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VOLUME 80, NUMBER 1 October, 1975

wisconsin engineer

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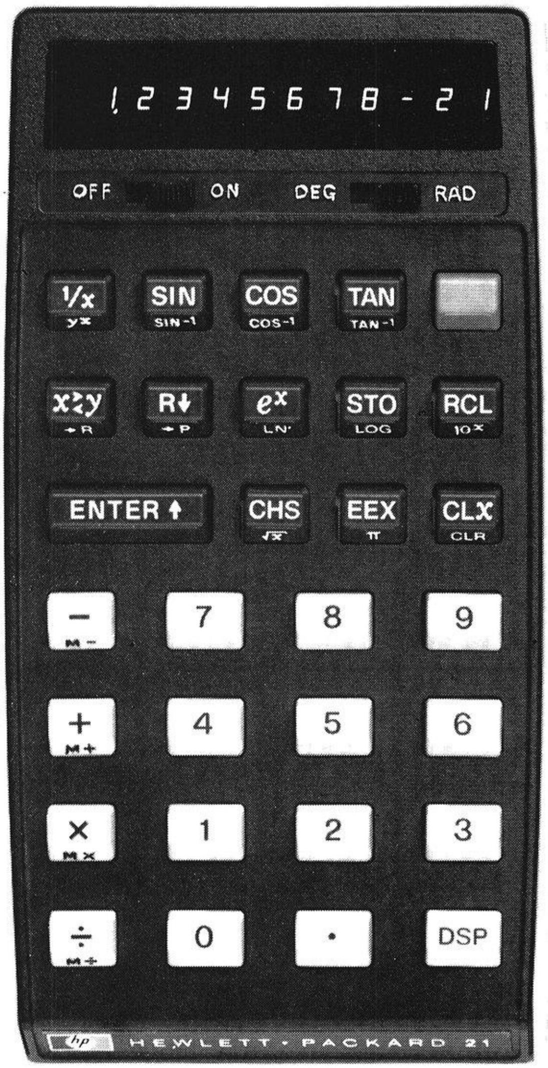

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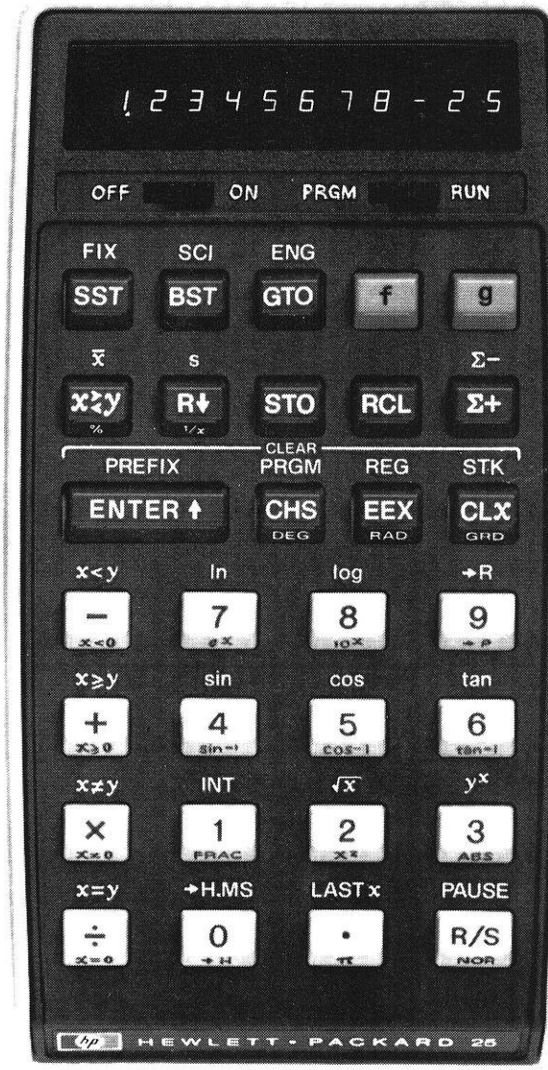

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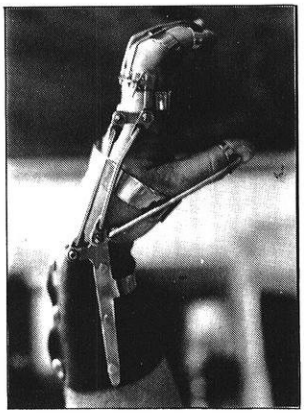
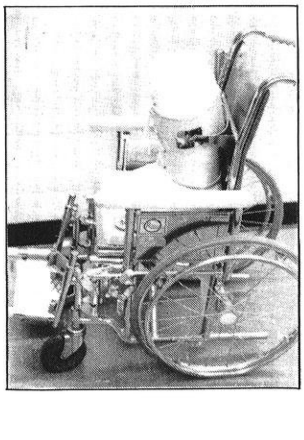
Orthoses — An Alternative to Surgery

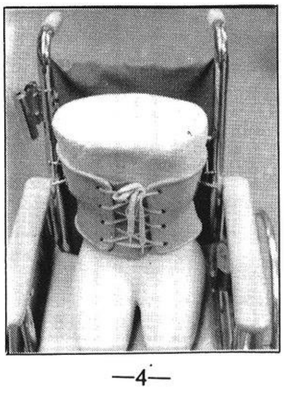
by Steve Schopler

"Since they are used in so many cases, . . . every orthotic device must be individually designed and hand crafted."



In December 1974, a Madison, Wisconsin woman made medical history. Shirley Seireg's "athlete's knee" was the first case of degenerative arthritis to be treated with an artificial knee brace. Orthoses, as external braces are called, can be used to give corrective treatment of spinal defects, supportive assistance to injured limbs, or provide controlled movements to paralyzed patients. Orthotists are the specialists who design and build the devices, applying concepts of anatomy, physiology, engineering, and materials science to reshape injured human bodies and restore their mobility.



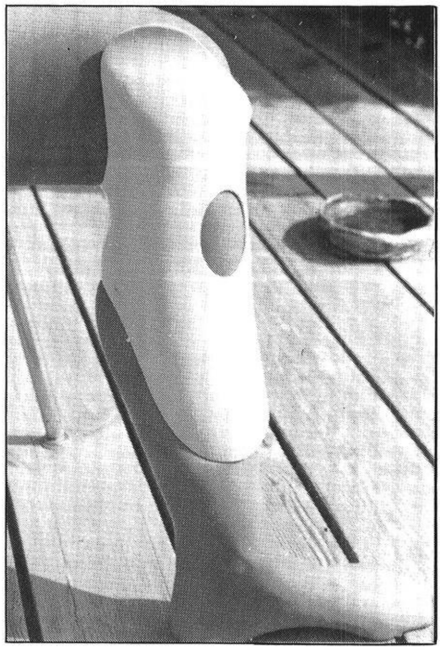


Mrs. Seireg's knee, injured in a riding accident, had been operated on in 1952 to remove torn cartilage. Such operations are common treatment for this knee injury, and many young athletes undergo the surgery every year. As a consequence of the operation and an active lifestyle, the remaining cartilege in her knee was worn down to a paper thin layer, a condition known as degenerative arthritis. Loss of the natural shock absorbing material in the joint caused friction between the knee bones and such severe pain that within a few weeks it nearly crippled her. Operations to replace the knee with an artificial joint or to break the leg and reset it deliberately "bowlegged" offered no guarantees of success. So, although her doctors doubted that the brace would help her, Mrs. Seireg visited the orthotics department of the

Steve Schopler *is a senior in mechanical engineering, currently studying bio-medical engineering. He is also a science and technology intern for the Wisconsin Legislative Council Staff.*

Rusk Clinic at New York University where an orthotist, Hans Lehneis, designed and constructed the brace in two days. "From the minute I put it on - no more pain." said Mrs. Seireg who has resumed her occupation and family life with full vigor.

When standing or walking, Mrs. Seireg's brace applies forces at the knee, calf, and thigh to separate the rubbing bones by a distance of one millimeter, less than a dime's thickness, but enough to make the difference between crippling pain and a normal life. This was the first such application of the fiberglass brace, originally intended for polio patients. Mr. Lehneis' knee brace is an example of how orthotists apply twentieth century technology with exacting craftsmanship to make such "firsts" common occurrances.



