Western Electric

WE

Third Quarter 1983

Sugar Grove, Illinois Installation
A Small Town Gets The Latest

With a population of 1,400, the village has one church, one grade school and one restaurant that closes at 2 pm.

This community center was built in 1930. The Police force and Village Clerk have offices in the rear.

Sugar Grove, Ill., site of our latest 5ESS* office, is a small village about 50 miles due west of the Chicago Loop. State Route 47 used to bisect the town, but since the by-pass was built about 15 years ago, Main Street is as quiet as a suburban cul-de-sac. Total population according to the sign at the town limits is an optimistic 1,400.

Prior to World War II, Sugar Grove was a typical Mid-Western farm center. It hasn't changed a great deal. The main crops are still corn and soybeans. For a few years following the war, practically all the villagers were retired farmers. Starting in the mid-50s, however, with the construction of the East-West tollway a few miles north of town, Sugar Grove became a bedroom community for Aurora and various other industrial communities to the east: A number of the residents now work at Western Electric in Montgomery, Caterpillar in Aurora and, before the strike, at the Federal Aeronautical Administration Training Center.

Like many of the towns in northwestern Illinois, Sugar Grove is approaching its sesquecentennial. The first settlers to arrive in the area crossed the Fox River at Oswego in the spring of 1834. There were five young men in the party. They came West from Medina County, Ohio, seeking opportunity and farms of their own. They came with two wagons and two yoke of oxen, four cows, two axes and each man had a flint-lock gun.

Until they could build cabins to house their families who had remained "back East," the young adventurers took shelter in an abandoned Indian shelter. The Indians called it "Sinquasip" meaning sugar camp. Apparently it was located in a grove of sugar maples although none grows in the area now. Main Street is lined with walnut trees.

The settlers began plowing the fertile, rolling prairie that summer of 1834. Even today, the soil is rich and black. Wives and children began arriving in the summer of 1835. And some of the current residents can trace their roots to those early arrivals. The land was not surveyed until 1839 and 1840. The settlers didn't pay for their claims until the great government land sale in Chicago in 1842.

Village of Sugar Grove is bisected by State Route 47 and old Chicago, Burlington and Quincy Railroad tracks.

Illinois Bell's step-by-step office was located in this rented building hidden behind the village general store.

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On the Cover

This imaginative rendering of our new symbol for the 5ESS™ switch overlooks a sea of information-processing keyboards—themselves symbolic of the new system's ability to switch vast amounts of information.

WE

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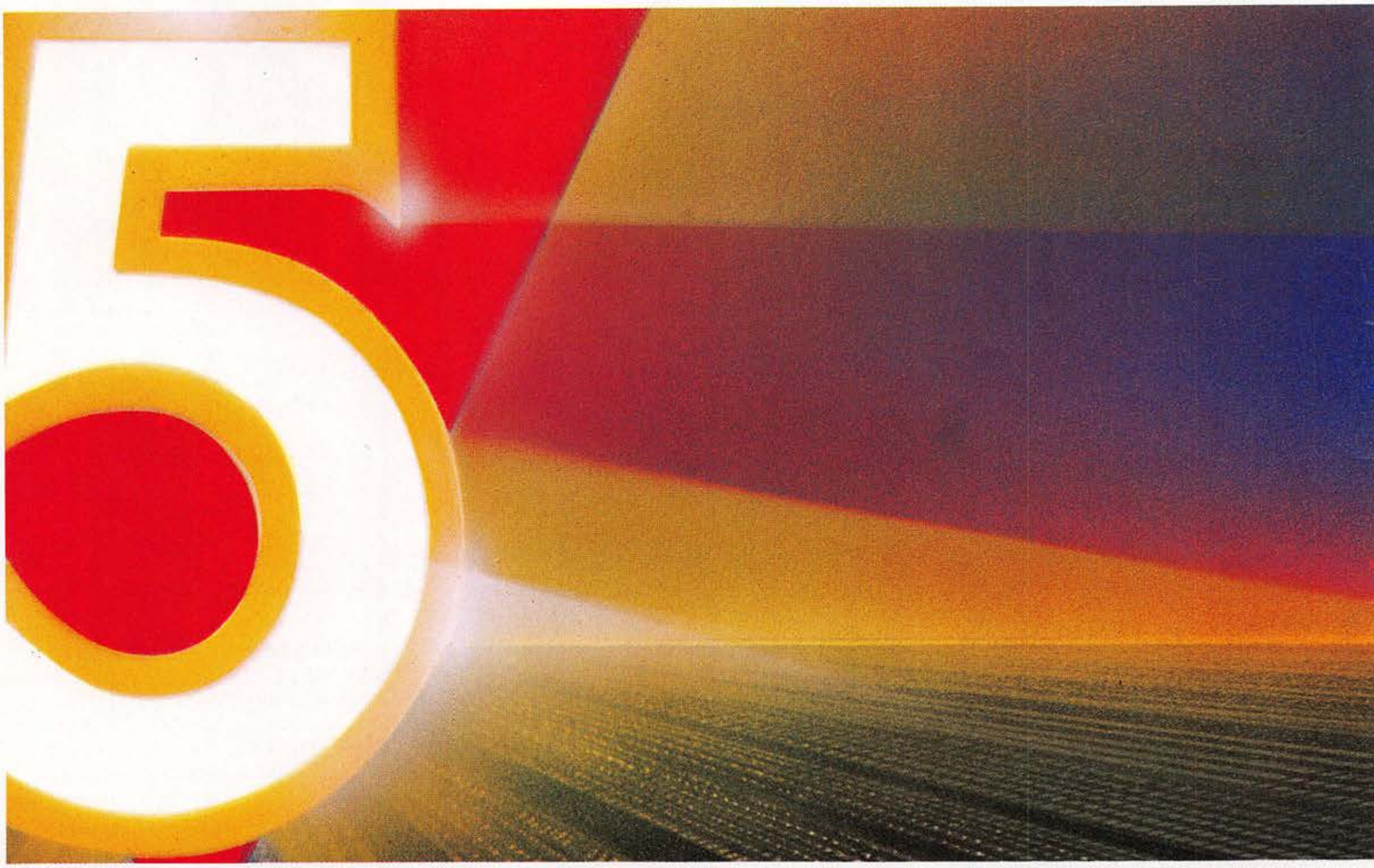
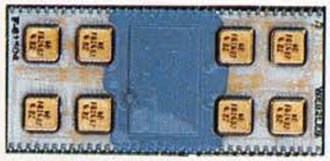




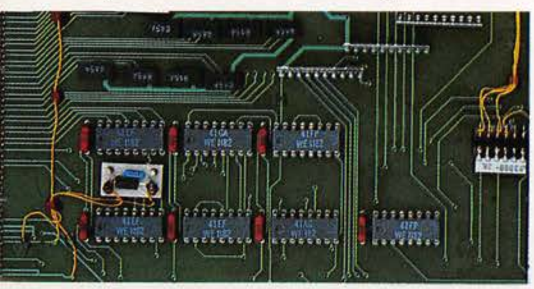
The 5ESS* Switch

I'm pleased to have the opportunity to add a few words about the 5ESS*-switch in this special edition of WE.

It's not often that a product comes along that revolutionizes an entire industry. Despite all the claims in advertising and television commercials, most new products are just evolutionary steps in a series.

The 5ESS switch, however, is a *revolutionary* switching system, the most advanced in all the world and the one that will change the telecommunications industry for all time. The 5 is a wealth of firsts: the first central office switch to use lightguide for its own internal communication and transport; the first to use software that is growable, shrinkable and upwardly portable; the first to use the 256K RAM. And we're the first to mass produce the 256K itself. There's a whole world of brand-new technology coming together in the 5ESS switch.

It's our flagship product and truly represents a new era in digital switching. It's an excellent product, so feature-rich that it will be the benchmark, the one against which all others will be measured for years to come.



I'm proud of the 5ESS switch, and I'm proud of the way it's being managed and coming on-stream. Our switches have always been at the heart of the Bell System and, in many ways, have contributed to America's reaping the benefits of the finest telecommunications network in the world. The 5ESS switch will ensure our success in this part of our business and guarantees that we will remain at the heart of the nationwide switched network and play a major role in the international marketplace as well.

The cutover in Sugar Grove, Illinois, is an important milestone in terms of realizing at least a portion of the awesome potential of the 5ESS switch. This cutover represents a great cooperative effort. Western and Bell Labs have been working closely and well together for years to make the 5ESS switch a reality. And, within WE itself, we have had exceptional efforts by our people in development, in manufacture, in marketing and sales. And, of course, we've been working very closely with our telephone company customers to make sure we are meeting all of their needs. I expect these cooperative efforts to continue and intensify as the 5 approaches its full potential.

Western Electric today is in wonderful shape to meet the challenges and opportunities of tomorrow. It's true we must continue our work to remain at the very forefront of technology and, along with Bell Labs, to develop and manufacture the new products that will be wanted and needed. But, today, we have the right people to do the job. We have the right structure and organization. We have the world's most advanced digital switch and a tremendous product line backing up that switch. We're ready for whatever tomorrow brings.

Donald E. Procknow
President

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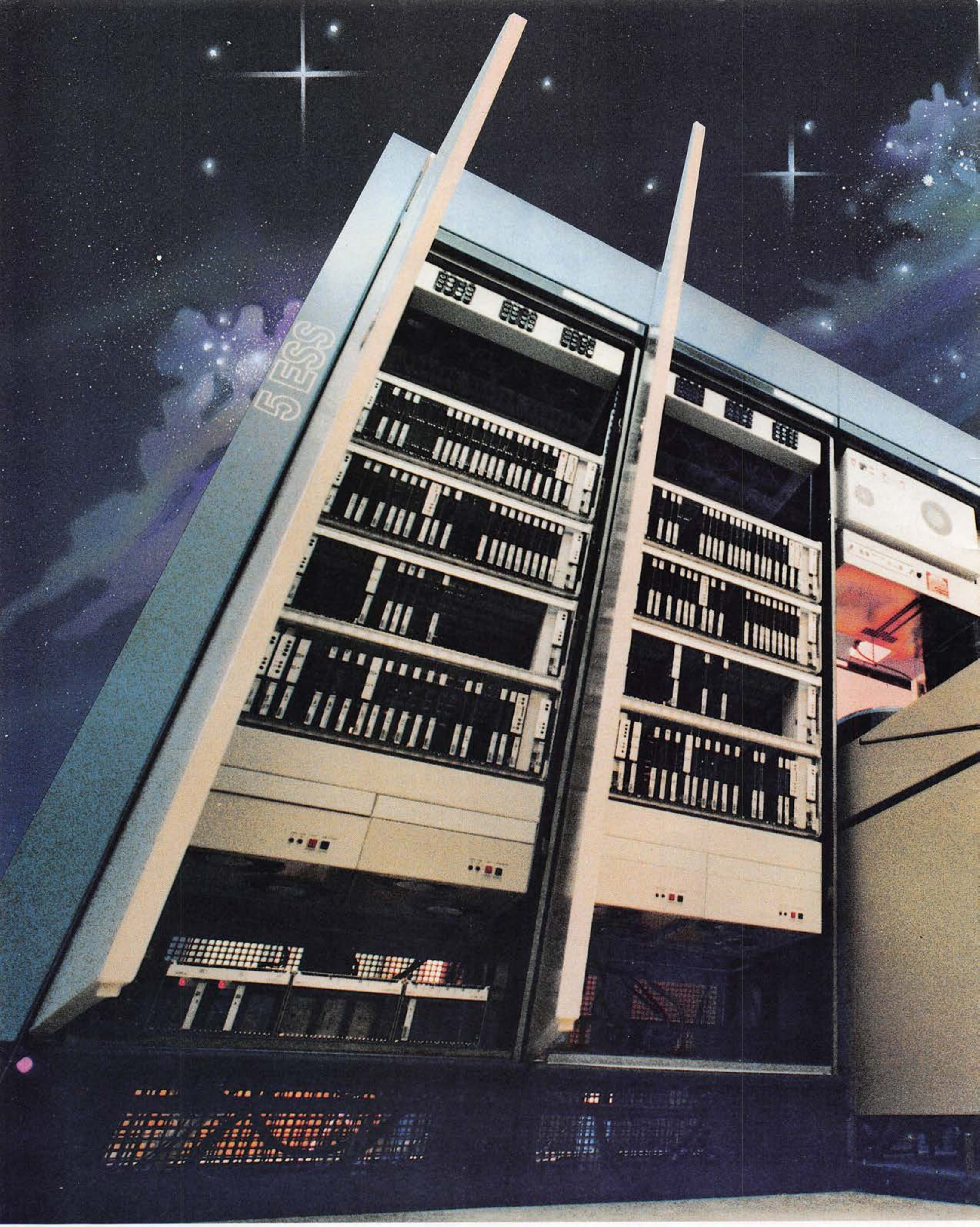
5 ESS

A New Era In Switching

By Kathy Fitzgerald

"The 5ESS* switch represents much more than Western Electric's entry into the local digital switch market." So says Bob Carlson, General Manager of WE's switching product line. "The development of 5 signals the beginning of a whole new era in switching."

And indeed it does. For the first time, the same system can be used to provide the latest electronic switching and custom calling features for rural, suburban and metropolitan areas.

"The 5ESS switch is a single-system solution to all switching needs," said Jerry Johnson, Product Manager for the switch. "And even more importantly, from a telephone company's point of view, it's the first switch that grows easily—from a few lines to over 100,000 lines.

"We like to tell our customers that it's a switch that grows, shrinks, or travels according to their needs," Johnson said. "It's an area planner's dream."

And it's easy to understand why. Let's say a suburban area suddenly gets an influx of new businesses with large communication needs. The Morristown, New Jersey area is a good example of exactly that situation—with the Bell System chiefly among the large businesses expanding in the area. With a 5ESS switch, the telephone company can add capacity as it's needed by simply adding interface modules. No massive equipment or software changes are required—which means meaningful savings in engineering and installation time.

If the population of an area gradually decreases, a telephone company needn't sit around with unused switching capacity. They can remove the appropriate number of interface modules and shrink the system. And because of their common architecture, those modules can be used elsewhere in their switching system.

And a remote switch module of the

*Trademark of Western Electric.

5ESS switch can travel up to 100 miles from a host switch to economically bring custom calling features to even the smallest rural area.

"The beauty of the 5ESS switch is its incredible flexibility," Product Manager Johnson points out. "That flexibility is the result primarily of two major breakthroughs in switching technology: distributed architecture and modular software control."

Briefly, distributed architecture means that the computer intelligence is distributed throughout the system instead of being concentrated in a central processor. Therefore, each interface module is capable of performing functions independently. The interface modules become the building blocks that allow the system to grow.

Modular software means that the binary coding that makes up the computer's instructions is produced in relatively distinct and independent programs. Thus, to add new features like Call Waiting or Conference Calling, you just add a separate software module. There is no need to reprogram the entire system.

"The modular design of the hardware and software of the 5ESS switch makes it the world's most advanced digital switching system," said Bob Carlson. "It really represents the second, or maybe even the third generation in electronic switching technology."

In addition to its modular design, the 5ESS switch is the first switch that uses totally solid-state devices. A unique Bell Labs creation, gated-diode crosspoints, replaces the traditional electromechanical switches and relays that are the industry norm. The result is a more reliable solid-state connection.

"The 5 is truly state-of-the-art," said Charlie Brown, BTL head of the first application for the 5ESS switch project.

"Many industry observers felt that we were late in developing a local digital switch," Brown says. "There are those of us who would still debate that. In terms of the economics of digital technology, we're right on time. Just as we were right on time in developing the 4ESS*switch when there were real economics for digital in the toll environment. But that's water under the bridge.

"The real point," he continues, "is

On Main St., Ed Natanek, Mike Renz and Ed Radke pose outside the new Sugar Grove central office.

that what was originally perceived as a disadvantage has really turned into an advantage. Our local digital switch is not just merely digital. It embodies every technology of the 80s.

"And perhaps more importantly, all of those technologies are open-ended. They allow this system—this one investment of the telephone company—to grow with the changing technologies; or to grow with the changing telephone needs. Our system is not just a 1ESS* turned digital. It's a major technological leap!"

Karl Martersteck, Bell Labs Executive Director responsible for 5ESS switch development agreed, "The 5ESS switch is structured in such a way as to make it easy and inexpensive to keep the system modern, and able to deliver new services to keep the customers' business viable. With this system, we *expect* change. It's designed for it, in both hardware and software. With small changes in the software, or perhaps new circuit packs, you can simply plug in new capabilities."

