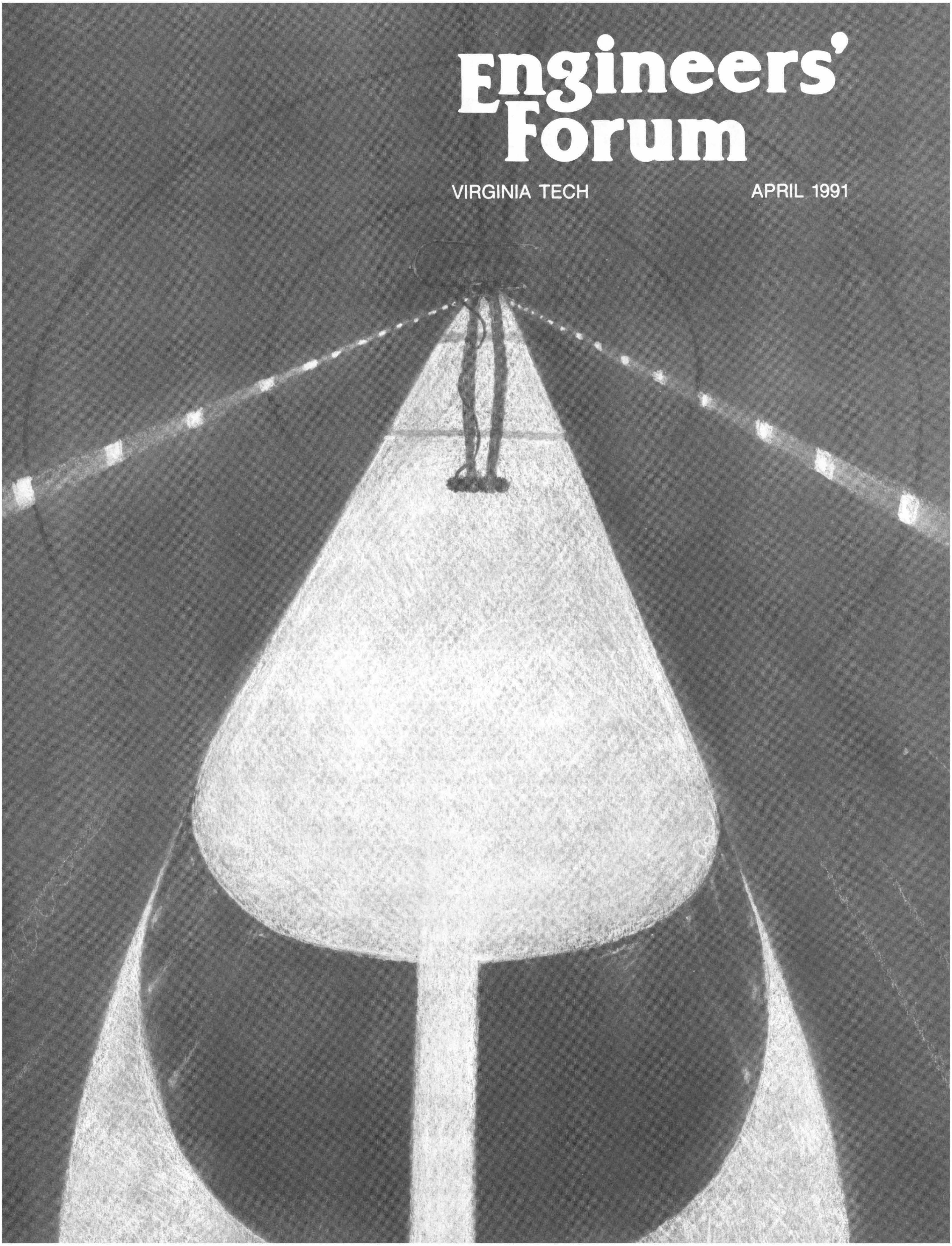
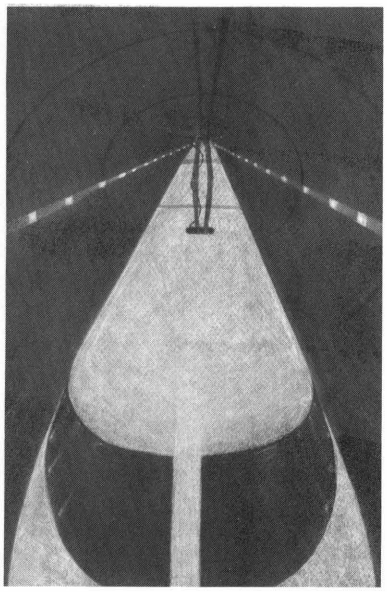
Engineers' Forum

VIRGINIA TECH APRIL 1991





On The Cover

Artist Aaron Golub depicts a scene in the EuroTunnel, an on-going project that is changing dreams into reality.

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EDITOR'S PAGE

The current degradation of the U.S. economy may be alluding to a need for less specialization

Recessionary effects are upon us and no one seems to be able to cool the fire with which they are spreading. Some of America's seemingly uncrushable giants are paralyzed, unable to operate, much like an infant strapped in a high chair. It seems the cries of the economist are valid and the only thing for industry to do is eliminate jobs in order to make an extremely trying situation just tolerable.

So what brought all of this on? Certainly we are not simply in a period of idle worry. Perhaps a contributing factor to the current snowballing of American industry is not the world's environment or other external factors which we are often quick to blame. Conversely, the reason for our trying times might very well be the people of our organizations. Moreover, it could be a direct result of this past decade's heightening emphasis on specialization.

This past February, at an Engineers' Week luncheon held at the Donaldson Brown Center, the 1990 Sporn Award winner, Dr. Paul T. Kemmerling, delivered a speech in which he addressed his fears of an over-specialized population. He introduced what is known as a paradigm, defined as an example or model. Interestingly, paradigms are not always good things; in fact they can often be the controlling factor behind the dismantling of a company and maybe the demise of an economy.

For example, in a video by John Barker, the almost total annihilation of the Swiss watch industry is cited as a case where an individual's paradigms can be destructive to the entire company. This example dealt with the invention of the quartz for watches by Swiss inventors and its subsequent denial by the executives of the Swiss watch company because their paradigms did not let them see the advantages of this invention simply because it did not have gears or a main spring.

As a result, this quartz invention was displayed by its inventors and Seiko and Texas Instruments bought the rights to it. Hence, the Swiss share of the watch market fell from a commanding 65% to an almost nonexistent 9% in ten years. Now the Japanese own the majority of the watch market — funny how quickly times can change when our paradigms limit our minds.

Now consider the past decade's relentless crusade to create a more specialized population at the university level, the industrial level, and beyond. From the above example we can conclude that individual paradigms are belittling when they limit our view of an idea.

Keeping this in mind, look at the emphasis of the past ten years; people are specializing in a single area. This could be considered a degrading paradigm of sorts, since in essence we are limiting our minds to a particularly small field of knowledge. Linking this with the gross overemphasis of human specialization, it would not be surprising if the majority of the United States work-force is a victim of having what is called "The Paradigm," by John Barker.

"The Paradigm" attitude among humans is what led to the fall of the Swiss watch market, and perhaps America's specialization paradigm is to be blamed for our currently raging recession.

