

# BusinessWeek

OCTOBER 12, 1998

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**ENTERPRISE**  
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Clark's  
next big  
idea



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Here come  
products that see



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Will the growth  
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going?



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# GLOBAL RISK

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OCTOBER 12, 1998

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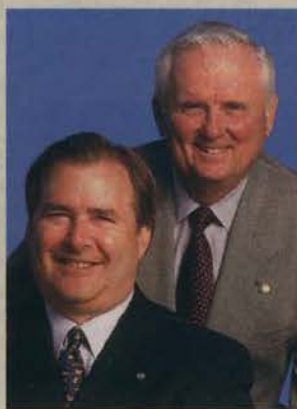
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# SILICON EYES

How chips that see will transform the way we live

**A**t a Kroger's grocery store outside Houston, customers cashing paychecks must first put their fingers on an optical scanner at the service desk. The images are relayed to a personal computer, which compares them with fingerprints stored in a database—and flashes a yes or no decision within seconds. The price of the device, now about \$1,000, should fall to \$100 in a year or two. Since it was installed in February, it has eliminated check fraud.

The key to the price drop is a dramatically new kind of imaging chip. The

of strategic marketing at Texas Instruments Inc., which supplies components to Nokia. When cell-phone networks get the capacity to handle video data, the phones will be ready.

Another application for the new imaging chips is being explored at Donnelly Corp.'s research and development center in Holland, Mich. Tiny digital-video cameras using the new chips are being mounted on a van's side mirrors and back end to provide a sweeping, wide-angle rear view on a dashboard display. Such digital rearview "mirrors" could show up in cars in two to five years.

These new devices and many others like them are pointing to the next wave in the digital world: machines

with human-like senses. The long-term potential of sensory computers can be glimpsed today at Massachusetts Institute of Technology, where a robot named Cog watches its creators through silicon eyes as it juggles a Slinky. Cog keeps a watchful silicon eye on the researchers' comings and goings, because that's how it learns. Cog is being educated as if it were a child. And it is now so perceptive that the researchers often treat it like a human, says its maker, MIT computer scientist Rodney A. Brooks.

Cog's silicon eyes are made with special chips that process images as deftly as PC chips chew through spreadsheets and words. These new imaging chips, with all of their applications, are creating "a huge new business opportunity," declares Donald M. Whiteside, head of Intel Corp.'s digital-imaging efforts.

**"THE MIND GOES CRAZY."** The imaging chips promise to transform the industrial landscape, the office, and the home. "The mind goes crazy thinking about all the ways these chips can be used," says R. John Fairholme, director of Motorola Inc.'s imaging-chip business. Cars could recognize when the front-seat passenger is a child and adjust air-bag deployment accordingly. Airplanes could have an army of chips standing watch over mechanical systems, from the landing gear to the fuselage joints and seams. And heart surgeons could leave tiny silicon eyes in a patient's chest to monitor their handiwork in the critical hours following an operation.