Jack Warner, a BTL supervisor in charge of site testing, had one of the clearest explanations of the architecture of the 5ESS switch: "Think of an interface module as a bookcase and units with circuit packs as books. You can add, remove, mix or change the units to fit any service that you need. This means you only have to buy the amount you need—then expand later. Also, you can add new equipment easily, as it's developed, just like you add a book to a bookcase."

The ability to "plug in new capabilities" will become particularly important to telephone companies in a post-divestiture mode. "After January 1, 1984, the telephone companies are going to be even more aggressive in seeking new ways to generate revenue," WE's Jerry Johnson explains. "They've got to figure out what new business to enter and new services to provide since basic telephone service is almost universal in the U.S.

"The 5ESS switch is designed to support new services," Johnson says. "I can't foresee a day when we won't have a new piece of hardware or software to add to the system."

The Remote Switch Module (RSM) announced this year is a good example. "An RSM is nothing more than an interface module located away from the host switch," he explains.

Able to be located up to 100 miles from a host switch, the RSM allows telephone companies to offer several widely separated rural communities the same digital capabilities enjoyed by major communication centers. The operating costs of the offering are low and the potential for the telephone company to earn revenue is great.

That the 5ESS switch is an evolving product is readily seen in the systems going into service this year.

Late this summer, the first multimodule office was cut over in Sugar Grove, Illinois. "The Sugar Grove cutover was the key 5ESS switch development milestone," BTL's Charlie Brown said. "It was what we were all working towards—the office in which the modular software became totally functional. With this office in place, we will be able to add new features in quick succession."

Obviously, that's true. In September, a 5ESS switch will cut over in Port St. Lucie, Florida, which will have the first application of automatic message teleprocessing, a highly sophisticated method of billing methods for the customer.

In October, the 5ESS switch starts showing its real versatility with the cutover of the first local/toll digital switch in Bradford, Pennsylvania.

And so the process will go on for years—with the new applications and features of 5ESS switch only limited by what the telephone companies decide they want to offer their customers.

One of the truly unique offerings of the 5ESS switch is called Business and Residence Custom Services. This means that a telephone company will be able to offer its customers a menu of all the traditional custom calling and centrex features plus an infinite number of variations on them.

For example, a telephone company, if it chose, could allow its customers

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to use and pay for Call Waiting or Three-Way Calling on a per call basis rather than only by monthly fee. This would allow customers who don't want the entire custom calling package to use certain services when they wanted.

"We're going to be talking to our telephone company customers to see what Business and Residence Custom services they want to be developed in the future," Johnson says. "The technology is there. It now becomes a market research job to see what the consumer would like to get from his telephone system."

The potential of the 5ESS switch is unlimited. "The 5ESS switch project is one of our top priorities at the Labs," says Doug Dowden, BTL supervisor in charge of 5ESS Switching System Architecture. "We've got a truly impressive team of very bright, enthusiastic designers on the job. With so much of our resources focused as they are on digital technology, you're not just buying a switch. You're buying a committed laboratory. And when you're talking about Bell Labs, that means a lot!"

And of course, when you're talking about Bell Labs and Western Electric, you're always talking reliability.

"We've put a lot of effort into developing a maintenance and recovery system," Jerry Johnson emphasizes. "Over half of the software found in the 5ESS switch enables the system to maintain itself. I think it would be fair to say it's the most sophisticated maintenance system in the industry."

Test after grueling test proved the system reliable. It kept processing calls even after being wrapped in a plastic envelope and cooked for 24 hours at 120°. Engineers fed garbled data to the switch's central processor and calls still went through. Circuit packs were disconnected and the switch simply re-routed the calls around the trouble.

"The system is designed to self-correct any system features without service disruption," Johnson said. "And that's what it does every time."

And that's Western Electric's 5ESS switch. More than a digital switch. Modular architecture, solid-state connections, the latest in micro-electronics, software and even photonics. The tops in reliability. The 5ESS switch—a new era in telecommunication switching.

Princeton Telephone's president, C. Kightly Trippet with a gated-diode circuit board in his central office.

Princeton Telephone Company

In May, the Princeton Telephone Company of Princeton, Indiana became the first independent telephone company to purchase and cut into operation a 5ESS* switch.

The 5ESS switch, located in Princeton Telephone's Fort Branch, Indiana office, incorporates several important hardware and software improvements over previous switches while providing a variety of services to the telephone company's customers.

Princeton Telephone Company President C. Kightly Trippet explained the company's reasons for choosing Western Electric's switch over its competitors. "It is the latest generation of electronic switching system and represents the most advanced technology available," Trippet said. "We were convinced that we would receive superior support from Western Electric and Bell Labs people before, during, and after installation." He added, "This electronic switching system has great features that will bring Information Age telecommunications technology to our customers."

Rotelcom, Inc., a subsidiary of Rochester Telephone Corporation, engineered and sold the switching system to Princeton Telephone under a contract agreement with Western Electric's commercial sales organization.

James C. Henderson, Chairman and Chief Executive Officer of Rochester Telephone Corporation, said, "This project represents a perfect application of digital switching technology. Through the use of remote switches, it allows the Princeton Telephone Company to expand and provide new services for years to come, efficiently and economically.

"Princeton is the first independent company to install Western Electric's 5ESS switch, which we at Rochester Telephone regard as a superior system. We are certain that over the next few years many other independents will elect the 5ESS switch basically for the same reasons as Princeton—performance, reliability, and flexibility."

Princeton Telephone's Fort Branch office initially has been designed as a single module switch with the ability to expand to meet the changing communication needs of area customers. The switch's design allows it to grow with the communities it serves by adding modules. Its features can also be expanded to provide services to areas within 100 miles with Remote Switching Modules.

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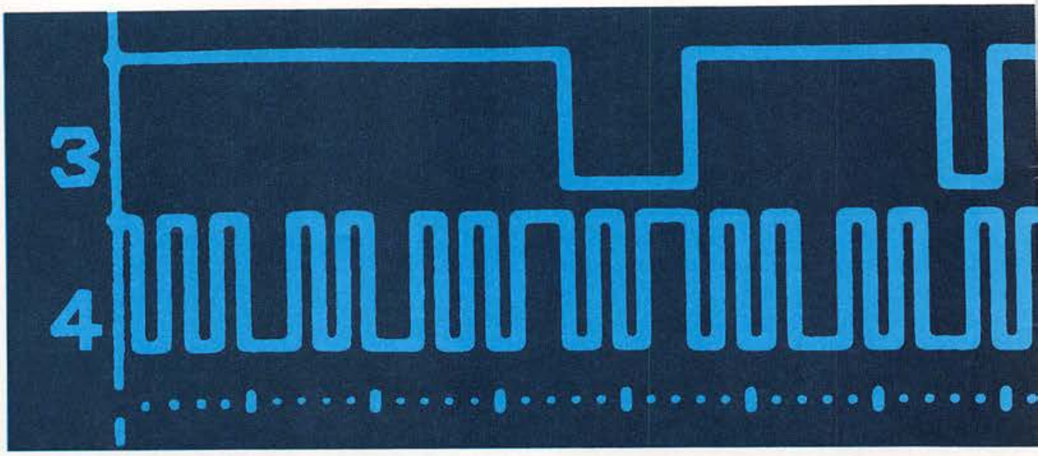

Why a Local Digital Switch?

By Don Leonard

Some insights into why we're going digital

Don Leonard is Vice President, Switching Systems at Bell Laboratories.

The 5ESS* switching system, a second-generation switch, is a product that uses to the best advantage advances in software, lightwave, microelectronics and digital systems. It was planned and developed as part of a digital product evolution in the Bell System network. Systems engineering and planning continues to be a major strength of Bell Labs, and the 5ESS switch is a benefactor of this planning. Let's explore how "digital" has been planned.

It became apparent with the successful introduction of transistors to circuit design by the mid 1950s, that digital, pulse-code-modulation carrier systems could be used for some applications more efficiently and more economically than analog systems. That is, representing voices in the ones and zeros of digital pulses—the language of computers—would "prove in" economically.

In 1962, Bell Labs and Western engineers introduced the D1 channel banks and T1 carrier systems to capitalize on digital opportunities. These systems convert telephone conversations into digital form for transmission between switching systems.

Advances in integrated circuits coupled with digital circuit design resulted in more and more use of digital T carrier. Soon it became more efficient and cost effective to digitize other parts of the network. In the early 70s digital technologies applied to switching provided a cost effectiveness which permitted the design of a toll (long distance) digital switch. In 1976, our 4ESS* system, known as the "super-switcher," became the first time division, digital toll switching system.

As more and more 4ESS switches were introduced into the network, the economies of digital trunks improved and their number grew. This was closely followed by fast-paced developments in the exploitation of lightwave technology, leading to the introduction of the world's largest laser-powered digital transmission system—eventually to link switching offices between Massachusetts and Virginia.

Just as T1 and lightwave systems digitize communications between central offices switching systems, in the late-70s, the SLC-96* system brought digits to the lines between switching offices and business and residence subscribers.

With trunks and loops going digital, the next logical step was the development of a local digital switch for telephone calls and data communications. In the late 1970s, Western Electric announced the funding of the Bell Labs development of just such an office, to be known as the 5ESS switch. Today, the first three working switching systems in Seneca, Ill., Cedarville, Ohio, and in Cedar Knolls, N.J., are already setting standards for reliability and ease of operation.

These installations are the first of a

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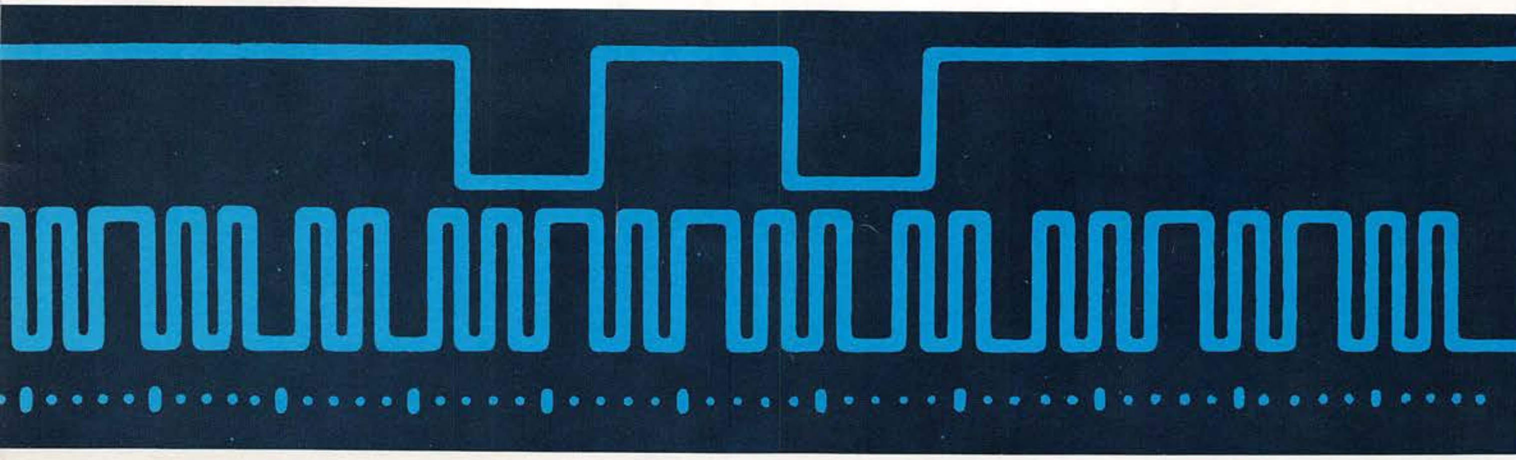

second-generation, time-division switch product line where one flexible digital switching system meets all the switching requirements of an operating company customer.

The key ingredient to 5ESS switch leadership is its modular design. The system can grow smoothly by adding modules controlled by microprocessors to serve more customers. This system was designed with the unique ability to serve anywhere from 1,000 to 100,000 lines.

The software that operates the switching system is also modular and flexible, using a high-level language. These coded instructions are of two kinds: instructions that control the switching equipment and instructions that provide calling services and new features that can create significant revenue for operating companies. Because of this, software used to provide revenue-producing features can be added without affecting the rest of the system. The software architecture is good for fast feature delivery.

The modular hardware and software design philosophy controls not only the overall design of the 5ESS switch, but also the 3B20D processor and its operating system, plus an array of impressive electronic and lightwave components which make the concept a reality.

The Western Electric 3B20D processor and its operating system controls administrative functions and coordinates automatic maintenance in the switching system.

Western Electric's 64K dynamic Random Access Memory (RAM), and later this year, the 256K RAM, give the 5ESS switch the most advanced chips for economically storing software instructions.

Unlike any other local switching system, the 5ESS system has totally solid-state transmission paths. New devices that can handle lightning surges as well as relatively high voltages used for ringing and testing replace electromechanical relays still used in other systems, allowing size reduction, cost and maintenance advantages.

Other call processing operations, such as tone generation, detection and signal filtering are handled by a computer-on-a-chip called a Digital Signal Processor which can make a million calculations a second.

Within the 5ESS switching system, lightguide fiber is used for internal data transmission functions. Lightwave is not at all affected by electromagnetic interference and is very broad band, that is, it has the capacity to transmit much higher volumes of information than copper links. Also, at Cedar Knolls, a lightwave cable directly connects the 5ESS system with a 4ESS toll switch.

While technological advances have made this switching system very powerful, it has also made it much more "friendly." Craftspeople communicate with the switching system by using an easy-to-read color screen. The actual language they use to talk to the system is a special international standard computer language called MML, developed especially for craftspeople to use.

The 5ESS switch has been planned as a broad range digital switching system. It handles a wide range of traffic without blocking—no traffic jams—as well as all types of traffic: local, local/toll and toll. Area planning tools have been developed which permit the planning of switching offices for a whole geographic area. The switching system's flexibility—its smooth growth capability as well as its remote capability, where switching modules can serve as remote call processing systems, operating up to 100 miles from a host processor switch—permit the cost efficient replacement of older switches while providing advanced features for smaller communities. In addition, we are planning to introduce operator services as well as Integrated Services Digital Network (ISDN) features. Simultaneous voice and data capabilities will make services from shopping to banking to recreation as easy as using the telephone.

As the 5ESS switching system goes into mass production, it will play a vital part in the emerging end-to-end digital network that will make it possible to provide information age services to homes and businesses throughout the country. It is the keystone of the digital future.

Cedar Knolls
An Installer's View

By George Gray

Photos by Joseph Gazdak

Lots of computer jargon to learn, but a self-diagnosing joy to work on once it's up and running

"It's like starting a completely different career. Fascinating. Even though of late I seem to be spending most of my time on the phone trying to get updated packs." That's how Bill Sumski summed up his role as supervisor on the 5ESS* switch at Cedar Knolls, N.J., a few days before cutover on March 4.

Bill has been a WE installer for 18 years, with all of his service in the Garden State. He works out of Morristown—only a few miles from where he was born and raised.

A total of eight WE installers worked on Cedar Knolls in shifts—with no more than five on any one day. Bill Sumski, Frank Regan, Dick Schipper and Mike Drugac were involved primarily with testing; Rich Bonadonna was the power man; Mike Lyness, Roy Koes and Kevin Svec helped out during the ironwork phase.

"Compared with, say, a No. 5 crossbar job, where I started," Bill said, "this job is relatively easy to learn. Practically everything is self-explanatory. The documentation is very good. There are a lot of plug-ins. Your biggest problem is learning what packs do what."

Frank Regan, who has also been an installer for 18 years, mostly in New Jersey, seconded that appraisal. Frank was one of the first WE installers to take the 5ESS switching equipment course at Dublin. It was a 12-day program, but proved a little confusing since hardware and software were changing, being updated and improved all the time as new features were developed and tested out.

"What made this job a little rough," Bill said, "was that we were designing it and building it and changing it all at the same time. Of course, that won't be true of any later installations, all of which will be a lot more routine.

"Very early on," he continued, "I spent three days meeting with the testers and transportation people at Oklahoma City—all the people I'd gotten to know over the telephone. Support from manufacturing is what makes something like this go."