Mrs. Seireg's knee brace.

Orthoses are used in a wide variety of situations. Patients with spinal damage or paralysis caused by automobile or sports accidents are often rehabilitated with the help of orthotic devices, but their most common use is with disabilities caused by Spina Bifida, Muscular Dystrophy, Cerebral Palsey, and Polio. These are diseases of the nerves or muscles which usually strike early in life and can permanantly cripple or paralyze their victims.

Since they are used in so many cases, and to account for differences in the size, age, and occupation of each patient, every orthotic device must be individually designed and hand crafted. No brace is built by a simple formula or prescription; Instead, orthotists consult with the physician, the patient, and a physical therapist before any device is conceived. For this reason, buying an orthotic device off the shelf is a practical impossibility.

A considerable amount of orthotics technology has come from research into prosthetics, those devices which replace amputated limbs. Orthotists, however, deal with the rehabilitation of natural limbs, and in many respects the problems encountered in constructing corrective devices are more complex than those of limb replacement. Comfortably bracing a tender joint or a youngster's growing spine requires careful judgement and a thorough knowledge of anatomy. Designing a sturdy, reliable brace which will give purposeful movements to paralyzed limbs involves special problems in mechanics, materials, and design.

Despite their specialized profession, a Certified Orthotist (C.O.) requires relatively little special training. Currently, four years of experience in a brace shop plus six weeks of instruction at N.Y.U., Northwestern, or U.C.L.A. (the only American universities offering the training) fulfills the eligibility requirements. Starting in 1976 however, a Certified Orthotist must have a two year associate degree in addition to these requirements.

The earliest orthoses of the late 1800's were crude devices made of wood or metal, used to correct clubbed feet in children. Partially successful at best, they all too often aggravated the deformity. It was not until 1946 that Drs. Walter Blount and Albert Schmidt of Milwaukee used a brace applying forces and torques (bending forces) to correct abnormal spinal curvature caused by the disease Scoliosis. The so-called "Milwaukee Brace" uses a chin and head rest supported by three vertical bars mounted on a hip corset to treat the disease which strikes mainly in adolescent girls. The brace applies lifting and bending forces to counter-act the curvature in the vertebral column and thus, the spine is allowed to "grow straight" a phenomenon known as compensatory straightening. Left untreated, a scoliotic spine can curve so severely that internal organs are displaced, sometimes resulting in fatal complications. The only other alternative for victims of the disease is a spinal fusion, a painful and risky operation that may leave the adolescent spine permanently stunted.

At the University of Wisconsin Hospital Rehabilitation Center, William H. Engel, Director of Orthotics, displayed some devices he has created, representative of the state of the art in modern orthoses. Entering into the field from what he calls the "recession of '58", Engel had worked in industry and had an engineering background but no previous exposure to orthotics. Now, with 17 years of experience he proudly claims "We don't do anything unless it's successful."

For spine injured patients with hand paralysis, Mr. Engel and his assistant, Dennis Henkel, have designed a brace that fits the wrist, thumb, and first two fingers of the hand. Made entirely of stainless steel and aluminum, the brace provides prehension (grasping) of the hand by joining the wrist bracelet and finger pieces with mechanical linkages. Bending of the wrist joint drives the mechanism which causes the fingers to grasp and release with a mechanical advantage that delivers as much as 14 pounds of force to the grip, stronger than most men can grip with a healthy hand. Without such a brace, the flaccid hand is almost entirely useless and since they could not eat or dress themselves, most of these patients would require special care in nur-

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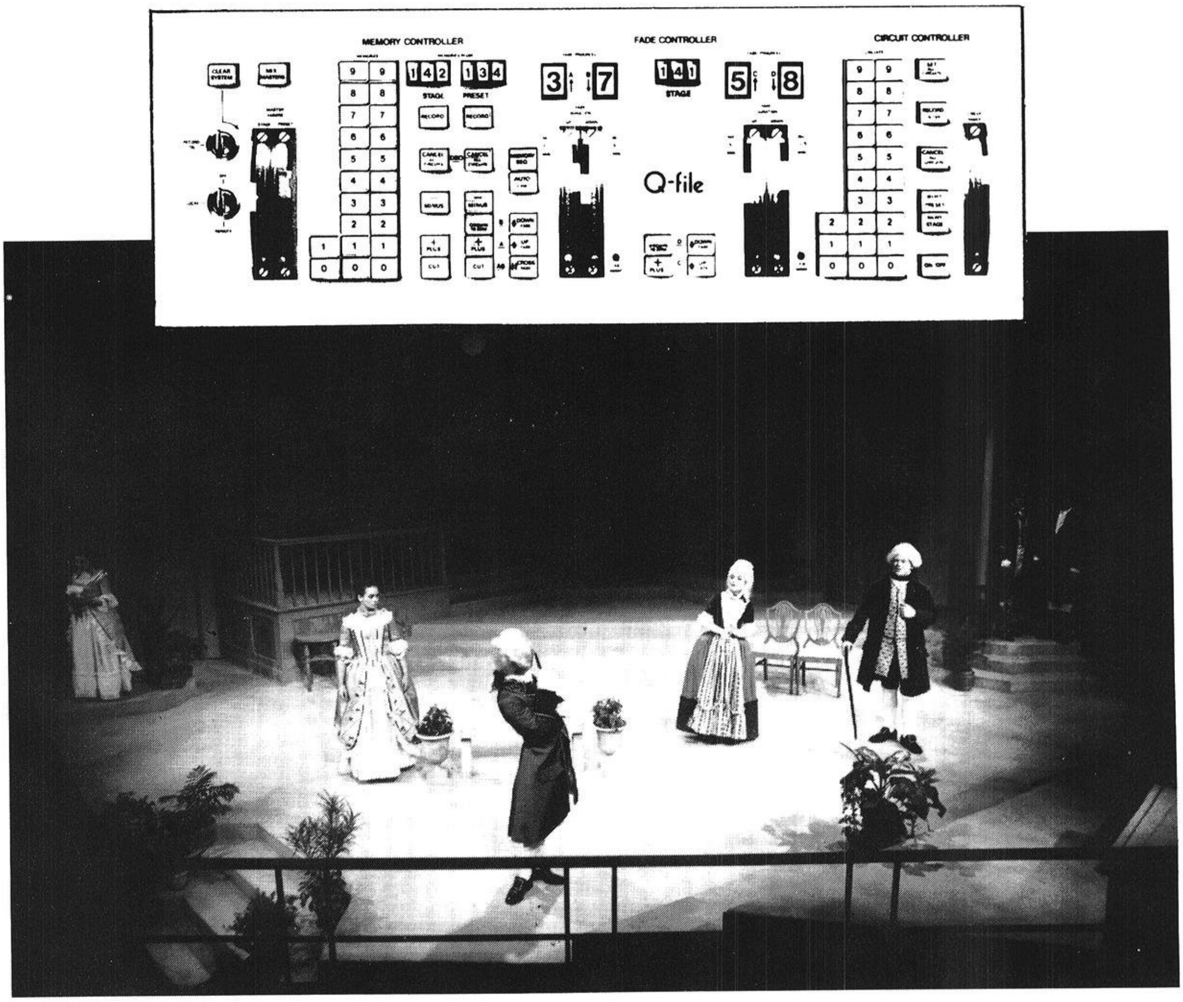
Q-File: A Backstage Hit

