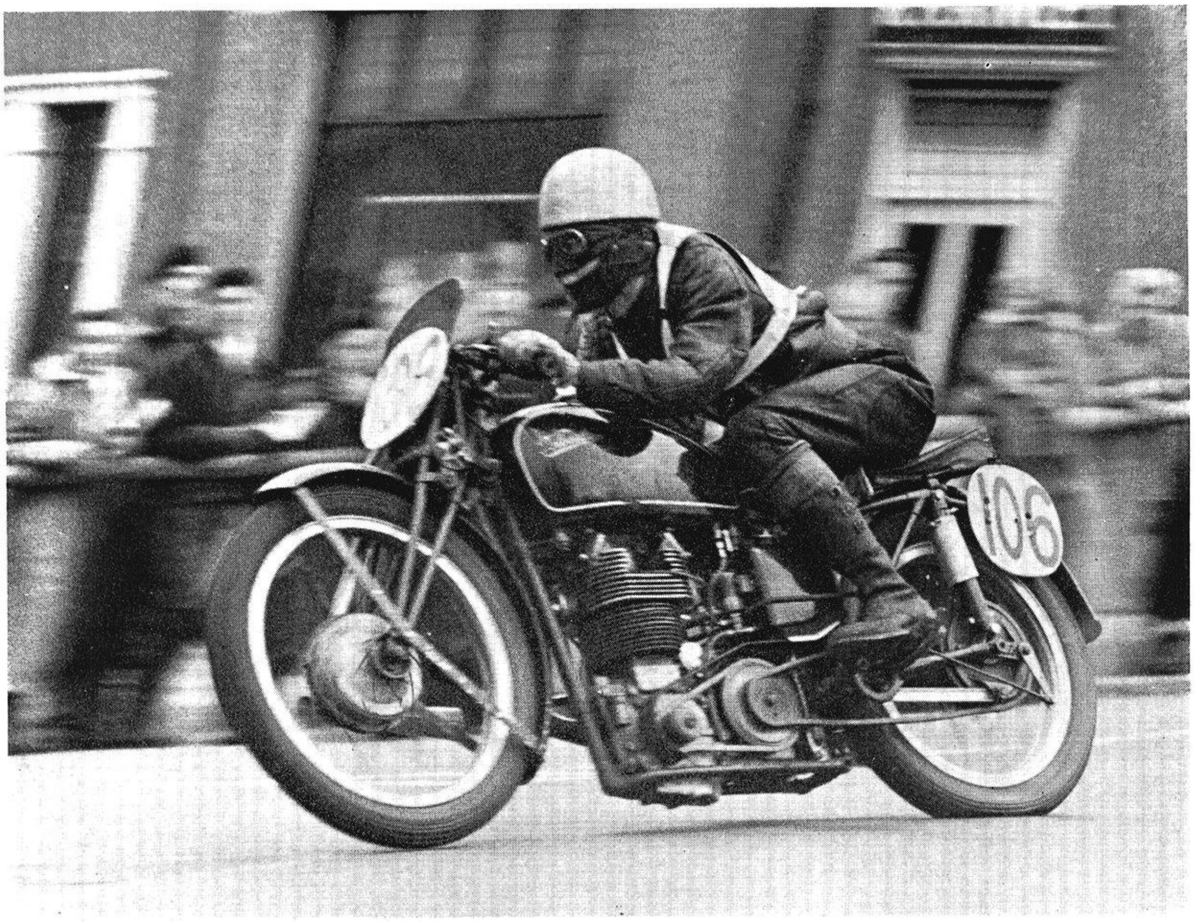


The Design of Engines for Motorcycle Racing

By Hedley J. Cox, ME-4



Hedley Cox is from Birmingham, England and has been in the United States for 7 years. He used to be a motorcycle racing mechanic and has raced a few times himself both in England and Canada. After graduation he plans to stay in the U.S. The above picture is Hedley racing in England.

MOTOR-CYCLE road racing is a thrilling and fascinating sport. The public sees the desperate battles to win the races, and the more knowledgeable enthusiast follows the contest between the different makes with keen interest. But the engineer has a much deeper interest. How can such fantastic speeds be squeezed from such small engines? How are the motor-cycles steerable at all? How do they keep up such speeds for two hundred miles or more?

Some of the finest engineers in the industry have applied their brains to the working of the internal combustion engine. There is little doubt that the type used in the racing motor-cycle has benefitted from this, because it is the most powerful normally-aspirated engine of its size in the world.

THE MANUFACTURER'S VIEWPOINT

What makes a motor-cycle factory decide to support racing? This is a complex question, and has grown more so with the years. In the early days, the pioneer makers would "hot-up" one of their machines, as well as they knew how, for one of their enthusiastic customers, for a price, of course. But motor-cycles then were extremely unreliable, and slow, so, apart from the money realized from their customer, the makers gained nothing. It was not long, however, that they began to realize that if one of their bikes won a race, they would immediately sell at lot more to the general public. The public, in effect, said to themselves, "Blank's bikes must be good, because they beat all the others in the big race last week."

So makers started to give assistance to those who raced their products, and widely advertised their successes. They reaped a rich harvest, because not only did they sell more if they won, but as they applied the lessons they had learned in racing to their standard machines, these were improved in their turn, and customers could easily see for themselves that the racing makers turned out better bikes. The extra research cost something, but they gained far more.

Fairly early, too, enthusiasts from different countries got together and formulated rules, under which they would compete against each other. So started the Federation Internationale Motocycliste, which now controls all phases of the sport in most of the countries of the world.

They decided to limit the capacity of the engine, and to allow only regular pump gasoline, and that was all. Several classes were set up, the engine size for the largest, or "Senior" class being set at 500 cubic centimetres, the next, or "Junior" class, at 350cc, and there were others at different times, of 250cc, 175cc, 150cc, and 125cc.

Now sportsmen of the world could get together and race as hard as they pleased, with equal opportunity. This they did, and the manufacturers supported them, and shouted the superiority of their machines and riders as hard as they could, for in this way they made sales.

Today things have changed somewhat. Non-racing makers copied many of the improvements of their rivals, as these were rarely patentable, and incorporated them. The expense of building and racing special bikes became astronomical. Nevertheless, machines made by one of the factories that support competition, do have "something" about them that others do not. Perhaps it is the accuracy of the steering, the ability to hold full throttle dependably for long periods, or the "taut" feeling of being one with their riders. Whatever it is, they have it. The early, crude motor-cycles, barely able to reach 40mph, and having to be pedaled up hills, have grown into the modern projectile, capable of over 150 mph, but having exactly the same engine size.

The story of the design of such a machine is fascinating. Behind it all, of course, lies the desire of the manufacturer to beat his rivals. He is paying the piper, so he will call the tune. His is the ultimate decision, to race or not?

Let us say a manufacturer has decided to enter racing, perhaps to increase his sales, which may have been lagging. The first question is, what shall he race? Shall he "hot up" one of his standard bikes? Any success would at once demonstrate their superiority. But in modern racing, success for a standard machine is just about impossible. Shall he then, call in his designer, and bid him design a world beater, regardless of cost, with no thought of making it similar to the bike he sells the public? Success is what sells, and it is the name the public buys, not the dubious similarity to a good racer. But such a machine is expensive and so is hiring the best talent to ride it. And it may not win however hard his designers work. This is his decision.

The Designer's Part

The designer is told to design a motor-cycle to compete with the best in international road racing. The manufacturer will have decided what type of machine he can afford, a "souped-up" standard machine, or a "wild-fowl". This is the designer's first restriction. The second is usually the engine size, as the maker will have his eye on a particular class, perhaps 250cc, perhaps 350cc, or even the 500cc.

Superchargers and exotic fuels are banned from road racing, so he can forget these. Two-stroke or four-stroke? Usually his boss will decide this too, on the basis of what the company sells. However, it is no exaggeration to say that, if he has no particular new ideas on two-strokes, he should pick a four-stroke. Two-strokes have rarely done well in road racing, as once they get away from the simple, low-powered, three-port crankcase compression design, they become so involved and complicated in design, that they are for two-stroke specialists only, and even then, they hardly ever beat the four-strokes.

BASIC CONSIDERATIONS OF ENGINE DESIGN

First Thoughts

Here is an engine, its swept volume no more than 500cc—equal to 30.5 cubic inches—about the size of a fair-sized kitchen cup. From it, to be competitive, must be squeezed about 55 brake horsepower, perhaps more.

Several factors are basic. First, the engine must be reliable. "They count the winners at the finishing line" is an old dictum, but true. If you can't finish, you can't win. This means reliability at maximum power for two hundred and fifty miles. A rule of thumb is that eight hours at full load and maximum speed on the test bench will ensure this. Obviously the engine must be powerful, but the power must be usable. Racing engines develop their power over a very narrow range of revolutions, and this range gets narrower, and creeps higher up the scale every year. Below 6000 rpm, few engines have much power at all, while 9000 rpm may be their maximum. Getting up into this range imposes severe strains on the clutch and the rider's skill, so the point must be remembered.

The engine must also be light. Every ounce hampers acceleration and braking, so the lightest construction consistent with adequate strength is used, and many parts are specially lightened. This improves handling, too. If two motor-cycles have the same power, the lighter one is faster through curves, as well as on acceleration.

How Many Cylinders?

Assuming that the designer has been given a fairly free hand, his choice of engine types is large. His engine may have from one to eight cylinders, or more if he wishes, and these may lie at many angles to the crankshaft and in the frame. He may choose air or liquid cooling, and there are several different forms of valve arrangement.

Taking the simplest type first, the single cylinder engine, he has a type that can produce a very high power output, but, like all the others, it has its limitations. The power produced by any engine is a function of the amount of gas burned during each power stroke and the number of times it is burned per minute. With the amount limited to 500cc, the most power comes from the engine that will turn more quickly than the others. So the aim is to get the highest rotational speed possible consistent with efficient "filling" of the cylinder, or volumetric efficiency. The engine with the bore approximately equal to, or slightly larger than, the stroke, will turn more quickly than the "long-stroke" engine, because of the latter's high inertia forces and losses in piston friction. Also, with the larger bore, bigger valves may be used, which can increase volumetric efficiency. So any "single" chosen will be a high-reviving type with approximately "square" bore and stroke.

Experience has shown that such engines can give high power outputs, and be extremely reliable while doing so. However, compared with a twin-cylinder engine, it will be found that the area of the inlet valve opening is definitely less for the single, and in today's very high speed engines, the inlet valve area, if not obstructed, defines the volumetric efficiency, and so is one of the basic factors in the design.

But in carburation, no "twin" can compete with a "single," as the manifold, with its bends and changes of section, is very inefficient. If the twin, though, is constructed as two singles, using two separate carburetors, it can "breathe" as well as the single, it has lower inertia forces due to its shorter stroke so its reciprocating parts can be lighter and stronger, and its balance can be better. It loses somewhat in mechanical efficiency, having two sources of piston friction, twice as many piston rings and cams, and more bearings and gears. On the whole, the balance favors the twin.

Every advantage listed for the twin over the single applies just as much for the "four" over the twin. But now a few more considerations are added. While the four may peak at ten thousand rpm, and its valve opening area may be much larger than that of the single, the inlet charge tends to be restricted by the small size of its passages. This is known as "wire-drawing." The stem of the inlet valve cannot be reduced below a certain size, and it can offer quite a large obstruction in the path of the incoming gases. The whole power unit becomes very large, and difficult to fit in a motor-cycle frame. Cooling without distortion becomes a big problem and reliability with so many moving parts is not easy. Four carburetors are required, and these must be perfectly synchronized. If eight cylinders are considered, such factors loom very large. The only "eight" ever built and raced was by the Italian Moto–Guzzi company. Although very fast when going well, it did not steer as it should, and often finished a race on only seven or fewer cylinders. It was discontinued.

THE COMBUSTION CHAMBER

The Shape

In the actual designing process, the combustion chamber is the first section to receive detailed consideration. It embraces not only the combustion space itself, but the passages leading into and out of it, and the valve and piston layout, as all these affect the power output. The ideal shape is a perfect sphere, with the ignition at the center. Then the flame would spread equally through the space. Obviously, this is impossible, as the spark plug must be on the wall somewhere. The next best design, theoretically, is the "pent-roof" combustion chamber, with the piston forming the floor, the plug at the top center, and the valves inclined in the flat sides of the "roof." The chamber is compact, and the flame will spread evenly from the plug at the center. However, some practical difficulties intrude. For best cooling, the head is cast in aluminum alloy, and as this is too soft to stand the pounding of the valves, valve seats of harder material must be inserted. For large valves these inserts almost touch at the center, so there is no room for a plug here. And in the side view, the head has some awkward corners. So the plug is usually moved to the side, and the chamber made hemispherical, which is easy to machine. The valves are set at an angle, because they, and the inlet valve in particular, can be much larger like this. The angle between the valves is about 60 degrees.

The Valves

The inlet valve is made as large as possible, which can be over half the bore of the cylinder and is opened as far as possible to allow maximum weight of charge to pass. It is kept fairly cool by the incoming stream of air and fuel.

The exhaust valve has to be opened against a high cylinder pressure, and is immersed in a flow of very hot gases while open. So it runs red-hot, and is one of the most highly stressed components in the engine. It is made of a special austenitic steel alloy, as ordinary steels weaken at these temperatures. The valve gets rid of most of its heat through the inserted seat, which is made of high-conductivity aluminum-bronze. To try and keep it cooler, which would allow higher compression ratios to be employed, the exhaust valve is sometimes made with a hollow stem and head. The space is filled with metallic sodium, which melts at running temperature. This conducts the heat from the head of the valve to the stem, where it is passed out to the valve-guide. The valve-guide is sometimes oil cooled, too. Copper can be used instead of sodium, but does not melt, and is not quite as good. The exhaust valve need not be opened as far as the inlet, as the gas inside rushes out under pressure, while the inlet gases have only atmospheric pressure to help them in.

Two-valve heads have always been superior to three- or four-valve heads in the past, although three or four valves offer a theoretically larger inlet opening area. If two small exhaust valves are used, the single inlet valve can be very large, but the two small valves have to lie radial to the hemispherical chamber, and the mechanism to operate them becomes rather complicated. If four valves are used, two inlet and two exhaust, the narrow space between the exhaust seats in the head gets dangerously hot, and the two incoming gas streams obstruct each other and are obstructed by the sides of the head. Moreover, if one carburetor is used, the port must be divided, and undesirable changes of velocity occur. If two carburetors are used, it seems impossible to synchronize them properly. These difficulties are very real, and have prevented the wide adoption of more than two valves per cylinder in racing. Recently the Japanese Honda has been enjoying some success, and as it uses four valves per cylinder, so the solution is not final yet. A three-valve A.J.S. has also had some wins.

Care always must be taken to see that the valves do not foul each other on full or part lift. This is very possible with the extended valve-timings used in racing. And both valves may come dangerously close to the piston.