Cedar Knolls, like the 5ESS switch installations that preceded it last year in Seneca, Illinois, and Cedarville, Ohio, is a single-module system. But unlike its predecessors, which will become remote switch sites operating off a larger 5ESS master switching office, Cedar Knolls will eventually grow into a large self-sustaining system. Additional switching capacity is provided in frames known as IMs (Interface Modules). Up to 29 IMs can be added later on, enabling the Cedar Knolls system to serve as many as 100,000 lines. Initially it will serve less

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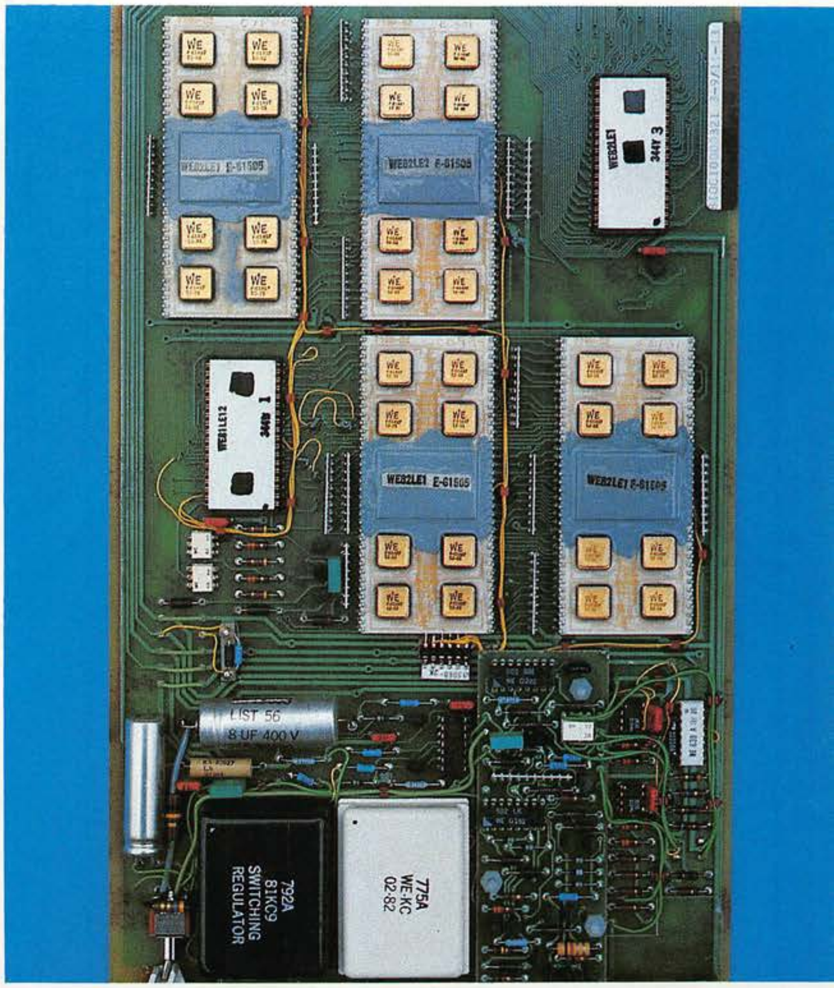
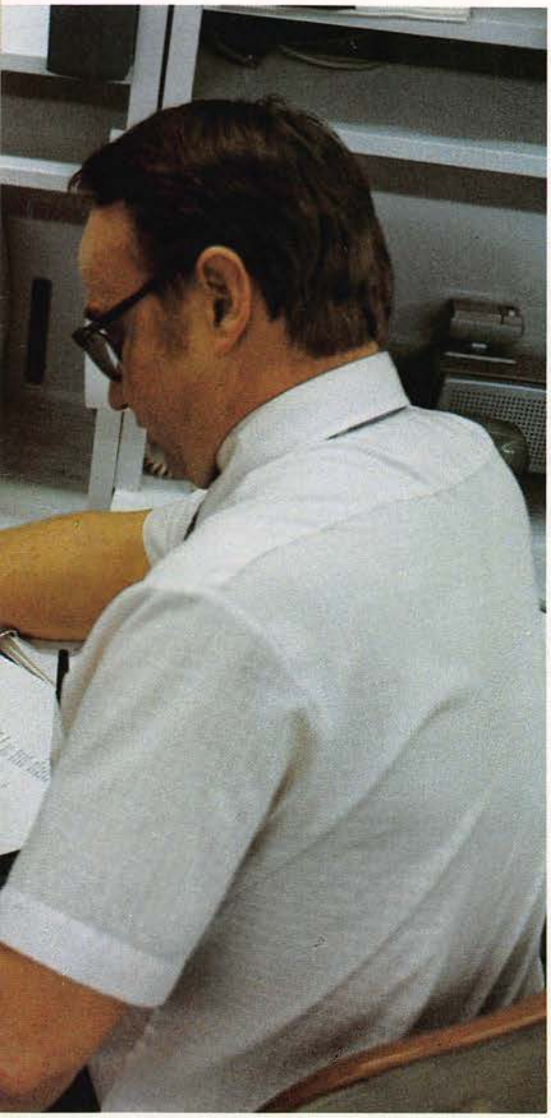
Installer Frank Reagan inserting gated diode circuit board in an Interface Module frame, heart of the local digital switch.

Closeup of gated-diode circuit board. Squares contain switching crosspoints.





WE Installers Frank Regan and Bill Sumski at the maintenance console of Cedar Knolls 5ESS switching center.*

than 1,500 lines in a nearby industrial park.

Each of the early 5ESS switch installations contains a number of "firsts" to be tried out before the product goes into mass production. Cedar Knolls was the first 5ESS switch to provide service for a new exchange area. Its predecessors replaced older electro-mechanical switches. Cedar Knolls is also the first 5ESS switch to be connected directly to a 4ESS toll switch. The connection to the toll office in Newark is by lightguide.

Perhaps the most notable enhancement in the Cedar Knolls system is its use of the latest processor and operating system. The new processor and operating system—the 3B20D Model 2 and DMERT Generic 2—completely automate most administrative and maintenance jobs in the switching system.

Maintenance craftspersons are kept informed on the status of the system by a color video monitor that is a kind of technicolor window into the heart of the switch. Color-highlighted diagrams and messages tell craftspeople the status of any part of the system at a glance. "Diagnostics can be done by the numbers," Bill said. "You just hit a couple of keys. There is very little typing necessary."

Cedar Knolls will be unmanned. Everything that shows up on monitors and terminals at master control is duplicated 20 miles away in a manned control center in Passaic. Someone may have to stop by once a month to change a pack, but after the initial flurry of activity with Bell Labs trying out software ideas, things should be relatively quiet. The machine diagnoses itself every midnight, checking every piece of equipment. It even has its own built-in clock. There is also a read-only printer made by Teletype that reports on status every 15 minutes.

"From the point of view of time elapsed," Bill said, "the biggest part of the job was bringing in the power. Even with everything pre-assembled and pre-tested at the factory, you still have to put up cable racks and hang rods down from the ceiling. There was a lot of cable to run to the main distributing frame. It's temporary. They're talking about replacing it with a Cosmic* main distributing frame. For the time being, the main frame is located on this floor but way over on the other side of the building. We worked a month on the cable racks and then started testing after three days."

Unlike Seneca and Cedarville, the New Jersey office came in pieces. It had been fully assembled at the factory and then broken down, because the location at Cedar Knolls is below ground. It could not be slid in as a unit. Pieces had to come in through a loading dock and then down a freight elevator.

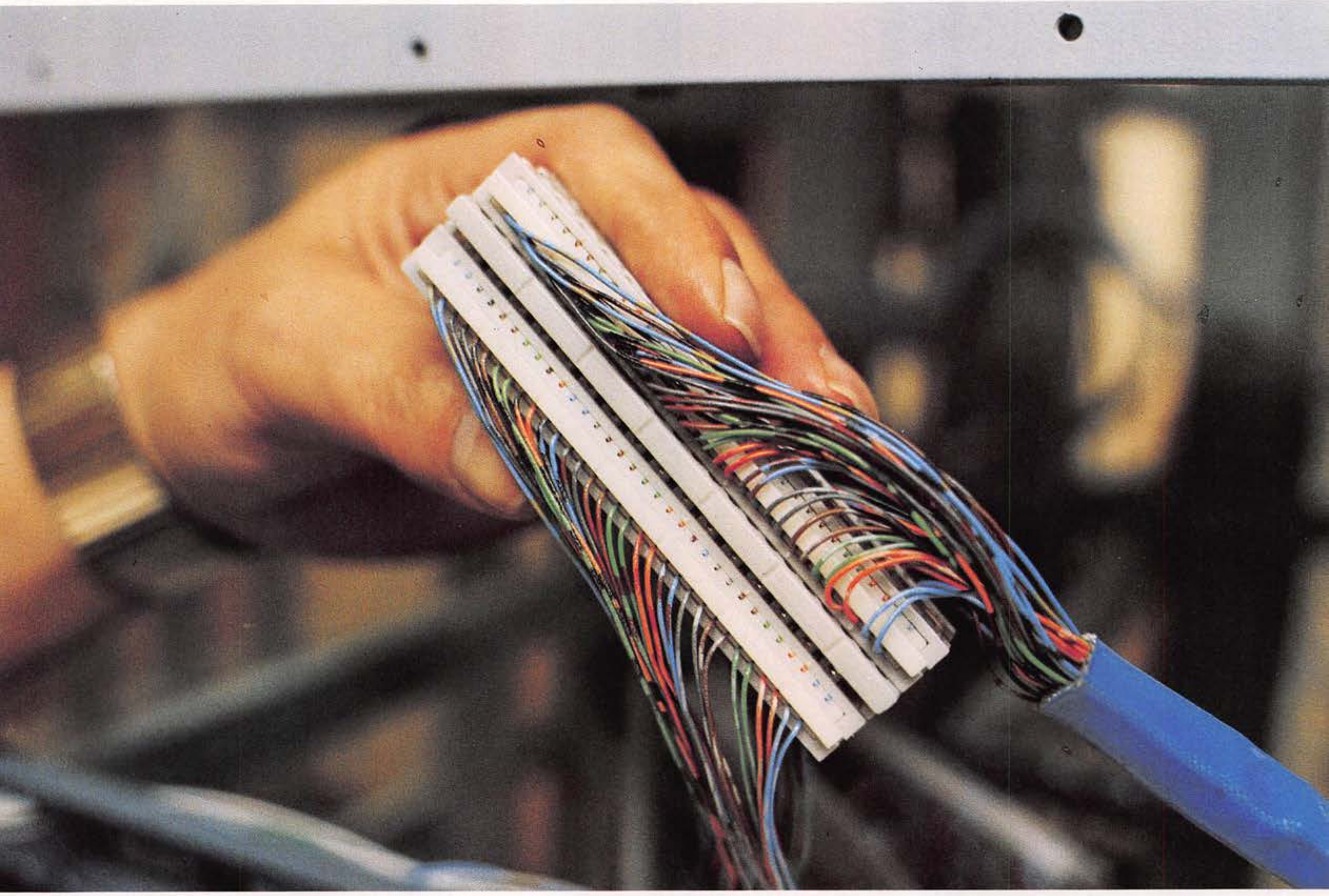
"We actually had the job only about four weeks, from the end of November until the first of the year when we turned it over to Bell Labs for some software updates," Bill said. "They had it for the month of January and then gave it back to us for a week of final testing. We actually turned it over to New Jersey Bell for their tests on February 6."

The 5ESS switch at Cedar Knolls is set up as two rows of equipment bays. Each row is about 18 feet long. The 3B Processor row contains the main processor in a double bay frame, three memory units known as MHD (Movable Head Disc) bays, and a fifth bay containing the TMS (Time Multiplex Switch) and other equipment that connects with the Interface Modules. You need the TMS for anything above 1,536 lines. It is the key to "growability." Everything fits into time slots.

The other row—referred to by the installers as the No. 5—also contains five bays—one for power equipment, three for the IM (Interface Module) and a fifth containing miscellaneous equipment for alarms, recorded announcements and protection.

One unit of circuit packs in the 5ESS switch takes the place of four processor frames in the 1ESS switch or one frame of equipment in the 1A. Installation is fast because all cables are connectorized and just have to be snapped in place on site. Much of the work involves checking out circuit packs. For this, installers must stand on a special mat and wear a ground-wire bracelet on their wrists. This prevents the components on the circuit packs from receiving a 30,000-volt jolt that can be generated by the static electric charge on the body. It's a new precaution that the installers have to learn.

The memory disks—which are located inside what look like top-load washing machines—also have to be



To simplify installation, many wire connections use snap connectors. This is at the main distributing frame.

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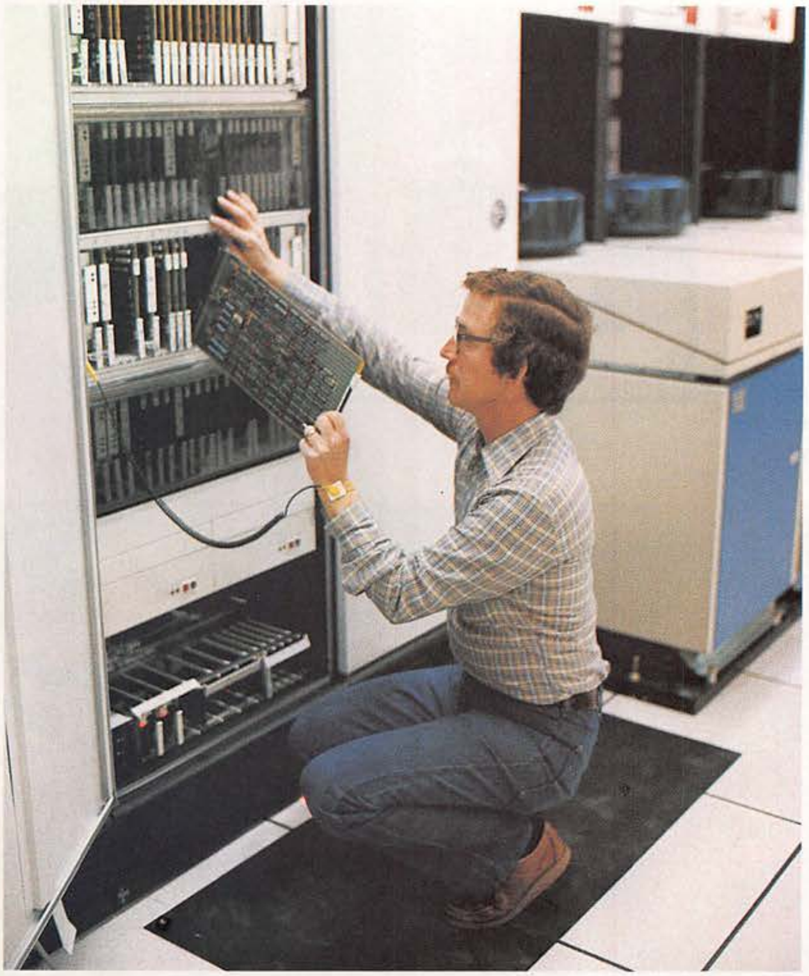


To prevent damage from static electricity, installers must stand on a special mat and wear a ground-wire bracelet.

Memory disk weighs about 20 pounds.

handled with care. They are kept virtually air tight. One speck of dust could destroy the whole program. In a typical system like Cedar Knolls there are three memory frames—one is running, a second is a "warm" spare that can take over instantaneously, and the third is backup.

Memory disks come in 10 layers with a total depth of five inches and a core diameter of 14 inches. However, you never see the core uncovered. Whenever it is outside the cabinet, it is transported inside a screw-on blue plastic dome that looks like the cover for a layer cake in a diner. "This can't weigh more than 20 pounds," Bill said, lifting one up. "You should try hefting memory mods in a No. 1. They weigh at least 65 pounds."

Each layer of the memory disk has information on it. In all, it can hold up to 300 megabytes. Only about half that capacity is currently used at Cedar Knolls. If you lived in the neighborhood, your telephone would have an address in there somewhere, along with your class of service and what your billing rate is.

This makes it very easy to add a new subscriber to the system. The telephone company people make a con-

Built-in fans air cool circuit packs.

nection of the incoming line at the main frame and assign a number. Then, at what is known as the Recent Change Terminal, a craftsperson types in the assigned number and class of service. The system then takes over and automatically assigns an address in the memory disk and you're in business.

"With the 5ESS switch," Bill said, "you can change the entire program in 20 minutes. You don't have to shut down anything. You just let one disk keep going while you change the other. This is a big plus. With the 1ESS* switch it took eight hours with four people working on eight program stores to change a program. With the 1A they cut it down to a little over an hour with one person, and now we're down to 20 minutes."