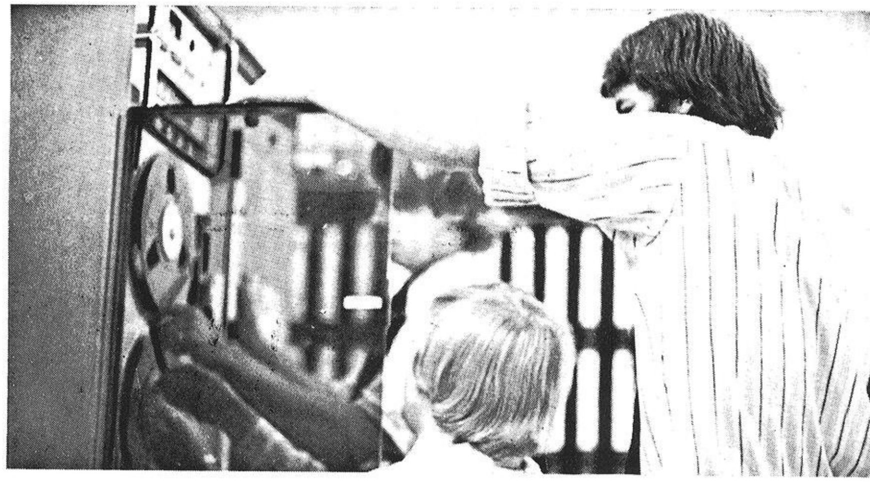


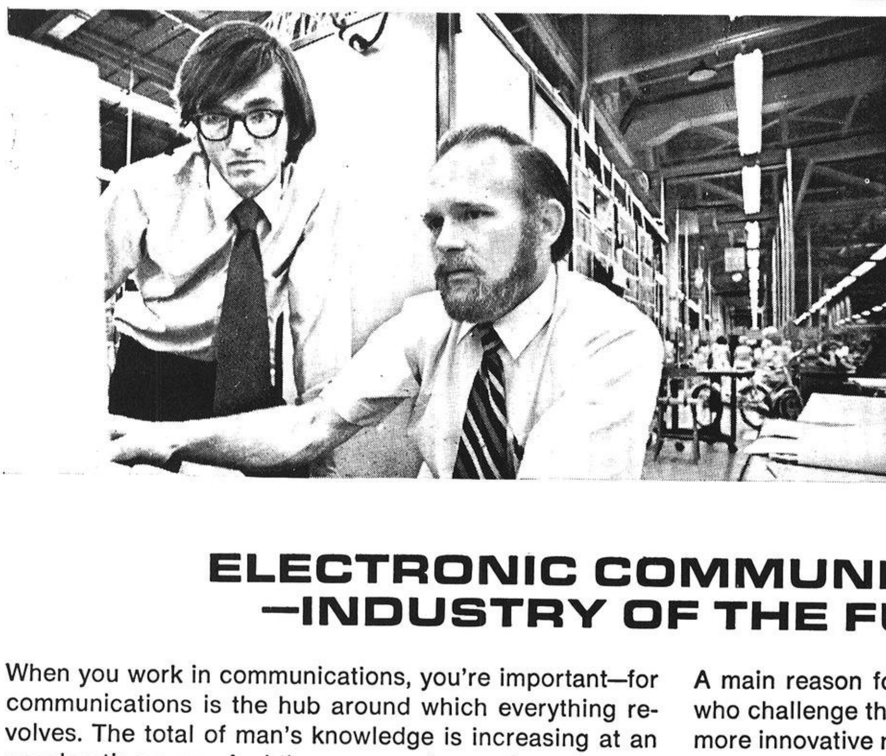
by David Shaw with Ken Emmerich

Perhaps, when attending theater, you are unaware of the complexities of backstage—beyond those of the acting performance. There is a whole world of activities that take place completely out of the audience's sight that require many hours of hard work from many unseen technicians.

One of these areas is the design and execution of the lighting of the play. Much is involved in the execution of actual lighting cues, in setting the level of each dimmer and then changing it as the needs of the play dictate.

In stage lighting, there are a series of developments in dimmer control based on technology borrowed from the computer industry. Stage lighting control has the same problem that other fields face—the processing of a great deal of small pieces quickly, accurately and in the proper order. In the average show, there are anywhere from 20 to 100 different lighting setups, or cues. These must be executed by the electricians as accurately as possible and, often, as quickly as possible. When many control channels, or dimmers, are involved, the complexity of the amount of information involved in making the magic of light work on stage are surprising to an outsider. For example, in Vilas Hall's Mitchell Theater, 60 dimmers are used. For the average show of 50





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"For the average show of 50 cues, over 3000 pieces of information are needed to make the lighting work."

cues, over 3000 pieces of information are needed to make the lighting work.

The earliest dimmer systems were, realistically, "one at a time" systems. These were basically comprised of either resistance or autotransformer dimmers each of which were worked by hand. The only types of mastering (moving more than one dimmer at a time) available were different methods of mechanical interlocking. These types of dimmers, due to the quantity of heat produced, required large cabinets that were located on stage, taking up valuable space.

Then, in the early 1930's, remote control of dimmers became possible. Roughly analogous to a relay-controlled switch, the system allowed small amounts of current, usually DC, to control large amounts of current in the dimmer. The control device therefore can be small, creates little heat, and can be located in a smaller space. The dimmers themselves can be located in a room away from the stage near the main source of power. The types of these remote—controlled dimmers, roughly in the order that they became available, were the saturable reactor, the thyratron, the mag amp and finally, solid state.

Since such small amounts of current were involved, electrical mastering for the first time became practical. This allowed proportional control over virtually an indefinite number of dimmers with a single handle. The logical extension of this idea was to have two or more controllers for the same dimmer unlit hooked up in parallel through a master. This arrangement, called multiple—scene preset, allows each lighting cue to be set up on a different "scene." The operation, then, was simply fading one scene down while the next was being brought up. It is also possible to add one preset to another, making more variations possible. Fewer operators, of course, are necessary. While several people may be needed to change the presets, one person can handle the mastering.

The only things limiting the multiple—scene preset board's flexibility are the number of scenes and the speed at which they can be reset. Various mechanical schemes were tried, such as plastic cards, one for each cue, that could be

quickly placed in special readers. Each cue could be set before the show and then inserted in the reader. However, the systems are limited, too, by the number of cards, readers and the speed with which cards can be changed.

What was needed, then, was an electrical rather than mechanical memory system. Theatrical lighting engineers borrowed from some of the technology developed for computers. The same information previously written on paper for multiple scene presets and on mechanical cards for a mechanical memory system was now stored electronically.

There are three basic types of memory systems used for theatrical installations. The first one developed was a tape system. This was simple and lightweight but allowed only consecutive access to previously recorded memories. The remaining types of memories can be considered to be volatile and non-volatile. Many computerized dimmer boards systems use a combination of the two. Volatile memory storage units are best for short term storage. They must have a constant supply of current in order to retain their contents. Core memories, which are non-volatile, are best for long-term storage—and they are best for the main memories of a computerized dimming system.

There are certain functions of a computerized dimmer board common to all different types of systems available. First, there must be a method of setting the lighting levels before recording them.

Second, there must be a place where this information is stored, a main memory. The major criteria for judging this storage unit is its capacity; its type, either tape, electronic or core; and the access time needed to store or recall any part of the memory.

There must be a playback system, used for actual show operation. The parts of this system are: a method of addressing the various cues in the main memory; an assigner to send this information where it is needed; and an operative system to perform the desired changes. Often associated with this is a timer, which automatically executes cues in a preset time. It can be split to control the up-fades and down-fades separately. Also associated may be a sequencer, which play back cues in a numerical order to facilitate rapid operation.

There must be a facility for altering cues once they have been written. Finally, there must be access to the system for manual operation. This can also be combined with some sort of back up in case of system failure.

The Q-File system, developed by Thorne Electronics of London for the BBC in the early 1960's, is an example of one of the most sophisticated memory systems available. There are 60 Q-File installations world-wide, 20 of which are located in the United States. There are four in the vicinity of Madison: two in Minneapolis one in Madison and one at the Lyric Opera in Chicago, the largest Q-File installation ever.