The Valve Ports

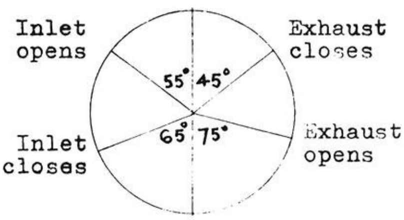
The inlet port should be as straight as possible, and highly polished, to offer as little obstruction to the incoming gases as possible. Where there is an unavoidable obstruction, such as the inlet valve stem and its guide, the port is widened gently in this area to maintain the same area. Different designers have different theories on the best shape for the port, and each one guards his secrets. Work has been done in laboratories to find the best shape to pass a known volume of air, but the results have not been made public. Downdraught ports, inclined at 15 degrees to the horizontal, are known to give better cylinder filling, and an offset to the center-line gives the charge a rotational "swirl" which promotes turbulence in the chamber. A turbulent charge scours the burned gases from the walls, and burns more rapidly.

The exhaust port, because the gases flow through it under high pressure does not require the same detailed attention given to the inlet port, although it should be clean and polished.

Breathing

To get as much charge as possible into the combustion chamber, the whole breathing system is carefully "tuned" to be in phase with its various parts. First, a wide overlap is given to the valves, they are both open together at the end of the exhaust stroke by as much as 100 degrees. To take advantage of this, inlet and exhaust passages are carefully adjusted for size and length. When the exhaust valve opens, a pressure wave travels very rapidly down the exhaust pipe to its open end, and is reflected as a suction wave. When the suction wave reaches the valve, it will remove the burned gases, and if the inlet valve is open, will suck in some of the fresh mixture. The exhaust valve then has to be shut quickly, or this mixture will be wasted down the exhaust pipe, but it does get the column of air and fuel moving. Then the descending piston adds its suction, with the result that when the piston stops at the bottom of the stroke, the column of air has considerable kinetic energy due to its velocity. The inlet valve is held open until the piston has risen a considerable distance, while the charge continues to pile in, then it is shut quickly.

For best results, the exhaust pipe must be a certain diameter and length, and at its open end must be fitted with a long cone-shaped device called a "megaphone." Also the inlet pipe must have the right diameter and length between the valve and the point of fuel entry, and must be fitted with the correct sort of air intake, usually a bell-shaped fixture. No silencing system is used. There is a formula that can be used to calculate the exhaust pipe length, but so many factors are involved, that best results can only be obtained by trial and error on the test bench. In general, the shorter the exhaust pipe, and the bigger the inlet port and carburetor, the higher will be the power. But race regulations now state that the exhaust pipe must not terminate before the plane enclosing the rear wheel, and as a result, although the top end power may be high, the acceleration suffers. So a com-



Value timing diagram.

promise has to be worked out on the test bench. If the engine is being prepared for a race on a long, high speed course, it will probably be fitted with a cylinder head having a large bore inlet tract, and the exhaust pipe may have a long, narrow megaphone. If the race is over a short, twisting circuit, where maximum acceleration is desired, the head fitted may have a smaller inlet tract, and the exhaust system used may have a small megaphone, or no megaphone at all. It should be remembered that below the range at which the system is in resonance, there is very little power at all, and the running is rough and erratic.

The Piston Crown

The next matter of concern is the piston crown. The most efficient shape for the piston crown is flat, to give a hemi-spherical chamber. But a low compression ratio results, so pistons have a crown on them, the shape varying with the engine. More is gained from the increase in compression ratio than is lost by having an inefficient chamber. Clearance pockets have to be cut in the crown in order to miss the valves, and the resulting shape is a far departure from the perfect. The crown should not be less than 0.250 in. thick, or it may burn through.

Sparking Plugs

One 14 millimetre sparking plug, offset to the engine centerline, as mentioned before, but radial to it, is usual. The type of plug is very important. It should have a long reach so that its inner end is flush with the head hemi-sphere and so that no sharp thread edges are left standing out to overheat and start detonation. "Soft" plugs that will stand a lot of oil, slow running, and a cold engine are used for starting and warming up, but in a race, or in power testing, "hard" plugs are used. The electrodes of "hard" plugs are recessed so they will stand hard driving better than the "soft" plug, whose exposed electrode tends to overheat. But the "hard" plug "oils up" more easily, which is more likely to happen when the engine is cold.

A late trend is to use two plugs, one each side of the cylinder. These do not spark simultaneously, but a micro-second or so apart. Proponents of the scheme declare that it gives better results, but this is uncertain yet, and the added complication and inaccessibility make it seem hardly worth while.

Compression Ratio

The compression ratio has little meaning, unless the cylinder is completely scavenged of burned gases and filled with fresh charge. In too many standard engines this is not so, and therefore they will stand compression ratios that would ruin an engine which had a high volumetric efficiency. But their power output will be disappointing.

The smaller the cylinder, the higher the compression ratio it will stand, but the output does not go up in proportion at all. The reason for this is that the smaller cylinder has a larger surface/volume ratio, so more of the work liberated by the combustion is lost to the cylinder walls. In fact, the greater power output of multi-cylinder engines is mostly derived from their greater volumetric efficiency and higher rotational speed.

The Ignition Point

Contrary to widely held opinion, the ignition point on racing engines occurs quite close to top dead center. This is because the combustion chamber is so well filled with fresh gas, which is so turbulent, that rapid flame travel is assured. Therefore, the gas is ignited just a sufficient distance before top center so that the flame has spread across the chamber at the instant the piston is at the top of its stroke. Any point later or earlier would be wasteful.

Summary, Combustion Chamber Section

By now, enough has been said to show that many points in the design of a good racing engine are difficult to decide from theory alone. Practical experience is invaluable, and from this comes the knowledge that when a new engine is being laid out, plenty of room should be allowed for future modifications. Many decisions will depend on the results of bench tests.

On the bench, variations will be made, one at a time, in valve timing, piston shape, inlet tract length and diameter, exhaust pipe length, megaphone size, ignition timing, carburetor settings, and all combinations of these. When the best setting has at last been obtained for the speed range desired, the compression ratio may gradually be raised. This will affect many of the variables just mentioned and many of the tests have to be run again! If the compression ratio is raised too high, detonation will begin, and may be recognized both by the tinkling noise made by the engine, and the way in which the top of the piston remote from the sparking plug becomes eroded. This is the origin of the phrase "The mice have been at it," because the top of the piston looks as if it has been nibbled by tiny mice!

MECHANICAL CONSIDERATIONS

The Cylinder Head

Once the basic layout and bench work have been done, many problems of a mechanical nature require consideration. The first of these is the cylinder head.

The cylinder head is a very vital part of the engine. Located in it are the valves, ports, the hemispherical combustion chamber, plug or plugs, and often the valve operating mechanism. Some of these have already been mentioned.

Usually, motor-cycle engines are air cooled, and, for this reason, are placed so that the exhaust port, the hottest region, is facing forward. There have been liquid cooled engines, but this was before the war, when supercharging was allowed. For air cooling, very deep fins are cast on the cylinder heads and barrels. It may seem that these are too deep for the air to get to their roots, but they do conduct the heat out from the still region of air behind the front wheel out into the air stream. And they certainly work.

Often the engine is inclined in the frame, so that the air will impinge on the center of the cylinder head, another hot part. Some engines are placed horizontal with the head foremost, and the B.M.W. flat twin has one cylinder protruding out each side into the air stream. These types are well cooled.

The cylinder head is made of cast aluminum alloy for maximum heat conductivity combined with strength. The valves have to have inserted seats. The exhaust seat is made of aluminum-bronze, for conductivity, as was mentioned before. The inlet seat does not have to pass so much heat, but does have to resist the effect of small particles of grit, drawn in in the air stream, being hammered on it by the valve. Aluminum-bronze is too soft for this, so austenitic cast iron is used. Both materials have a coefficient of expansion close to that of the head material, so they are a parallel fit, inserted cold after the head has been heated in an oven, and there is no danger of them coming loose. Volumetric efficiency seems to improve if the inlet seat is slightly proud of the surface of the chamber, and the valve seating is kept narrow. The exhaust valve seating can be wider.

The Cylinder Barrel

Cylinder barrels are made of cast aluminum alloy, and are deeply finned for air cooling. They must have a liner of cast iron to take piston wear and thrust. Sometimes the heated iron liner is put in the mould, and the aluminum cast around it. But this may result in warping after the bore has been machined, and the temperature is raised in running. A better method is to insert the liner after the aluminum muff has been machined, heating the muff, and dropping the liner in cold. The heat path is probably not as good in this case, but distortion is largely avoided. The Wellworthy patented "Al-Fin" process claims a perfect metallic bond between the two metals, making a good heat path, and this should be better than the two methods of manufacture mentioned.

Barrels for multi-cylinder engines are often made singly, so that if one distorts, or is better cooled than the others, it will not pull them out of line. The barrels are usually clamped between the crankcase and the head by long studs which pass right up from one to the other. In this way, combustion pressures are taken by the crankcase, and not by the barrel, which would probably distort if it were so loaded. The barrels are deeply sunk into the crankcase at the lower end for rigidity.

The Pistons

The crown of the piston has already been mentioned in connection with the combustion chamber. The piston is made of forged aluminum alloy, with its weight equally disposed each side of the wrist pin. Pistons usually carry three rings, two compression, and one scraper, and are relieved at the sides to reduce piston friction, which accounts for fifty percent of the mechanical losses in an internal-combustion engine. The crown must be well supported, and internal ribs help this, and assist in cooling. The scraper ring groove is drilled through to the inside of the piston to drain away the oil the ring scrapes from the cylinder walls. The wrist pin is fitted after the piston has been heated, to reduce excessive clearance at working temperatures. Spring circlips retain the pin.

Piston Rings

Piston rings are made by specialist concerns and are of alloy cast iron, special for racing. They are given fairly wide gaps by standard practice, and are lapped into the piston with fine turkey stone and oil. They must be free in their grooves, with practically no side clearance, as, if too free, they act as oil pumps, pumping oil up into the combustion chamber. They may tend to flutter, too, at high speeds, when they will not hold the pressure. It should be remembered that the piston gets rid of most of its heat through the rings to the cylinder wall.

The Crankcase

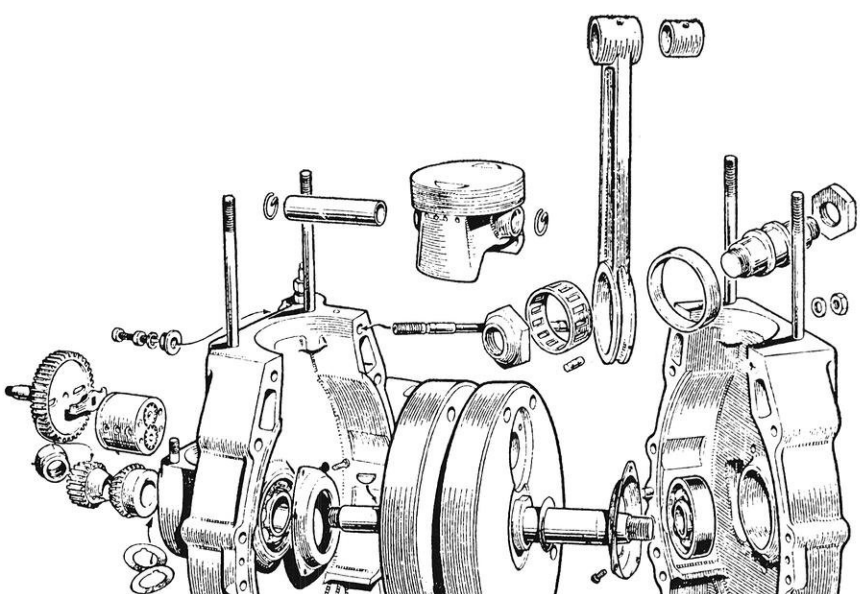
The crankcase houses the crankshaft, and is a mounting for the cylinder barrels, cylinder head studs, ignition system, oil pump, and various accessory drives. It is bolted to the motor-cycle frame, so that it and its points of attachment must be massive and rigid. It is usually cast in Elektron, a magnesium alloy, for lightness. The upper part is built up around the barrels to lend them support, while the underside is finned for cooling.

The crankcase may contain the transmission gears if unit construction is employed, or may be a separate item from the gearbox. In singles and twins, it is usually made in two halves, with the joint vertically at the center-line, for assembly of the crankshaft. In fours, it is split horizontally. In the latter case, the upper half may be cast in one piece with the cylinder barrels, when aluminum alloy is used.

To obviate external oil pipes as much as possible, oilways are drilled in the crankcase walls. This may lead to trouble if the casting is slightly porous, as then air and oil leaks can occur. To make sure that this does not occur, crankcases are sealed up after machining by bolting plates over all openings, and a hot solution of a special reactive agent is poured in. Then air pressure is applied through a valve in one of the plates. This forces the solution into any porous places, and it reacts with the aluminum, forming a salt, which grows, and blocks up the porosity. Magnesium is less liable to this trouble than aluminum.

The outer rings of roller bearings, and ball bearing assemblies, used for the crankshaft main bearings, are fitted cold after the case has been heated. They are thus tightly held in position when both are at the same temperature. Still, in service, it is quite possible for them to work loose, and turn in their housings. To stop this, two or three grooves are ground in the outer race of the bearing, and a thin steel plate is placed over it and screwed to the crankcase wall. Then the plate is punched into the grooves with a center-punch, and the bearing is thus locked in place.

The crankshaft has to have a very minimum of end float, especially when bevel gears are used for the drives. For this, the main bearings are fittted at assembly with shims. The shims are placed



A typical lower-half assembly.

in the crankcase before the bearings are shrunk in place, so the adjustment cannot easily be disturbed. At the bottom of the case is a small sump which collects the oil that is thrown from the crankpin, and which drains down the cylinder walls. This oil is picked up by the return side of the oil pump, and returned to the tank.

The Crankshaft

The crankshaft may be regarded as the heart of the engine. It must take all the piston forces, and translate them into rotary motion. It does this through the crankpin, which takes very high inertia forces, sometimes over a ton at the higher speeds. Therefore nothing must be sacrificed to rigidity, as any flexure will only waste power, and lead to failure of components.

In most singles and twins, as may be seen in the illustration, the crankshaft is built up from two internal flywheels with their mainshafts, and a crankpin. This enables the designer to use an unsplit connecting-rod and a roller bearing at its crankpin end. This loses less in friction than a plain bearing, and the parts may be replaced when worn. Inside flywheels centralize the flywheel forces about the connecting-rod, although the crankcase is made larger and heavier. The built up assembly must be extremely rigid and the mainshafts lined up to run truly within 0.001in. Sometimes an outside flywheel is used. Then the case may be smaller, and only balance weights are placed inside it, but a couple is introduced, so the assembly must be even more rigid.

In fours, a one-piece crankshaft is used, so they are rigid enough, but they cannot use roller bearings at their crankpins, and the connecting-rods must be split for assembly, always a potential source of trouble. Higher oil pressures must be used with plain bearings.