One thing is for sure, if we continue to limit ourselves to such the extreme extent that trends have shown in the past decade, sooner or later our successful past will be just that — a blurred vision of prosperity dangling out of reach.

Jonathan S. Hess

Jonathan Hess, Editor

OOPS! The *Engineers' Forum* would like to apologize for some errors in the February issue. In the article "The Environment and Modern Society," Dr. William Knocke was incorrectly identified as the Lunsford Professor of Civil Engineering. Actually, Dr. Clifford Randall holds that title. In the same story, Dr. John T. Novak was inaccurately referred to as Dr. Bill Novak.

Lastly, in both the table of contents and the headline for the article, the acronym of the American Society of Mechanical Engineers (ASME) was mistyped.

HAM RADIO:
Where does the future lie?

by Mike Reese & Steve Payne

HAM radio, a form of two-way radio communication, has been looked at with controversy in the past few months. The controversy is over codeless licenses. A codeless license would allow someone to operate a HAM radio without having to learn Morse Code.

Since it was first introduced to radio communication in 1901 by Marconi, international Morse Code has been the foundation of amateur radio. During World War II, army and other military personnel concentrated primarily on Morse code to relay information.

As these technicians came home from the war, they had the skill to obtain the first class of license in amateur radio, the Novice Class. The requirement for this class is the ability to code five words per minute in Morse code and learn a small amount of theory and radio regulations.

As operators become more engrossed, they usually move onto the next step. This level, Technician Class, involves the learning of more code and radio theory. When the operator becomes more proficient in this class of Morse Code, this person moves up to the General Class. This step requires the ability to code 13 words per minute.

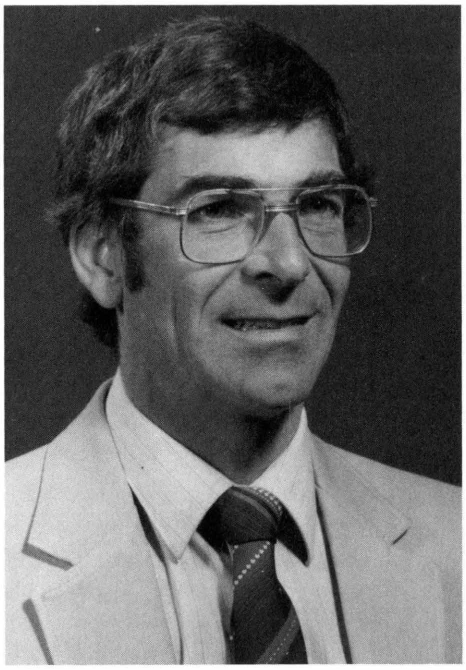
This is followed by the Advanced Class, which again requires more theory. The final class, the Extra Class, requires a proficiency of 20 words per minute and an advanced understanding of communication theory and radio regulations.

In the last few years, however, the number of operators has been diminishing rapidly, due to the lack of new prospectives. Beside the number of operators diminishing, the amount of students enrolling in the scientific and technical fields has also declined.

An example of this is a prediction by Dr. Timothy Pratt, a professor of Electrical Engineering at Virginia Tech, who said, "There will be a great shortfall of Electrical Engineers by the year 2000."

The latest trend has been to try and recruit more young people to develop skill and interest in HAM radio. The reasoning behind this is that if adolescents develop a fascination with amateur radio, this could in turn spark an interest in one of many technical fields.

This is important because we live in a highly scientific and technological society, and a decrease in the number of these students could only hurt our country's standing in the world of technology.



Dr. Timothy Pratt

With the addition and push for new operators, there is a new generation of individuals who want to use HAM radios. These people are computer users who see HAM radio as an inexpensive and effective source of communication among one another.

In order for communication without Morse code to commence, a new set of equipment must be purchased by these computer communication stations.

A Terminal Node Coder (TNC) is the first piece of equipment needed for computers to transmit radio signals amongst themselves. This piece of equipment, whose price averages a few hundred dollars, interfaces with a microprocessor drive and sends blocks of text in a special format. With a HAM radio, this information can be sent along repeaters to its destination.

Repeaters are a set of antennas linked together that carry information from one point to another. With the use of repeaters, there is only a few seconds delay for information to be sent in between each antenna.

Some repeaters even use satellites as a means of communication. The only delay with the use of satellite communication is waiting for stored information to be transmitted to the satellite when a communication window, the interval when the radio signals can be sent to the satellite, opens.

The recent interest in the business and technology of HAM radio does not come without a push for change in licensing. They are trying to set up a new test where Morse Code will not be involved, since Morse Code does not coincide with their interest.

The Technician Class will, in effect, be slowly phased out, because new operators will not have to learn Morse Code. The "codeless license" is the basis of the controversy of this new development in HAM radio, since this would lead to a greater number of under-qualified users and over-crowded airwaves according to existing amateur radio operators.

The pursuit of lower licensing standards has been met with opposition by the Amateur Radio Relay League (ARRL).

These lesser-qualified users would crowd radio bands and would make it more difficult to monitor for illegal activities. An increase in the number of voice transmitters and the addition of computer interfacing to the network would also eat away at the tradition of HAM radio.

See HAM, page 5

Design and CONQUER

by Kendall E. Giles

It's BAD. It's BULLET PROOF. It can STORM THROUGH SMALL WALLS on a single charge. It is the IEEE Hardware Project Team's entry in the IEEE SOUTHEASTCON Hardware Project Design Competition, to be held this year in Williamsburg, VA.

Each spring IEEE hosts a design competition for engineers who want to use their theoretical knowledge, to get their hands dirty, and to build some working device designed to solve a given problem while competing against teams from other universities. Every university is allowed one entry and the nature of the race changes each year.

Last year's team had to build a car which would first follow a white tape and then a wire carrying a small amount of current along a winding track. This was a race of pure speed — the fastest car in the double elimination contest was declared the winner.

Last year's team from Virginia Tech won first place, and returning team member and chief designer Michael Keitz thinks the team has a good chance of winning again.

The contest is different this year, however, and requires a different and more complex vehicle to be built. "This year's car will have to be a bit more intelligent than the one last year," said Keitz.

Indeed, this year's robot will have to do more than to simply follow a white piece of tape.

OBJECTIVE

As stated in the contest rules and regulations, the goal is to design, build, and operate a device which will move on a mapped surface, retrieve a small steel ball from a specified location, and deposit it at a second specified location. These locations will be identified by a serially transmitted, optically coupled ASCII code.

THE TRACK

The problem is a bit more intricate than it at first sounds. Figure 1 shows the track, composed of two sections and a final gate. The first section is flat with a cartesian grid marked with white tape superimposed onto a black surface, each square having 10" sides.

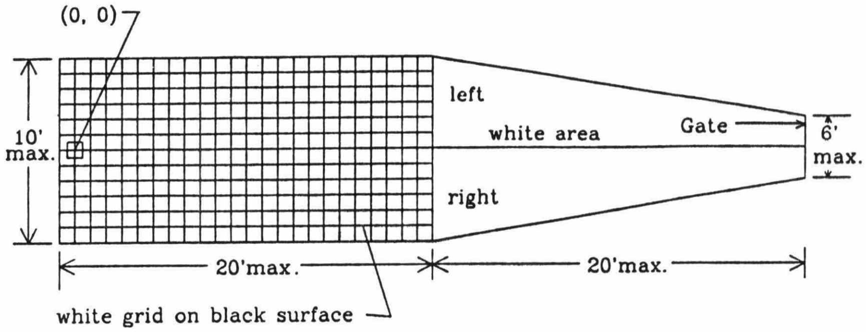


Figure 1. Track.