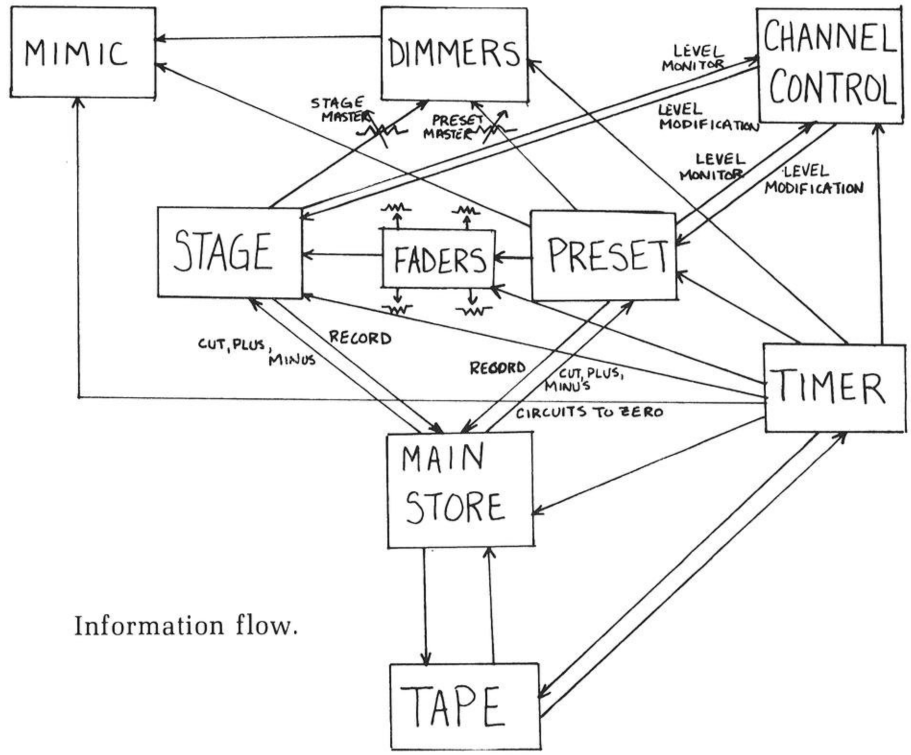
The Q-File has a capacity of 400 channels (dimmers) and 200 total memories. In the main storage unit the resolution is 30 steps, or (6 bits). The main timer, which synchronizes the whole system, looks at each channel 140 times per second. Each channel is processed every 25 microseconds in the operating storage.

The two auxiliary stores have a resolution of 120 steps or (eight bits), and each is a core type. The stage store is fed to the channels while the preset, holds what is coming up next. In each memory there is an off/on bit which indicates whether that channel is being used in that memory.

The Channel Controller serves as the system input—levels are set up here to be recorded in each memory for each cue. It is a decimally selected servofader which can either be driven by the servomotor or by manual control.

The mimic provides a visual indication of what is recorded in each memory. It consists of one lamp for each dimmer, and consists of two different types. The preset mimic, which "reads out" the information contained in the preset store, merely indicates whether that channel has been recorded as "on" or "off.' The stage mimic, reading from the stage store, uses a feedback principle. The lamps in the mimic give an indication of the output of the dimmer by changing their intensity.

The information in the main storage can be transferred to the stage or preset stores and is assigned via digital pushbuttons. Memories can be added or subtracted from memories either in stage or preset. Instant blackouts of either stage or preset are possible. Memories can be recorded into



Information flow.

either stage or preset. Blind plotting is possible; a memory can be recorded in preset without affecting what is on stage. There is also an auto—sequencer that allows memories to be selected in numerical order.

There are two up-faders and two down-faders the times for which are separately adjustable. Each timer has a range of one second to 70 minutes in two overlapping ranges. The main fader will allow additions to, subtractions from or complete replacement of the memory on stage. The subfader will allow additions to or subtractions from stage. The main fader and the subfader can be working with different memories and different times simultaneously. All fading is completely proportional—dimmers going to different levels take the same amount of time. Each fader is capable of fade within fade, allowing overlapping fades on the same fader. Each will finish in the time set on the fader.

One of the memories can be used as a over-riding memory. It can be used to modify dimmers in memories previously recorded without affecting the main storage, just the operating stores, stage and preset.

As you can see, the Q-File system provides a great deal of sophistication in the control of theatrical lighting. It gives the lighting designer and the board operators almost complete freedom from the paperwork necessary for the average show, while at the same time eliminating human error in duplicating presets. It provides a great deal of operational sophistication even with novice operators. Finally, it is a good teaching tool as it will allow demonstrations of lighting capabilities to beginners with a minimum of pre-preparation time.

David Shaw *is a graduate student and teaching assistant in the Theater Department. He is working on his M.F.A. in lighting design and technical theater.*

Ken Emmerich *is a senior in electrical engineering. He has worked for two years as a field engineer for the Q-File for Kliegl Brothers. He has done maintenance, design and construction of eductional television equipment for Communication Arts Department television and WHA-TV.*

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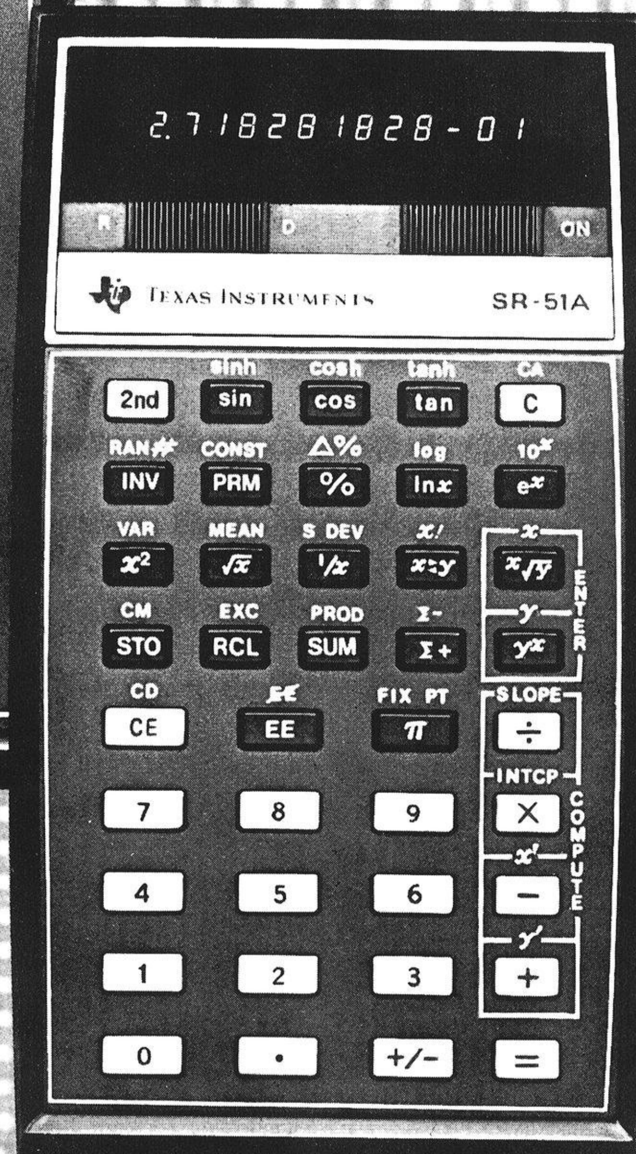

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e^x	yes	yes
10^x	yes	no
x^2	yes	yes
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x!	yes	yes
Exchange x with y	yes	yes
Exchange x with memory	yes	no
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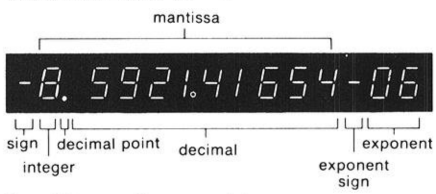

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Winning in the SCORE competition

by Ken Kriesel

"Five hectic days of set-up and testing followed . . . The Madison team was awarded first prize for coal utilization."

During the Mideast oil embargo in 1972, our dependence on foreign energy supplies was shown to be unacceptable. Because of this, the search for alternative oil and gas was intensified. Both private corporations and government agencies funded research in this area.

SCORE (Student Competitions on Relevant Engineering), a non-profit corporation, had held the Clean Air Car Race in 1970, and the Fire Safety Competition in 1972. The decision was made for SCORE to sponsor an Energy Resource Alternatives (ERA) Competition in 1974. The Coordinating Committee was located in Madison.

In August of 1974 a team to compete in the ERA competition was formed, with Professor A.A. Seireg as faculty advisor and Ken Kriesel as team captain. A study of alternative energy sources and the needs of homeowners and small industry was made and by January of 1975 the decision had been made to design and build a system which could be added to existing oil furnaces to enable the furnace to burn pulverized coal, and possibly other solid fuels.

The system was composed of a storage bin for the pulverized coal, an auger to feed the coal at a predetermined rate to the furnace, two cyclone separators, one of which was a wet scubber, and a control system to operate the system from a thermostat.

Construction began in late January, continuing into July. The team's membership changed every semester. By June the only original team member remaining was Ken Kriesel. Mike Arvey joined the team in June; by August he and Ken made up the entire team.