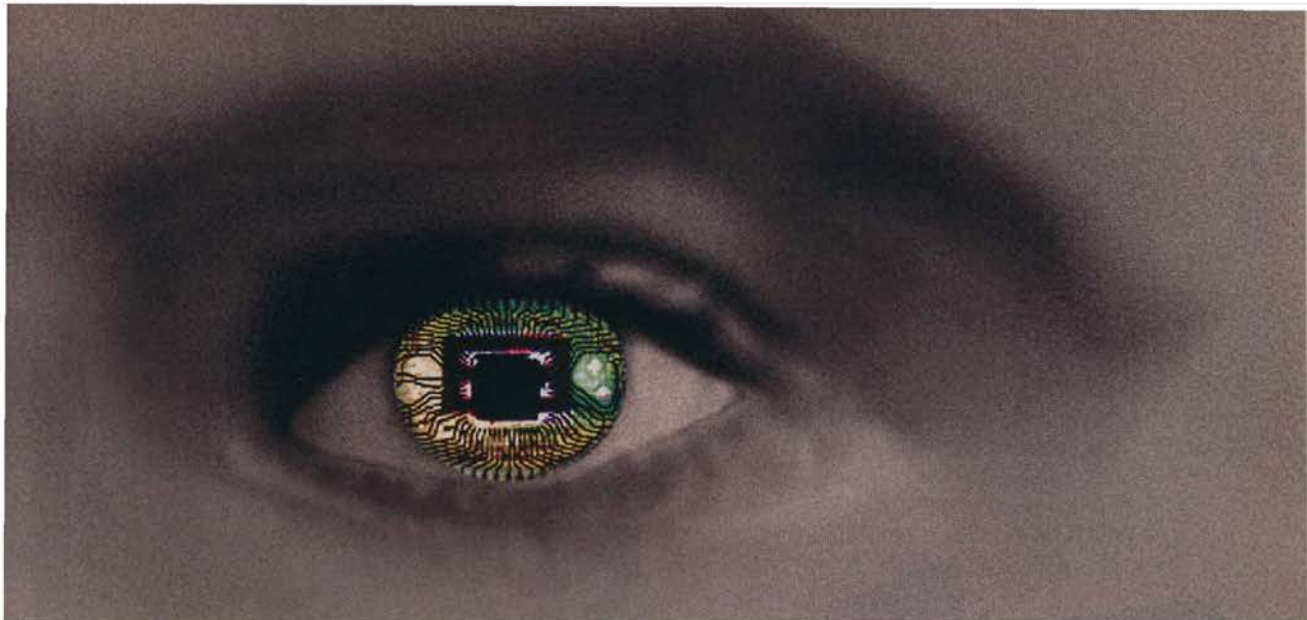
The hottest market at the moment is for digital cameras, which are already on the shelves. But impending applications will gobble up far more chips. "Cameras are just the tip of an iceberg," says David Escobar, director of digital imaging at Rockwell Semiconductor Systems Inc., which has been

## Science & Technology

chips, just now arriving, are sparking a dizzying variety of applications.

In a Sony Corp. research laboratory in Silicon Valley, for example, scientists have developed the prototype of a pen-size digital camera that plugs into a cell phone. The combo can snap a photo of a newborn baby while the phone records the cooing between mother and child and then zip the multimedia package off to the grandparents in seconds. Finland's Nokia Group is also "pushing hard on putting an imager into a cell phone," says Douglas S. Rasor, vice-president





making top-secret imaging chips for the military since the early 1990s. Now, its silicon spies are coming in from the cold and entering the commercial realm. Consultants at Cahner's In-Stat Group, based in Scottsdale, Ariz., see the imaging-chip market, including the products the chips are used in, growing by 60% to \$23 billion in 2002, with a 300% increase in the number of products sold. In-Stat research director Mark Kirstein says that estimate is conservative.

In any case, the market projections have prompted silicon heavyweights to pump hundreds of millions of dollars into imaging technology. In the U.S., Atmel, IBM, and National Semiconductor are among the chipmakers racing to stake out market positions. The compe-

tition includes NEC, Sony, and Toshiba in Japan and Philips Electronics and Siemens in Europe. There are also a bunch of ambitious newcomers, such as G-Link Technology Inc., Photobit, and Scotland's Vision Group, which shipped more imaging chips in 1997 than in its previous six years.

**LIGHT INTO INFORMATION.** The digital-imaging wave has built since 1969, when Bell Telephone Laboratories invented a new breed of chip—the so-called charge-coupled device, or CCD. These old-style imaging chips convert light into streams of digital information that can be used to assemble images. CCDs soon replaced the video tubes in yesteryear's bulky TV-studio cameras, paving the way for today's portable camcorders.

The next important development, which kicked off the consumer-products revolution, was another Bell Labs innovation in 1979: the digital signal-processing chip. DSPs are specialized chips designed to deal with the enormous digital content of pictures and sounds, which can choke ordinary computer chips. Texas Instruments Inc. believes so strongly in the future of sensory computers that it has sold off all of its other businesses to focus on DSP chips. "DSP spans everything from digital cameras and cell phones to PCs and consumer electronics—and more," says TI Chairman Thomas J. Engibous.