There are four 1" diameter holes (see Figure 2) located at currently unknown grid intersection points; the exact location of the holes will be revealed on the race day. The holes are ¾" deep and each contains a ½" diameter steel ball. The hole containing the ball to be retrieved (the initial ASCII code will specify which one of the balls to be picked up) will be illuminated from the bottom with an LED.

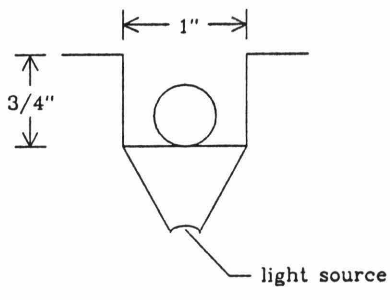


Figure 2. Hole and Ball.

The second section of track consists of a trapezoidal area painted white. The surface is sloped from the center to the outside edge and it tapers in width from beginning to end (see Figure 3).

Figure 3. Edge view of white portion of track.

The ball, previously retrieved from the correct hole in section 1, when dropped will activate a gate which will open at the end of section 2. If the ball is dropped on the correct side the gate will open immediately. If the ball is dropped on the incorrect side, there is a four minute gate delay before it opens.

The starting area consists of a 12" x 12" square area painted non-reflective dark blue. At grid coordinate 0,0 an embedded LED will transmit a code series, signalling the start of the race. The code will contain the grid location of the ball to be retrieved in section 1 and the correct side (left or right) where the ball must be dropped in section 2.

THE RACE

The race is a double-elimination event. Each heat will consist of two opposing teams racing on identical tracks and under identical conditions (both will have to retreive the ball from the same relative grid coordinate and will have to deposit it on the same relative side of the track in section 2).

The team which crosses through the gate first is the heat winner. In the likely event that neither team crosses through the gate, the one which was first able to retreive the ball will be the heat winner. If neither team picks up the ball, both teams lose.

DISQUALIFICATIONS

As posted by the IEEE Rules Commit-

See Design, page 12

Wilkes marshals ceramer research efforts

by John Cole

Ceramers represent a very new development in Chemical Engineering, combining polymers with ceramics to achieve materials with different and unique properties.

The field of ceramer research is presently a small, but growing, very specialized area. The man heading the operation here at Virginia Tech is Dr. Garth Wilkes, who has been involved in all of the breakthroughs in the field of ceramers.

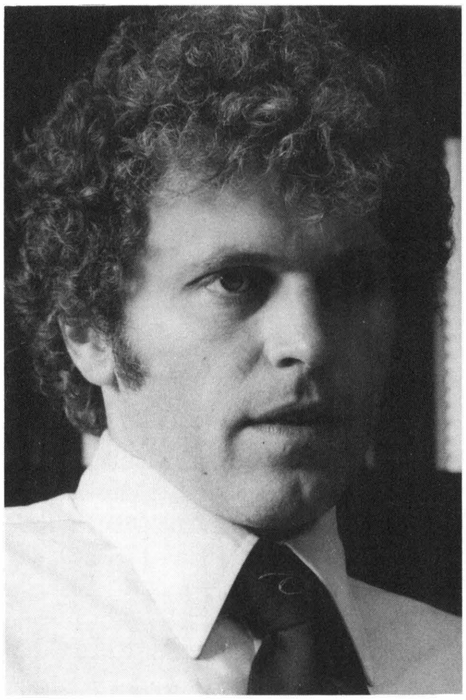
Since coming to Virginia Tech and organizing the Polymer Materials and Interfaces Laboratory (PMIL) with his co-director, James McGrath, in 1978, Wilkes has won several prestigious awards, including the Alumni Award for Research Excellence from the University, a Best Paper award from the Rubber Division of the American Chemical Society, and the Creative Polymer Chemistry award from the American Chemical Society. Wilkes was also presented a named Professorship of Chemical Engineering, four years after arriving here.

The idea for ceramers came to Wilkes about seven years ago as he was talking to a friend involved in ceramics. He followed up on the idea, which led to the cross between ceramics and polymers to create ceramers. The term "ceramer" was coined in a paper Wilkes wrote five years ago.

Since that time, a lot of developments have been made. Roughly nine patents have been filed for materials created, even though none of the ceramers created yet are in the marketplace. Ceramer research is supported by, among others: Eastman Kodak, Johnson & Johnson, the office of Naval Research, and their largest supporter, the AKZO Corperation, a large chemical company based in Holland.

A ceramic is a nonmetallic material made from firing inorganic compounds at high temperature. Polymers, which include plastics, elastomers, and thermosets, are combinations of many small molecules to form large chain-like molecules. Polymers are usually organic, containing carbon and hydrogen, while ceramics are inorganic, and may contain elements like silicon, oxygen, or titanium.

The path to combining the two fields of materials science to form ceramers started four or five years ago as Wilkes began experimenting with the sol-gel process of forming ceramics. The sol-gel process is when the ceramics are soluble but as they react, they form a gel which can be later "fired" into a high-temperature ceramic. Some organic materials can be used in the sol-gel process, which combine with the inorganic components to form an inorganic-organic hybrid network. This inorganic-organic network of a polymer and a ceramic led to the first coining of the term "ceramers," and increased exploration of the field of combined ceramics and polymers.



Dr. Garth Wilkes

Many materials with increased benefits can be created using ceramers. One of the only drawbacks of the ceramers is that they cannot be superheated as the organic would be chemically destroyed. Some of the areas being looked into for applications of these materials are for mechanical, optical, and electrical devices.

Refractive indexes for materials being used in lenses now range from 1.4 to 1.6, which is a measure of how much light can be bent. Titanium-based ceramers Wilkes has developed have refractive indexes above 1.6, which potentially means thinner and more flexible lenses could be made, relative to pure plastic lenses.

Research efforts concerning ceramers focus on the synthesis, structure, and the property response of these systems, while also testing their thermal and chemical stability. Wilkes estimates his research group spends 30 percent of their research effort on ceramers.

An upcoming event for Wilkes is his being Chairman of a symposium in New York City presented by the American Chemical Society next fall. The symposium will deal with Pre-Ceramic and Inorganic-Organic Materials.