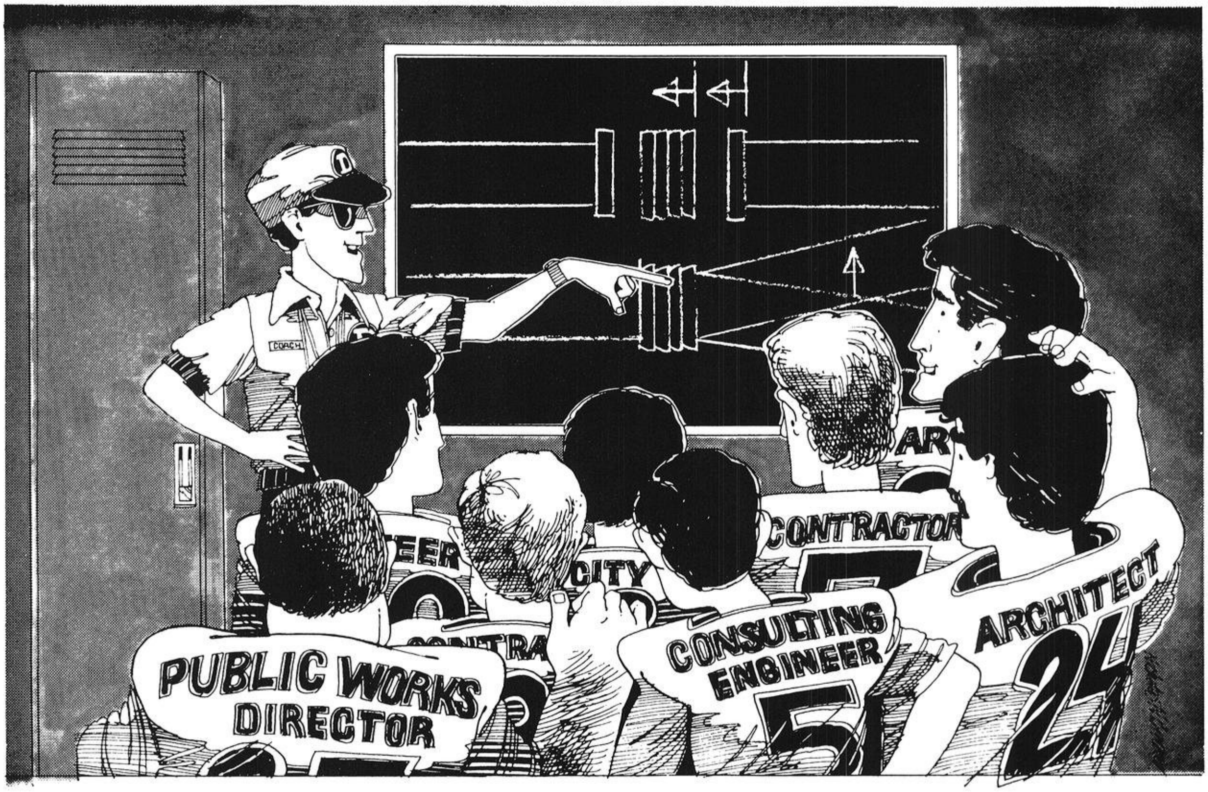
Testing of the system was performed both in Madison and at the competition. An efficiency of 76% was obtained in Madison. Emissions control was very good—the coal exhaust after being scrubbed was cleaner than the oil burning exhaust both with and without scrubbing.

On August 8 the trip to Albuquerque, the location of the final test event of the competition, was begun. Arriving at midnight August 11, the team checked into the Visiting Officers Quarters of Kirtland Air Force Base, which was providing housing for the teams during their stay at the competition.

Five hectic days of set-up and testing followed. Presentations to the judges of the competition on performance and market-ability aspects of the system, last minute adjustments to the equipment, and a frantic search for testing instrumentation conspired to prevent the appearance of any spare time.

August 16, Press Day, finally arrived. Open house was held for six hours. The guest speaker for the awards banquet had arrived—Buckminster Fuller, inventor of the geodesic dome.

Awards were presented for efficiency, innovation, utilization of various energy sources, and overall performance. The Madison team was awarded first prize for coal utilization, and third prize for efficiency, in spite of a drop in efficiency to 48% caused by larger



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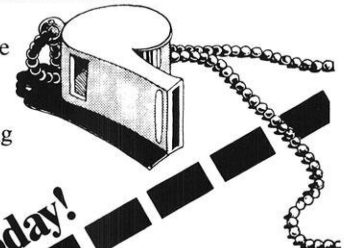
We call our new coupling system PEP, for Plain End Pipe. The ends are plain. No bells. And the joints set new standards for the industry. It's available in sizes to fit six through twelve inch pipe.

Users, in unsolicited testimony, already report impressive results and economies from Dickey PEP and we know you'll want to use it when available in your area. So, arrange now for a PEP talk. We'll pit our best men against your toughest questions. They're waiting to bring you the full Plain End Pipe story.



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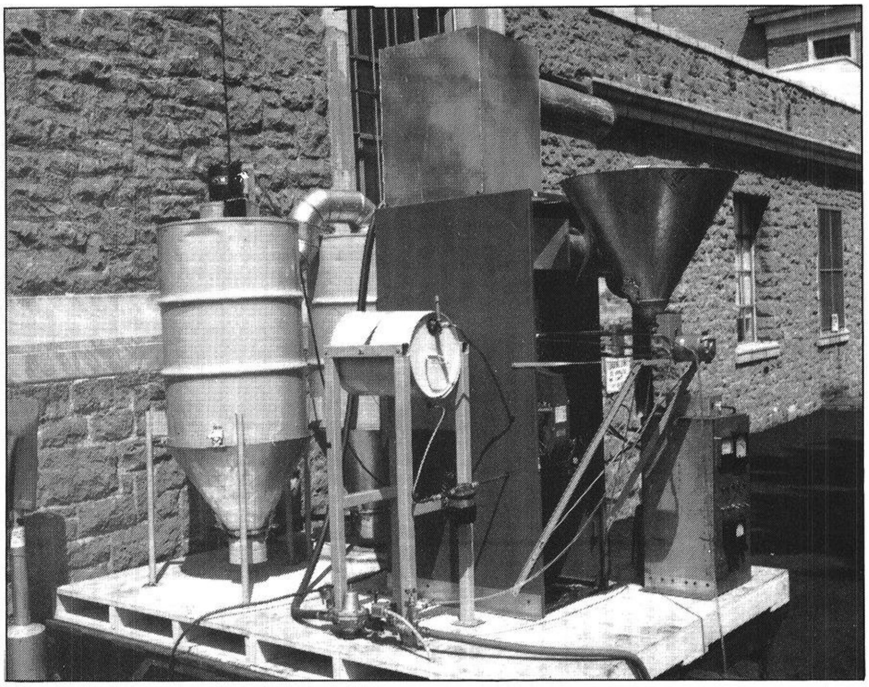


Left side view of setup.

coal particle size.

The competition was not only national, but international. Thirty-seven U.S. teams, three Canadian teams, and a team from Loughborough, England were present. Plans are being made for ERA II, another Energy Resource Alternatives competition, which will be oriented to electrical output only.

At Madison, work will continue on the pulverized coal furnace system, focusing on coal handling to the furnace, optimization of the combustion process, exhaust scrubbing, and scrubber effluent water treatment. Alternative designs for ERA II are being considered. Interested readers are invited to contact Professor Seireg or Ken Kriesel.