If you visited an early 1ESS switching office prior to cutover, the load box was a large equipment case that looked like a 21-inch TV console. This load box simulated busy-hour traffic in a central office to give the new switch a realistic workout before it was actually cut into service.

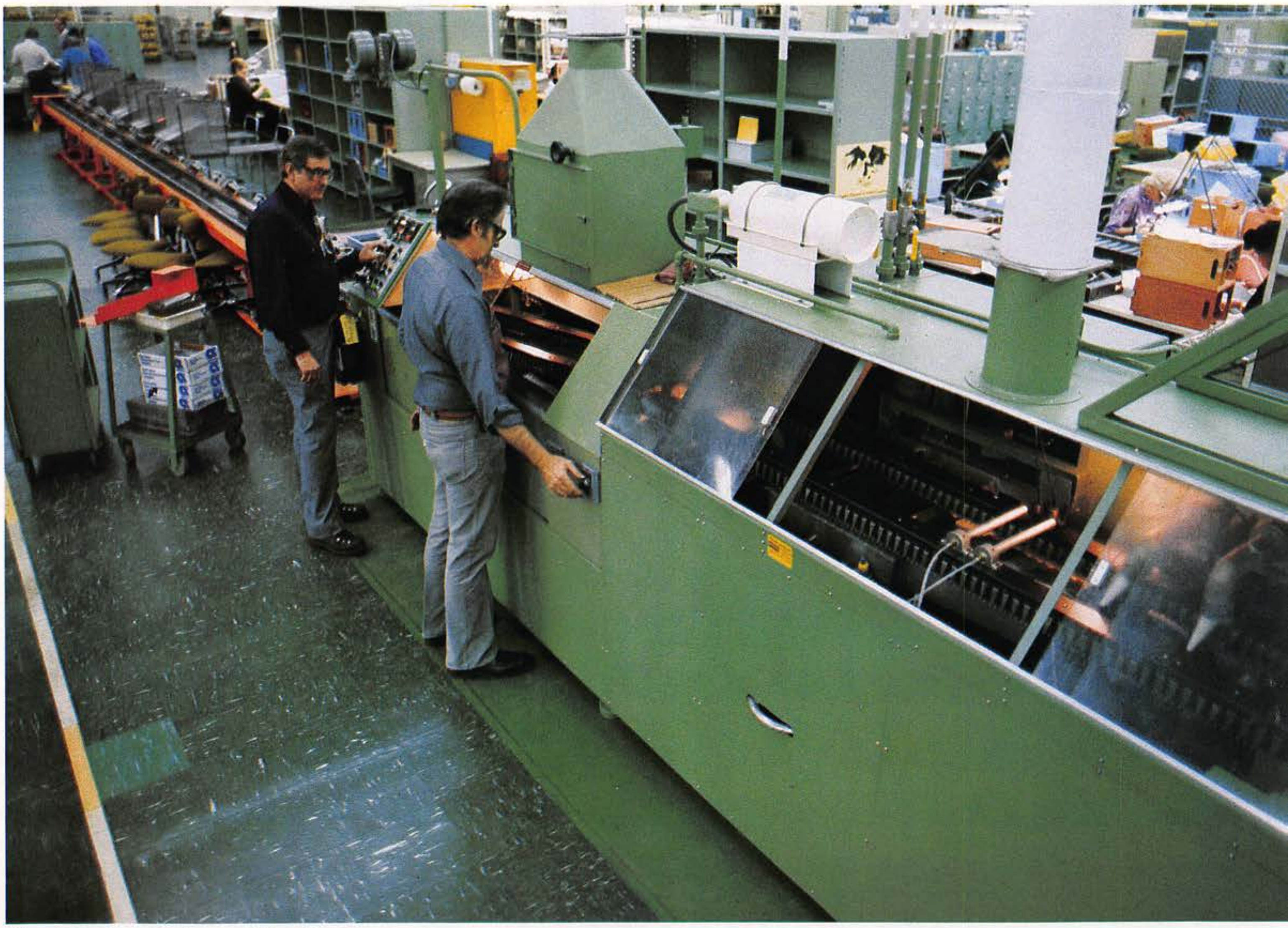
Just like almost everything else, it now comes in smaller packages. The load box for the 5ESS switch is about the size of an electric typewriter and sits on the corner of a desk. It's called Procall and it's made at the Illinois Service Center. It does all—and more—that the whole roomful of boxes used to do.

"It's been an interesting job," Bill said, "to say the least. And I can tell you there is not one part of Western Electric that is not totally committed to making it work."

Making It

By Judy Seikel

Right. Al Swang, T. J. McNeely and Bob Green study a Spearhead drawing detailing the latest factory layout.



Above. Delbert Rains and Ray Rose at the soldering machine in Oklahoma City's new "fast line."

A sign of the times: the shipping cartons for ESS parts now carry international symbols.

Almost everybody at Oklahoma City Works has been caught up in the excitement of making our most important product.

It had to be one of the gargantuan juggling acts of corporate history. The 5ESS* switch, a major product that would eventually occupy some 300,000 square feet of shop floor space was coming to life. Most of the initial operations were being moved from Illinois to Oklahoma. In Oklahoma, what had previously occupied those 300,000 square feet, had to be consolidated, cleared away and, in some cases, transferred out to other plants. The time frame: a scant two and a half years.

All through the reorganization, production had to be maintained. There could be no gaps simply because additional machines were being installed. At the same time, Bell Labs was at work redesigning and updating the products being transferred. Some circuit boards were subjected to many design changes during the transition period, as new features were added or, in some cases, "bugs" were tracked down and eliminated.

The cost of the move was considerable—not only for purchase of new equipment, transportation charges and overtime, but also in training a whole work force for new jobs. Thousands of people at the Oklahoma City Works have undergone extensive training not only for the 5, but for support jobs, as well. As senior people moved into the new technology, others shifted into the established products to fill the vacancies. Over the past year, roughly two thirds of the people at the Oklahoma City Works changed jobs.

Planning

"Hardly a square foot of the 900,000 square feet in the total factory was untouched by the arrival of the 3B Processor and the 5ESS switch," says T. J. McNeely, department chief, Engineering—Factory and Machinery Procurement.

A 28-year veteran with WE engineering, McNeely has lived the reorganization night and day for as long as anyone at Oklahoma City. It was his responsibility to get input from the product engineering department and consolidate its needs into a reasonable working package. Assisted by Al Swang, senior engineer, and Bob Green, engineering associate, they proposed plans which were chewed over endlessly. "Since I had the whole plant floor space to worry about," McNeely says with tongue in cheek, "I was very objective."

The plans, which were formalized as huge colored drawings, were code named Spearhead I, II, III and IV. Spearhead I, which began in October, 1980, included everything that had to be done to make room for the new products. "After asking all of the product people what they needed to do the job, we added it up and found we simply didn't have enough to go around.

"We had to make some very hard decisions about how much floor space a group could be allocated and we had to stick by our guns," McNeely said. "By the time it's all over, we will literally have changed every square foot of the factory. All of these changes are intertwined and they all impact on one another. There is a domino effect that can take place if moves are not precisely planned."

How hard is it to filter out real needs and work them into a master plan? "Very hard," says Swang. "It's dozens of product engineers holding their heads in frustration and trying to squeeze out a little more space. It's trades working 60 hours a week. And that's not to mention the administrative side."

The cost of moves and rearrangements is staggering, and if that isn't enough, timing is critical. "One illogical, poorly-timed move could easily cost thousands of dollars. You can't afford to make that kind of mistake," McNeely says. "Too many changes can be demoralizing for everyone involved."

McNeely, Swang and Green have worked hard to minimize the costs and domino effect for the past two and a half years. At meetings every Thursday they come up with a "Most Wanted" list, a "Next Most Wanted" list and, finally, a list for routine things that must be done. This approach has given the trades people some flexibility in managing their work load.

The 46 trades employees under Department Chief Bud Bricmont worked approximately 100,000 hours per year during the transition on mechanical and labor jobs and about 95 percent of it was in connection with 3B and 5ESS switch installation.

Engineer Colin Elliott checking out lightguide on the 3B processor.

From the onset of Spearhead I to Spearhead IV, Roy Blasius, section chief for Trades, Electrical New Construction, and Frank Cory, section chief of Trades, Mechanical New Construction, spent many hours of planning with McNeely. They also worked closely with purchasing, operating and the employees in their trades organizations who analyzed and wrote the orders for thousands of dollars associated with materials needed for the jobs.

Cory says that in his 22-plus years in the company, all 900,000 square feet of Oklahoma City's manufacturing floor space were rearranged at least once, but nothing in those years presented the kind of challenge brought by the introduction of 3B and 5ESS switch facilities. Along with this job, the 128,617 square feet of available space in the office building had, or will have, major rearrangements to accommodate changing supervisory structures. In addition, a new switching office for a Dimension® PBX system had to be included.

Discussion of capital/plant requirements for producing the 5ESS switch first cropped up in long-range planning meetings at the Oklahoma City Works early in 1979. Other ESS*

*Trademark of Western Electric.

A typical Oklahoma City employee last year spent 38 hours in a classroom. This is a course in Bellpac modification.

Mel Gering and Janet McReynolds test Interface Modules for the 5ESS switch.

Bill Rigsby and Lewis McCurley check gate array circuit boards on these computerized test sets.

"If it's blue, it's new." For two years, construction was the name of the game.

switches had been allocated to the Works on short notice and the hope was that the new product on the drawing board—the 5ESS switch—could be assigned early so that everything would not have to be done on an expensive, rush basis.

However, it was not until December of 1979, that the 5ESS switch was formally allocated to Oklahoma City. At that time, the switch was still under development at Bell Labs-Indian Hill and early production prototypes were being built at Northern Illinois Works.

It was the charter of the Oklahoma City Works Long Range Planning Committee (LRPC) to utilize the plant's major resources—people, floor space and capital—to the fullest.

The first meeting of the Works' technical-professional employees soon followed in February 1980. They began the work of getting the Oklahoma City Works in shape to produce what was characterized as "the primary modernization vehicle of the mid and late 1980s."

Sam Kysar, now an assistant manager in engineering for the 5ESS switch, and Dennis Partlow, a senior engineer, worked with the Northern Illinois Works engineers on the specifications for specific capital appropriations for the 5ESS switch covering circuit pack assembly, circuit pack test, unit assembly and verification, cable assembly and test, and unit, frame and system assembly, wire and test.

Kysar, the project coordinator at the Oklahoma City Works, had the equipment personnel reporting to him while the apparatus personnel reported to Paul Odor, an engineering department chief. The liaison engineers spent 50 to 100 percent of their time in the Lisle area from early in 1980 until mid 1981 when they returned to Oklahoma to engineer the introduction of their specialties in their factory.

"We worked much more intimately with Bell Labs and Lisle on the 5ESS switch than on any other product in my memory," says Ed Condron, department chief, Engineering—5ESS switch Circuit Pack Test. "There has been a lot of travel back and forth and internal communications have become critical. Part of the problem has been the short lead time. The other part is the complexity of the product. My department works with more than 200 codes of circuit packs used in the 5ESS switch. The number is somewhat vague because it is still evolving as we combine and separate functions or add new features."

"The 5ESS switch is the system that has put us squarely in the midst of the 'Information Age'," says Kysar. "It now occupies about 35 percent of the factory floor space and that percentage will undoubtedly increase. The capital expenditure for new facilities, primarily test sets, will run about $90 million by the time we get into full production. It is an extremely high-stakes game.

"The first Oklahoma City-built system was shipped to Cedar Knolls, N.J., in November 1982," says Kysar. "About 50 systems are scheduled to be shipped in 1983, and by 1985, production should be on the order of one 5ESS switch per work day."

There are countless manufacturing innovations that will be appearing in trade journals after patent possibilities have been fully explored. There are also some adaptations of good ideas from other locations. The fast-line used at the Denver Works in the production of PBXs has been adapted for use with circuit packs for the 5ESS switch.

Training

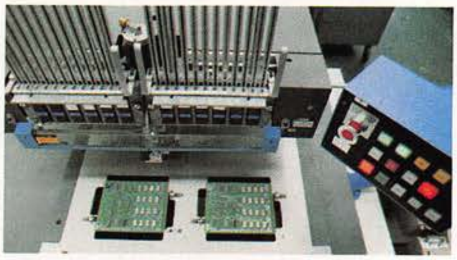
Preparing people for work on the 5ESS switch has become a major operation at Oklahoma City. Technical training classes are conducted on all three shifts. The 41 people who work in the Managed Education and Training Department, headed by Dr. Clem Lepak, conducted 168,207 hours of classroom instruction in 1982. That's an average of 38 hours for every person on roll. And, the classroom hours represent only a small portion of the training iceberg.

In 1976, before the buildup for the 5ESS switch, there were only two people on the Works' roster as trainers, but the demands of the business and the nature of the product have escalated the need for instruction of all kinds. "Our charter is to keep the Oklahoma City Works at the leading edge of technology and to prepare management for continuing change," says Dr. Lepak. "Requirements are changing every day. These courses are just as alive as if they were living and breathing.

"All of our courses are bent toward troubleshooting," Dr. Lepak said. "Troubleshooting is recognizing, locating, analyzing and clearing defects. This same philosophy holds whether it's a course on 5ESS switching equipment or an established product. We are interested in applied knowledge. We are not interested in knowledge for the sake of knowledge. We teach only what you need to know for the job.

"What we provide," Dr. Lepak said, "is high-tech training that you can't find in most technical schools. Our employees are getting something here at company expense that would take them two years in conventional schools—if the schools could afford to get and keep updating the latest equipment.

"Our primary emphasis in 1982," Dr. Lepak said, "was on 'tester training' and it is again the priority in 1983." Last year, a total of 243 testers received 44,000 classroom hours in courses on BELLPAC® power units and systems for the 5ESS switch and the 3B processor family. Through the first four months of 1983, 231 testers have received 22,000 hours of training.



A component insertion machine.

Tester training involves more than just the new technology products. Many employees are entering the test ranks for the first time to fill jobs on the new products. In 1982, there were 247 moves in the tester universe, which meant that 54 percent of the testers at the plant shifted to new jobs.

Testers now make up 20.6 percent of the Oklahoma City shop production work force. Before electronic switching arrived on the scene in the mid-60s, testers represented only 7.3 percent of the population. Testing is a very strong indicator of the changing character of the work at Western Electric.

Dr. Lepak said testers must have basic training in digital logic, BELLPAC® circuit pack logic and instrumentation. The shortest training path for a tester is a little more than 200 hours for a sophisticated circuit pack test. The systems and testbed testers require more than 300 hours training, plus a lot of practice on the shop floor.

"Of course, there is a lot of training that goes on outside of this department," he said. "Supervisors, especially section chiefs, do the bulk of corporate training and development. Training is and will be a prime management function in the 1980s. We train here in the classroom only when the magnitude of training exceeds the ability of the functional shop."

Gene Blalock, who teaches the 3B system course in electronics, believes one of the most important things in his job is to establish credibility with the students "because you have to teach them so much in so little time. Our objective is to develop a course that is straightforward and at the same time, includes all of the information necessary to perform the job. Our students are required to troubleshoot down to the chip level. The technology is such that installation people cannot repair them out in the field the way they used to."

A Growth Process

David Orme, manufacturing manager for 5ESS switches, sees the process of getting people trained, getting the right materials ordered and getting the product into manufacture despite many design changes as "growing pains."

"The kind of problems we are having are ones that you can anticipate when looking at the growth of the program, but we can deal with the process—and we will," Orme said. "We've had a Long-Range Planning Committee for quite a while that's always looking out five years from now. We aggressively pursued allocation of the 5ESS switch. We let the company know that we wanted it and that we were trying to get ready for it.

"The 5ESS switch is the future of the Switching Equipment Division," he said. "It serves all of our customers from the small offices to the large offices designed for major cities. There's a market window of orders for equipment that the telephone companies are going to be buying in any given year. The orders are going to be filled by some company, and we want to be that company. We're trying to hold as large a portion of that business as we can."