Balancing is important, but the aim is to have the motor run smoothly in its operating range, say from 7000 to 9000rpm. Below 7000rpm, some vibration does not matter, as these speeds are never used. Different factories employ different percentages of the reciprocating weight for balancing purposes. Some balance 60 percent of the reciprocating weight, some 70 percent, others in between. The internal flywheels or balance weights are drilled for final adjustment, and some designers close the holes with light alloy plugs. The flywheels should be polished to minimize oil drag, and the shafts are a tight fit in the inner races of their anti-friction bearings.

The Connecting Rods

The connecting rods are highly stressed components, having to carry such high loads and inertia forces at such high speeds. They are especially vulnerable to fatigue failures, so are highly polished on the outer edge, and all machining marks and points of stress concentration removed or avoided. They are preferably not split at the crankpin end, where the highest loads are carried, but if this cannot be avoided, it must be very carefully designed and made. High tensile nuts and bolts must be specified, and these must be polished and tightened with a torque wrench to obviate excessive strain and distortion. The caps are not interchangeable, and locking wire or pins must be used on the nuts.

The material used for the connecting-rod is a high strength alloy steel forging. Sometimes a designer will use a forging of one of the aluminum alloys. These reduce the inertia loadings a lot, but have not been found to have the reliability required. Steel rods are best replaced every second season, as they may be too fatigued to last another year. If, at any time, they overheat, due perhaps to an oil failure, they should be replaced without question, and they should be crack detected whenever removed, when they should also be checked for parallelism of the two bearings.

THE VALVE GEAR

Valve Location

As four-stroke engines are being considered here, at least two valves will be needed in the engine; one inlet and one exhaust. It must be decided where to locate them, and how to operate them.

The side valve engine, with its valves lying inverted beside the cylinder barrel, is not used in international racing. The combustion chamber has an inefficient shape, the valves are shrouded by their chamber, and the cylinder barrel carries a large mass of metal at one side, which tends to distort it. These faults can be minimized, but are always there. Paradoxically, these engines can attain very high revolution rates, as their valve reciprocating weight is small, but poor cylinder filling prevents them from developing much power at these speeds. They are only used for racing in the U.S.A., which does not belong to the F.I.M., and where they are allowed to use an engine 50 percent bigger than other type engines.

Valve Operation, Overhead Valves

The type of engine with the valves in the cylinder head operated by rockers and long pushrods, is known as the "overhead valve" type. These can be good, but the weight of the long reciprocating rods limits the speed of the valve operation. For this reason, it has been replaced for serious racing by the "overhead camshaft" type.

Overhead Camshafts

The single overhead camshaft is located above the cylinder head, and operates the angularly inclined valves through straight rockers. The camshaft is driven at half engine speed by one of several methods. The simplest is by a chain, as in the A.J.S., but simplicity is not always a virtue in engines. The chain must have a spring steel strip rubbing against the slack side, and this must have a damping device applied to it, or the chain will jump the sprockets. The chain wears, altering the valve timing, and it is difficult to break the links in it and re-rivet them on dismantling and re-assembly. The vertical shaft, as used on the Norton and Velocette, is driven by bevel gears from the mainshaft, and has Oldham's couplings, which separate easily for dismantling. The timing does not vary, but the shaft has clearance endways, as it expands at a different rate from the cylinder. The N.S.U. uses another method. Two eccentrics at the end of the camshaft are linked to a similar pair by the mainshaft by two long rods, something like the connecting rods between the wheels of steam locomotives. It appears to work well.

Even the overhead camshaft engine became too slow, so to allow for greater speed, twin overhead camshafts came into fashion. These did away with the reciprocating rockers entirely, one camshaft being placed over each valve, and operating it through short tappets. The tappets were used to prevent the cam imposing side thrust on the valve, and to allow for clearance adjustment. However, greater complication arose because the widely spaced camshafts had to be driven by a train of five gears from the center shaft. This train not only had to be enclosed and made oil-tight, but imposed severe loads on the vertical shaft and bevel gears when the speed changed. So, these had to be redesigned to take the higher loads.

The latest development is the "desmodromic" valve gear. Springs were failing to return the valves to the cam contour, so the springs were dispensed with, and one rocker opens the valve, while another closes it. Four cams are required on the single central camshaft, two being obverse copies of the others. Care must be taken that the valve is not slammed shut on its seat, or its head would be pulled off. Cylinder pressure is relied on for the last fraction of movement in closing the valves, and the engines seem to work very well.

Valve Springs

Most engines still use valve springs, so a word or two on these will not be amiss. Coil springs went out of favor for racing because of their tendency to "surge" and break at high speeds, which is partly due to the stresses on them being a combination of torsion and shearing stresses. They were replaced by "hairpin" valve springs, which are subjected to bending stresses only, and are free from "surge." They are shot-peened to increase fatigue life. They are rather large, however, and restrict the flow of cooling air to the cylinder head if enclosed. If open, grit from the air can get to the valve guides, and oil is apt to leak onto the head from the cam gears.

Unconventional Valves

Every so often, an unconventional valve, usually rotary, is loudly proclaimed, but so far, none has been successful. The sealing against combustion pressures, and adequate lubrication and cooling, together with distortion problems, has prevented their adoption, in spite of their theoretical advantages.

CAMS

As has been seen, the most powerful engine is the one that burns the greatest amount of fuel in the shortest time. The valves control the fuel inflow, and the cams control the valves. As the spread rises, however, the valves tend to leave the cam shape under their own inertia. This will be less likely to happen if the cam contour is designed correctly.

Design

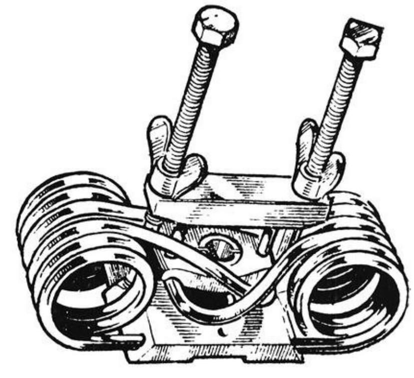
The best shape for the cam contour is the constant acceleration curve. This puts lower loads on the operating mechanism, and evens out the wear. The designer has to decide how much acceleration the drive gears will stand, and the springs will tolerate. The inertia forces rise with the square of the acceleration, so he must be careful, as a broken valve can wreck an engine, and over-strong springs only waste power.

Material

Cams are made from case-hardened steel. Care has to be exercised in the choice of the material in the follower which bears against the cam. Speeds and loads are high. Oil must always be fed to the rubbing surfaces, or serious overheating will result. The follower surface may be of stellite deposited on steel. Sometimes copper plating is used on hardened steel, and hard chrome plating gives very good wear resistance. The cam itself is occasionally plated with one of these metals, but this does not seem as effective here as on the follower.

LUBRICATION

Lubrication is vital, as a poor oil supply can ruin a promising engine, or hide its qualities. Gear type oil pumps are used exclusively in racing. They are dependable and reliable, but a filter should be incorporated in the system to keep foreign matter out of the gear teeth. End clearance should be reduced to a minimum, and it is better if the feed and return pumps are separated completely, as leakage is possible if the two pumps are incorporated into one unit.



Hairpin Valve springs.

The "dry sump" oiling system is used. Oil is carried in a separate compartment, or an oil tank. From there, there is a gravity feed to the pump in the engine. The pump takes a pressure line past a pressure adjusting valve, and to the crankpin, and to the cams. The amount of oil each receives is controlled by the size of the jet at the feed point. For a single cylinder engine with roller bearing crankpin, about 0.050in. is a reasonable size for the crankpin jet, and 0.035in. for the cam jet. Most other parts are lubricated by oil flung from the various moving parts, though feeds may be taken to any point deemed necessary.

Oil drains to a low point in the crankcase, where it is picked up by the return pump, and returned to the tank, sometimes through a cooler. Oil is used not only as a lubricant, but as a coolant, so a copious supply is required. In fact, the trouble is often over-lubrication.

Oil may find its way down the valve guides or up past the piston, into the combustion chamber. Here it may be deposited on the plug, which entails stopping the engine to put in a fresh plug, or it is burned as fuel. But its caloric value is far below the regular fuel used,

(Continued on page 41)


THERE WILL BE AN EAGLE
PRATT & WHITNEY AIRCRAFT
DEPENDABLE ENGINES

Principles of Human Learning

By Arthur J. Carey, ME'63

Arthur graduated from the University of Wisconsin with a B.S.M.E. Degree in June, 1963. He is currently employed as an engineer by the Waukesha Motors Company.

This is an interesting article that explains the basic principles of learning both physical and mental skills. The author credits most of the informational content of the article to lectures given by Professor Archer of the University of Wisconsin.

THE way in which the learner distributes his practice is one of the most important factors in learning a physical skill. Usually short intervals of practice with frequent periods of rest permit more efficient learning than is continuous practice.

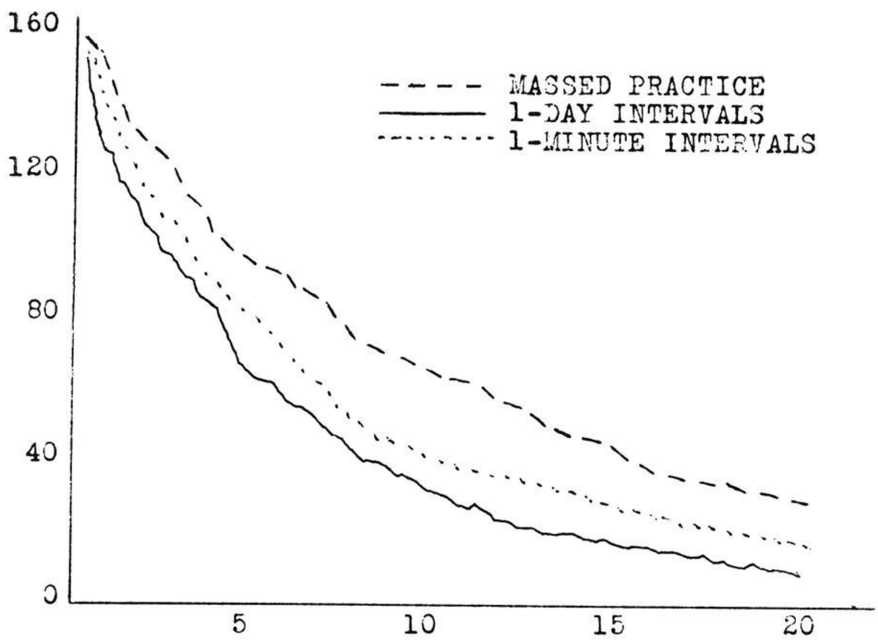
In general, practice periods should be kept short. The longer they are, the more they tend toward continuous practice. However, if they are too short, the task being learned is broken up into artificial or meaningless units. More often than not, the rest periods should be fairly long. A study made by I. Lorge in 1930 produced the following results, "The longer the rest, the more effective a given amount of practice." This holds true, of course, only up to some optimal point; and the ideal length of rest varies widely for different tasks. For more complex tasks, such as typing, juggling or piano playing, long practice periods and short rests are favorable. Simple tasks, such as shuffling cards or pounding nails, are learned quickest with many rest periods and relatively short practice sessions. The only general conclusion that can be drawn concerning distribution of practice is this: short practice sessions interspersed with frequent, short rest periods are superior to long practice sessions and long rest periods.

Another important factor in learning a skill is knowledge of results. When learning to shoot a rifle, a person does far better when he can see the mark of each bullet on the target before firing the next shot. The same holds true when driving golf balls. If the flight of the ball is observed, a correction or an adjustment can be made before the next ball is driven. Knowledge of the results, then, speeds up the learning process because it allows the learner to associate his physical action with the outcome.

Knowledge of results, or "feedback" of information is also an incentive to learning. When a person knows how he is doing, he becomes more interested in his task. Playing golf but not keeping score would show a lack of motivation for improvement, and learning to play the game well would take much longer.

If we were to plot the rate of learning with practice, we would have what psychologists call a "learning curve". When a person knows how he is doing, improvement is slow but steady up to some optimal point. Without feedback of information, there is little or no incentive for improvement, and there is chance to make corrections. In some of the more complex tasks, such as playing the piano or receiving telegraph messages, the learning curves are not smooth and continuous.

Look at the curve of a person's learning to receive by telegraph. Notice the flat portion of the curve around the 20th week. This period of little or no improvement is called a plateau. Learning seems to temporarily stop or slow down because he has reached the limit of his ability to receive letter by letter and has not yet begun to receive by word by word. When beginning to take piano lessons, improvement is rapid at first as the fundamentals are easily mastered. After then, however, improvement



Number of trials vs time to complete an exercise showing that intervals of rest increase learning rate when compared to continuous practice.

is extremely slow until one learns to integrate the separate movements of the hands and fingers. Another reason for a plateau is lack of motivation. If a child is forced to practice the piano against his will, his rate of learning will slow down and almost stop.

Transfer of Training

Curves that show a rapid rise during the early stages of learning could be the result of positive transfer of training. This is applying the results of one situation to aid learning in another situation. After a person learns to drive one car, he can learn to drive a second car much easier. An expert tennis player can become proficient at ping-pong in a very short while.

Negative transfer applies when the responses in two situations are opposites. Steering a sled and piloting a plane call for two different responses to the same stimulus. To make a sled turn left, the right foot is extended, but to make a plane turn left, the left foot is extended. A person who has done a lot of sledding would find it difficult at first to steer a plane. Even after he has become accustomed to the controls of the plane, in an emergency he might revert to his old habit of extending his right foot for turning left. Only by further practice can he break this old habit and form the new association of extending his right foot to turn right.

Transfer of training in formal education has been a widely disputed subject. It was once thought that training a limited number of mental faculties would help in a variety of situations. It was believed that studying Greek, Latin, Euclid, and Aristotle would train the mind and make learning easier. There was also a widespread belief that teaching a child to be neat in his arithmetic and spelling would cause him to be neat in his appearance and in the care of his belongings. Today, this theory has been almost completely abandoned. In 1940, J. B. Stroud reported the results of transfer of training dealing with certain school subjects. He studied the transfer of Latin grammar to English grammar, of Euclidean geometry to the ability to solve reasoning problems, and of Classical physics to the ability to understand the mechanical problems of daily life. In each case the results were discouraging. There was very little positive transfer of training.

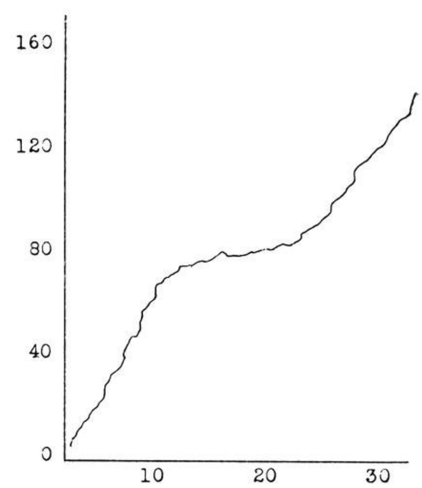
In recent years, educators have been concerned with producing the greatest amount of positive transfer from school subjects to everyday life. They try to make school problems as realistic as possible. If a small child is taught that one nickel will buy one lolli-pop and one dime will buy two lolli-pops, he more easily learns that two times five is ten.