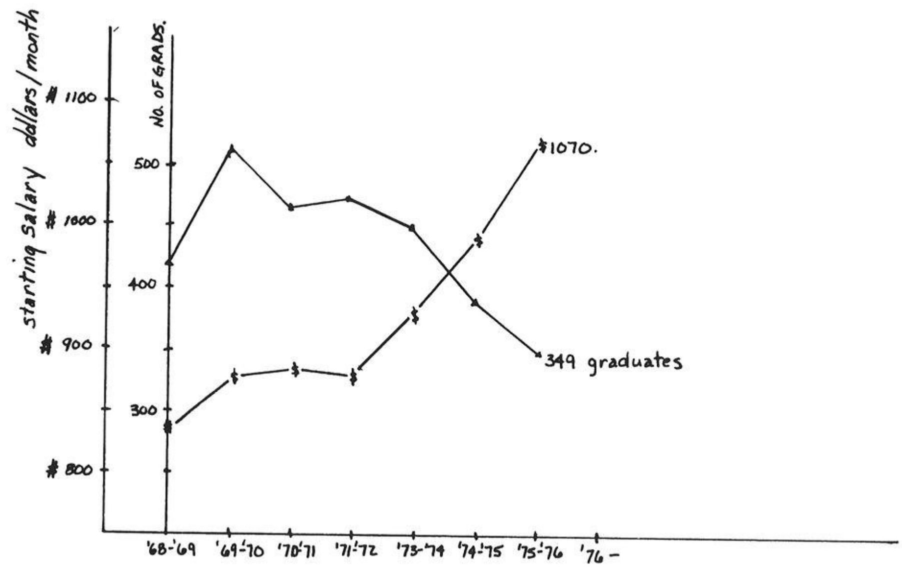
Ken Kriesel *is a senior in mechanical engineering and a member of Pi Tau Sigma. For the past two years he has been involved in work on windmills, solar energy, and coal usage under the guidance of Prof. Ali A. Seireg.*

Write Your Own Ticket

by Rudi Beck

In these times of scarce resources, it is not surprising to find that we engineers are as scarce a resource as any. For the graduating engineer the perspectives are promising—ever-rising salaries, smaller and smaller graduating classes and a Placement Office on campus that has one of the most innovative placement programs in the nation.

Enrollment in the college of engineering has been steadily decreasing over the past six years. We have done a great job by going around saying engineering is "really tough". Of course, we know better, and we can now merrily watch the parade of interviewers who come to our campus and outnumber the job seekers three to one. Among the best rewarded are the Chemical and the Metallurgical and Mineral Engineers, the prime choice of our college. The less fortunate: Civil Engineers have been receiving the smallest starting salaries for about four years. Needless to say, not all the candidates land a job, but it's also needless to say on which end of the class list the unsuccessful stand. To give a rough idea of the situation, let us examine last year's graduating class: 349 fresh, tender (with a few, no doubt honorable, exceptions) new engineers, the smallest class since way back in the mid-60's. Of these, only 60%



entered the rat race, of which 78% are now diligently earning their daily bread, deep in the heart of our industrial society, while you are comfortably reading these lines, diligently wasting your time.

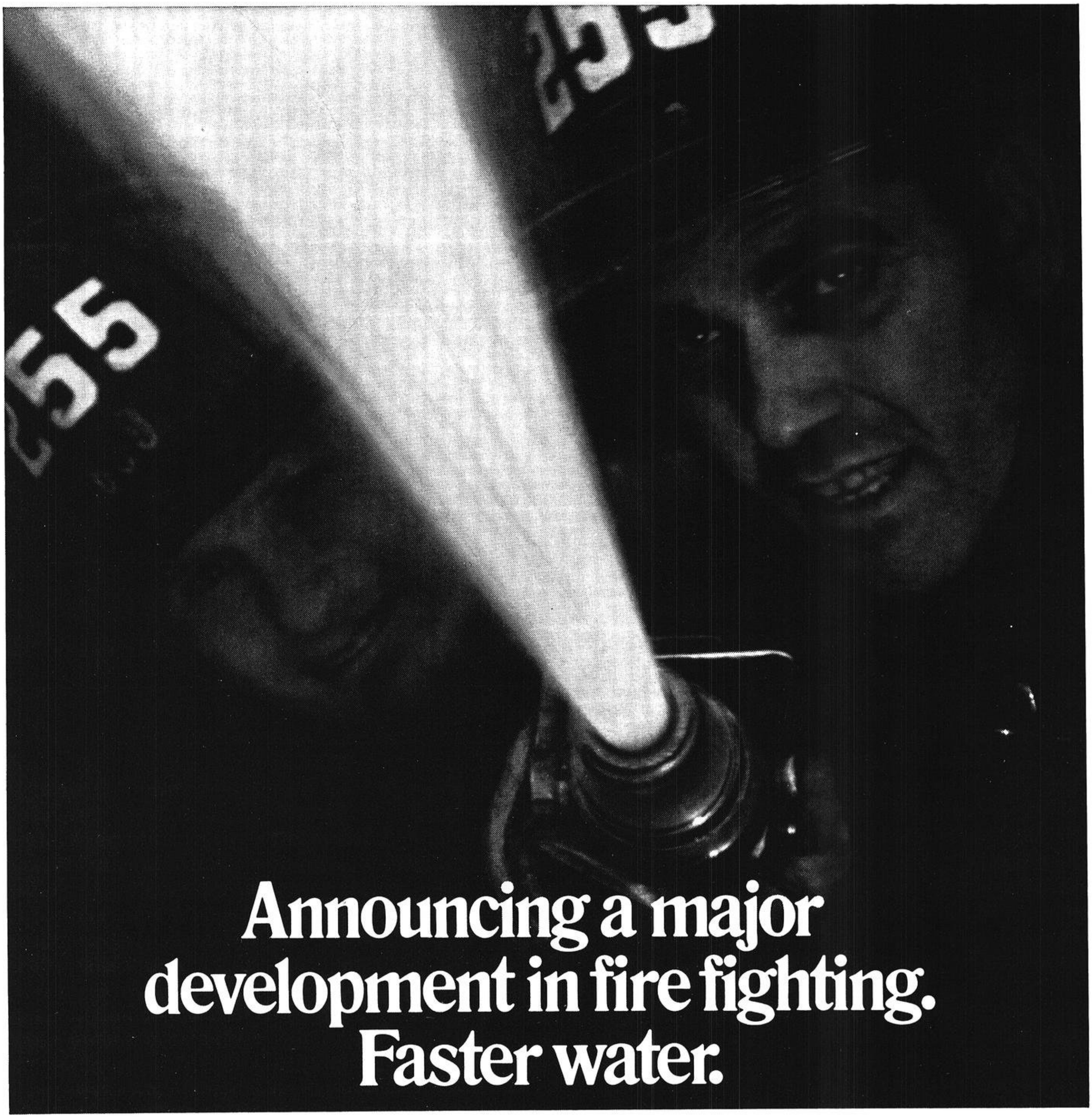
And since no engineering endeavor is complete without a graph, let us portray the current situation with one of these contraptions. It can be clearly seen that the salaries are swooping upwards and the class size is sloping down. And we hope it stays that way, at least until you and I get our piece of the pie.

For our job hunting we are provided with a remarkable pool of information as well as with an efficient way of making our services available to whomever may be interested in them. This is what the Placement Office is about, bridging the gap between the new graduate, eager to start the rat race, and the industrial machine, eager to get him or her started.

Heading the Placement Office, Professor Marks has come up with the Pre-Selection Program. This program, is used to its full potential, serves a double purpose: it helps us define our interests and it permits that information about us and our interests reaches a very broad spectrum of companies that we could and would not reach individually. The first part of the program consists of a series of lectures arranged by Professor Marks in a course under the name of Professional Orientation. These lectures provide contacts between candidates and interviewers and industry people. The topics covered consist of tips on interviewing, description of job titles and orientation on what to look for and what to expect in the job hunting enterprise. The second part is a compilation of data about you, your experiences and your scholastic record, as well as, and most important, what you are looking for. These compilations are mailed out to scores of companies that request this information and are also given out to companies with which you have an interview on campus.

This program is new and it hasn't yet been proven successful, according to Professor Marks. But even though one year isn't time enough to make a judgment, you'll agree with me that the odds are heavily in favor of it being a smash hit.

So the outlook is good for the start. From what I hear, however, once you land a job it's all going to be a question of hanging on for dear life, because the going is rough, and it's bound to get rougher.



Fighting a fire is fighting time.

Every minute wasted may cost thousands of dollars in property destroyed. Every second saved may be a life.

And yet, a fire fighter can't always move as fast as he would like.

Because his basic weapon, the 2½-inch fire hose, when full of water, is about as hard and unyielding as a steel pipe. The only way to bend it around a corner is to shut the water off.

And to lug it up a flight of stairs is a test of any man's stamina.

All of this makes it easy to understand why a Union Carbide product called UCAR Rapid Water Additive is revolutionizing fire fighting.

Rapid Water Additive mixes easily with water and makes it flow faster through a hose by reducing friction.

Because the water flows faster, fire fighters can get just as much water as before using a smaller 1¾-inch hose that weighs half as much.

The smaller hose makes a much better weapon. It bends around corners. It can be carried up a stairway fully charged. In short, it helps firemen get water to the fire faster.