HAM

Continued from page 3

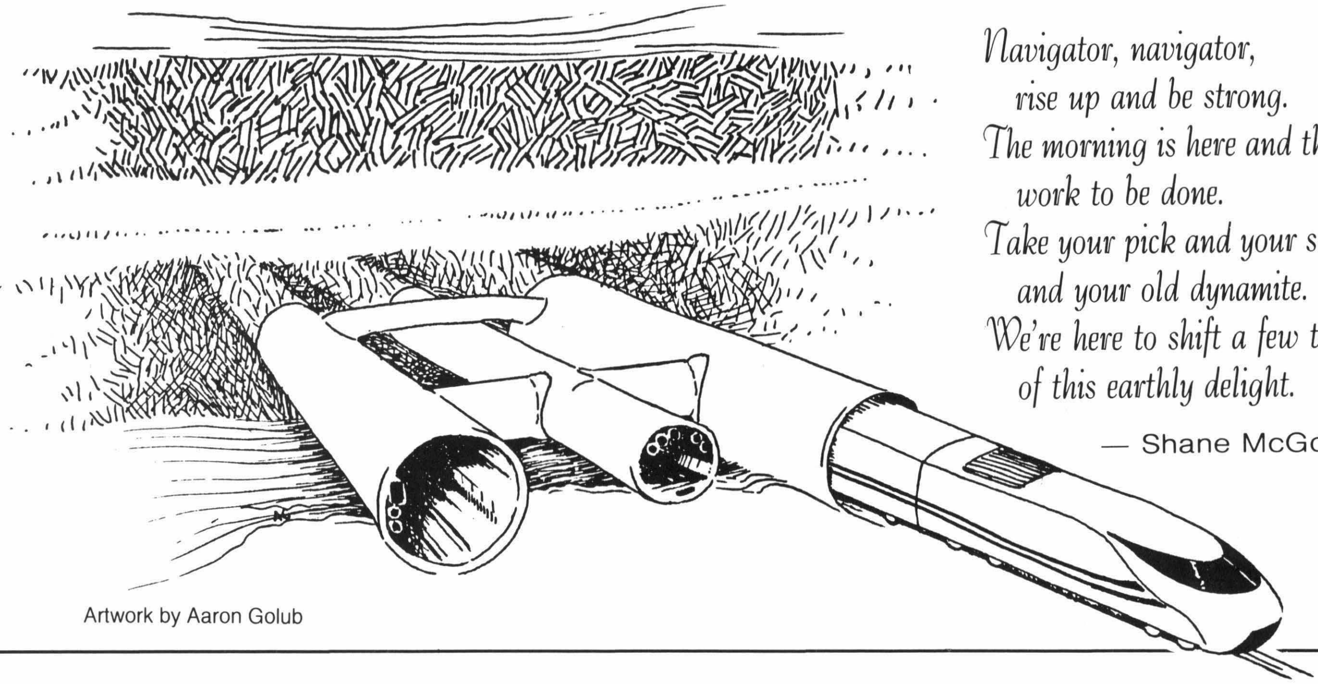
However, this technology does have its advantages. A greater popularity among younger people would hopefully increase the number of students interested in science and technology. It is also a cheaper source of transmitting information, especially compared to the use of long distance telephone lines by computer users.

On Feb. 14, 1991, the Federal Communications Commission (FCC) passed the resolution, agreeing to allow code-free licensing at a frequency above 50 megahertz. This would only allow individuals to take advantage of the bill. There is a restriction on the use of the radio airwaves by businesses.

John Musson, a member of the Amateur Radio Club at Virginia Tech, says "It is now up to ARRL to make new amendments to the bill accepted by the FCC, and in the end, either accept or defeat the proposal."

Will HAM radio be affected by this new license, and will this be a good or bad effect? These questions and many more are in the hands of the ARRL to decide on the future of HAM radio.

EUROTUNNEL:



Navigator, navigator,
rise up and be strong.
The morning is here and there's
work to be done.
Take your pick and your shovel
and your old dynamite.
We're here to shift a few tons
of this earthly delight.

— Shane McGowan

Artwork by Aaron Golub

by Andrew Predoehl

INTRODUCTION

History records dozens of plans to tunnel under the English Channel. Although the dream is perhaps as old as dreaming itself, the serious plans are only as old as the study of civil engineering.

Most of the ideas never got anywhere, but a few brave entrepreneurs did start work, such as Colonel Beaumont, who, in the 1880s, began excavating a channel tunnel. His workers had dug more than a mile before the British government, afraid of invasion, shut down his operation.

The tunnel being built today, by Transmanche Link (TML), will not be cancelled. It is more finished than unfinished. By this fall, TML will finish digging the maintenance tunnel; the railway tunnels will take another eight months. By winter of 1992 TML plans to complete the railway terminals, and the whole project should be approved and running by June, 1993.

Japan's Seikan tunnel, which connects Honshu and Hokkaido islands, is similar to the channel tunnel. Both are about the same length, and both were constructed with modern tunnel-boring machines (TBMs).

Many of the engineers who worked on the Seikan tunnel and the Seikan TBMs are consultants for Transmanche Link, and their experience shows — the Seikan tunnel took 24 years to build, but the channel tunnel, start to finish, will take just seven.

The channel tunnel is a privately-funded project, and the group paying for it is called Eurotunnel. Early on in the project, when the two governments were accepting proposals, a group of interested bankers and engineers worked together closely. When the group's proposal received permission, the bankers and engineers separated into two parties, Eurotunnel and Transmanche Link. Eurotunnel is a consortium of British and French banks, and it will own and operate the completed tunnel. They keep themselves quite busy in the meantime raising the money.

Doomsayers have prophesized Eurotunnel's collapse almost since the project started; however, Eurotunnel chairman Alastair Morton says, "The rumors of our early demise were much exaggerated." Admittedly, the project is over budget; it will cost around $10 to $12 billion, and that makes it the largest privately funded construction project of the century.

Transmanche Link (la Manche, "the Sleeve," is the French name for the channel) is a consortium of engineering firms. It has been contracted by Eurotunnel to design, build, and commission the system; Eurotunnel and TML are legally separate entities. TML comprises five British and five French firms, including the firms responsible for building such recent projects as the Thames Flood Barrier and the French TGV trains (those trains that zoom over 300 miles per hour). Arguably, the channel tunnel outstrips both of these.

THE PAPER TUNNEL

The design goal for the channel tunnel is 24-hour-a-day transportation across the channel for car passengers, train passengers, truck cargo, and freight trains. TML's design solution is three parallel tunnels: two are dedicated to running trains, the third, in the center, is for maintenance and emergencies. The system has a capacity of about 50 trains each day, and trains can travel up to 100 mph.

Trains will either be ordinary diesel trains run by the national railways, or special shuttles run by Eurotunnel. The Eurotunnel shuttles will carry cars and trucks from one terminal to another. Thus the terminals will link up

Engineering the channel tunnel

with the national highway networks as well as the railway networks. The terminal on the English side will be at Folkestone, in Kent, west of Dover. The French terminal will be at Coquelles, near Calais.

Margaret Thatcher and Francois Mitterand signed a treaty in 1986 to allow such a project, and in 1987 the French Parliament, and later the British Parliament, approved Eurotunnel's plan, and gave them permission to begin. In November, they did. Let's examine this tunnel they are building.

THE BORING GRIND

How do you dig a hole under the sea? First, have geologists tell you what is down there. It turns out that the channel floor is divided into strata. On top there is white and grey chalk, which is hard and rather fractured. The layer below that is chalk marl, which, in the tunneling business, is good stuff; it is soft enough to make tunneling easy, it is durable, and it is water-impermeable.

A tunnel in chalk marl will last. Recall Colonel Beaumont's tunnel from 1880: When TML intersected it, they found that, even without a lining, the tunnel withstood over a century (then they filled it with concrete).

Beneath the chalk marl there is a layer of gault clay, which is also hard to tunnel through. Thus the route that TML takes under the channel is through the chalk marl as much as possible, trying to follow its contours, without building in a grade of more than 1.1%; the route is not perfectly flat, and it stays around 100 feet below the sea bed.

There is only one real geologic bugaboo: near the French portal, the tunnel must pass through several layers of faulted chalk, sands, and gravels. The tunneling here was especially difficult because the sea kept trying to come in.