Techniques of Study

Although positive transfer does aid the learning process, techniques of study is a subject that should be more helpful to everyone, especially students. The difference between reading and active recitation in the memorizing of verbal material has been widely discussed. Simply reading the material is vastly inferior to reading plus active recitation. A study made by A. I. Gates in 1917 revealed that if as much as 80 percent of study time is spent in active recitation, more is learned than if all of the time is spent in reading.

The issue of whole versus part learning has been extensively studied. This question is of particular interest to actors and actresses who must memorize a large amount of material. Should one go over a poem or a long part in a play until it is mastered or memorize it piece by piece? Should a student study the sections of a chapter one by one or work through the whole chapter several times? Early experiments on memorizing poetry indicated that the whole method was superior to the part method. Since then, studies made by J. A. McGeoch and A. L. Irion in 1952 have proven that each method has its advantages and disadvantages.

The part method is advantageous when: (1) a part is easily separable from the whole, as putting is from golfing, (2) the whole is so



Letters per minute plotted against weeks of practice. The plateau occurs when the subject stops receiving letter by letter and starts receiving word by word. (Bryan, 1899)

large that one cannot go through it without running into the disadvantage of massed practice, and (3) the material is of such a nature that interest in it cannot be maintained for long. The part method has the additional advantage of giving the learner knowledge of his results and a sense of achievement more quickly. On the other hand, there is the disadvantage that one must link the parts together after each of them have been learned. The whole method is more effective: (1) when the learner is intelligent enough to learn things quickly, and (2) when practice on the whole can be distributed over a number of sessions.

In mastering a chapter in a textbook, a student should combine both methods. He should read it over once, watching out for difficult parts that need special study. After giving special attention to these parts, he should go back to the whole method and reread the entire chapter. The whole versus part learning technique should be a part of every student's study routine.

Many students lack a well organized study routine. They do not set aside a certain time and place for study, nor do they apportion their time well among their various subjects. A good student will make up a definite schedule for study based on the amount of work to be expected in each course. He will follow it reasonably well; and when he studies, he will not daydream or listen to the radio. The good student has learned that he cannot mix recreation with studying and expect to get good results. Just as important as a well organized study routine is the proper study method. Research conducted by F. P. Robinson at the Ohio State University in 1946 favored the Survey Q 3 R Method. This is a soundly tested system that consists of five specific steps. They are Survey, Question, Read, Recite, and Review.

When studying a chapter in a textbook, the first step a student should do is leaf through the various sections and notice the different headings. They show the author's organization and make clear what the main subject of each section is going to be. By first surveying the chapter, a student learns generally what the chapter is about and knows what to expect.

Having surveyed the material, one should ask questions. Some textbooks contain lists of review questions at the end of each chapter. Most students usually neglect to read these questions because they fail to realize their value. Asking your own questions and trying to turn the headings of sections into questions have several benefits. They help maintain interest in what is being read, and they make you actively participate in the learning process. Finally, questioning yourself is a way of testing yourself to see what you are learning or have learned.

The next step is to carefully read the material. Do not read passively, as you would read a novel, but read to answer the questions you have asked yourself. Be sure to read everything, including tables, graphs, charts and illustrations. Often an illustration will tell more than a whole page of printed material. At other times, a graph or a chart will convey information that cannot be easily expressed in words.

Explaining the idea presented in a graph, chart, or illustration to a roommate or even to a blank wall is the most important technique of effective study. This method of recitation is usually neglected, though, because it takes effort. Recitation is a good learning method for two reasons. First it helps the student keep his attention on the task, and secondly, it lets him correct his mistakes. It shows him where he is weakest and where, in a review reading, he can profitably spend the most time.

The last step in the Survey Q 3 R Method is review. If a student learns something well but does not review it, he will usually retain only a small part of it. The best times for review are immediately after first learning and again just before an examination. These reviews should be mainly recitation. Other reviews in the meantime should be somewhat shorter, and they should emphasize rereading more than recitation.

In conclusion, it can be said that reviewing should not be crammed into the last few hours before an examination. This makes the final task too difficult, and the amount retained for the final exam is much less.

Programmed Learning

Regardless of whether the student just reads, just recites, or does a combination of both, he will learn faster if he uses scientific learning principles.

There is no doubt that textbooks and teachers do help students to learn. However, they have two serious limitations. First of all they emphasize presentation rather than doing. Teachers and textbooks tend to limit active recitation by the student. Secondly, they provide no immediate knowledge of results. Examinations usually tell a student how he is doing, but they provide too little information too late. To compensate for some of the things teachers and textbooks lack, movies, slides, and demonstrations are shown. Even so, these aids are lacking in the same two important respects—providing for active recitation and providing knowledge of results.

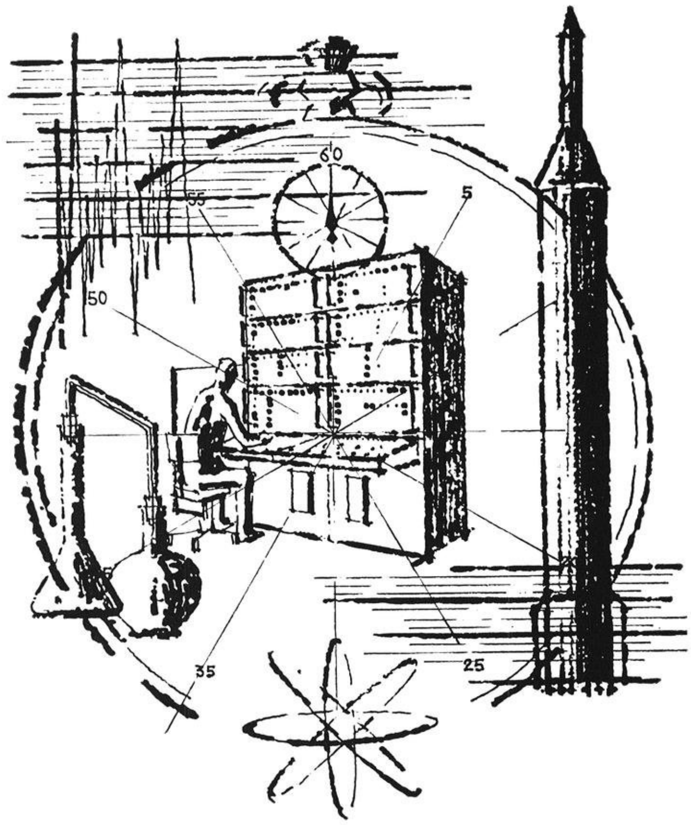
In the past few years, educators have tried to solve these problems through the use of teaching machines and programmed textbooks. In the late 1950's, B. F. Skinner of Harvard University designed, built, and tried out a series of teaching machines. These machines present problems or questions to the student one at a time. The student answers these questions by pressing certain keys on the machine. If his answer is right, the machine rings a bell or flashes a light. The machines can be controlled so that only questions answered incorrectly will appear again at the end of the set.

Teaching machines, then, seem to have three advantages over teachers and textbooks. They get the student to respond, they give him immediate knowledge of results, and they enable him to study what he does not know rather than what he has already learned.

Disadvantages of teaching machines seem to offset some of the good points. First of all, they are fairly expensive, some costing hundreds of dollars. Secondly, they are

(Continued on page 42)


TELEPHONE MAN-OF-THE-MONTH



SCIENCE HIGHLIGHTS

By Robert Rosenberg, ME'65

PROGRAMMED X-RAY SPECTROMETER

A significant advance in scientific research has been made with the development of a versatile Pro-Programmed X-ray Spectrometer. the development of a versatile Analysis of alloy composition which formerly took several days to complete can be done in a fraction of the time with the new electronically-programmed equipment recently installed at International Nickel's Research Laboratory, Bayonne, New Jersey. This precise and sensitive equipment, believed to be the first of its type in the world, can, in a matter of minutes, analyze an alloy sample for up to eleven different elements.

The initiative for development of the instrument came from International Nickel's Development and Research Department and the equipment was designed and built by the X-ray Department of the General Electric Company. Although required by International Nickel to serve metallurgical needs, the Programmed X-ray Spectrometer is adaptable to chemical analysis of a variety of materials.

Once programmed and loaded with as many as 90 alloy samples, the equipment can be left completely unattended until all samples have been accurately analyzed. Another outstanding feature of this equipment is that it can be reprogrammed to analyze for most of the elements known today. The equipment consists of the Control Panel; a standard G.E. Spectrogoniometer, with the Automatic Sample Changer attached; the detector or read-out system, and the programmer console.

SPLIT SECOND LIFE DURATION MAY SPELL LONG LIFE FOR GEMINI ASTRONAUTS

The trend toward wider use of instrumentation for automatic measurement and control, signal transmission, and the increased utilization of data-processing devices has expanded the need for a variety of transducers. These transducers are used by industry and the military to provide suitable signals for automatic control and telemetry systems. Because of varying demands and individual system requirements, the development of transducers has resulted in some highly specialized devices, while others offer general adaptability to a number of instrumentation systems. The need to accumulate transducer data in a single source, and thereby facilitate information search and retrieval, has become increasingly critical, which can be seen by the development of transducers for Project Gemini.

Less than ½ second is the expected life duration for a transducer during critical stage separations of the Air Force Titan II launch vehicle for the National Aeronautics and Space Administration's Project Gemini.

During that infinitesimal span of time, however, data will be telemetered which could affect the entire Gemini mission and the lives of the astronauts riding the capsule.

Before it is consumed in the super heat of Aerozene 50 and nitrogen tetroxide igniting to separate the first and second stages of Titan II, the High Frequency Response Pressure Transducer will telemeter on a 70 kc subcarrier oscillator the shock pressure encountered during separation firing. By utilizing this data in conjunction with other information, the performance of the Gemini launch vehicle's 100,000-pound-thrust second stage and its adherence to the programmed flight plan can be accurately determined.

Fairchild Controls is supplying the solid state silicon semi-conductor strain-gage pressure transducer to the Martin Company, the prime contractor for the Gemini launch vehicle.

The Air Force Titan II has the greatest payload capability and range of any U. S. ICBM. Because of its great power and use of storable propellants, a modified Titan II was selected to boost the two-man Gemini capsule into orbit.

Altogether, eight pressure transducers will be aboard the launch vehicle. In addition, two instruments will monitor the fuel and oxidizer propellant pressures on the first stage and two transducers will do the same job on the second stage. Three others will measure pressure in the hydraulic pressure accumulators. All data will be telemetered to the ground for blockhouse correlation.

In addition to these airborne systems, Fairchild Controls is also supplying Martin with the 990S126 system. This system is ground-based and is utilized in fueling operations for the booster to remotely monitor fuel and oxidizer pressures at two separate locations simultaneously. The system consists of a Pressure Transducer, two direct reading indicators and calibration switches. The system includes integral SELF TEST which enables the entire system to be checked out remotely prior to any fueling operations.

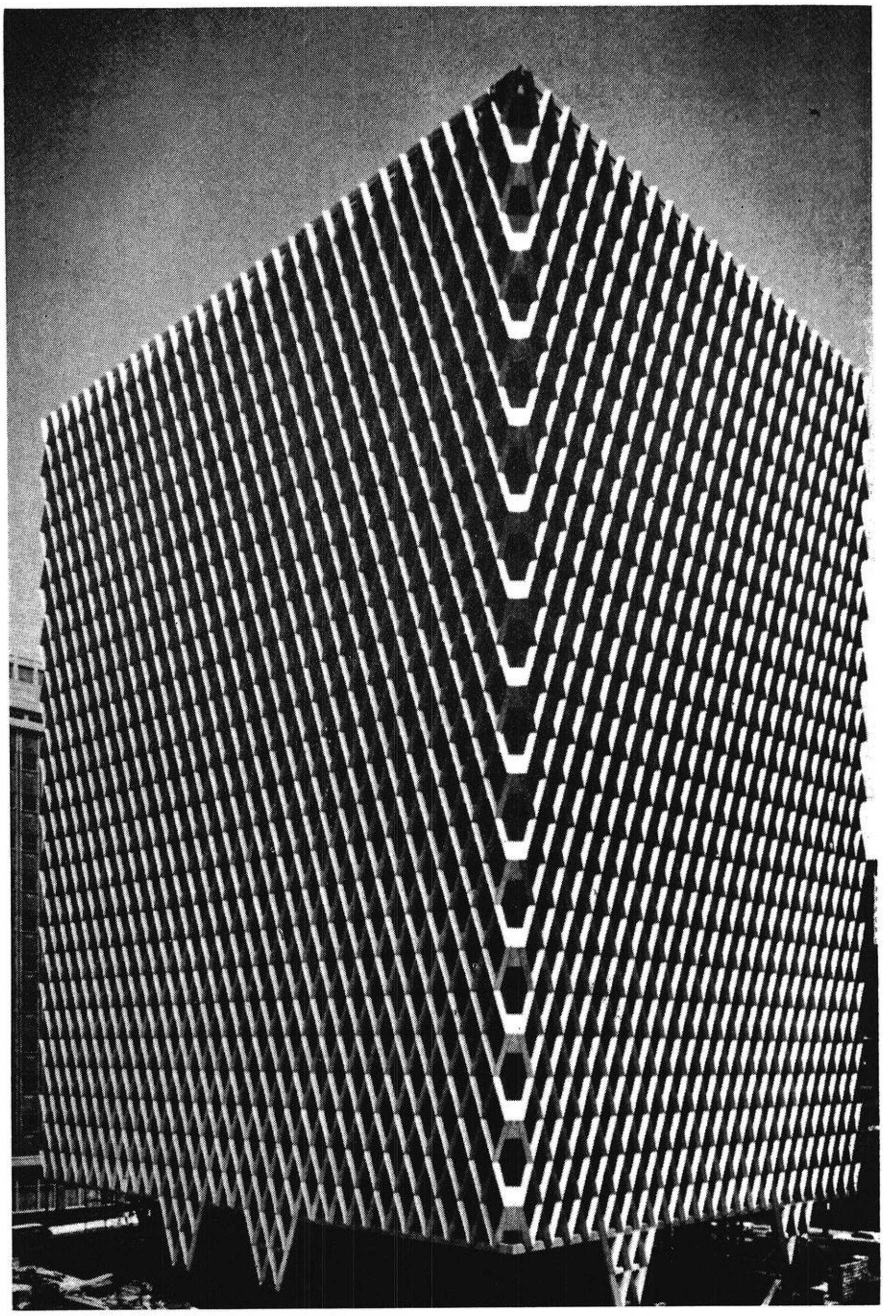


Photo at right shows International Business Machines building with Trussed-steel walls.