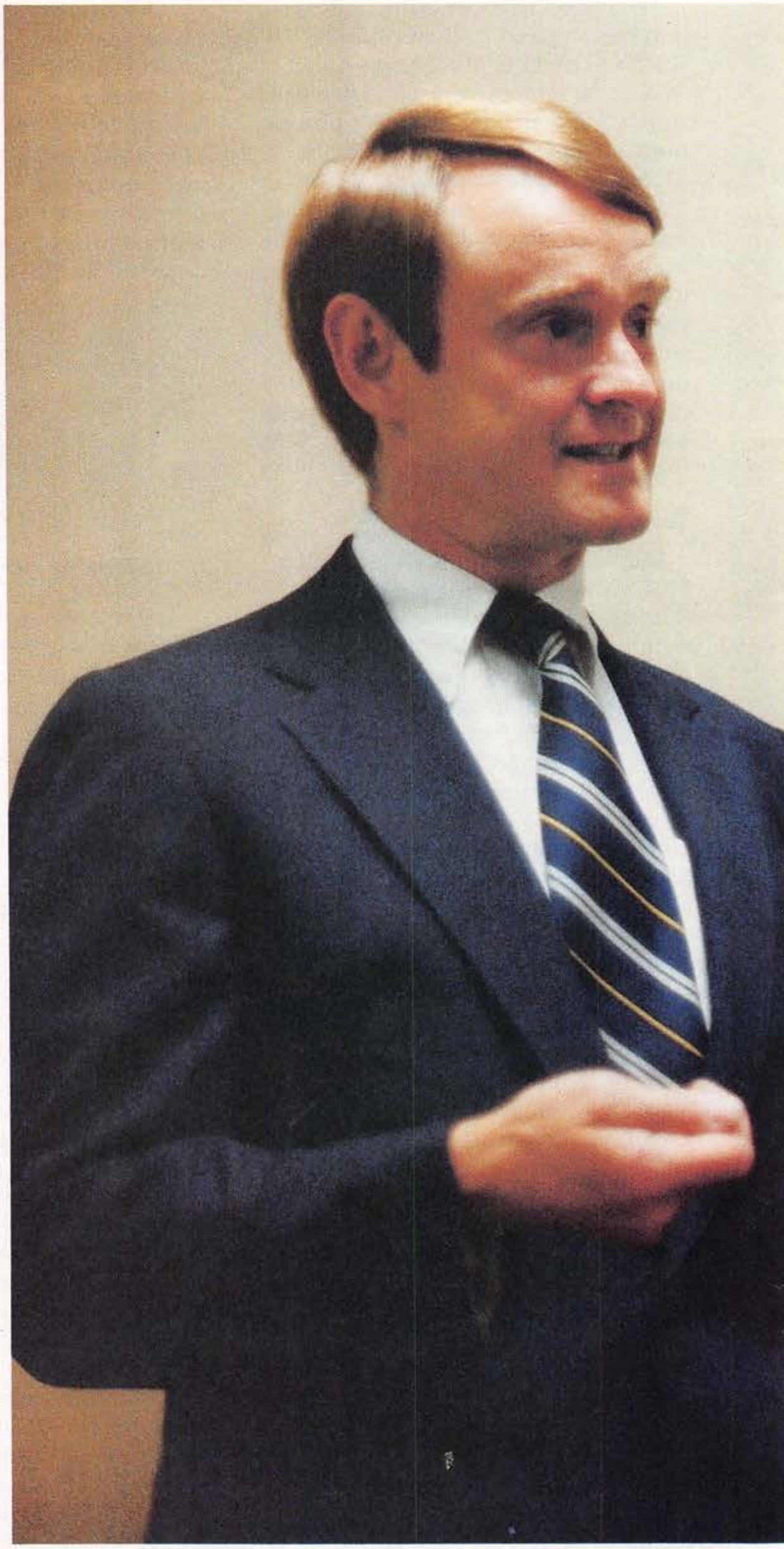
Orme, who has worked with the 5ESS switch program from the beginning, says he likes these "start-up kind of jobs. I like to think that our systems have not totally been designed yet, and that there's a high rate of evolution in our product and in our processes," he said. "Training people for new jobs, managing the growth of the program and coping with all of the design change activity are a part of the start-up process. That's the challenge we accepted. We can do it."

Marketing the 5

By Adele Donohue-Evans

One of several new Western Electric ads appearing in trade magazines. Others are in the works.

WE vice presidents Jim Edwards and Tony Izzo confer in the hall at Southgate. Edwards is responsible for marketing development, Izzo for market planning.



The way we sell the 5 will be different from the way we sell any other Western Electric product.

The 5ESS* switch is "a real winner by every measure" according to Marketing Development Vice President Jim Edwards.

"It's clearly a flagship product," says Edwards, who joined the company in January and has extensive experience in marketing and sales in competitive, high-technology companies. "The 5ESS switch is the result of an enormous investment in R and D and capital. It's the stuff that makes or breaks a company. And it looks like a success story is upon us."

Of course, the customer will play the all-important leading role in the story of the success of the 5ESS switch. The prime customers for the system are the operating companies, or RBOCs (Regional Bell Operating Companies), as they will be known after divestiture.

Market Planning Vice President Anthony Izzo says, "In the future as in the past, the RBOCs will be our number-one customers. We won't abandon them. We'll continue to work to increase their ability to enlarge their revenue streams and develop new and innovative features." Izzo has a first-hand knowledge of operating company problems and needs having spent most of his career in the operating company network services area before joining Western Electric.

Although the RBOCs are the prime targets for the 5ESS switch as well as WE's traditional customers, selling the switch to them will be different from selling any other WE product.

This is true for a variety of reasons: First is the nature of the product itself.

*Trademark of Western Electric

The 5ESS switch is a clear technological leader in electronic switching systems and marks a new era in switching. After 1984, it will be Western Electric's principal switching product.

Another difference is that the product is being introduced in the midst of the divestiture of the operating companies from AT&T. Western Electric will be entering a new era and so will our customers. In selling the 5ESS electronic switch to the RBOCs in the post-divestiture environment, we will have to change our customer contacts and the manner in which we approach them. In the affiliated environment of the past, our sales representatives dealt mainly with telephone company planning and operations people. Now, they must also address the telephone companies' marketing concerns.

After divestiture, the RBOCs, anxious to increase their revenues, will be looking for products that not only are cost-effective, but also generate significant amounts of revenue. In addition to telling the RBOCs what the 5ESS switch does and how it works, WE sales people will also be telling them how the switch's features translate into customer benefits.

Southern New England Telephone's Elliot Wilcox (left) examines fiber optics for 5ESS at the Network Software Center. Guiding him were Art Olsen, Jim Russell and Jim Videtic. Customer visits to the Center are part of the sales strategy for 5ESS.

The third factor affecting the way the 5ESS switch is being positioned is that it is being introduced into a marketplace in which competitive digital switching machines are already in place. In order for our switch to emerge as the leading product in the field, WE sales reps must clearly demonstrate its superiority to other products.

Jim Edwards and Tony Izzo agree that if the 5ESS switch is to be successful, it will require a bold, aggressive marketing strategy.

"The intensity of the competition in the marketplace for the 5ESS switch is going to be much greater than in the past," explains Edwards. "And our style of dealing in such an environment will also be different. A system does not sell itself—even a system as outstanding as the 5ESS switch. We have to translate the value of the product's superior architecture and manufacturing quality into terms that our customer understands."

Izzo adds, "The strategy for marketing the 5ESS switch *must* be different. It's WE's first major product to be introduced just prior to divestiture. So in a sense it is our first major product introduced into the new marketplace.

"With the 5ESS switch, we will be facing competition for similar products—digital switching machines—that are already in the marketplace," Izzo explains. "This 'incumbency' is something relatively new to us."

In addition to the RBOCs, the 5ESS switch is being aggressively marketed to international, independent and government customers. "The switch's adaptability to small and large companies makes it a great product for independents as well as the Bell companies," says Izzo. "Its 100,000-line capacity coupled with its new technology and flexibility make it competitive for use by the AT&T interexchange entity, as well." Izzo also sees plenty of potential for application of the electronic switch and its technology in government business.

Western Electric is counting on the 5ESS electronic switch to make up an increasingly larger portion of its sales in the next few years.

"The successful marketing and sales of the 5ESS switch is critical to the future of this company," says Izzo. "It's the kind of switch customers have been asking for. Its modular design makes it a flexible machine from the standpoint of application and size.

"Using a combination of hardware and software, the customers can mix and match and buy as they want, achieving cost reduction and enhanced revenue streams in manageable pieces. With the full-feature package, the 5ESS electronic switch becomes one of the most versatile products our customers ever had."

To develop an effective sales strategy and appropriate sales message for the 5ESS switch, Corporate Account Management brought together a team known as a Sales Program Development Team (SPDT). The SPDT included representatives from WE's Product Line Planning and Management, Service Line Planning and Management, account teams, Public Relations, Legal, Market Operations, Market Planning and Bell Labs. The team worked together to analyze the selling situation for the switch, set program goals and objectives, and develop sales strategies as well as a plan to communicate these strategies to our customers.

"It was up to the team to come up with strategic selling thrusts for the 5ESS switch and to decide what to say, to whom, and when," explains Ray DeMatteo, Manager, Sales Program Development and Assurance. "The team had to address a dynamic buying situation in which the customer is changing. This required a new selling language that translates product features into customer benefits."

Adds Dick Crean, General Manger, Market Operations, "An important selling step we are taking with this product is writing the 'salesware' in the language of the buyer and not the seller. This is the way we will be marketing and selling our products in the future."

The key to the 5ESS switch's marketing strategy is positioning. The strategy seeks to position the switch in the customer's mind in three ways: first, as the premier digital switch in the Information Age; second, as the standard of excellence in switching, both in terms of reliability and in ease of operation; and third, as the most economical and versatile local/toll switch to meet the Information Age needs of the RBOCs. To allay any doubts about the switch's capabilities and availability, the strategies also attempt to build customer confidence in the stability of the project.

The account management organization will be putting those strategies into practice primarily through direct selling of the switch by sales representatives.

Augmenting the efforts of the sales reps will be sales presentations by the seven regional vice presidents to RBOC executives; advertising; exhibits for use at trade shows; and other printed and audiovisual sales aids. These and other sales aids and tools are part of a comprehensive communications plan developed by the SPDT to support the efforts of our sales representatives. The communications plan also includes a media strategy designed to convey the message to our customers, the general public and employees through advertising, press coverage and company publications.

Six distinctive ads on the 5ESS switching system are running in *Telephony* and *Telephone Engineer and Management* magazines—publications whose readership is largely made up of telecomunications company executives. The ads talk about the new era in switching ushered in by the 5ESS switch and describe a host of opportunities and capabilities that it offers to the industry. Each ad highlights a particular customer benefit of the switch, such as its ability to grow, modular software, reliability, remote capabilities, and revenue-generating features.

A special training session was held in May for all the people involved in selling the 5ESS switch. It was particularly geared towards switching sales representatives, network systems sales managers, and managers of account management. The session was designed to accomplish three objectives: to give our sales people the most current information on the switch and its capabilities; to unveil specific sales strategies and tactics developed for use with customers; and to present a program designed to spread enthusiasum for the sales mission to all our employees.

Sales representatives were given a variety of materials prepared to support their efforts and were then instructed on how and when to use them. For example: when to take a customer on a tour of the Network Software Center or Oklahoma City Works to see the 5ESS switch in production; how most effectively to use the slide-supported sales presentations with a customer; and which of several new eye-catching brochures on the switch to distribute to a particular telephone company customer.

Account managers will be working closely with market planners to identify rapidly and pass along information on their customers' problems or needs.

"We see ourselves as problem-solvers for the account managers' customers," explains Izzo, referring to his Market Planning organization. "It's our job to respond to a customer's problem or need by coming up with a unique application of a standard product."

According to Izzo, his organization's top priority is to honor the commitments that have been made to customers on delivery of the 5ESS switch and specific features.

"We have no doubts about the product's performance," Izzo affirms. "Our number-one challenge is to make available first in 1983 and then in 1984 the product and features called for by our customer."

Edwards adds, "We'll be shipping twice as many 5ESS switches in 1983 as originally planned.

"Demand for the product is so strong that our customers want more than we can make. Right now we are manufacturing-constrained. The solution is to make more of this product. And that's just what we're going to do.

"Western is the premier manufacturing company in the world and has been solving manufacturing problems for a hundred years. I have no doubt that we can handle this manufacturing challenge."

Edwards sees the success of the 5ESS switch as vital to WE's future and the future of the whole network line of business.

"This switch is a winner, but we all have to get behind it to ensure its prolonged success," Edwards says. "It's a big job and represents a tremendous challenge. It is important that everyone in Western Electric understands that we each have an enormous stake in the success of this product. We all have to work together as a team to ensure that the 5ESS switch will continue to receive a winner's reception in the marketplace."

You Can't Tell It From the Real Thing

Photos by Joe Gazdak

Some of the economies associated with 5ESS* switching equipment don't actually come with the equipment. Take the matter of training for telephone company craftspeople and Western Electric installers. This vital function costs a lot less for 5ESS switching equipment than for any other electronic switching system. One reason is that its advanced technology has simplified maintenance so much that both doing it and *learning* how to do it take a lot less time. This means that courses at Western Electric's Training Center in Dublin, Ohio, are considerably shorter—only 33 days for the 5ESS switch maintenance course compared to 64 days for 1A ESS switching equipment, for example.

But there's another reason, too, and it shows how the same kind of innovative thinking that created the 5ESS switch extends into all the Western Electric activities that support it, including training. This second reason goes by the name of *machine simulation*, which is a good name, because it means exactly what it says. Machine simulation is a means of simulating the behavior of real telephone office switching machines, including the 5ESS switch and the 3B20 processor that provides most of its intelligence.

With machine simulation, telephone company students can complete a significant portion of their training without ever leaving their home base. What's more, they can do it at exactly the same kind of terminal they would be using if they were at an actual 5ESS switching office. In fact, they can't tell it from the real thing. Even an experienced craftsperson diagnosing an ailing 5ESS switching office at a simulator terminal can't tell that he is not dealing with an actual switching machine. The beauty of this is that craftspeople are learning their craft on something that costs only a tiny fraction of the real thing.

What exactly is it that does so much for so little? Well, on the hardware side, it consists of a micro-computer system complete with two disk memories, all neatly packaged in a trim white box about the size of an orange crate. What makes this box such a great simulator of real-world systems is, of course, its software. Developed at the Dublin Training Center, this ingenious software can mimic just about every kind of problem an electronic switching office can run into and,

Dick Cieklinski looks on as one of his students "talks" to a simulator.

*Trademark of Western Electric

then, in response to keyboard interrogation from students, communicate that vital information to them.

This kind of keyboard maintenance is known as *diagnostics.* Basically it works like this: When a craftsperson punches in the right code on a terminal requesting diagnostics of a particular unit, the system's software begins comparing that unit's actual behavior with the way it's supposed to behave. It does this on the basis of point-by-point logic, or voltage checks, from one end of the circuit to the other. Whenever there is a difference, it points it out on the terminal's TV screen or on a printer. With further queries, the craftsperson can track the problem down to a particular circuit pack, which is then replaced. The simulator models this complex process without actually running the diagnostic tests.

The simulator's software also incorporates all the rules and constraints that prevent craftspeople from making the kind of mistakes that would put a real ESS switching office out of action. For example, in a real 5ESS switching office, every piece of equipment is duplicated so that one unit can remain in action while the other is diagnosed. This kind of redundancy allows craftspeople to take one unit out of operation for diagnostics while substituting its twin—all while seated at a terminal's keyboard. Real ESS system software won't permit the accidental uncoupling of both identical units, and neither will the simulator. It mimics the redundancy, and it mimics the safeguards that prevent maintenance people from making costly mistakes. It even mimics the exact intervals a real 5ESS system takes to do a complete diagnostic.

The only things not simulated are the time and money saved. For example, 18 of the 33 training days needed for 5ESS system maintenance are devoted to its 3B20 processor. Of those 18 days, students have to go to the Dublin Training Center for only six. They can complete the first 12 days' work at a local Western Electric or telephone company school. The savings in room and board expenses are substantial and effectively reduce the already low cost of the 5ESS switch.

Department chief Bill Malloch, the project manager of Dublin's Machine Simulation Group, sees a host of less tangible, but equally important benefits. "First of all," he says, "the simulator makes courses a lot more interesting. We keep hearing from the field how it motivates students, turns them on and things like that." Reports do, in fact, confirm that students are often seen still working at their terminals at lunch time and other breaks.

"What's more," adds Malloch, warming to his theme, "the simulator eliminates a lot of communications problems between trainers and students by replacing words with hands-on training. The students learn a lot by their own discoveries at the terminals. They can get their own answers to 'what if?' type questions that instructors can't always answer, and they can get them fast."