At the same time, it makes their job safer and less strenuous.

Rapid Water Additive was invented by Union Carbide and perfected in cooperation with the New York City Fire Department.

It's already helping fire fighters do their job more efficiently in many American cities.

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"Despite successes enjoyed by orthotists . . . orthotic devices are not widely accepted as a surgical alternative."

sing homes or rehabilitation centers. Of the patients Engel has fitted with the brace, many wear it eight to twelve hours a day, and about 37 percent are employed.

Patients with total paralysis of the lower arm can use the same brace if it is driven by a small battery-powered motor instead of by wrist movements. Control of the electrically driven hand may be maintained by electromyographic circuitry which uses three small electrodes placed on the skin to pick up the electrical impulses of muscles in the upper arm. The circuits utilize the signals to control the motor that opens and closes the hand. If these impulses are absent, a small foot switch or breath controlled switch, operated like a drinking straw, may be employed to give the patient precise control over his "motorized" hand.

Except for a few standard screws, every part of the wrist brace (W.H.O. for Wrist-Hand Orthotic) is made by hand and fitted to the patient in person. Every W.H.O. requires over forty man-hours to construct. The cost to each patient is $525, a bargain price for a useful hand.

Children born with the lower spinal defect called Spina Bifida lose all muscle tone and feeling below the waist. As a result of sitting constantly immobile in a wheelchair, they often develop sores on the thigh and buttocks or serious cases of Scoliosis. For these patients, Engel and his staff have developed the suspended body jacket, a corrective upper body corset that fastens with two hooks to the frame of a wheelchair to support the patient's weight and correct the scoliotic spine.

The first step in the construction of such a jacket is the casting of an accurate plaster model of the patient's torso. This model is then modified so that when the corset is built upon it, it will take the form required for spinal straightening. It is in this stage of construction that the judgement of the orthotist is most crucial; he must call upon experience to decide how much straightening can be safely and comfortably attempted. By sculpturing plaster away where the corset must grip tightly or apply pressure, and by adding plaster where the patient's movements or growth will cause discomfort, the model reaches its final form and the construction of the corset begins.

Sheets of plastic are laid over the model and allowed to harden. The plastic frame is then padded and covered with leather, to give a firm but comfortable corset with strap closures. Two hooks are added to the sides of the brace, and other hardware is added for reinforcement. In the final stage, the patient puts on the brace and is lowered with a hoist into the wheelchair until properly seated. When the supporting brackets are aligned with the corset hooks and are fixed to the wheelchair frame, the suspended trunk support is complete.

For most of the patients requiring them, two or three such braces must be made in various stages of the corrective treatment. Models made of many patients before and after treatment with the suspended body jacket testify to its success in reshaping severely distorted spines without surgery.

Despite successes enjoyed by orthotists like Mr. Engel of Wisconsin and Mr. Lehneis of N.Y.U., orthotic devices are not widely accepted as a surgical alternative. Dr. B.J. Brewer, Chairman of the Deaprtment of Orthopedic Surgery at the Medical College of Wisconsin, explained that he uses braces as a "temporary supportive measure" and prefers surgical reconstruction of injured limbs wherever possible. Said Dr. Brewer, "If you have a repairable defect then it ought to be repaired. If you have an irrepairable one, then it's going to have to be braced." Engel's assistant, Dennis Henkel, admits that orthoses cannot replace all corrective surgery, but replies that "Surgery doesn't always work. The people that we see have often already had surgery and it didn't work." Mrs. Seireg refused the operations recommended to her and chose instead to have her knee braced. The Lehneis brace corrected her problem but in Dr. Brewer's opinion, "If there is any reconstructive surgery that is indicated, she should be operated on rather than rely on the brace for the rest of her life."

Regardless of the controversy, the future of orthotics is a bright one. With innovations like the Lehneis knee brace and the electrically driven wrist-hand orthotic developed by Mr. Engel at Wisconsin, two trends seem to be developing. The knee brace is a contoured fiberglass shell with no moving parts and represents a milestone in designs which are elegant in simplicity. In contrast, Engel's W.H.O. is a device that has at least 74 parts and many employ sophisticated circuitry in its control system. Although a complex device, it performs controlled prehension of the human hand under voluntary nervous control - exactly what a healthy hand can do.

Fracture bracing, a new technique that replaces the plaster cast used to set bone fractures with an orthotic brace, is gaining wide acceptance. Engineers at the University of Wisconsin have built a powered exoskeleton which can be worn externally and, under computer control, is capable of walking, sitting down, overstepping obstacles, and other tasks. Constructed as a full, lower body brace, hydraulic servo motors drive each leg joint in a computer synchronized pattern, accurately duplicating the natural walking profile. In the future, orthotists may build such "braces" with a self contained microcomputer and power supply, enabling today's wheelchair patients to move confidently on two legs tomorrow.

GET A JOB

FRIDAY, OCTOBER 3
Elmco
Firestone Tire & Rubber (2 of 2)
General Foods
Harnischfeger
Illinois Central Gulf R&D
Radian Corp.
Westinghouse electric (2 of 2)
Zimpro Inc.

MONDAY, OCTOBER 6
General Dynamics (Ft. Worth)(1 of 2)
Globe Engineering
Johnson Controls
Litton Guidance & Controls (1 of 2)
McQuay Perfex Inc.
Morton Chemicals
Standard Oil of California (1 of 3)
Wisconsin Electric Power (1 of 2)

TUESDAY, OCTOBER 7
Applied Physics Labs (1 of 3)
Cleveland Cliffs
General Dynamics (2 of 2)
Institute of Paper Chemistry
Litton Guidance (2 of 2)
Institute of Paper Chemistry
Litton Guidance (2 of 2)
PPG Industries (1 of 2)
Standard Oil of California (2 of 3)
The Trane Co. (1 of 4)
Wisconsin Natural Gas Co.

WEDNESDAY, OCTOBER —
Applies Physics Labs (2 of 3)
Curwood Inc.
Owens Corning (1 of 2)
Standard Oil of California (3 of 3)
Stauffer Chemicals
The Trane Co. (2 of 4)
Union Oil of California
U.S. Gypsum Res. Center
N.O.A.A. Corps. (1 of 2)

"Brother can you spare a job?

THURSDAY, OCTOBER 9
Arthur Andersen Co. (2 of 2)
Factory Mutual Engr. Association
Gibbs & Hill
Globe Union Inc.
Procter & Gamble (2 divisions)
Sperry Univac - Data Systems (2 of 2)
Sperry Univac - (Defense)(2 of 2)
Stanford University - Graduate School
The Trane Co. (3 of 4)
B.A.S.F. Wyandotte
Eaton Corp.

FRIDAY, OCTOBER 10
C.P.C. International
Chicago Dept. of Public Works
Commonwealth Edison
Giddings & Lewis
Material Service Corp.
Oscar Mayer & Co. (2 of 2)
Modine Mfg.
Stauffer Chemical
Trane Co. (4 of 4)
Warner & Swasey

MONDAY, OCTOBER 13
Bucyrus Erie
Cutler Hammer
Harley Davidson
Dow Corning (1 of 3)
Eastman Kodak Co. (1 of 3) PhD's
B.F. Goodrich
Kohler Co. (1 of 2)
Eli Lilly & Co.
Marathon Electric
Ohio Brass Co.
Upjohn
A.O. Smith

TUESDAY, OCTOBER 14
Aerojet Nuclear
Armco Steel Co.
Bell Telephone (1 of 3)
Continental Oil (Conoco)(1 of 2)
Consolidation Coal (Consol)(1 of 2)
Dow Corning (2 of 3)
Exxon Corp. (1 of 3)

WEDNESDAY, OCTOBER 15
Continental Oil (Conoco)(2 of 2)
Consolidation Coal (Consol)(2 of 2)
Exxon Corp. (2 of 3)
Indiana Dept. of Natural Resources
Morse Chain
Motorola Inc.
Nekoosa Edwards
Energy R&D Administration
U.S. Navy (1 of 2)

THURSDAY, OCTOBER 16
Battelle Columbus (1 of 2)
Chicago Bridge & Iron Co.
Exxon Corp. (3 of 3)
General Dynamics-Electric Boat
Gulf Oil
Maytag Co.
Northern States Power (1 of 2)
Corps of Engineers
U.S. Navy (2 of 2)