Trussed Walls Mark New Trend

A NEW family of exterior walls for multistory buildings may be developing. It represents a return to, but an improvement over, old-fashioned load-bearing construction.

The new trend is typified by the 13-story International Business Machines office buildings in Pittsburgh, whose trussed-steel exterior walls serve both architectural and structural functions.

Advantages

The new family of walls combines the advantages of old-fashioned masonry bearing walls with those of modern curtain walls, which serve only to enclose a skeleton-framed building.

As compared with masonry walls, the new wall systems save great quantities of materials that would be required for the masonry walls themselves, and for the massive foundations required to support them.

As compared with curtain walls, the new walls eliminate the need for exterior columns and spandrel beams. Thus, they normally weigh less than the structural members and curtain-wall panels they replace. On the IBM building, the engineers estimate that they saved

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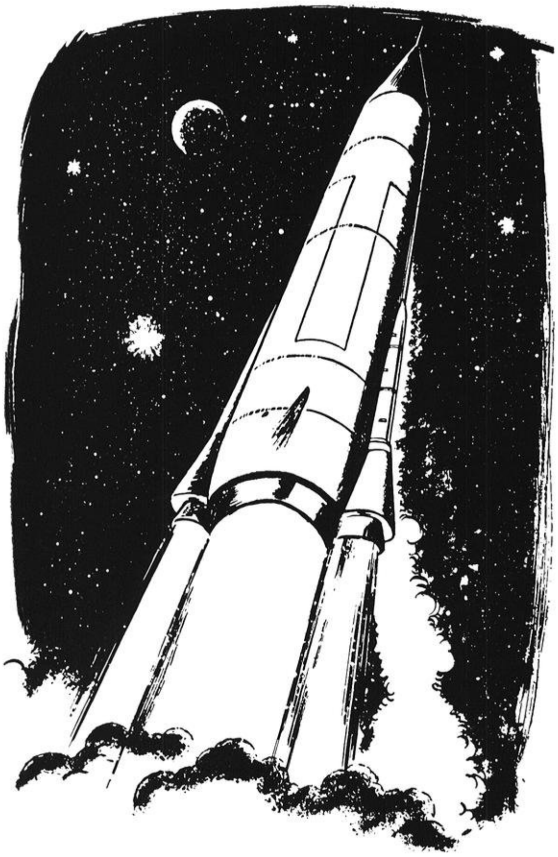

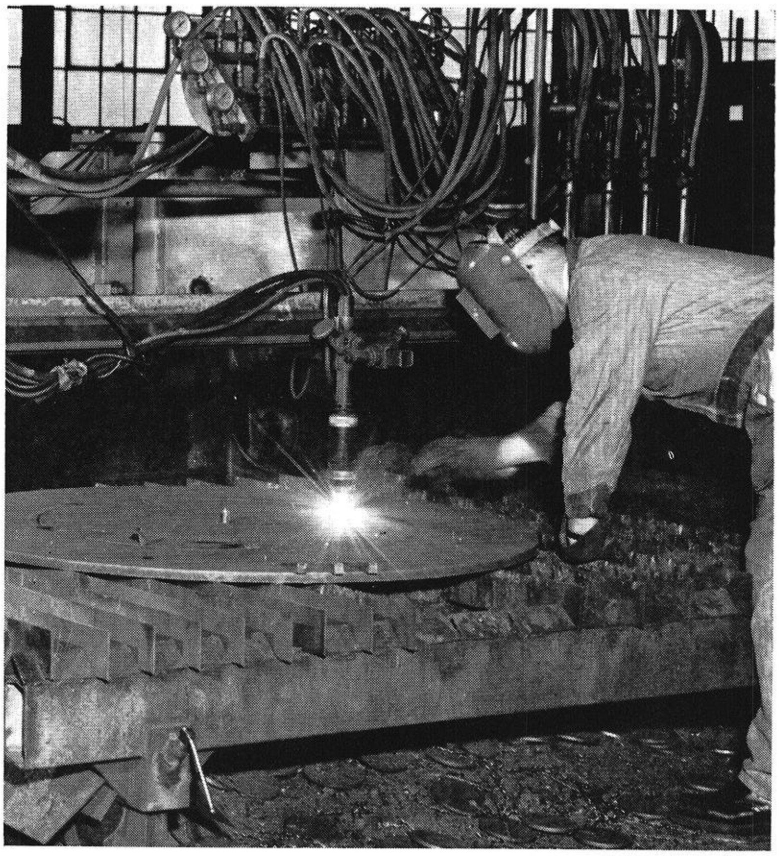

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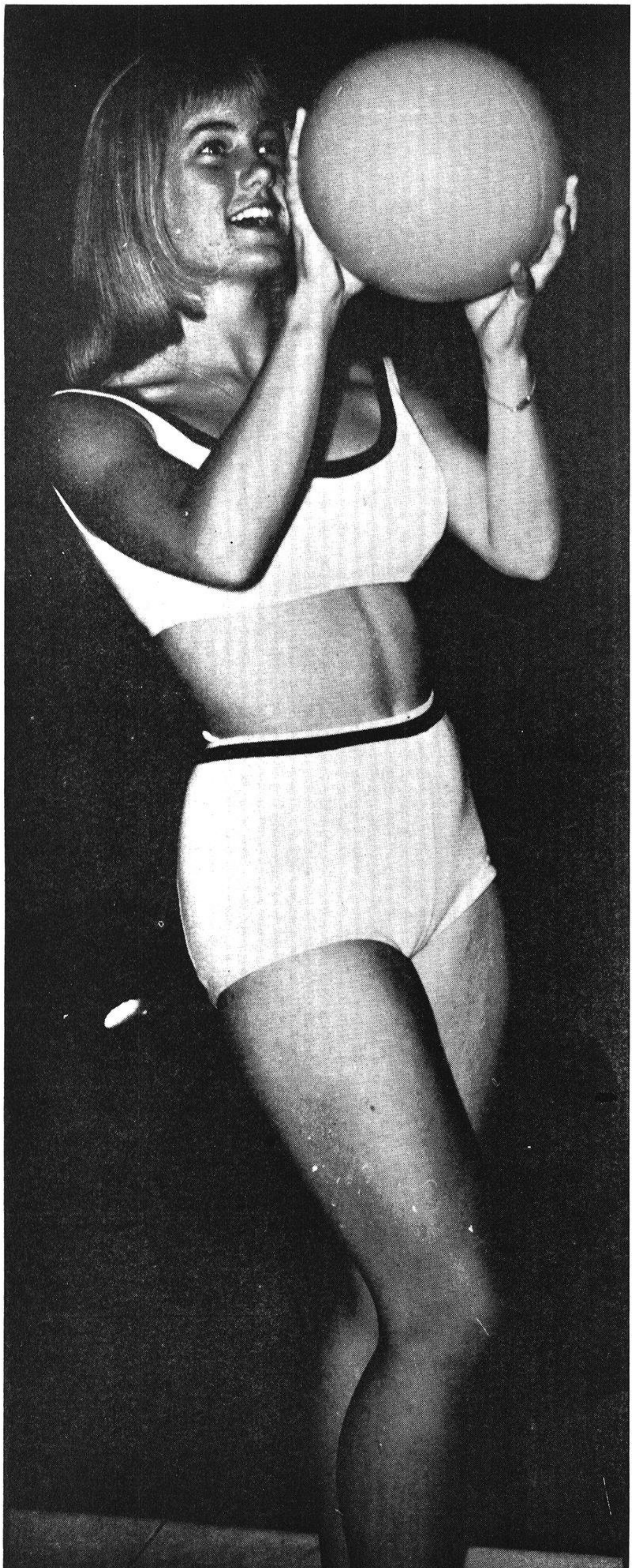


Miss November

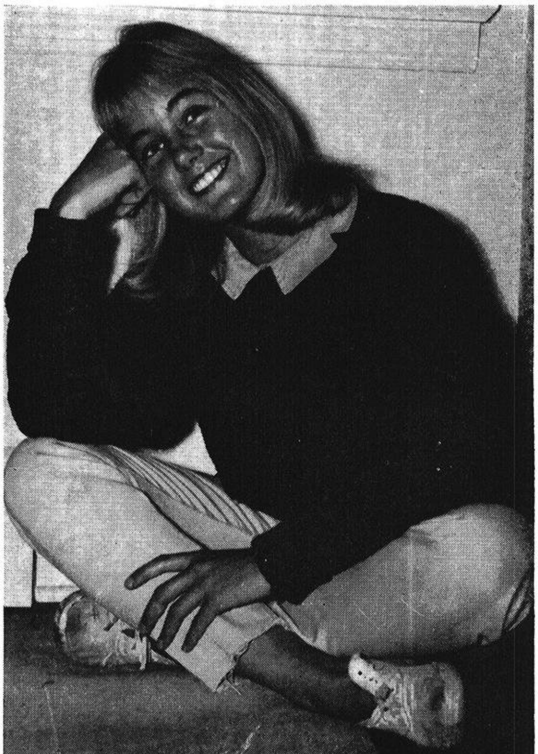
JUDY GRIMM

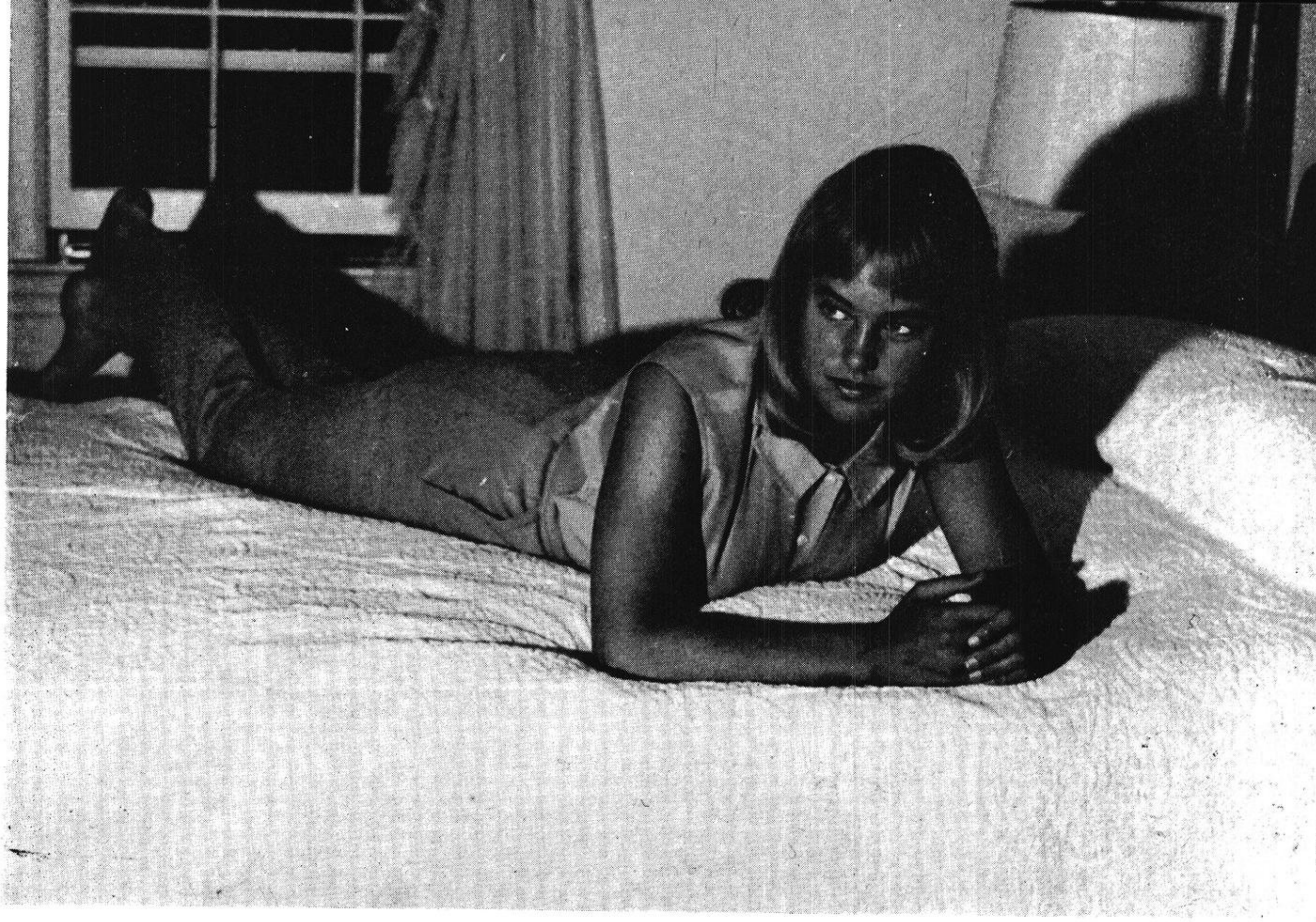
Our Miss November is a nineteen year-old, ash-blonde beauty from our photographer's hometown, Wilton, Connecticut.