Of course, the first problem is how to bore the hole; later you can worry about keeping the sea out. Enormous machines, the TBMs, do this. In essence, they are self-propelled drills, thirty feet across. Two big gripper shoes on the sides brace the machine while the huge, 95-ton tungsten-carbide cutting disk on the front revolves (about six times a minute), chewing up the chalk marl in front of it.

Teeth on the disk constantly move the chewed-up rock, known as *spoil,* towards the center of the disk, through holes, and onto a conveyor belt, which dumps the spoil onto a train headed for the surface. The cutting head is built on a telescopic chassis, so that the cutter advances while the gripper shoes remain set in place. Thus, the gripper shoes get a purchase on the tunnel walls, and thrust cylinders push the turning cutter into the chalk.

The TBMs creep forward at about 1.3 inches per minute, 53 yards a day. To people (like me) used to microwave cooking and CNN, that sounds slow. According to Carl Decker, a Detroit engineer who worked on the very first TBMs, "Modern tunneling goes 20 times faster than the old methods and uses 20 percent of the people."

Are the TBMs slow? Think of the TBM speed in terms of volume; these machines tunnel through solid rock at the rate of about 1.3 cubic feet per second.

But these machines do more than eat chalk. TBMs are aligned with lasers, and they keep some 300 workers busy. The TBM operator sits in a booth and watches a closed-circuit TV view from the cutting head, plus a laser-alignment display. By adjusting the proportions of thrust from the thrust cylinders, he can steer the machine to correct misalignment.

The TBM also includes equipment for cleaning the air and ventilating the tunnel, and circulating water to cool the tunnel; the massive electric motors in the TBM get quite warm. In addition, on the French side, the TBMs have to contain the immense pressure of the water leaking through fissures in the rock.

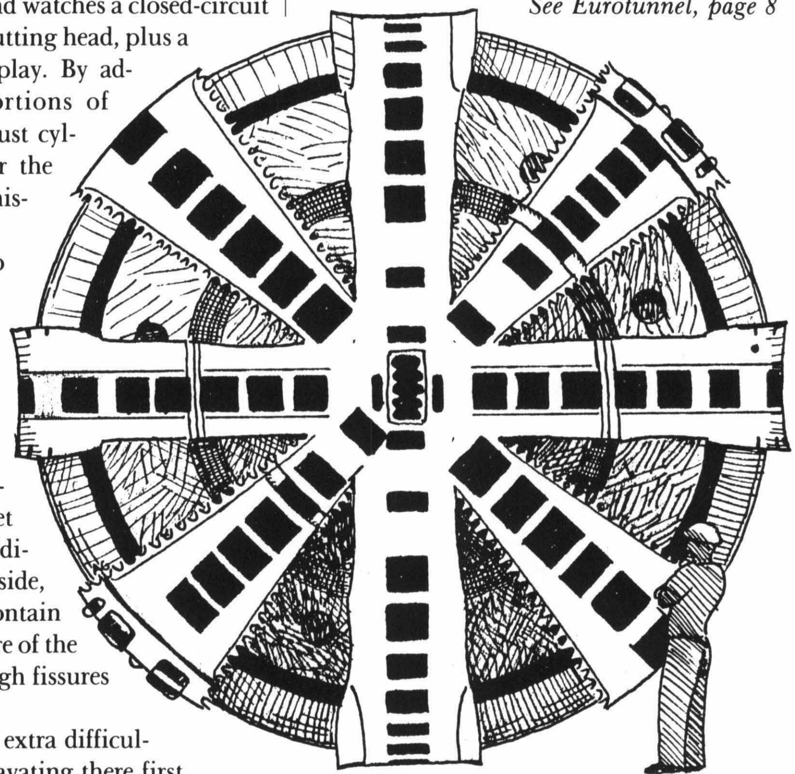
Because of this extra difficulty, TML began excavating there first. The tunnel-boring machines there have special seals designed to withstand some ten atmospheres of pressure, which makes the spoil flow like toothpaste. To further withstand the pressure of the sea, the concrete lining (see below) is specially constructed.

To keep the sea out, and to strengthen the tunnel, the entire tunnel is lined with concrete. The lining is made of rings of precast segments, which the TBM installs as it advances. The rings lining the British side of the main running tunnels are made of eight segments, with one small segment fitting like a keystone. Then the crevices between the segments are filled with grout to make the lining waterproof.

On the French side, because of the fractured chalk, the lining in the main running tunnels is even stronger. The rings are made of six segments, and the segments are bolted together. Furthermore, a gasket between the segments makes the seal strong as well as waterproof.

The segments are made in TML's own casting plants, one on each side of the channel.

See Eurotunnel, page 8



Artwork by Aaron Golub

Eurotunnel

Continued from page 7

The various segments, weighing between 0.7 and 10 tons, are paragons of concrete technology, with some tolerances of 0.1mm, but a rejection rate of only 0.2%.

The concrete is not only formed precisely, it is also the strongest ever cast. Ninety days after curing, the concrete has a crushing strength of up to 100 N/mm^2; compare that to the concrete in a pressure vessel for a British nuclear reactor, which typically has a strength of 50 N/mm^2.

As a final note, the TBMs have names. The British call them things like The Running Tunnel Seaward Drive and The Marine Service Tunnel Boring Machine. The French call their TBMs Brigitte, Europa, Catherine, Virginie, Pascaline, and Severine. Draw what conclusions you will.

CUSTOM CRAFTING

Not all the tunnels are dug by TBMs. Plenty of tunneling still must be done by hand or with more conventional earth-moving equipment. Every 375 meters (1230 feet) the three tunnels are connected by a cross-tunnel, which provides maintenance access and an evacuation route. Every 250 meters (820 feet) there is a "piston relief duct," which is a tube that connects the running tunnels but arches over the center service tunnel; the duct equalizes the air pressure in the two tunnels when a train passes. Both these little tunnels are dug with bulldozer-sized machines called roadheaders, which work as big drills on wheels.

There are underground rooms as well. The tunnel has three main pumping stations that will pump out any liquid that accumulates in the tunnel. There are also rooms that house various equipment, such as power and communication equipment. However, the most impressive underground rooms are the crossover caverns.

In two places under the channel, TML built huge caverns in which the tunnels converge and the tracks cross, so that Eurotunnel controllers can, whenever necessary, switch a train onto the opposite tracks. These crossovers allow trains (during maintenance or an emergency) to travel in the opposite tunnel. All the digging was done by conventional earth-moving equipment, such as roadheaders, and by hand. It represents a significant amount of the work put into the tunnel excavation.

FIXING A HOLE

Once the hole has been bored and lined, work crews must then install tons of fixed equipment. The teams that install the fixed equipment move through the tunnel in order; behind the TBM crews come the rail crews, the power crews, the water main crews, the control and communication crews, and so on.

Each crew is tightly bound to its schedule, and one crew's delay can disrupt the schedules of other crews. For example, if the track-layers fall behind, the power crew cannot install the catenary (the overhead power line) on schedule.

Another difficulty is moving all the equipment and materials into the tunnel while moving the spoil out. On the French side alone, TML estimates that the installation of the fixed equipment is comparable to building ten cement factories or two nuclear power stations. The tunnel will use over 280 miles of pipe, over 11 tons of railway track, and over 100,000 supports and brackets.