FRIDAY, OCTOBER 17
Asiatic Petroleum
Babcock & Wilcox
Battelle Columbus (2 of 2)
Cargill Inc.
Falk Corp.
Inland Steel (2 of 2)
Nestle Co. (2 of 2)
Northern States Power (2 of 2)
Outboard Marine
Washington & Lee University (Law)
In 40 Science Hall
National Security (2 of 2)

MONDAY, OCTOBER 20
Amoco Oil (Refining, Transp. & Engr.)
Amoco Research Center
Amoco Chemical (Mktg.)
Mead Corp.
DuPont (1 of 5)
The Milwaukee Road
Union Carbide Corp. (5-7 Divs.)(1 of 2)

TUESDAY, OCTOBER 21
American Appraisal
Amoco Chemicals
DuPont (2 of 5)
FMC - Northern Ordnance
N.L. Industries (1 of 2)
The Oilgear Co.
Union Carbide Corp. (2 of 2)

WEDNESDAY, OCTOBER 22
American Can Co.
Combustion Engineering
DuPont (3 of 5)
GTE Atuomatic electric Co.
General Motors
Kimberly Clark (2 of 2)
N.L. Industries (2 of 2)
Square D (1 of 2)
Wisconsin Power & Light (1 of 2)
U.S. DOT - Federal Highway

THURSDAY, OCTOBER 23
DuPont (4 of 5)
Eastman Kodak (1 of 2)
Ethyl Corp. (1 of 2)
Goodyear Tire & Rubber Co. (1 of 2)
Harvard Grad. School of Bus.-40 Science Hall
Honeywell (1 of 2)
Peoples Gas Light & Coke
Phillip Morris
Square D Co. (2 of 2)
Standard Oil of Ohio (1 of 2)
Texaco (1 of 2)

FRIDAY, OCTOBER 24
Burroughs Corp.
Container Corp. of America (2 of 2)
DuPont (5 of 5)
Eastman Kodak (2 of 2)
Ethyl Corp. (2 of 2)
Goodyear Tire & Rubber Co. (2 of 2)
Hercules Incorp.
Honeywell (2 of 2)
Standard Oil of Ohio (2 of 2)
Texaco (2 of 2)
Wisconsin Public Service

MONDAY, OCTOBER 27
Conwed
Koehring Co. (1 of 2)
3M Co. (1 of 5)
Newport News Shipbldg. (1 of 2)
The Olin Corp.
Raytheon Co. (1 of 2)
Shell Companies (1 of 3)
Shell Companies (1 of 2) PhD's
Waukesha Engine (1 of 2)

TUESDAY, OCTOBER 28
3M Co. (2 of 5)
Procter & Gamble International
Raytheon (2 of 2)
Shell Companies (2 of 3)
Shell Companies (2 of 2) PhD's
Sundstrand Corp.
U.S. Steel Corp.
Mare Island

WEDNESDAY, OCTOBER 29
Air Products & Chemicals
American Cyanamid (2 of 2)
Illinois Dept. of Transportation
Interstate Power
3M Co. (3 of 5)
Rohm & Haas (1 of 2)
St. Regis Paper
Shell Companies (3 of 3)
Union Carbide (1 of 2) PhD's
Capital Area Personnel

THURSDAY, OCTOBER 30
Clark, Dietz & Associates (1 of 2)
Ford Motor (1 of 2)
Rohm & Haas (2 of 2)
Scientific Design
Shure Bros.
Union Carbide (PhD's)(2 of 2)
Wabco
Naval Sur
Naval Ship R&D)
Energy R&D Administration-Division of Naval Reactors

FRIDAY, OCTOBER 31
Allen Bradley Co.
Clark, Dietz & Associates (2 of 2)
Pfizer
Pillsbury

MONDAY, NOVEMBER 3
Amoco Prod. Res. Center - PhD's
Baxter Labs
McDonnell Aircraft (1 of 2)

TUESDAY, NOVEMBER 4
Foseco Incorp.
ITT
Lawrence Livermore
McDonnell Aircraft (2 of 2)
Nalco Chemicals
U.S. Marines (1 of 3)

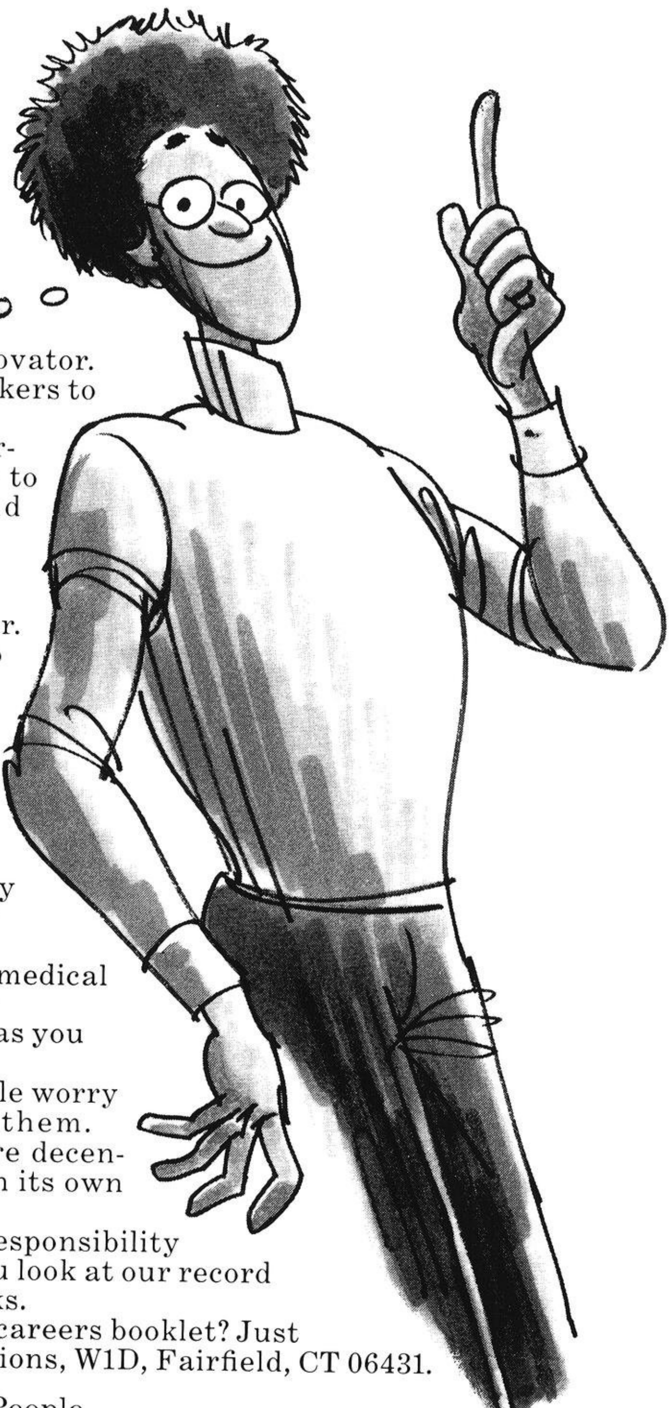
WEDNESDAY, NOVEMBER 5
Rockwell International (3 divisions)
U.S. Marines (2 of 3)

THURSDAY, NOVEMBER 6
Wisconsin State Government
U.S. Marines (3 of 3)

WEDNESDAY, NOVEMBER 12
U.S. Navy (1 of 2)

THURSDAY, NOVEMBER 13
U.S. Navy (2 of 2)

We're looking for engineers who think like Thomas Edison.



Ever since Thomas Edison helped start our business, GE has been known as an innovator.

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Or maybe one day work on one of the developing energy technologies like the fast-breeder reactor. Coal gasification. Solar heating. Battery storage for peaking power. Laser applications for fusion and fuel enrichment.

Or perhaps work on sophisticated diagnostic medical devices. Or engineering plastics like our virtually unbreakable Lexan® resin. GE is big in lots of areas you might not have known about.

But a word about that word "big." Some people worry that General Electric might be too big for them. Actually we're not like some big companies. We're decentralized. Into strategic business units. Each with its own plans and business objectives.

The whole idea is to give everyone plenty of responsibility and plenty of room to try new ideas. And when you look at our record of innovation and growth, you can see that it works.

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