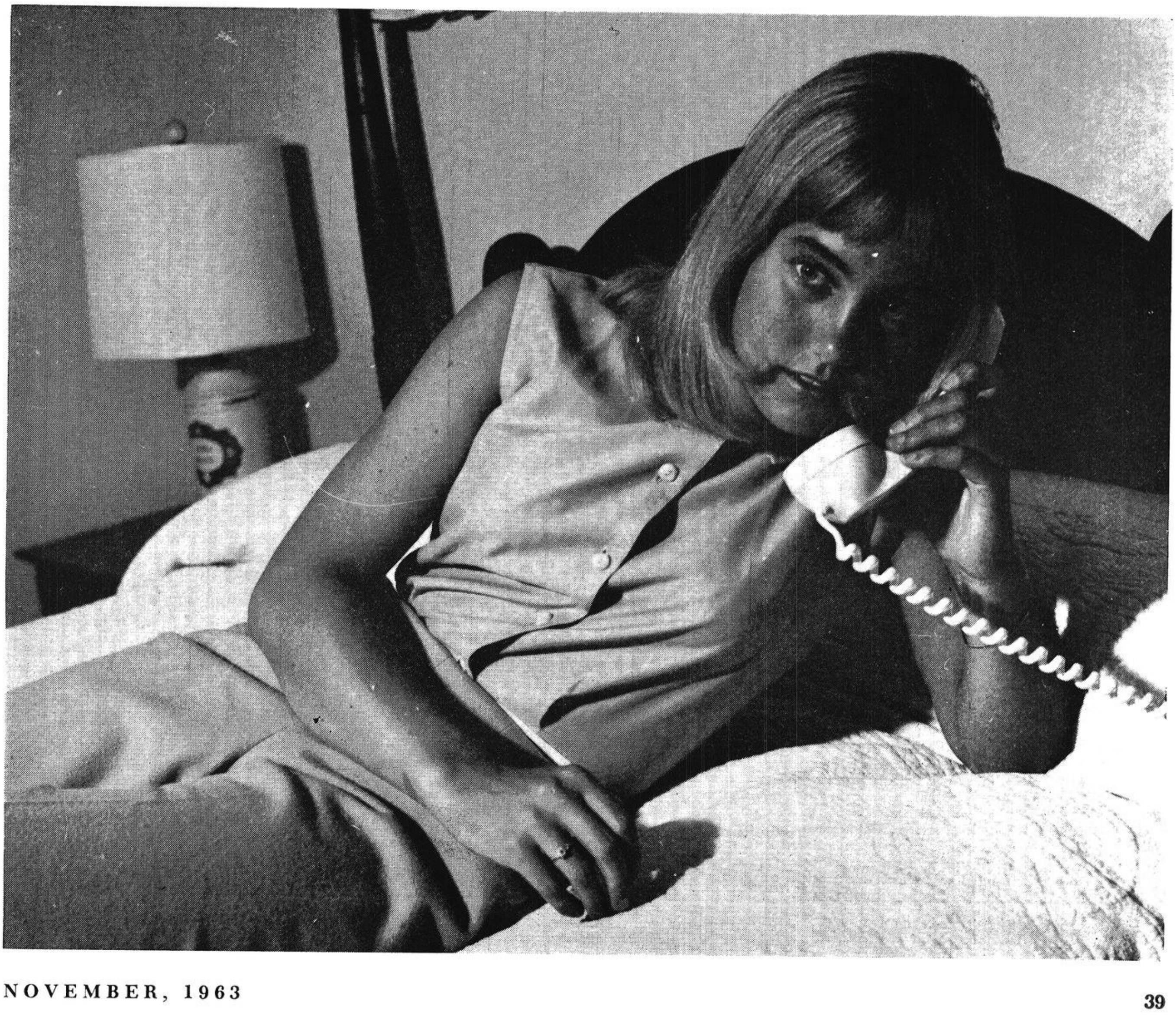
Judy is a sophomore at Colbe Junior College in New London, Vermont. Her favorite sport is skiing the slopes of Vermont.

As for other details, you can guess about them.

How did we get her? Simple—the photo editor lives in Wilton also.







Motorcycle

(*Continued from page 25*)

and less fuel is drawn in if part of the space is already occupied by oil, so it can be seen that a lower power output will result. Therefore this trouble must be dealt with. Sometimes felt caps are fitted around the inlet valve but this introduces a friction factor into the speed of valve operation. Many different types of scraper rings may be fitted to the piston, and baffles may be placed at the crankcase mouth. These will help little, however, if the trouble is due to barrel distortion. In fact, the piston may become short of oil. As remarked before, the barrels should be kept free of stress in the design stage.

For many years, vegetable or animal oil was used exclusively for racing. These oils retain their "oiliness" to very high temperatures, when mineral oils break down. Lately, additives have greatly improved mineral oils, which are also cheaper, and do not become "gummy" if left for a long period of time.

IGNITION

Ignition is usually by magneto, which has some advantages over coil ignition. For one thing, the strength of the spark increases with the increase in speed, and it is a small, self-contained unit. The spark, in the coil system, tends to decrease in strength as the speed rises, and a battery must be carried. These are heavy and bulky, and may fail. But some new, silver-iodide batteries are small, and light, if made to last just the length of a race, and coils have been improved. So coil ignition is used more now, as a magneto takes about half a horsepower to drive.

CARBURATION

The manufacture of carburetors is a very specialized business, especially the instruments used by racing machines. All are of the sliding choke type. The T10TT is the simplest, having a slide which is completely removed from the air stream at full throttle. However, the metering needle and the flow of fuel into the air stream still obstruct the passage. In the Remote Needle carburetor, these are moved to one side, but the instrument is harder to tune, though giving more power. The G.P. carburetor is better than either for power, but even more finicky to tune. So for preliminary trials, the T10TT is often used, to be replaced by one of the other types for final tests and the actual race.

TESTING

The above are many of the points that a designer must bear in mind when laying out the design of a racing engine. But however well he does his job, troubles are bound to arise when his engine is first bench tested. This is its trial, something like the rehearsal is to the play, and nobody really knows what will happen.

If the designer is smart, he will have allowed room for modifications, as it is almost impossible to stress a racing engine adequately. If a pair of gears, for instance, should fail, there should be enough room to increase their size or width. The inlet and exhaust ports should have a good thickness of metal around them in case they require enlarging. A change from magneto to coil ignition should not prove too difficult.

Testing, especially in the early stages of a new design, is a very difficult period, and extensive changes are sometimes necessary in one direction to overcome what may seem quite a small fault in another direction.

LESSONS TO THE DESIGNER OF THE ACTUAL RACE

The designer usually accompanies the team to a race or two, and here he should be careful, as totally different conditions prevail.

On the test bench, the engine is rigidly bolted to a bench, and a cooling stream of air is blown over it. In the race, the engine is moving, and the air is still. Atmospheric conditions nearly always require changes to be made to the carburetor settings. Banking the motor-cycle over for a corner may adversely affect the fuel supply. The rider's legs may obstruct the air passage to the carburetor, though this is a design fault that should have been found earlier.

Finally, he has to rely on the rider's words, instead of his own judgment and observations. A good rider may obscure the shortcomings of a poor design, while a bad rider will wreck a good engine. Still, factory teams pick the best riders, but some of these are very hard on their mounts while others treat them very gently.

The machines are never fast enough for their jockeys and hair-raising tales are told in practice of how fast the "opposition" is. It must be remembered, though, that a lot of bluffing is the rule in practice. Senior, or 500cc, machines can go out bearing Junior, or 350cc, plates, and it has been known for a machine to leave the course at one point, and rejoin it at another, after taking a short cut. (This once broke the lap record, and nearly caused heart failure among the opposition!) Some work with a stop-watch will often prove useful, timing one's rivals and one's own machines. Inspection of rival machines by the designer may bring new ideas to mind for increasing power or reliability, though he will not be allowed too near them. At the end of it all, the race itself will give the answer to how well he and his team have done their work. There is no fooling here, no using Senior plates on Junior bikes, no short-cuts. All the cards are on the table.

He is unlikely to be satisfied, men never are, and new machines have an amazing capacity for developing "teething" troubles. But if his machines have lasted the actual length of the race without breakdown, he may congratulate himself, and return to search for more power.

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Learning

(Continued from page 30)

large and bulky and not very portable. Finally, teaching machines must be specially programmed to fit the needs of each student. It must be kept in mind, however, that teaching machines are not built to replace teachers and textbooks, but to supplement them. Why not, then, use a programmed textbook instead of a teaching machine?

Programmed textbooks differ from common textbooks in one important aspect. They pose questions or problems for the student to solve, and this motivates him to make responses. However, programmed textbooks cannot provide immediate knowledge of results, and they cannot repeat only the questions the student had wrong. Consequently, both teaching machines and programmed textbooks have advantages and disadvantages over each other, but both have a place in providing more effective teaching through programmed learning.

All in all, machines and books lack the personal touch of teachers. Moreover, mechanical programs are not suited to "explaining things" or teaching complicated concepts. Thus, it is safe to say that programmed learning methods will never replace teachers, but will help them, just as machines have helped but not replaced the workingman in industry.

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Science Highlights

(Continued from page 35)

200 tons of structural steel over what curtain-wall construction would have required.

Triangular Bases

Each of the IBM building's four walls rests on two triangular-shaped columns, whose trussed pattern matches the triangle-and-diamond pattern of the walls themselves (picture). The apex of each triangular column is at the column base. The walls cantilever beyond the columns to the corners of the building, which measures 110x137 ft. in plan.

The walls comprise criss-crossing, diagonal steel angles with horizontal plates at each floor supporting floor beams. Sheathed in stainless steel, the latticework presents a striking architectural appearance. Moreover, with only 30% glass area, and that partly shielded by the latticework, there is relatively little solar heat gain through the walls. This naturally cuts air-conditioning costs.

The IBM building walls mark an advance over previous load-bearing, trussed-wall designs. Some of the predecessors incorporated heavy vertical members, which the new design eliminates. Also, the diamond-shaped windows in the IBM building walls are located in the plane of the walls themselves, instead of being set back of the walls, as in some similar designs.

Variety of Steels

Use of four strength grades of structural steel (from 36,000-psi to 100,000-psi yield strength) enabled the engineers to keep the truss members uniformly slender, even in the lower stories where stresses increase. Maintaining uniformity of steel sizes permitted use of constant-size windows, sash, and mullion sheathing.

Structural analysis of the trussed walls posed a challenge. X members in the trusses make them statically indeterminate to an extremely high degree (i.e., incapable of stress analysis by statics alone). Consequently, the engineers made an "exact" analysis only for the lower five stories. Above that, since in the higher wall areas the structural action resembles that of a deep plate, they made justifiable simplifying assumptions.

Tight Tolerances

The IBM building's wall panels are shopwelded units two stories high, measuring 25 ft. high by 13½ ft. wide. Each diagonal member comprises two steel angles. At each floor line, where the diagonals intersect, are horizontal plates. They connect the floorbeams to the wall trusses and serve as gussets for the truss diagonals and as horizontal members for the trusses. Both vertical and horizontal field splices are made with high-strength bolts.

To limit secondary stresses resulting from inaccurate fabrication, the fabricator, American Bridge Division of U.S. Steel Corp., had to assemble the panels in a jig to unusually tight tolerances of plus 0, minus 1/32 in. If the negative tolerances should accumulate, shim plates would have to be inserted between the frames during erection. (Unbalanced lengthening of a tension-resisting member, or shortening of a compression member, would result in excessive stress in that member under external loading.

Other Problems

The engineers specified shoring for the wall trusses until wall and floor framing up to the sixth floor were completed. Beyond this level, the integral plate action of the wall trusses keeps stresses within final design limits.

Differential foundation settlement posed a danger of overstressing the stiff wall trusses with secondary stresses similar to those that would result from inaccurate fabrication. To limit foundation settlement, steel piles were driven to refusal into bedrock.

Wind Resistance

The wall acts as a four-sided box in resisting wind loads. Horizontal bracing connecting to each floor-level panel point transmits loads from wall surfaces perpendicular to the wind forces to the floors, which act as diaphragms, and then to the parallel wall trusses.

After completing the elastic analysis of the walls, the structural engineers checked each entire wall for ultimate strength against load factors of 2 or more, slightly higher than the 1.85 load factor normally used for ultimate design of steel structures.

Roswell E. Cutler (left), U. of Illinois '40, chief project engineer for regenerative engines, discusses the T78 program with Gordon E. Holbrook, M.I.T. '39, chief engineer for product design and development at Allison.

OPPORTUNITY IS AT ALLISON IN TURBINE ENGINE ADVANCEMENT

Allison—long-famous leader in the development and production of aircraft engines—is pacing state of the art advancement in the turboprop area.

A regenerative turboprop engine—embodying concepts further advanced than in any known turboprop in the world today—is being developed for the U. S. Navy by Allison . . . The Energy Conversion Division of General Motors.

Featuring a regenerative cycle which transfers heat from exhaust gas to compressor discharge air, Allison's T78 will extend long-range and on station capabilities of anti-submarine warfare through greatly improved fuel economy . . . thus projecting the usefulness of turboprop engines well into the future.

Too, hollow, air-cooled turbine blades—under development at Allison for the last 5 years—will permit higher inlet temperatures for a major improvement in engine performance. Greater reliability and simpler maintenance will be achieved with a unique, unitized propeller-reduction gear box.

Perhaps there's a place for you in our long-range engineering program here in the creative environment at Allison. Talk to our representative when he visits your campus. Let him tell you what it's like at Allison where Energy Conversion Is Our Business.

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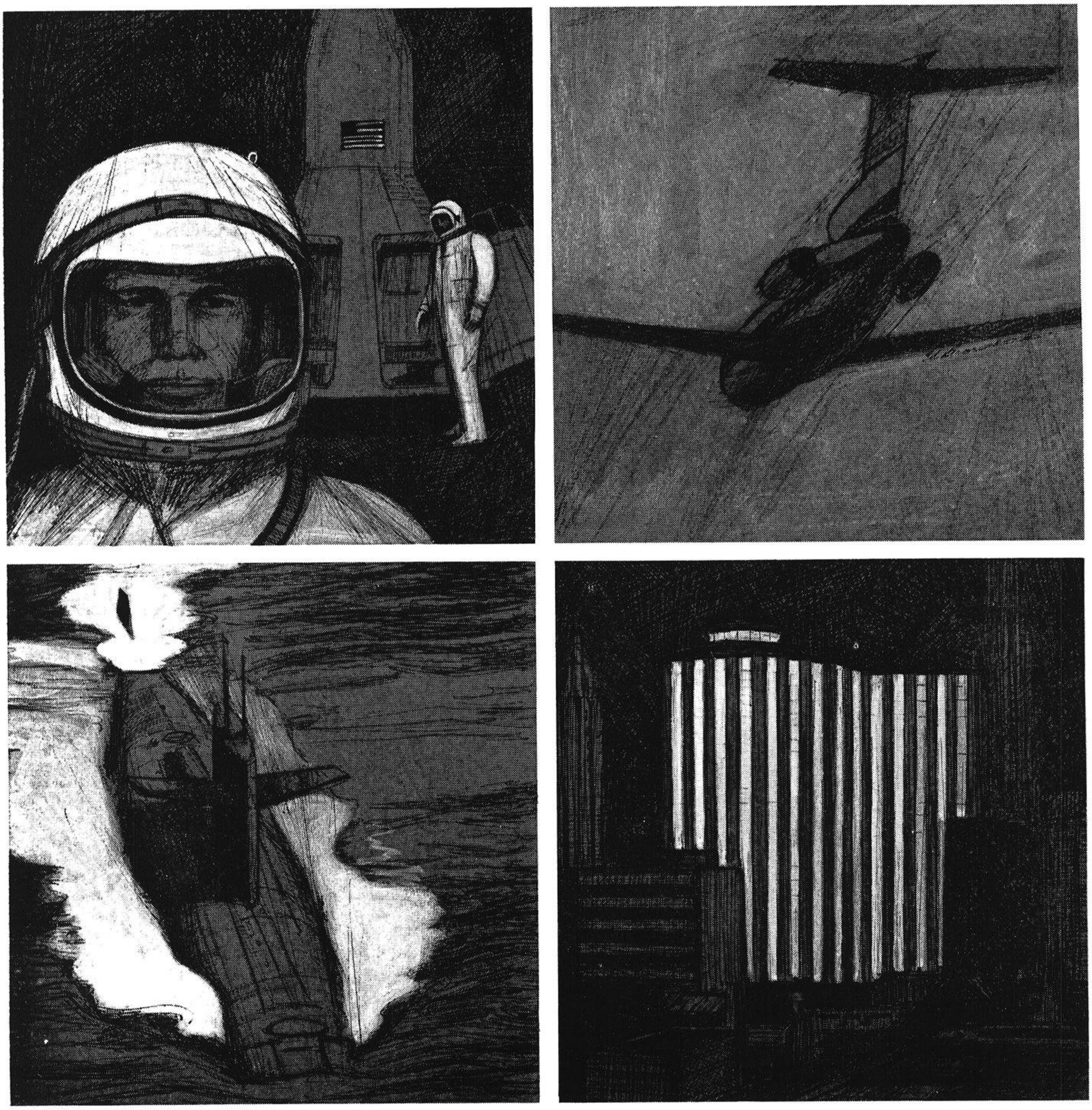
THE ENERGY CONVERSION DIVISION OF GENERAL MOTORS, INDIANAPOLIS, INDIANA



KNOW YOUR PROFESSIONAL SOCIETIES

("Many opportunities for extra curricular affiliations are associated with the College of Engineering. Participation in professional societies enables the student to meet and exchange ideas with fellow students, faculty, and professional engineers. It provides experience in public speaking, expressing ideas, and working with groups. Prospective employers place great emphasis on extracurricular activties."—From Bulletin of the College of Engineering. We devote this month's column to briefly explain the engineering organizations at the University of Wisconsin.—Ed.)