As for the outflow of chalk, on the British side alone the seawall built to contain it will hold some seven million cubic yards of spoil. It all has to flow above the work crews while they are working.

The channel tunnel will use over 62 miles of continuously welded railway track set in concrete. Because the track is continuously welded and set in concrete, each rail crew must bring all of their materials with them at the beginning of a work shift.

Water mains throughout the tunnel keep the tunnel cool, and provide water in case of a fire. Sensors on the tracks can detect overheated train axles, smoke, and other dangerous conditions. If there is a fire, and it is extinguished with water, the water will be removed by the pumps. (Liquid can accumulate in other ways also — from fuel leaks, cargo spills, rainfall entering the tunnel portals, or even a leaky lining).

The control centers on the surface communicate with the trains and shuttles by radio transmitters throughout the tunnel. And, the control centers in Britain and France communicate with each other through a fiber-optic cable. Further, the maintenance tunnel contains telephones that connect to the control centers.

Ventilation is a major concern. The fixed equipment, including fans and remote/locally-controlled pressure dampers, will keep the air pressure in the service tunnel higher than in the running tunnels; this, plus the fire-retaining doors, will keep the service tunnel clear of smoke or fumes during an accident.

The shuttles operated by Eurotunnel will be electric, generating 7600 HP (5.6 MW). They will draw power from the overhead catenary, kept at 25 kV, 50 Hz. This catenary is connected to the power grids of both Britain and France, and if one country has a blackout, the other can supply all the power to the tunnel.

Also, many devices installed in the tunnel require electrical hookups — the pumps, the lights (the tunnel is always illuminated), the communication equipment, the track sensors, and the ventilation equipment.

Lastly, two cables are embedded in the service tunnels. By design, the service tunnel is wide enough to accomodate Eurotunnel's tunnel trucks. These diesel vehicles have been custom-built by AEG Daimler-Benz to travel in the tunnel. They are bi-directional; that is, they have a driver's seat in both ends, so they don't need to be turned around. They will be used for maintenance, as ambulances, and as fire-trucks.

These trucks don't need to be steered: a truck can follow the cables embedded in the floor like a bloodhound on a trail. Two cables, laid parallel, allow the trucks to pass one another going in opposite directions.

CONCLUSIONS

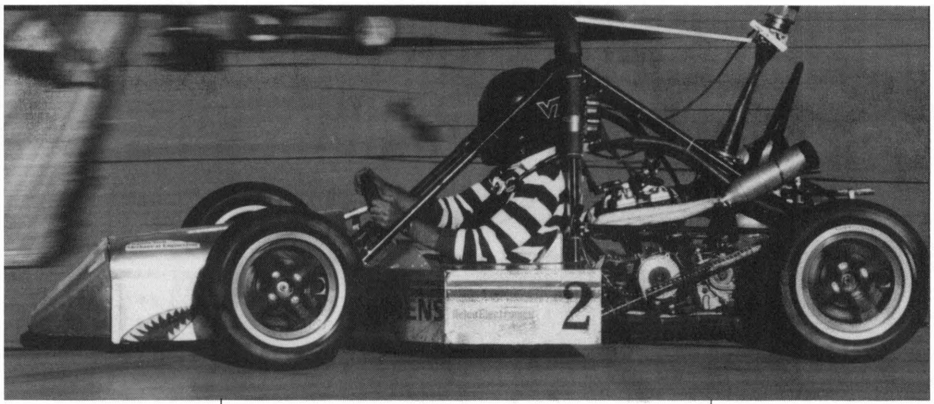
The channel tunnel is quite a marvel; and we have just seen a fraction of the entire project; the construction of the terminals, the contruction of the portal sites, the design of the locomotives and shuttles, and the operation of the tunnel are just a few of the related topics.

Further, the tunnel project is an impressive example of two governments cooperating with private industry in a massive physical and economic enterprise.

Finally, it is the fulfillment of more than a century of dreams; with a little luck, it will inspire dreams for the centuries to come.

SAE readies cars for competitions

by John Cole



Having just attended the 1991 Society of Automotive Engineers International Congress & Exposition in Detroit, Michigan, the SAE will turn its plans to completion of their cars, which are to be raced in mid-May.

At the International Congress & Exposition, held the last week in February, the club presented a booth consisting of photos and information about the Mini-Baja and Formula cars.

For its booth, the SAE won an honorable mention award from the Exxon Corporation, consisting of a $125 prize. Dr. Rick Roby was also presented an award, an Outstanding Faculty Advisor award from the International SAE organization.

The SAE is currently completing work on a Mini-Baja car and a Formula car. Later, tests will be run to determine the performance of the cars, and modifications will be made. Final completion of the cars is projected for early May, in order to train the drivers and to be ready in time for the mid-May competitions against schools from the United States and Canada.

The Formula competition is to be held on a track at the GM Proving Grounds in Millford, Michigan. The Mini-Baja car will participate in the Mini-Baja East competition which will be held on off-road terrain.

Each year the Mini-Baja team starts on a fresh car while the Formula team is allowed to carry over the car from the last year, as long as it was new the previous year.

Last year the Formula team raced two cars, both carryovers (with modifications) from the previous year. Both ranked in the 20s as the cars performed very well in presentation and design, but both had engine failures because of a broken fuel-injection system.

This year the formula division will present one completely new car, since both of last year's cars were carryovers. There will be one new Mini-Baja car presented.

Formula competition cars are pretty open when it comes to requirements. There is a volume displacement limit, a horsepower limit, and a few other minor restrictions but otherwise it is left to the disgression of the clubs as to how they design their engines.

This is opposed to the Baja competition, which starts by giving everyone the same Briggs & Stratton engine. The allowable modifications to the engine are minimal, thereby placing emphasis on the structural design.

The Mini-Baja car must be able to handle off-road terrain. It is tested in such areas as crossing logs and being able to float and propel itself on water. Both cars face safety considerations as a high priority in the judging of their performance.

The SAE cars are designed, built and raced by students, mostly juniors and seniors. Dr. Roby, the Formula car advisor, and Dr. Hal Moses, the Mini-Baja car advisor, oversee, give guidance, and review the students' technical work.

Students of any major are encouraged to participate. Help from freshmen and sophomores (and graduate students) is especially welcome because they can carry on their knowledge to the next years. Students from such diverse majors as business and computer science have participated in the past.

The SAE kicks off with an interest meeting in September; however, students may join at any time. For more information, contact the current president, Vince Hatcher.

According to Dr. Roby, "The industry really looks favorably on students with this kind of hands-on experience."

SEC News

by Howard Kash

Engineers' Week, February 17 through February 23, 1991, was a great success and we would like to thank all those involved. Special recognition goes to SWE (Society of Women Engineers), ASME (American Society of Mechanical Engineers), IIE (Institute of Industrial Engineers), and AIAA (American Institute of Aeronautics and Astronautics) as the overall participation point winners in that order.

The week began on Sunday, February 17, with the second annual SEC Olympics. The American Institute of Chemical Engineers (AIChE) won first place in the competition.

After a week of special seminars and presentations, an Attitude Adjustment Celebration (party) was held in the Terrace View Clubhouse. The exceptional turnout showed that engineers really do know how to have a good time.