The most recent development, which is leading to the rapid drop in prices for imaging chips, occurred in 1996. That



## SILICON EYES WILL SOON BE EVERYWHERE

**CONSUMER PHOTOGRAPHY** New "smart sensors" will automatically correct exposure and allow images to be edited, by cropping or reducing redeye, right on the camera.

**COMPUTERS** "Eyeball" digital cameras will be built into monitors for video mail or for verifying the user's identity. Keyboards with built-in fingerprint scanners will substitute for passwords.

**HANDHELD GADGETS** Small digital cameras will soon become common accessories for cellular telephones and personal digital assistants.

**RETAILING** Fingerprint and retinal scanners that can instantly verify someone's identity will be widely used by retail stores, banks, and government agencies.

**MEDICINE** Imaging chips may help blind people see and will be commonly used in surgery.

**CARS** Digital cameras will supplement rearview mirrors, check tire pressure, and monitor occupants as part of advanced safety systems.

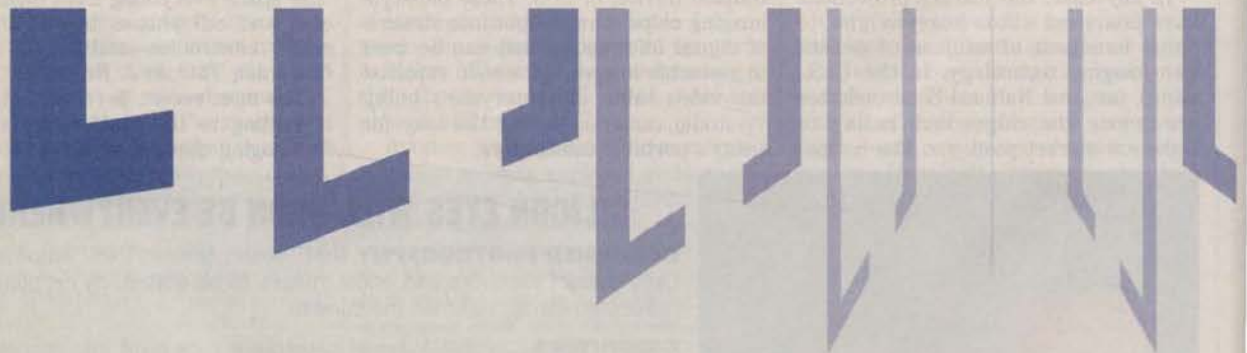
**INDUSTRY** Among hundreds of possible applications, digital technology will sharply reduce the cost of sophisticated security systems and allow aircraft makers to monitor hard-to-reach places inside airframes.

**VISION GROUP'S PETER DENYER PEERS THROUGH A DIGITAL CAMERA**

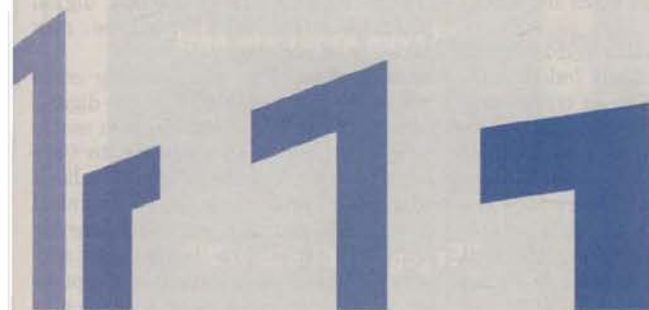
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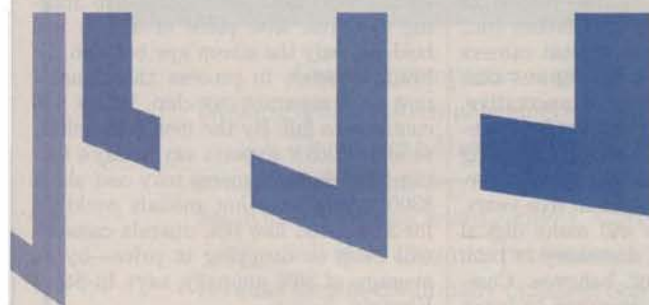
**Is your network, or your company, the same as it was two years**







go? Neither is Windows NT Server 4.0.