Want to simulate a different machine? Just change the disk.

Not surprisingly, the instructors are learning almost as much as their students. "For many of them," says Malloch, "the simulator is like going back to Dublin for a refresher course."

The capabilities of the simulator belie its small size. Each unit can handle several terminals simultaneously, and each terminal can handle several different kinds of switching offices. If a student has to break off in the middle of a problem, the simulator will remember where he was and take it from there when he returns.

Dublin's George Teasdale (Department Chief 5ESS Technical Training) points out another of the simulator's many advantages. "A 5ESS switching office is real small," he says. "A complete switcher doesn't even take up as much space as a 1A processor. Because it's so small, our system here at Dublin physically can't accommodate as many students for hands-on training as earlier ESS system gear. The simulator's ability to handle a number of terminals is a big help."

Teasdale's group includes some of the course developers who worked with Malloch's programmers to create the simulator's software. "We put the fenders on the car," he says, "and Bill's group put the motor in."

Sticking to that analogy, he could have added that his people have since come up with a whole new car to cope with the space problem. Called ***hands-on enhancement***, it is a customized software package that doubles the training capacity of Dublin's 5ESS switching equipment. With the ever-increasing popularity of the new digital switcher, they may have to come up with software to double even that capacity.

Thanks to the simulator's multi-terminal capacity, the operating companies don't have any space problems at their training centers. Every company has bought at least one simulator so far, and, if enthusiasm is any indication, things look bright for future sales.

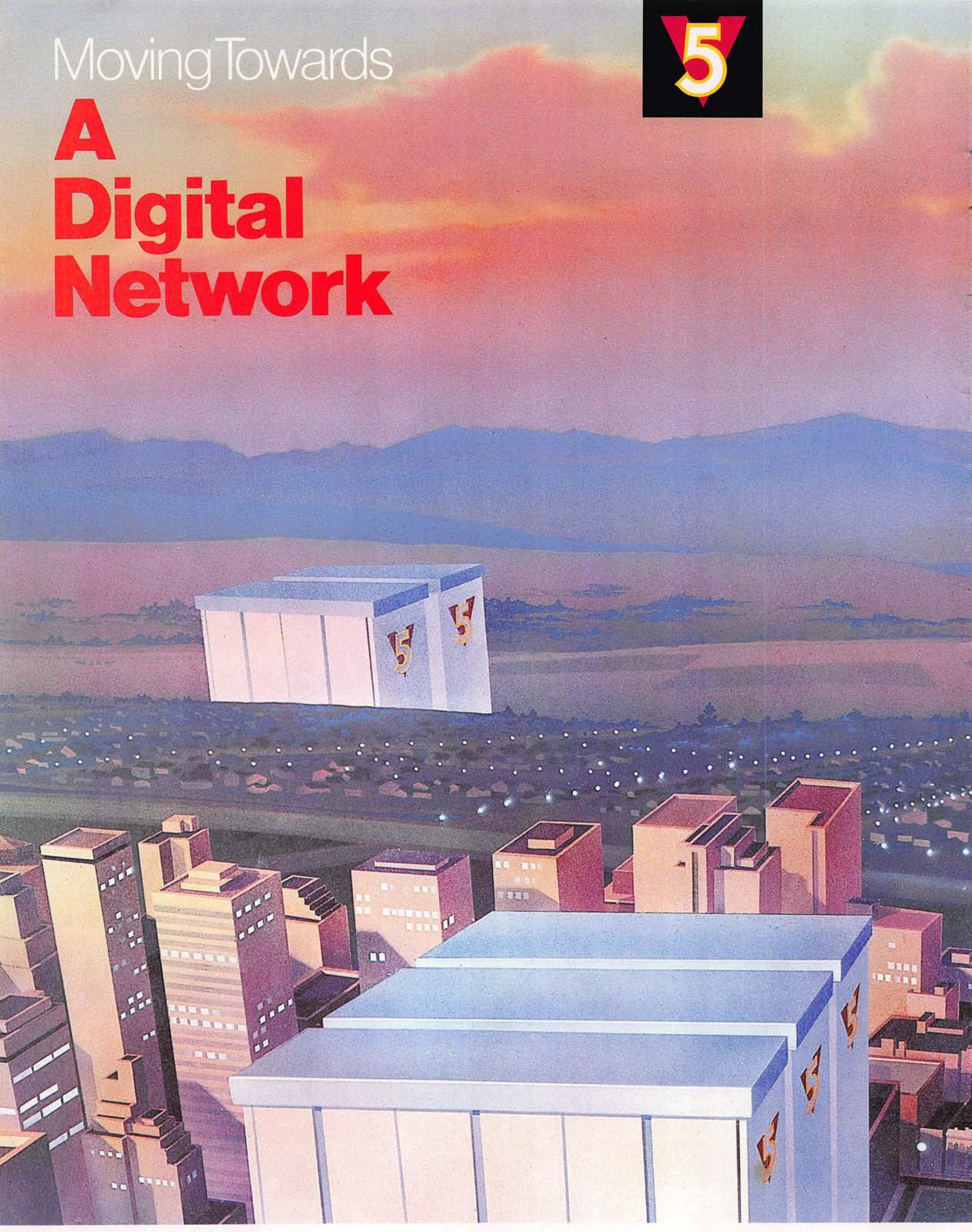
Dick Cieklinski, a New Jersey Bell instructor at the company's Corporate Training Center in South Plainfield, is an avid supporter of the simulator. "It pays for itself very quickly," he says. "Our students used to have to use Dublin's simulator over telephone lines. Our dialup costs alone ran to over $1,500 a month. Now, our only cost is a small yearly maintenance charge for the software."

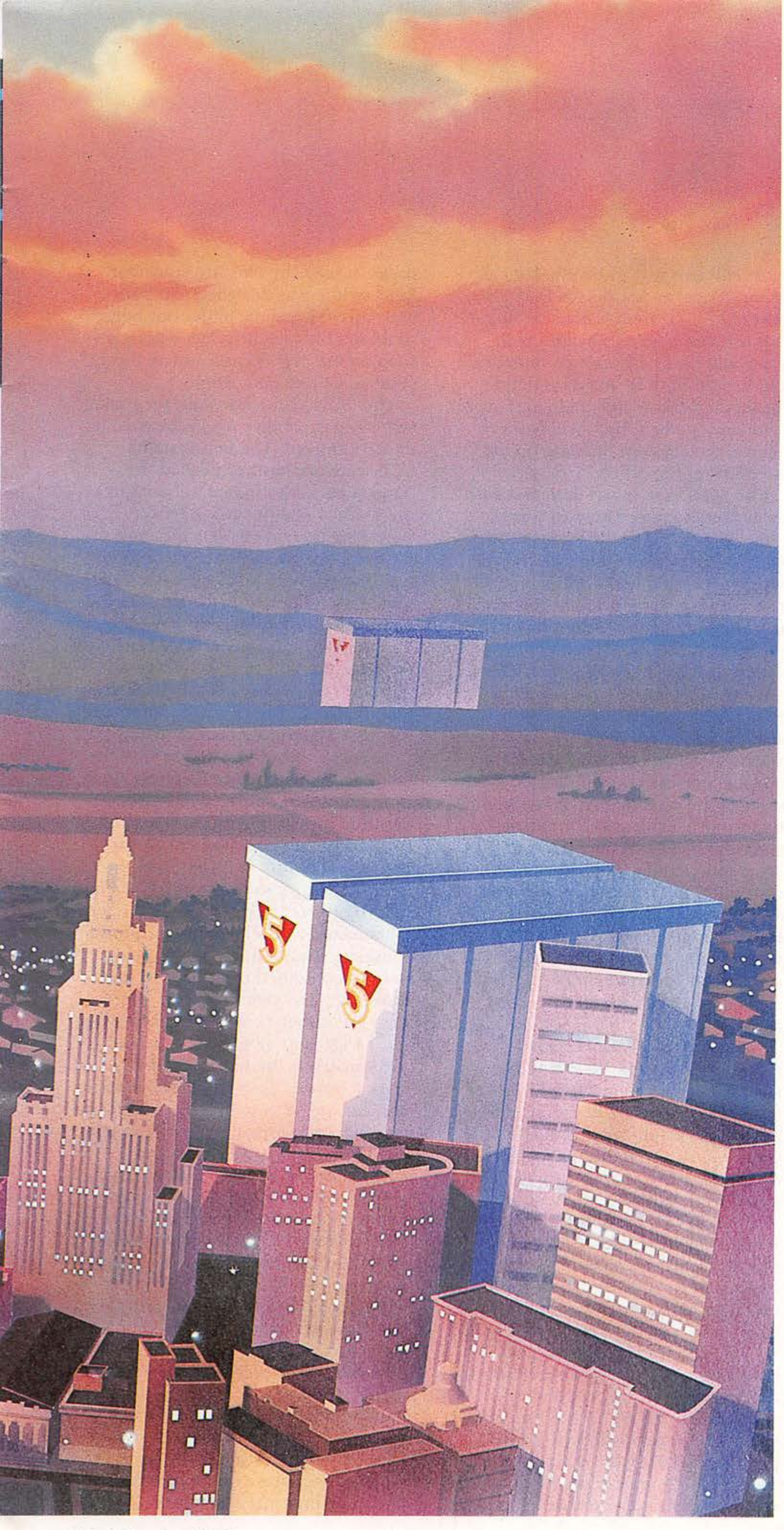
There are three simulator terminals in Cieklinski's classroom, each a hive of activity between lectures. "Students enjoy the course a lot more now," he says. "Without the simulator, the course wouldn't be as interesting, and every instructor feels the same way. It also makes it easier for me. My students know they're going to an actual hands-on assignment after each lecture, so they listen better."

Cieklinski's boss, Bill Wymbs, couldn't agree more. "It was a cinch to install," he says, "and it has worked exactly the way it's supposed to. We think it's fabulous."

Moving Towards

A Digital Network





By Lewis Bayers

Other Corporations are planning for it. We're building it.

There is a vision of the future shared by most planners in the telecommunications industry today. It is called ISDN, which stands for Integrated Services Digital Network. ISDN is a vision of a network that can handle voice, data, video; a network that can handle the needs of the Information Age. In Geneva, Switzerland, a United Nations agency is laboriously working towards defining it. Manufacturers and telephone companies around the world are studying it. Large corporations everywhere are taking steps toward planning for it. In the Bell System, we're already building it. And the 5ESS* switch, our newest, is not only available for today's needs, but is also another major step toward fulfilling the vision of ISDN.

Why ISDN? Well, today, the Bell network handles over half a billion calls each day. These are primarily voice calls, that is, people talking to people. But increasingly, the network is being asked to do more. The Information Age sees computers calling computers, special custom calling services, video teleconferencing, and more. The network needed to handle this must be a network of sophisticated equipment providing sophisticated services. It must be able to handle voice and data, simultaneously. It must be able to switch and transport data, facsimile, video, and special services as easily as it handles voice.

*Trademark of Western Electric

Can today's Bell network handle this? Of course! The vision of the future called ISDN is little more than what we in the Bell System have been building for years—a network of stored program controlled switches, common channel interoffice signaling (CCIS), and digital trunks; a network being built to eventually provide any type of communications transport and service. It's been evolving, growing, improving, since the beginning. Now, with new customer needs, and new technologies available, it will continue to grow. As new products come out of our shops, and new designs come out of the Labs, the network will increasingly handle even more traffic, provide even more services. And the 5ESS switch is a major stepping stone in that evolution.

The ideal ISDN is made up of three network elements. First of all, the ISDN vision calls for an integrated switch. The bulk of today's traffic is best handled by the traditional circuit switching method. Some traffic, however, is most efficiently switched by a method known as packet switching. In the ideal ISDN, we see a single switch that will incorporate both circuit switching and packet switching capabilities. A switch that can simultaneously handle voice, data, even video. A switch that will also provide all sorts of special custom features. A switch very much like the 5.

The second element of an ISDN is an adaptive link, sometimes called a "digital pipe." These are the digital transmission facilities that will carry ISDN traffic. Western's T-Carrier, lightwave, and Subscriber Loop Carrier systems will all be key components of the evolving ISDN. The 5ESS switch is designed with integrated interfaces to all of these systems.

The third ISDN element, in the ideal vision of the future, is a standard interface for all customers. Today, the telephone simply plugs into a wall outlet. Computers need another method to hook into the network. In the ultimate ISDN, this will all be integrated. The customer simply plugs in and starts communicating. The network itself will figure out the best, most efficient way to handle the call. Today, Western's Local Area Data Transport (LADT) system is a major step in that direction, able to handle both voice and data with a single interface, and handle both at the same time. Again, the 5ESS switch and LADT were planned together. They will work together, each system building on the strengths of the other.

The 5ESS switch was designed with evolution in mind. The goal was to build a switch versatile enough to function in virtually any capacity in today's network, while still being able to cope with the inevitable changes that the network or technology will present in the future.

The goal has been achieved. This is possible, in part, because the 5ESS switch is designed as an assembly of semi-independent modules, with a superior software operating system that administers and coordinates the functions of the modules. Each module has its own processor and a modular, structured software architecture, giving it independent capacity and capability. To create a new service, only a small part of the system needs to be changed, perhaps only the software. You just modify the module responsible for that service, plug in some new circuit packs if necessary, and that's it.

In fact, a lot of ISDN capability is already "plugged in" in the 5ESS switch. For example, the 5ESS switch modules are already interconnected by fiber optic links, providing fast communication of internal control messages today, and the promise of broadband capability in the future.

The ISDN vision calls for a high-speed, 64 kilobits per second, data communications capability—that's 64 thousand bits of information per second. The 5ESS switch has this capability today, built into the trunk circuits.

"The breakthrough technology here," says John Leary, Western's Product Manager for Special Networks, "happened with the 1A ESS* and 4ESS* switches. Circuit Switched Digital Capability (CSDC) will be available shortly on those systems. All you need is some additional software and circuit packs. It uses the existing loop. Our 5ESS switch was designed and built with this experience under our belt, so 64 kilobit switched data will be a snap on the 5ESS switch and all three systems will be compatible."

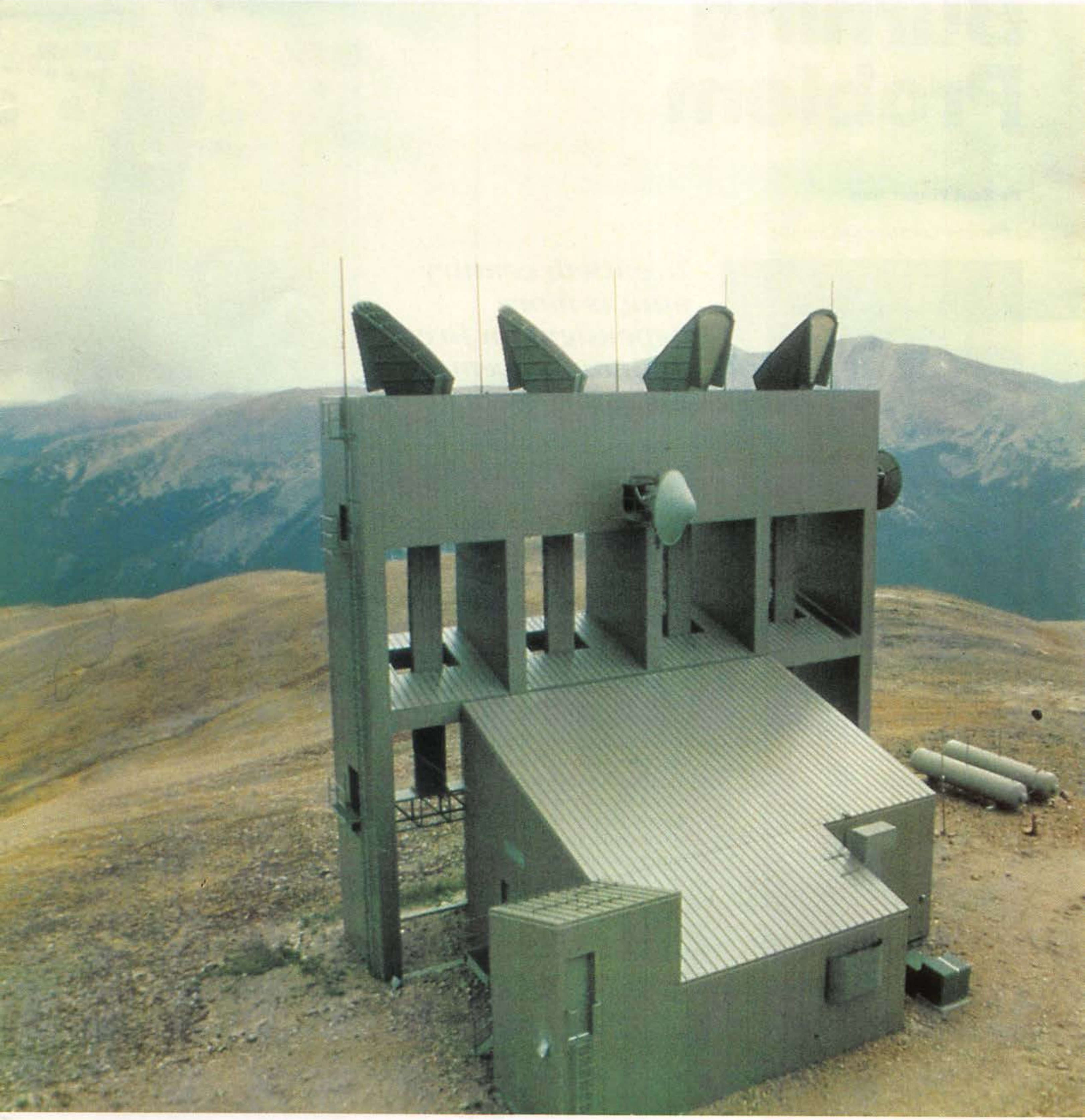
The ISDN vision also calls for packet switching capability. Again, Western is in the forefront. The Bell System's CCIS network has been called the "largest packet-switched network in the world." And our No. 1 Packet Switching System (PSS) is the most powerful packet switch available today. It is based on the 3B20 processor, the same processor that is the heart of the 5ESS switching system Administrative Module. Furthermore, as Karl Martersteck, the Bell Labs executive director responsible for the 5ESS system explains, "Conceptually, internally, the 5ESS system *is* a packet switch."