BELONGING to any campus organization is a broadening thing. Belonging to an engineering organization offers opportunities in a specialized way. They are common interest groups, and plan their programs with engineering in mind. We hope you will choose to belong to one or more of the organizations listed below. Since space prohibits an extensive explanation of any of the groups, we urge you to get in touch with them upon your arrival on campus. Advisers are listed in the Student Handbook and the Engineering Bulletin.

A.F.S.

The student chapter of the American Foundrymen's Society is open to all engineering students. It is a society of the metal castings industry.

A.I. Ch. E.

The American Institute of Chemical Engineers student chapter acquaints its members with the organization of the national A. I. Ch. E. and helps them meet men who are chemical engineers in industry. Any chemical engineering major is eligible for membership.

A.S.M.E.

Fellowship and a feeling of professionalism while giving an insight as to opportunities in mechanical engineering is the aim of the American Society of Mechanical engineers student chapter. All ME students may join.

A.N.S.

A student chapter of the American Nuclear Society, A. N. S. is open to all engineering and science students. A relatively new group, it is devoted to activities regarding nuclear energy.

I.E.E.E.

The purpose of the Institute of Electrical and Electronic Engineers is to disseminate knowledge of the theory and practice of all aspects of electrical engineering and allied fields, as well as to further professional and social development of students. Any undergrad engineer may join.

A.S.C.E.

Social events and meetings of the American Society of Civil Engineers brings faculty and students together to form a working unit. Opportunities for CiE students to meet and learn what men are actually doing in the profession are provided.

M.&M. Club

The Mining and Metallurgy Club acquaints student members with professional and educational aspects of the field of minerals and metals engineering. Any M. & Met. undergrad is eligible for membership.

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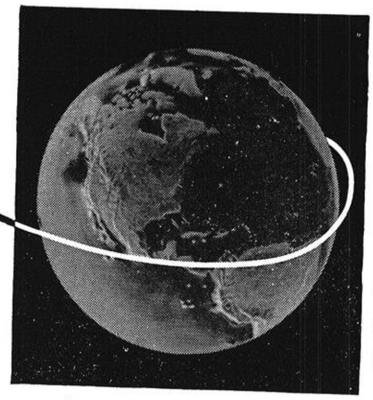

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Fill in your Own Lines

Two moonshiners were discussing their operations. "When I take the stuff into town," one said, "I always drive slow—about 20 miles an hour."

"Skeered of the law?" jeered the other.

"Nope," said the first. "Ye gotta age the stuff, hain't ye?"

* * *

Two residents of the backwoods country greeted each other one morning.

"Say," queried the first, "what did you give your mule when he had the heaves?"

"Turpentine," offered the other helpfully.

Two weeks later they met again.

"What did you say you gave your mule when he was sick," again asked the first.

"Turpentine," answered the helpful one.

"Well, I gave it to mine and it killed him."

"Killed mine too," said his pal.

* * *

A tramp knocked on the door of an inn known as "George and The Dragon." When the landlady opened the door the tramp asked, "Could you spare a hungry man a bite to eat?"

"No!" snapped the woman, slamming the door.

The tramp knocked again and slipped his foot in as the woman opened the door. "Could I speak to George?"

A drunk who had been wandering around Times Square finally went down into the subway at 42nd Street. About half an hour later he emerged at 44th Street, and bumped into a friend who had been looking for him.

"Where on earth have you been all this time?" the friend asked.

"Down in some guy's cellar," the drunk said, "and, boy, you should see the set of trains he has!"

* * *

A white rat, recently returned from the laboratory to his cage, ran up to a fellow rat in great excitement. "You know what?" he exclaimed. "I've got Dr. Zilch conditioned!"

"How so?" asked his buddy.

"Well," said the first rat, "every time I go through the maze he gives me food!"

* * *

Bachelor: A man who can open his apartment window and have more dust blow out than in.

* * *

"My psychiatrist says I have a persecution complex. But I know he says that because he hates me."

* * *

Response of a Cuyahoga Falls, mother of 17 upon being asked by the judge how she'd liked spending the night in jail on a drunk charge. "Your Honor, that was the first good night's sleep I've had in 20 years."

The University turns out some great men."

"When did you graduate?"

"I didn't graduate. I was turned out."

* * *

Engineer: "Whisper those three little words that will make me walk on air."

Coed: "Go hang yourself."

* * *

An elderly man entered a local doctor's office recently and requested a blood test.

"Now, what would you be wanting that for?" asked the doctor.

"I'm getting married," was the reply.

"Married," gasped the doc, "would you mind telling me how old you are?"

"Ninety-four!" was the proud reply.

"And how old is the prospective bride?"

"Twenty-two," answered the old fellow.

The doctor was flabbergasted. "Why an age disparity like that could easily prove fatal," he exclaimed.

The aged romeo thought this over for a few seconds and then after weighing the pros and con carefully, made up his mind.

"Well doc," he said, "that's her tough luck. If she dies, she dies!"

At three o'clock in the morning, the drunk returned home from a particularly rambunctious night of bacchanlia. About five minutes after he opened the door his wife heard a loud crash in the living room.

"George, what are you doing?" she asked.

"Teaching your damned goldfish not to bark at me."

* * *

"So you see, Olga, with world tensions as high as they are . . . with humanity threatened with total destruction through atomic war . . . with Russian–American diplomatic relations strained almost to the breaking point, it's up to people like you and me to cooperate!"

* * *

Life Insurance Salesman: At the age of 75 there are 18 per cent more women than men."

Prospect: "At the age of 75, who cares?"

* * *

Two men, neither very bright, were helping to build a house. One kept picking up nails, looking at them, keeping some and throwing others away.

"Why are you throwing away so many nails?" asked his companion.

"Because they are pointed the wrong way. They have the head on the wrong end."

"You fool. These are for the other side of the house."

* * *

The one-ring circus was visiting a town in the hills. The folks there all recognized all the instruments of the band except for the slide trombone.

One old settler watched the player for quite some time, then, turning to his son, said: "Don't let on that you're watchin' him. There is a trick to it; he ain't really swallerin' it."

* * *

Victims of an accident in Scotland were still lying on the road. Along came a native and said to a man lying on his back "Has the insurance man been 'roon yet?"

"No," was the reply.

"Ah, weel," said the Scot, I'll just lie doon aside ye."

When a company's ace salesman was transferred from the West Coast to the East, his old boss sent along a letter to his new boss, in which he explained that the fellow was a crack salesman, but unfortunately had a serious vice—gambling. When he arrived on the job, the new boss said, "I hear that you like to gamble. What do you bet on?" "Anything" was the reply. "For example, I'll bet you $25 that you have a mole on your back." "I'll take that bet," said the new boss, peeling off his shirt. The salesman paid off and the next day the new boss wrote his western counterpart, in which he boasted that he had already taught the salesman a good lesson. In a few days he received a reply. "He wins again. Before he left, he bet me $200 that he would have the shirt off your back within five minutes after he met you."

* * *

An attractive young lady lay on a bed in the receiving ward of a Washington hospital covered only with a large sheet. Two young gentlemen passed by and were struck by the young lady's lovely features. One stopped, drew back the sheet, and carefully examined the patient from head to foot.

"Do you think you will have to operate?" the girl asked anxiously after a few minutes.

"Oh, you'll have to ask one of the doctors," said one of the young men cheerily, "We're engineers."

* * *

Seems that a wife, who was dearly loved by her husband, died. This devoted husband believed in cremation. After which he placed the ashes in a vase. Wishing to display his love for his departed mate by having her ashes near him, he placed the vase on his study desk.

After a while, as is the human habit, he more or less forgot her "presence" and became quite careless with his cigar ashes by using the vase for an ash tray.

One evening, a friend who had known the departed well, was visiting the widower, and casually glanced into the vase.

"Ah," he said, "I noticed your wife has put on a little weight."

Policeman (producing notebook): "What's your name?"

Motorist: "Aloysius Alastair Syprian."

Policeman (putting notebook away): "Well, don't let me catch you again."

* * *

In Boston, there were two brothers, one a bachelor and the other married, who looked so much alike you could hardly tell them apart. One lost his wife, and shortly afterwards the other lost his fishing rowboat, a quite dilapidated craft which fell apart and sank suddenly.

A few days later, a kindly old lady met the boat owner and mistook him for the brother whose wife had died: "Oh, Mr. Jones, said she, "I'm so sorry to hear of your loss."

He, thinking she meant the boat of course, said: "Loss? Forget it. I should have put the axe to that old tub long ago; she belonged in the bottom of the ocean. Smelly thing full of fish odors. Tried to sell her but who would have her? Even that thick paint job couldn't hide the fact that she was all chewed up. Finally I couldn't handle her; I rented her to some guys looking for a good time; but there were too many of them, and suddenly she just cracked up and fell apart. . . Hey, somebody, quick! This old lady has fainted!"

* * *

A couple of sailors laying over for a day or two in Sweden decided to go to church. Knowing no Swedish, they figured to play safe by picking out a dignified looking old gentleman sitting in front of them and doing whatever he did.

During the service the pastor made a special announcement of some kind, and the man in front of them started to rise, at which the two sailors quickly got to their feet, to be met by roars of laughter from the whole congregation.

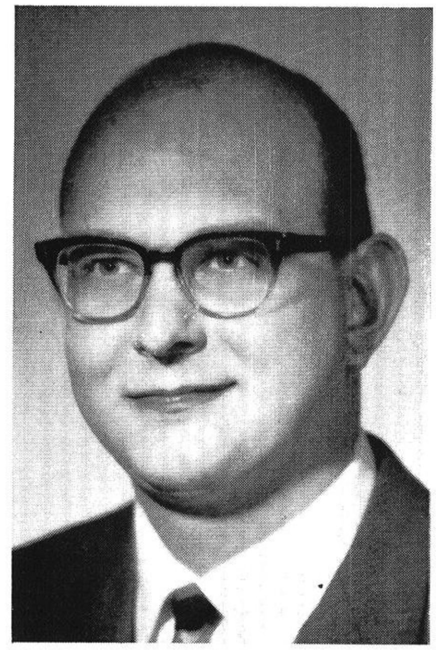
When the service was over and they were greeted by the pastor at the door, they discovered he spoke English and naturally asked what the cause of the merriment had been.

"Oh," said the pastor, "I was announcing a baptism and asked the father of the child to stand."

THESE GRADUATES THRIVE ON CREATIVE CHALLENGES...THEY'RE

PROJECT MANAGEMENT
R. J. Hayes
Indiana Tech—BSME—1956

SALES ENGINEERING
R. J. Hummer
University of Toledo—BSEE—1961



DEVELOPMENT ENGINEERING
J. H. Trumble
University of Dayton—BSEE—1960

There's a challenging, rewarding future for

C.W. Ludvigsen, Manager—Systems Sales, tells how creative graduates contribute to pioneering, automation developments.

Now, to meet the pressing challenge of industrial automation, Cutler-Hammer has formed a number of automation project teams.

These teams combine the technical and manufacturing talents of versatile, seasoned specialists and you, creative-minded engineering and business graduates.

Their primary job: to make sure that a customer's automation investment pays an adequate return.

How they work

How do they meet this challenge? By working with customer engineers and consultants to isolate cost problems in industrial process, manufacturing, and warehousing operations. Then, by applying their individual talents and creative ingenuity to develop, design, build, and install practical automation systems that will insure good return on investment.

Where they work

Automation teams work together in a Milwaukee-based, modern, 500,000 square foot plant specifically designed to house every activity involved in the evolution of a complex system . . . in a creative climate that is conducive to imaginative planning and pioneering development.

What they have done already

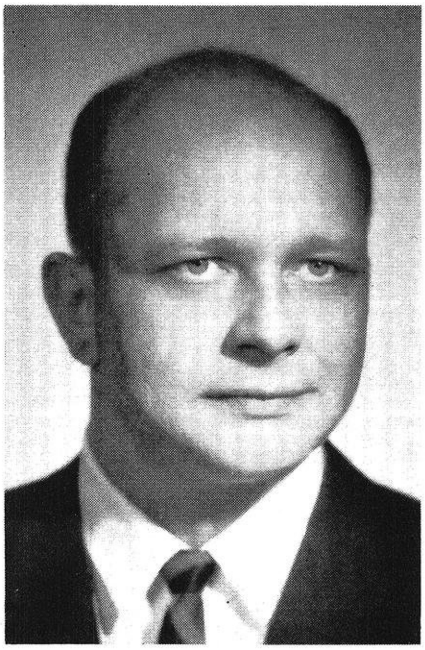
This approach has paid off! Though industry has barely scratched the surface of the automation potential, our credentials already are quite impressive.

Profit-making automation systems such as . . . a bundle-handling system for 30 major newspaper mail rooms . . . a package-handling system for a prominent publisher . . . U.S. Post Office mail-handling systems in 14 major cities . . . pallet-handling systems . . . more than a score of major steel-mill finishing lines . . . automatic warehouse control systems . . . and auto body-line handling systems are just a few examples of our creative planning and developmental skill at work.

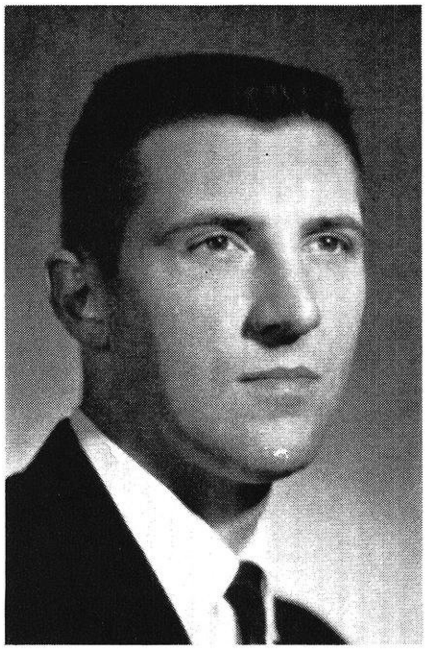
What is your opportunity?