The concluding event, 15-minute airplane rides around Blacksburg, turned out to be a bigger success than we expected. 250 people showed up to take the 15-minute tour but unfortunately we were only able to give 69 rides. We apologize to those who did not get to participate. Next year we'll bring a 747.

By the time this issue is printed, the SEC and NSPE sponsored EIT exam lunch will have been given and the annual SEC Superstars competition held. A full report will be forthcoming in the September issue.

Pupil becomes teacher

by Paul E. Gray

(Editor's Note: A professor of electrical engineering at the University of Wisconsin-Platteville, Paul E. Gray graduated from Virginia Tech in 1962. At Tech, he received his B.S. and M.S. degrees in electrical engineering).

At one time or another each of us reminisces about our first undergraduate course in linear circuits. We often share our experiences as horror stories especially during an alumni gathering where classmates abound and laughter is unrestrained. Stories are good things to share.

I have a favorite story about the professor who taught me linear circuits. The story is not one of horror, but one of growth — my growth to his off-the-cuff challenge as he taught my youth and tolerated my immaturity.

I remember sitting beside his desk expressing my feelings of boredom. Boredom with the repetition required to do multiple wye/-delta calculations for the assigned problem shown in Figure 1. He accepted my complaint, "...that it took two sets of batteries and 20 hours of sweat to calculate only one of the three required Thevenin equivalent impedances." He didn't want to hear that.

Adding fuel to the fire, I complained that "we" needed to be shown a less frustrating way to solve the problem. I jabbed a raw nerve.

Irritated, he declared that he did not know a better way because one did not exist. My ignorance assumed the defensive, saying that "we" might find a better way somewhere in the library. That defense was weak.

With a gotcha chuckle he challenged, "Ok, you go find one and show me." I was trapped! Mumbling several colorful adjectives, I retreated from his office.

He was right: library visits did not produce a better way and the assignment was scored at a lousy 85%. The story should end here. However, stubbornness replaced common sense and I plotted my revenge, i.e., to find a better way — and show him.

As years passed, I did not find a "better way" to solve that problem. I simply made one up and gave it a name — the reference node r model. Obviously one should get to name what one invents — selling the idea is another matter.

Preparing the r model as my defense, I phoned my linear circuits professor and scheduled a "show him" session. My objective was to achieve a change-of-grade from 85% to 100%.

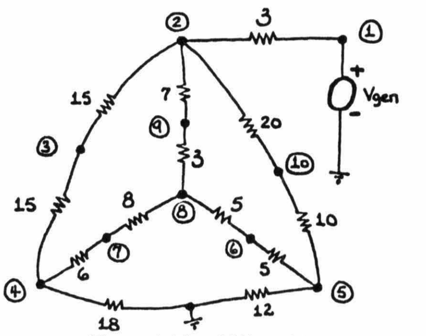


Figure 1. The 85% problem.

At Homecoming in late October, I found him talking to a group of "we's" (my old classmates) whom he had briefed as to the "show him" event. Laughter was unrestrained, but I resisted being roasted.

Wasting no time, I steered the conversation toward the 85% problem (schematic in Figure 1). "We" recalled the task — that of sweating too many hours to calculate three Thevenin equivalent impedances (ZTH) at node-pairs (5,6); (7,8); and (6,7). He immediately recognized the problem and defended his position, i.e., a change-of-grade would be made, if and only if, this r model idea proved its worth. And so I laid the 85% paper in the center of the table.

Anticipating a change-of-grade battle the "we's" edged closer to the table and the discussion became technical. My teacher listened as I prepared to show the r model to be a "better way."

My defenses required a foundation. Specifically, "we" talked about the progression of concepts (series/parallel/wye/delta) used in solving the problem shown in Figure 1. I told him that I appended the r model idea as an extension to this progression, i.e., series/parallel/wye/delta/r model.

Smiling, he asked if the r model results produced the three correct answers — as he pulled a solution sheet from his pocket. Nodding in the affirmative, I countered with the tabulation

1. ZTH(5,6) = 4.1 ohms
2. ZTH(7,8) = 6.0
3. ZTH(6,7) = 9.1
4. ZTH(2,0) = 2.5
5. ZTH(4,0) = 7.9

He responded that the first three answers were correct and asked how I calculated ZTH(2,0) and ZTH(4,0). Remarking that the r model calculates all the ZTHs, I showed him how to find the equivalent impedance at each of the 55 node-pairs within the network.

Watching his eyes, I could see the change-of-grade inching closer. He wanted a simple example — to see how the r model worked. Producing the schematic shown in Figure 2, "we" derived the KVL equations where

```
|  1.0    -0.5  |   | V1 |   | 0 |
|               | * |    | = |   |
| -0.5    0.75  |   | V2 |   | 0 |
```

and solved for the matrix inverse

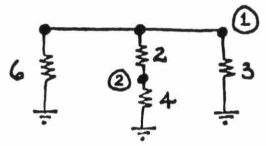
```
                   [P] = [U] * [Q]
| V1 |   | U(1,1)  U(1,2) |   | 0 |   | 1.5   1.0 |   | 0 |
|    | = |                | * |   | = |           | * |   |
| V2 |   | U(2,1)  U(2,2) |   | 0 |   | 1.0   2.0 |   | 0 |
```

One of the tipsy "we's" made the remarkable observation that Gray's solution was the zero matrix. Our professor only increased the laughter when he remarked, "Finding ZTHs within a network requires that it be source free or dead drunk." He returned to examining the tabulation where

```
ZTH(1,0) = U(1,1) = 1.5 ohms
ZTH(2,0) = U(2,2) = 2.0
ZTH(1,2) = U(1,1) + U(2,2) - U(1,2) - U(2,1) = 1.5
```

```
figure2.txt========================N=O=C=A======================V3.55.08
                     I N P U T   N E T W O R K
           F i g u r e   2 .   S i m p l e   e x a m p l e .
17-MAY-89=================================================07:53:06

     * Figure 2. Simple example.
     R1 1 0 6.0
     R2 0 2 4.0
     R3 1 2 2.0
     R4 1 0 3.0
```




```
figure2.txt========================N=O=C=A======================V3.55.08
                     M A T R I X / S E T - U P
           F i g u r e   2 .   S i m p l e   e x a m p l e .
17-MAY-89=================================================07:53:06
     ROW( 1) IS V( 1)
     ROW( 2) IS V( 2)
figure2.txt========================N=O=C=A======================V3.55.08
                          M A T R I X   M
           F i g u r e   2 .   S i m p l e   e x a m p l e .
17-MAY-89=================================================07:53:06
     ( 1, 1)=  0.1000E+01
     ( 2, 1)=  -.5000E+00
     ( 1, 2)=  -.5000E+00
     ( 2, 2)=  0.7500E+00
figure2.txt========================N=O=C=A======================V3.55.08
                          M A T R I X   U
           F i g u r e   2 .   S i m p l e   e x a m p l e .
17-MAY-89=================================================07:53:06
     ( 1, 1)=  0.1500E+01
     ( 2, 1)=  0.1000E+01
     ( 1, 2)=  0.1000E+01
     ( 2, 2)=  0.2000E+01
```

Figure 2. Simple example.

Refilling our glasses, he pocketed the 85% paper — accepting the object of my revenge. It was forgotten. The evening was young. "We" shared more horror stories, agreeing to meet at tomorrow's luncheon. It was a happy evening. I wanted to stay but he did look ancient and tired.