There's another key reason why the 5ESS switch will be our stepping stone to the future: it has the necessary depth of development resources and total corporate commitment. It has been designed by Bell Labs, the premier laboratory in the world. It's being built by Western Electric, the premier manufacturer of telecommunications products. And both are committed, fully, to continued evolution. In some ways, the 5ESS switch is really more than just a switch. Working along with our 1A ESS and 4ESS switchers, the 5ESS switch is the hub of the ISDN. Jerry Johnson, Western's Product Manager for the 5ESS switch describes it as "the most important project in switching. Not just to Western and our customers, but to the public at large. It'll do more than any other switch; provide more reliable service, more custom services, allow the real benefits of the Information Age to reach more people. It's not only compatible with future visions, but also provides real expense savings, improved operations, and revenues, today."

In other words, it does more for the money—not only for today, but for tomorrow as well. With the 5ESS switch, we're not just building switching equipment anymore. We're building the future of the nation's telecommunications network.

*Trademark of Western Electric

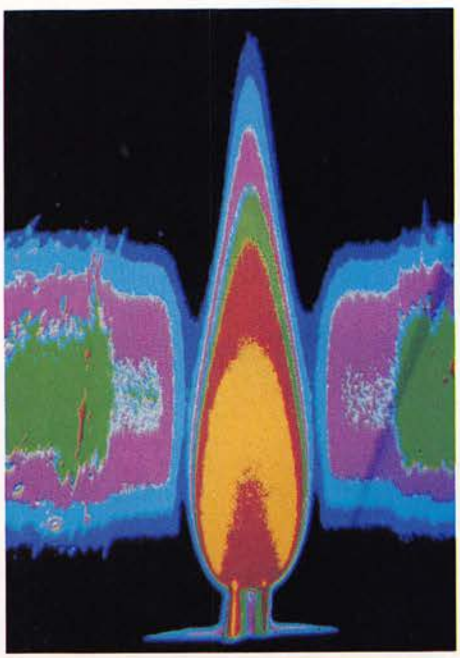
This microwave radio station at Berthoud Pass, Colo., epitomizes the new digital transmission look.



Combustion Is A Burning Problem

By Saul Fingerman

Photos by Len Stern and Sandia



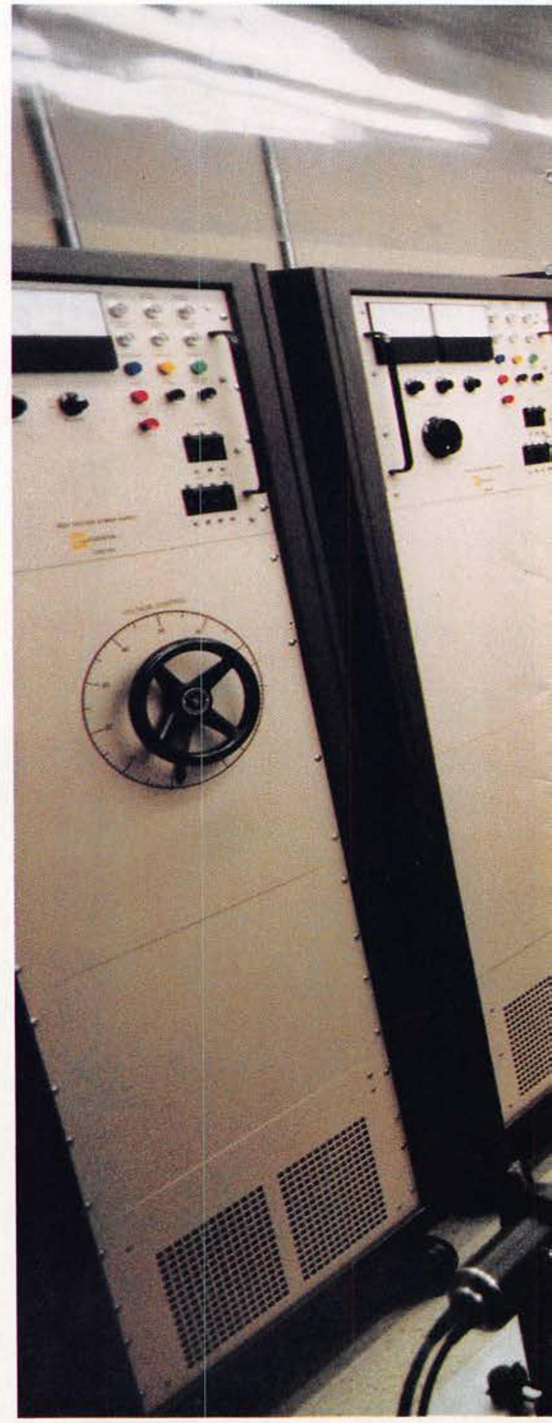
A computer-enhanced photo of laser light scattered by a hydrogen flame.

Twentieth century man is more dependent on fire than our caveman ancestors were

A recent movie devoted nearly two hours to the misadventures of three likeable, but not particularly bright, cavemen who had been sent on a "Quest for Fire" by their tribe. The tribe's own fire had been inadvertently quenched, triggering an immediate outburst of near total panic. Everyone knew that, without fire, life was going to be a whole lot more dangerous and uncomfortable.

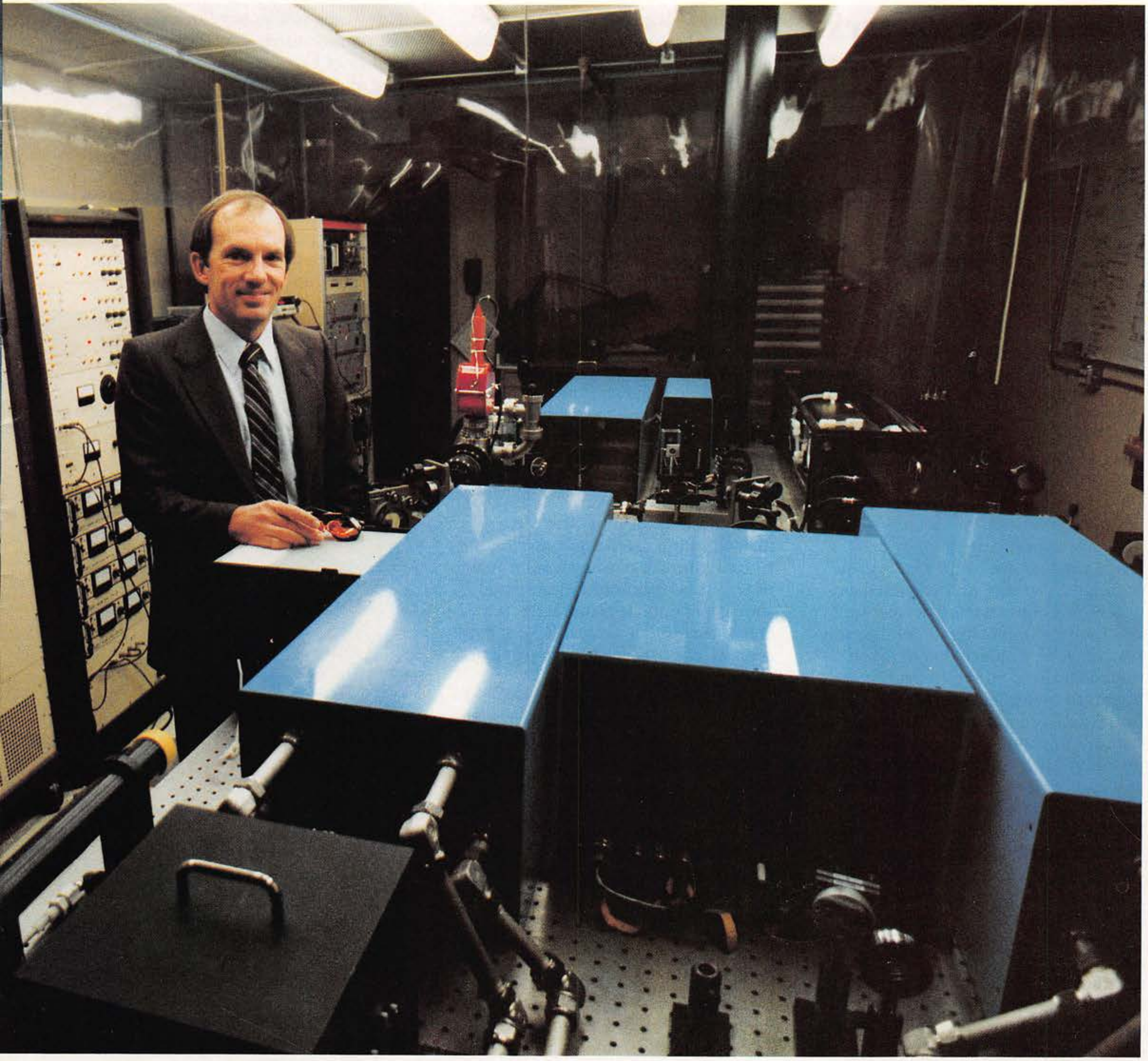
"Quest for Fire" was datelined 80,000 B.C. We've come a long way since then, but our need for fire hasn't really changed that much. We may call it combustion rather than fire, but, in one form or another and by whatever name, we are even more dependent on it than the cavemen were. The fact is that we provide more than 90 percent of our civilization's energy needs by burning something—oil, gas, coal, kerosene, wood and so on.

If you doubt it, think of autos, trucks, buses, aircraft and rockets. Think of power plants and steel mills and cement kilns and factories and virtually any industrial heat source. And, finally, think of how you heat your home. At this point, you should have a pretty good idea of how important combustion is to your life, so you won't be surprised to learn that our government has instituted a twentieth-century version of the quest for fire.



This time, however, the seekers are scientists rather than cavemen, and they are armed with lasers and computers rather than spears and stone knives. And, most importantly, they are looking not simply for fire, but for a better, more efficient and pollution-free fire. Their work is called Combustion Research, and they're doing it in a cluster of five closely-spaced buildings at the Sandia National Laboratories in Livermore, California.

Heading this vital project is a slim and energetic PhD in aerospace engineering named Dan Hartley. An articulate and highly enthusiastic advocate of combustion research,



Dan Hartley and laser at Sandia's Livermore Laboratory.

Hartley was probably the prime catalyst in the creation of Sandia's newest and most important energy research facility. As he tells it, in 1973, President Nixon asked all of the government's National Laboratories for ideas on solving our nation's energy problems. Hartley, who was using lasers to solve fluid flow problems, suggested tackling combustion problems with the same techniques.

"I was excited about it," he remembers. "I saw that virtually all combustion equipment existing today is based on old technology—some of it going back as far as the last century." He also saw that, unless America instituted a major effort, it would never catch up with the extensive combustion research going on in Europe. Marshalling his considerable expertise on the subject, he wrote a proposal for a National Center for Combustion Research.

Washington got the message and funded the project in 1978. In 1980, Hartley and his group of about 90 scientists, technicians and support people moved into their brand new buildings—one of which was, and probably remains, unique in all the world. This is Combustion Research's laboratory building, and what makes it unique is the economical way it handles lasers. The building was, in fact, designed and built around two high-power lasers, both of which are too large and expensive to be cloned in each of the facility's 14 laboratories. Instead, the output of each laser is "shipped" to any lab experiment through a complex system of periscopes and ducts.

Like some latter-day Houdini, Hartley explains that, "It's all done with mirrors." Actually, the mirrors are controlled by computers, and the only magic is in the millions of dollars saved by getting the use of 14 lasers

The auto industry's long-cherished view of hydrocarbon emissions was flat wrong

for the price of one.

The lab building is unusual, too, because it is so vibrationproof, it effectively serves as one huge, optical platform for the laser systems. Researchers are convinced that nothing short of a major earthquake can interrupt the piped-in laser beams around which almost all their experiments are based.

As Hartley's colleague, Dr. Peter Mattern, manager of Sandia's Combustion Science Department, explained, the reason laser beams are so important to combustion research is simple. They are the only medium in existence you can use to "probe" a flame without disturbing it. If you stick any other kind of measuring device, such as a thermocouple, into a combustion system, you've changed it so much, the information you're extracting is bound to be misleading. And, combustion is tough enough to understand without introducing additional complications. It is not only a turbulent and highly transient process—things happen very, very fast—but it also involves interactions between two scientific disciplines that are difficult enough to master by themselves. These disciplines are chemistry and fluid mechanics.

Ironically, everyone who has ever taken a course in elementary chemistry thinks he or she knows all there is to know about combustion. It's just a chemical reaction between fuel and oxygen that generates a lot of heat and light—right? Well, not really . . . .

For one thing, combustion is rarely a single chemical reaction; it is almost always a host of chemical reactions occurring sequentially at dizzying speeds. Just the chemistry involved in the burning of a tiny lump of coal could fill a thick volume—and probably will before Hartley's researchers are finished. The chemistry of pollutants could easily fill another volume.

We know, for example, that ideally, all of a fuel's hydrogen and carbon molecules should combine with oxygen to form energy and a harmless exhaust of carbon dioxide and water. We also know that, like most ideals, it doesn't happen that way, and we're pumping a lot of nasty pollutants into our atmosphere. What we don't fully understand is how this happens. Nor do we understand the instant-by-instant mechanics of the turbulence that makes combustion so violent a process. Complex almost beyond any known mathematical description, such turbulence is largely what combustion fluid mechanics is all about. This highly esoteric science is devoted to the study of gases in motion, and, flames—for all their special characteristics—are made up of moving, ever-changing gases.