What are the advantages to you

AUTOMATION PROBLEM SOLVERS



MANUFACTURING ENGINEERING
R. H. Menzel
Michigan Tech—BSME—1955



CONTROL ENGINEERING
L. Gall
University of Illinois—BSEE—1960

ANALYTICAL ACCOUNTING
A. E. Morgan
University of Wisconsin—BA—1960

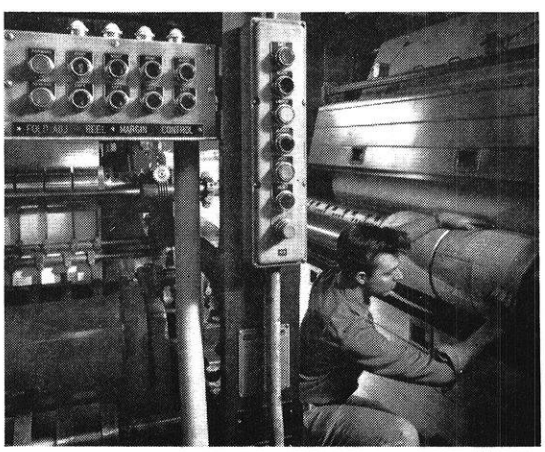
you, too, on a Cutler-Hammer automation team

as a young, creative-minded graduate? Short range, it's an exceptional opportunity—if you spark to the challenge of finding new solutions to tough manufacturing problems. An unusual opportunity to get deeply involved in problem solving right from the start!

Long range, being a key member of a Cutler-Hammer automation team is an excellent way to get the diversified experience so essential to continuing career development and future advancement. It's particularly beneficial if you have aspirations to move into management ranks.

Want to know more?

Write today to T.B. Jochem, Cutler-Hammer, Milwaukee, Wisconsin, for complete information. And, plan to meet with our representative when he visits your campus soon.



A CUTLER-HAMMER AUTOMATION TEAM helped the WALL STREET JOURNAL solve major production and distribution problems of a national newspaper by designing and building control systems for two new, highly automated printing plants. Controls permit the world's fastest presses to produce newspapers at the rate of 70,000 per hour.

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WHAT'S NEW? ASK...

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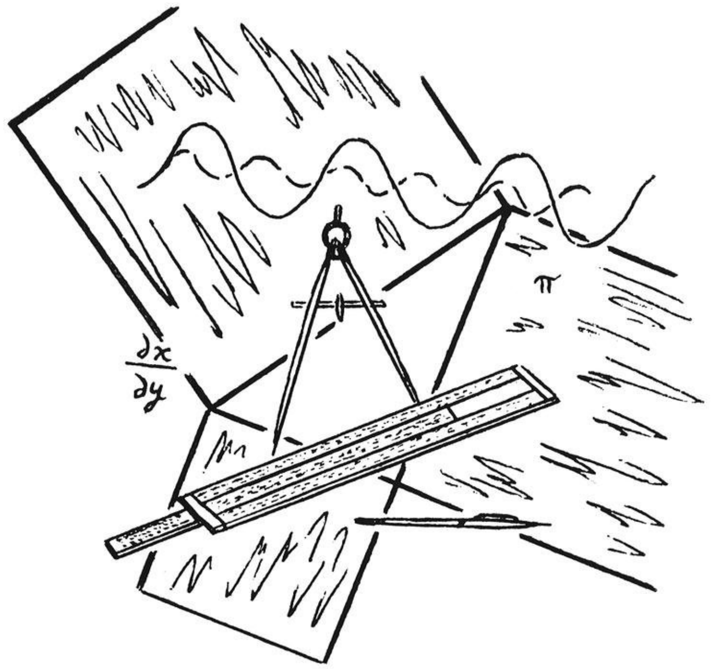
CONTROL

THE

MENTAL MAZE



By Clifton Fonstad, Jr., EE'65

TO KEEP pace with the ever changing world of engineering, the brain-teaser department of the *Wisconsin Engineer* keeps changing also. This column is under new management but the adjustment should not be hard for you to make for little has been changed. Each month the Mental Maze will contain about a half dozen puzzles—several of average difficulty and one or two, hopefully, hard challengers.

So, let's get started on the first puzzle—the first turn in this month's Mental Maze.

1. An appropriate beginning for the year is Tartaglia's Riddle. In ancient times it was often posed to beginning logicians and goes like this:

If half of 5 were 3, what would a third of ten be?

2. That one shouldn't have been hard but while you're still getting back in shape for these mental gymnastics, let's try another quickly.

Remember the farmer who counted his cows by counting the legs and dividing by 4? The same gentleman kept his sheep and chickens in the same manner. If he counted 78 legs and 35 heads, how many sheep and how many chickens did he have?

3. All puzzles aren't mathematically based, of course. Relativity problems, relativity as used with families, that is, have been around for many years and most of them are so obvious they're hard. See how fast you can solve this next proposition.

"Sisters and brothers have I none,
But that man's father was my father's son."

What relation was the speaker to the subject of the portrait?

4. And, here's a word puzzle. These are always tricky so don't do anything drastic if the solution eludes you.

What does this say?

Stand taking to taking.
I you're throw my

5. Most of the puzzles comprising the Mental Maze will be workable without an excess of mathematics, but once in awhile a puzzle will come along which requires a little extra preparation. See if you can spot the fallacy in the following proof that $0 = 1$.

Integrate $1/x\,dx$ by parts letting $u = 1/x$, and $dv = dx$. Thus, $du = -1/x^2\,dx$, and $v = x$.

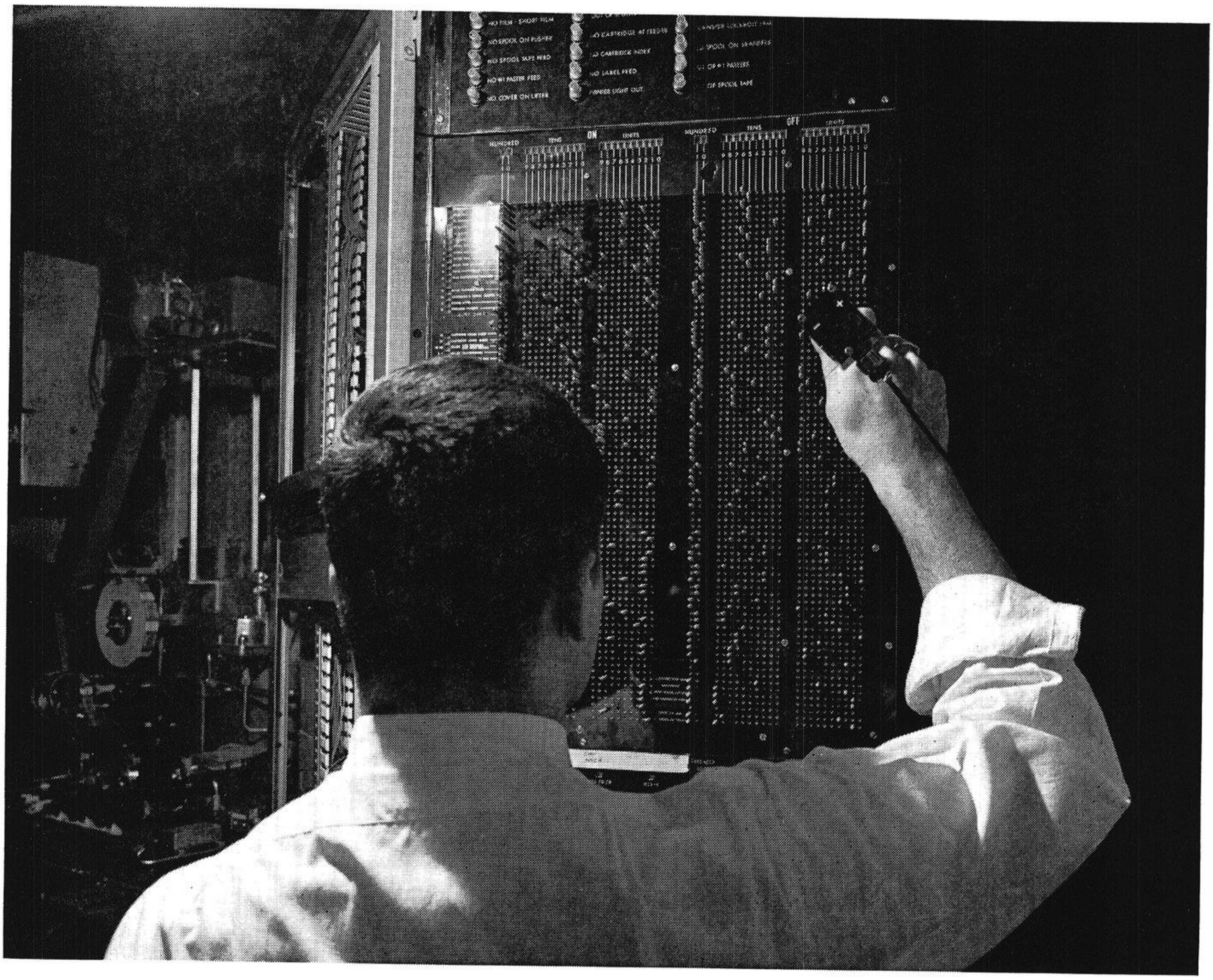
$$\int 1/x\,dx = x(1/x) - \int x(-1/x^2)\,dx$$
$$\int 1/x\,dx = 1 + \int 1/x\,dx$$
$$\int 1/x\,dx - \int 1/x\,dx = 1$$
$$0 = 1$$

If you really know your calculus the answer should be a snap.

6. Even if you've breezed through this month's maze thus far, this problem should make a fitting challenge for you. It's one that confronted us several months ago.

The *Wisconsin Engineer* staff wanted to attempt a trip across four hundred miles of barren desert last summer so they bought a sand buggy in which to make the trip. The buggy had a gas tank which held twenty gallons of gasoline. The buggy also had a 180 gallon spare tank (gas in this tank could be removed for storage or put in the gas tank proper; but gas in the gas tank could not be removed) and the dealer threw in with the purchase a large supply of Goodyear rubber "balloon" storage tanks; all of which the staff thought was a bit odd until they discovered the buggy got only one mile to the gallon. If the profits from the Engineer left only enough money to buy 1600 gallons of gasoline, did the staff get across the desert and, if so, how? Remember, the buggy could only take a total of 200 gallons on each trip, i.e. the balloon tanks could be carried along but not while filled with gasoline.

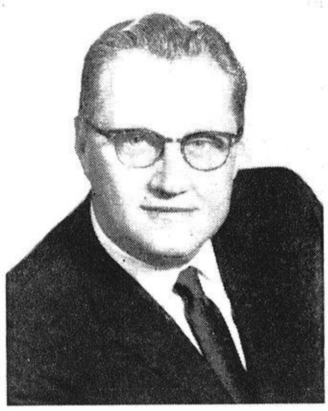
ANSWERS: Answers to each month's puzzles will appear in the following month's issue. Several years ago, the *Wisconsin Engineer* offered prizes to readers who sent in the answers the soonest and, while there is no such contest this year (as of yet), I invite you to send your solutions and comments to me—Clifton, Fonstad, Jr., % *Wisconsin Engineer*, 333 Mechanical Engineering Bldg., Madison, Wisconsin. If interest is large enough, the contest might be revived. In any event comments are always welcome.



COULD YOU OUT-THINK A COMPETITOR?

Consider a Career in Technical Marketing

An Interview with G.E.'s J. S. Smith, Vice President, Marketing and Public Relations



Mr. Smith is a member of General Electric's Executive Office and is in charge of Marketing and Public Relations Services. Activities reporting to Mr. Smith include marketing consultation, sales and distribution, marketing research, marketing personnel development, and public relations as well as General Electric's participation in the forthcoming New York World's Fair. In his career with the Company, he has had a wide variety of assignments in finance, relations, and marketing, and was General Manager of the Company's Outdoor Lighting Department prior to his present appointment in 1961.

For more information on a career in Technical Marketing, write General Electric Company, Section 699-08, Schenectady, New York 12305.

Q. Mr. Smith, I know engineering plays a role in the design and manufacture of General Electric products, but what place is there for an engineer in marketing?

A. For certain exceptionally talented individuals, a career in technical marketing offers extraordinary opportunity. You learn fast what the real needs of customers are, under actual industrial conditions. You are brought face-to-face with the economic realities of business. You participate in some of the most exciting strategic work in the world: planning how to out-engineer and out-sell competitors for a major installation.

Q. Sounds exciting. But I've worked hard for my technical degree. I'm worried that if I go into marketing, I won't use it.

A. Don't worry—you'll use all the engineering you've learned, and you'll go on learning for the rest of your life. In fact, you'll have to. You see, the basic purpose of business is to sense changing customer needs, and then marshal resources to meet them profitably. That means that you must learn to know each customer's operations and needs almost as well as he understands them himself. And with competitors trying their best to outdo you, believe me—every bit of knowledge and skill you've got will be called into play.

Q. Is that why you said you wanted "exceptionally talented people"?

A. Technical marketing is not everybody's dish of tea. It takes great personal drive and energy, and a talent for managing the work of others in concert with your own. It takes flexibility . . . imagination . . . ingenuity . . . quick reflexes . . . leadership qualities. If you're nervous with people or upset by quick-changing situations, I don't think technical marketing's for you. But if you are excited by competition, like to help others solve technical problems, and enjoy seeing your technical work put to the test of real operation—then you may be one of the ambitious men we're looking for.

Q. Now what, actually, does a man do in technical marketing?

A. Let me describe a typical situation in General Electric. A field sales engineer is in regular contact with his customers. Let's say one of them makes an inquiry, or the sales engineer senses that the time is right for a proposition. With his field application engineer, he determines the basic equipment needed. Then he contacts the marketing sales specialist in the G-E department that manufactures that equipment. The sales specialist, working closely with his department's product engineers, specifies an exact design—realistic in function and cost. Then the sales engineer and his supporting team try to make the sale, changing and improving the proposition as they get cues from the competitive situation. If the sale is made—a very satisfying moment—then the installation and service engineers install the equipment and are responsible for its operation and repair. With the exception of the product design engineers, all these people are in technical marketing. Exciting work, all of it.

Q. In college we learn engineering theory. How do we get the sales and business knowledge you mentioned?

A. At General Electric, a solid, well tested program of educational courses will quickly advance both your engineering knowledge and your sales capacities. But perhaps even more important, you'll be assigned to work with some of the crack sales engineers and application and installation men in the world, and that's no exaggeration. A man grows fast when he's on the sales firing line. As a FORTUNE writer once put it, the industrial sales engineer needs "that prime combination of technical savvy, tactical agility, and unruffled persuasiveness." Have you got what it takes?

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