Lunch included memories that I had long since forgotten, rudely interrupted by the dinging that spoons make glasses cry out in pain. It was time to listen to speeches and awards — how boring. Everybody got an award!

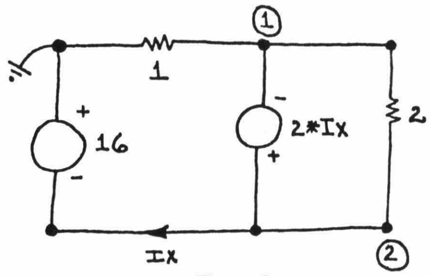


Figure 3.

I too was called forward to receive an award — not recalling what I had done to earn it — Oh! Oh! my thoughts signaled that the "we's" may be planning to roast me. Instead, I was awarded my 85% paper, framed in glass and clearly restored to 100%. At the bottom was written in his ancient scrawl, "I am vanquished... Gads!... the teacher is now the student." We said our goodbyes.

He liked the example and prodded to see others: one containing controlled sources and one containing energy storage components. I came prepared and laid three additional examples on the table (schematics shown in Figures 3, 4, and 5).

The "we's" examined the example shown in Figure 3 concluding that his hand calculations matched my r model result, i.e. ZTH(1,0) = 2.0 ohms. He asked, "Is this r model a new way to look at old problems?"

Tasting the change-of-grade, I pointed to the example shown in Figure 4, challenging him to hand calculate ZTH(5,0). He looked at me and complained that maybe we could find the solution in the library. The "we's" hooted in their laughter when I wrote {ZTH(5,0)= 2.0 ohms} on a table napkin and displayed it in matador style. I was prepared to present all thirty-six of the ZTHs to be found within the network but they weren't needed.

Explaining the fourth order network shown in Figure 5, I produced ZTHs, voltage gains and transimpedances as ratios of polynomials in complex frequency, s. For example the characteristic polynomial is

```
                                   2         3        4
  char poly  =  0  +  3*s  +  17*s   +  22*s   +  8*s
```

where the zero root says that the network possesses a node which does not have a dc path to ground. Using the r model computer simulation

```
                                            2          3
                        0  +  6*s  +  23*s   +  16s
ZTH(6,0)  =  U(6,6)  =  {------------------------}
                              char poly
```

I showed the r model solution to contain whatever behavior is needed by the problem solver, e.g., transadmittances, current gains, etc. That did it! He waved the napkin in surrender. Revenge, sweet revenge, to find it dissolve into laughter.

Three weeks later he called to say that my promised examples and derivations had arrived. He expressed interest in how I derived the r model and used it to examine the op-amp, the transistor and other network behaviors including driving point impedance. Of special interest was how the r model permitted him to "better" manipulate networks containing controlled sources.

He stressed the idea that the presence of controlled sources traditionally prevented an intuitive grasp (by his students) as to how a network behaves. He felt my idea could address this problem and wanted permission to use the r model in his introductory circuits course — "of course I'm delighted," as my head swelled.

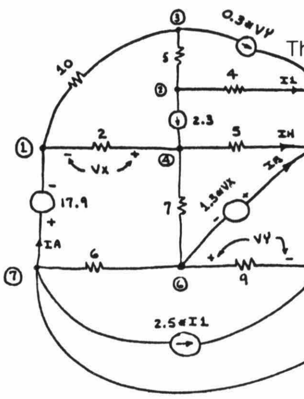


Figure 4. The complicated example.

Then he chuckled his revenge. He wanted to co-author a book about the r model. I should have sensed it coming — that man is always sending me to the library to find nothing and invent something.

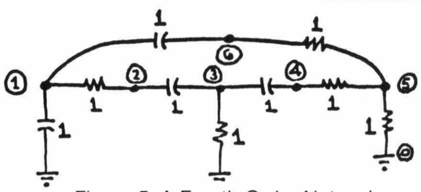


Figure 5. A Fourth Order Network.

Continued from page 4

tee, a team's car will be disqualified from the heat if:

1. Any flying apparatus is used,
2. Any team member touches the car after the race is started,
3. Any remote controls are used,
4. Willful damage to the track by team members or car occurs,
5. Willful damage to an opponent's car, the judges, or the opponents themselves by team members or their car occurs,
6. The vehicle emits jamming signals, or
7. A combustion engine of any type is used.

THE TEAM

This year's team is made up of ten electrical engineers and one faculty advisor, Dr. William T. Baumann. Since the start of fall semester, the team has met each week in strategy and design sessions. Each person or group of two people received their own subsystem to design, and have put in many hours seven days a week soldering, tweaking, drilling, and cutting various components of the car.

Says team member Rob Bergstrom, "The experience is great. It allows you to actually build what you designed rather than simply solve a problem with predetermined constraints and boundary conditions." Here, the only constraints are given by the race rules. Beyond that, team members are free to design and build what they please — and students get exactly what they design, good or bad.

"You have to take into consideration many variables and concerns that do not come into play in book problems. In the real world you have to consider, among other things, cost, part availability, part defects, tolerances, and, most of all, error caused by the human factor," says Jeff Nevits, another team member.

THE CAR

The robot itself has three wheels, the back two being driven by high-torque motors. These powerful motors are needed to power the battle-ready chassis, built around a 12″x11″ sheet of ¼″ aluminum. The car is limited in its dimensions by race rules, but Tech's team designed the car to stretch the limits.

The motors are secured with steel clamps and all sensors, the computer, and the ball handler are held in place with nuts and bolts rather than epoxy, which some teams have used in the past. "Components mounted with epoxy tend to break loose at the least opportune moment," said Keitz.

Last year, the team was testing the car in New Orleans the night before the competition, when they had trouble with the servo. They had brought spares for all the other components *except* the servo. Murphy's Law strikes when least expected and never plays fair.

"This year we are using lots of metal to make the car as sturdy as possible," said Keitz. Outside of encasing everything in lead, every effort has been made to render this year's car indestructible.

But as the Solar Car team learned last year in the Tour de Soul, the mechanics can be perfect but the electronics must be fully developed as well.

On the electronics side, a whole array of technology has been utilized to produce a winning combination. With the need for added intelligence, the robot this year has brains provided by the PCOW, or Personal Computer On Wheels.

The 80188 microprocessor receives data through the interface board from an assortment of sensors. Bumpers on the front and sides of the car are complete with microswitches to indicate when the robot collides with an obstacle (the entire track is surrounded by a wall).

Hall Effect sensors count the number of times the motor gears revolve. They work in conjunction with the line sensors to allow the robot to navigate its way along the grid to find the ball and make it through the gate.

There is even a sensor to determine whether the ball has been picked up or not. A modem is used to receive the transmitted codes at the start of the race.

CONTINUING THE WINNING TRADITION

This year's team has high hopes for the April 8 event. As the deadline nears, team members are hurrying to get all the systems working. "I will be a lot happier when we get all the stuff mounted on the car so that we can test it," said Dr. Baumann.

Testing will be a crucial part of the ultimate success of the car. The seperate subsystems will have to work smoothly together in order to have a winning combination, and many hours will have to be spent debugging the software and adjusting the sensors and motors.

This year's IEEE Hardware Project Team appears to be up the the tough task of bring home the gold once again.