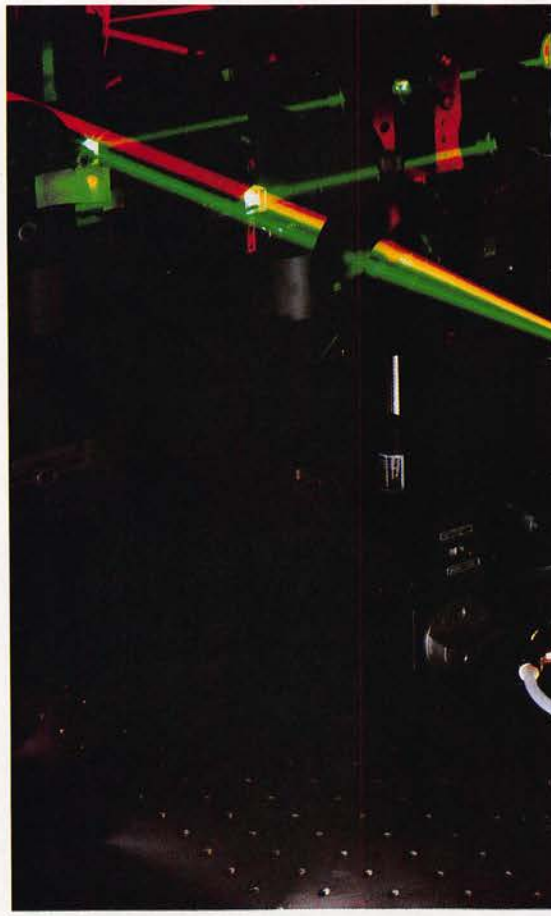
It's not too useful for producing energy, but there is such a thing as a non-turbulent flame. Romantics call it candlelight; scientists call it *laminar* flame. What makes it laminar is that the fuel (paraffin) mixes with oxygen by diffusion, and does it so slowly there is no turbulence. What there is instead is a lot of soot. The truth is that, although candlelight may be the stuff of intimate evenings and romantic poetry, it is based on the formation of soot. The lambent gleam reflected across the dinner table in lovers' eyes actually consists of glowing particles of the stuff.

Less romantic, but far more useful are turbulent flames, since they're the only kinds capable of productive work. Interestingly enough, they are made up of lots and lots of little laminar flames—which is one of the reasons they are so complex.

Fortunately, lasers are perfect for unraveling the mysteries of turbulence as well as of the intricate chemistry that accompanies it. As we already noted, their beams don't perturb the gases under study. What's more, their light-speed velocities permit nearly instantaneous "snapshots" of the violent events that go on in combustion. These "snapshots" are actually long sequences of data, but to scientists they are just as graphic as photos.

Hartley's people have figured out a wide variety of ways to use their laser beams to extract all kinds of vital information. In one laboratory experiment, for example, three laser beams are fired into a one-cylinder gasoline engine. The beams enter through transparent portholes of thick artificial sapphire and exit out the other side through a similar porthole. Once out, however, the beams are no longer the same. In the cylinder's turbulent inferno of burning gases, the beams combine to form a fourth beam of a different wavelength. This beam is loaded with the kind of information that warms researchers' hearts—things like temperatures, densities and velocities of gases at different points of time and space.

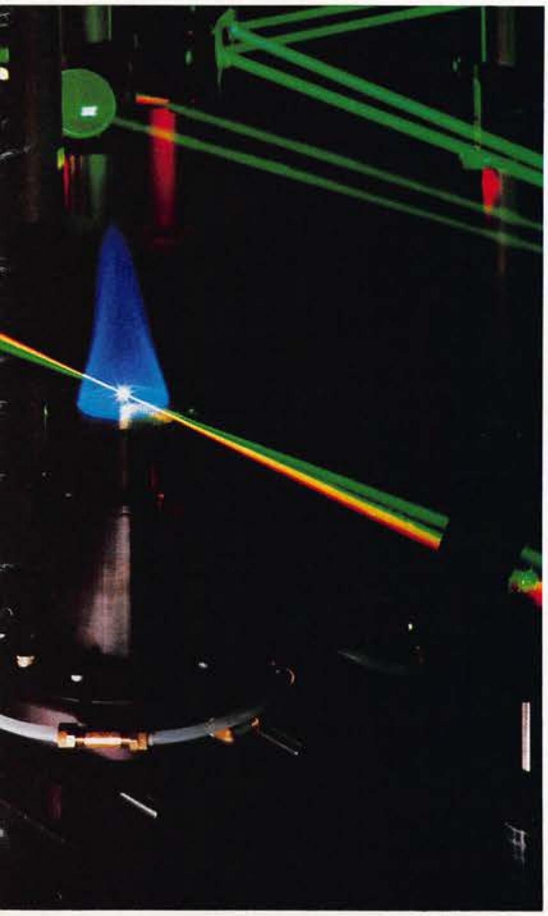
One of the lab's one-cylinder engines is like no other you've ever seen. In addition to its sapphire portholes, it has four spark plugs. Why four plugs for a single cylinder? "So you can tailor the flame spread to study a variety of knock and pollution problems," answers Hartley. "Efficiency depends on how, when and *where* you ignite the fuel. For example, the current location of spark plugs may be all wrong because the designers didn't know how to take into account all the processes going on. We're trying to describe these processes well enough to find the best location for ignition. We don't know these details yet, but we'll find out."



Three laser beams probe a cone of flame to provide Sandia researchers with vital information.

In point of fact, Combustion Research has already found out plenty. For example, Sandia scientists and their co-workers have proved that the auto industry's long-cherished view of hydrocarbon emissions from engines was flat wrong. "Prior to this work," says Hartley, "they assumed a flame propagated out to the cylinder wall, where it was quenched because the wall was relatively cold. They were sure this quenching left a thin layer of unburned fuel that was exhausted as pollutants. We proved it doesn't happen that way."

What this team proved was that a fuel's hydrocarbons diffuse into the flame (which isn't quenched, after all) and are consumed. That bit of hard-earned information has set auto indus-



try researchers off looking in other directions for pollution sources. At the moment, they are fairly convinced the culprit is fuel trapped in piston ring crevices. And, if they can understand it, they can fix it.

Some of the information Combustion Research regularly feeds to the auto industry has already paid off handsomely in terms of significantly improved gasoline mileage and pollution control—a fact that was graciously acknowledged by General Motors.

"Right now," adds Hartley, "a big push in the auto industry is to come up with computer-controlled engines." The missing link is a definition of combustion precise enough to tell computers what to do to correct everything from cold start to mountain driving. The microprocessor chips are smart enough to handle almost anything you can measure—but how do you know which things you want measured and how you want them controlled by the computer unless you understand all the interrelationships?

Hartley is convinced that, even if the path to understanding is still pretty dimly lit, his group's work will help light the way for others. "Our approach," he says, "is to not only do research, but also to develop the special tools you need for that research." By special "tools," he means more than laser systems, see-through engines and other technological esoterica. Primarily, he means the many computer programs and mathematical models his researchers develop for other scientists who share their quest.

And there are many. The auto industry isn't the only beneficiary of Combustion Research's work. Any industry involved with any kind of combustion is privy to their findings. If they want, outside companies can even send their own scientists to Sandia to do their own research. "All the companies have to do is pay their salaries and living expenses," says Hartley. "As long as their work is important and not proprietary, we'll provide the facilities. In our two years of operation we have had nearly two thousand daily visitors with over three hundred staying for the better part of a week to several months to solve a special problem in combustion. The system works."

In addition to state-of-the-art lasers and electronics, those facilities include access to a Cray computer—the fastest and most powerful machine of its kind. It takes a voracious number cruncher to cope with the convoluted mathematics of combustion.

Not surprisingly, there are a number of mathematicians on Hartley's staff. There are, in fact, several disciplines represented at Combustion Research, including physics, chemistry, engineering and mathematics. Hartley considers this interdisciplinary approach vital. "You can't go to college and major in combustion," he says by way of explanation.

The synergetics of the interdisciplinary approach are reminiscent of Bell Laboratories. "Sandia's Combustion Research facility," acknowledges Hartley, even has a Bell Labs' scientist on its advisory board." This is only partly due to the fact that Western Electric runs Sandia for the government. "It's also because we want all the input we can get." says Hartley.

Lately, he has been getting more than just cerebral input. In recognition of the good things that have already come out of his laboratories, the government has granted Hartley the researcher's ultimate accolade—increased funding. His lab building is being expanded; a new high-power laser is being installed, and he will likely receive an additional $21-million in fiscal 1985 for the expanded lab space and equipment.

That money isn't going to go into new engines or fuels. "That's not what we do," says Hartley. "Ours is the long-term goal of inventing scientific methods for doing combustion research."

Even so, what those methods may lead to in the hands of industrial researchers makes for exciting speculation. And the excitement is heightened by little tidbits such as the recognition that a mere one percent increase in auto engine efficiency can save this country nearly one-billion dollars a year in imported oil.

"In addition," says Hartley, "our research can lead to alternative fuels, such as coal derivatives. This is an area that has been virtually ignored up to now." A firm believer in the promise of coal, Hartley presented a paper on the subject in 1982 to the House Subcommittee on Energy Development and Application. In it, he pointed out that, although America's coal makes up nearly 90 percent of our entire energy reserves, its use accounts for less than 20 percent of the energy we consume.

This vast hoard of black gold holds the promise not only of easing our energy problems, but also of improving our unfavorable balance of payments situation overseas. However, Hartley made no attempt to minimize the enormous problems dimming some of the luster of that promise. "Coal," he admitted, "is a dirty, nasty, inconsistent fuel, and it burns in a highly polluting, corroding, and unreliable manner."

Can these problems be solved? "Yes, indeed," says Hartley. "If we can unravel the chemical paths in coal combustion, we may be able to find practical ways to interrupt them and prevent soot formation and other kinds of pollution."

With characteristic optimism, he notes that, "We've already had some promising results from our coal research. We're on our way—well on our way!"

By Bobbie Campbell

Threads of Gold

Del Nauman at the lab at Indianapolis Works.

A number of years ago, there was a great Hollywood epic called "The Crusades." In the climactic scene, King Richard the Lionhearted, in the white armor, comes face to face with Saladin, the arch villain.

There was a minimum of dialog in such epics, and so Richard, the strong silent type, to demonstrate the strength and technical superiority of the Christians, takes his heavy broadsword and comes down with all his might on a huge timber. Precut by the prop department, the timber breaks on cue. Saladin, in response, tosses a silk scarf in the air, draws his sword, and as the gossamer material floats across the curved blade, it is cut in half.

It's questionable that any such a confrontation took place in real life, but the dramatic scene did demonstrate effectively that 1,000 years ago, when the Western World was involved with wrought iron and cast bronze, in the desert city of Damascus, alloys were being made that could take an edge equivalent to our modern razor blades. The secret of how that metal was made has been lost for centuries.

Another metallurgical mystery that has intrigued researchers for years are the so-called "gold threads" in ancient tapestries and ceremonial robes. Although they look to the naked eye like fine gold wires, the threads are actually silk or linen cores spirally wrapped with incredibly thin strips of gold-coated metal. The mystery is how did artisans hundreds, perhaps even 1,000 years ago, make the paper-thin metal, cut it into almost invisible strips and face it with gold.

The answer is that we still don't know for sure. But when a new exhibit called "Fabrics in Celebration" opens at the Indianapolis Museum of Art after Labor Day, visitors will be able to see the results of one of the most thorough investigations of the subject ever made. About 100 major pieces in the exhibit, which spans the years from 250 BC to the present, incorporate precious metal threads.

The investigators were Leon Stodulski, a professor of chemistry at Indianapolis University/Purdue University in Indianapolis, and Del Nauman, a senior engineer at the Indianapolis Works.

After Prof. Stodulski completed his emission spectrographic bulk analyses, Del used sophisticated equipment in the WE laboratory to cross section the threads and analyze the metal overlays. This was done using an ultramicrotome and a scanning electron microscope/energy-dispersive X-ray.

"Hospitals use a microtome," he said, "when analyzing biopsy samples. For studying the fibers from the museum, I first mounted the thread in epoxy resin and then sectioned it with the microtome using a diamond knife. The specimen was then placed in the vacuum chamber of the microscope and scanned with a narrow beam of high energy electrons. A series of photographs of the thread, at magnifications of up to 10,000 times, and X-ray analyses were obtained for measurement and study."

The electron microscope examination of the cross sections showed the gold to be a very thin layer on the outer surface, so the entire thread appeared gold.

An intriguing part of this work was comparing the metal wrappings in the ancient textiles with the metal deposition on contemporary products.

Del's X-ray investigation of the construction of metal overlays showed that the gold layer thickness averaged only about 8 millionths of an inch.

"It is remarkable to me," he continued, "to see how thin ancient artisans could make the gold. At Western Electric, we cannot use the techniques demonstrated in these fabrics. To get gold as thin, Western Electric turns to expensive equipment.

A supplier uses a rolled method to laminate about 200 millionths of an inch of gold on the frequency springs for the Touch-Tone* telephone dial. Even though it's 25 times as thick as in the threads, we have had trouble getting the gold overlay that thin on these parts."

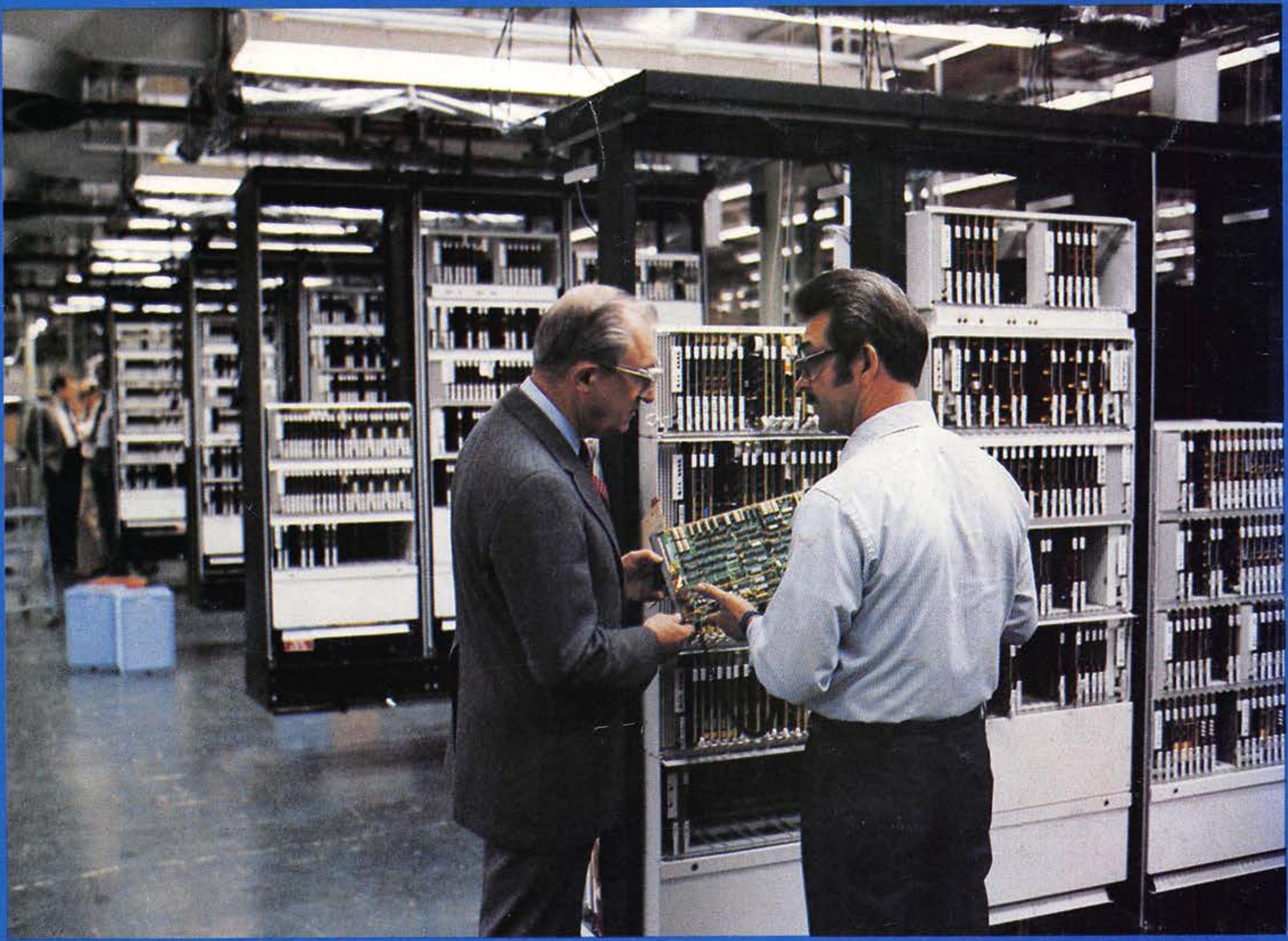
The museum is excited about the team work that brought industry and education together in this project.

This is the first time an analysis has been done on the fabrics in the Museum's collection. The staff says it was only possible at this time because of the generosity of Western Electric in lending its resources under Del's guidance.

The Western Electric Fund has previously supported the Indianapolis Museum of Art through Performing Arts grants.

*Trademark of AT&T

Del Nauman, Prof. Stodulski and the museum's Harold Mailand.



Don Procknow
in Oklahoma City test area with Mel Gering.

See page 14.

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