On July 29, 1996, we introduced Microsoft® Windows NT® Server 4.0. The idea behind this server operating system, as with 3.51, 3.5 and 3.1 before it, was that customers would benefit from an OS that runs their network and their business applications. It was about integration, and it still is. But a lot has changed in two years.

To keep up with the changing needs of customers, we've added hundreds of enhancements since 1996. In fact, today's Windows NT Server 4.0 is far different from the one we first shipped. For starters, we've improved file and print performance, and updated Web and application services. We've also enhanced networking and communications services, and enabled streaming media. And, we're committed to continued improvement as we work to provide a solid migration path to Windows NT Server 5.0.

So how have these improvements been received? In just two years, about 640,000 U.S. companies have installed over 1 million copies.

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## CHECK IT OUT

Kroger's supermarkets in Houston are the first stores to scan fingerprints. The images are sent to a computer database, which can then authorize a customer's check within seconds

ing its focus to even faster digital imaging. Many experts say that digital photos from the better digital cameras, costing about \$700, match the quality of film snapshots—and digital cameras could soon be even cheaper than today's film models. That could make for a buying surge.

The dramatic reduction in prices has already led to a remarkable device—a credit-card-size \$50 camera for use in Nintendo's Game Boy, its portable video-game machine. The camera slips into the cartridge slot built to accommodate video-game cards. During its first month on the market in Japan, Nintendo sold 800,000 of the cameras.

By 2002, predicts market researcher International Data Corp., filmless cameras will be running neck-and-neck with analog models. Digital sales will zoom more than tenfold, to 29.5 million units, says IDC. Nikon Inc., which unveiled its first digital camera for consumers last March, figures that IDC's projection could be conservative. Nancy Carr, national marketing manager for Nikon's new Electronic Imaging unit, says filmless models might overtake conventional cameras in five years.

Plummeting prices will make digital cameras a popular PC accessory in both homes and offices, IDC believes. Companies will install PC cameras to boost teamwork and facilitate collaborative projects that span departments or multiple geographic locations.

Videoconferencing will provide a cheap alternative to business travel, because eyeball cameras perched on computer monitors will soon cost no more than a computer mouse.

The "killer application" for digital cameras could be video mail. Today, text-based E-mail dominates Internet traffic. Adding still or moving digital pictures could lift E-mail to new plateaus of popularity.

**BRAINS, TOO.** The new imaging chips are expected to grab 60% of the digital-camera market by 2002, up from essentially zero last year, according to Cahner's In-Stat. And they'll grab the lion's share of other markets for items linked to PCs. For example, semiconductor researchers expect low-cost imaging sensors to appear on keyboards and laptops as fingerprint readers or vision chips that can recognize faces. That will end the need to remember passwords. In July, Compaq Computer Corp. unveiled a fingerprint reader that costs just \$99.

A further advance in imaging chips should occur next year: single-chip imaging systems. One piece of silicon will hold not only the silicon eye but also the brain it needs to process the signal—now on a separate DSP chip. Prices will continue to fall. By the new millennium, semiconductor experts say, today's top-tier \$800 digital cameras may cost about \$300, while snapshot models could go for \$100. And like PCs, upscale cameras will keep on dropping in price—by an average of 30% annually, says In-Stat's Kirstein.

Even digital optimists doubt the new technology will

was the arrival of a new kind of imaging chip that uses CMOS technology. That stands for complementary metal-oxide semiconductor—it's the same technology used to make ordinary computer chips. The new imaging chips, then, can be made as cheaply as PC chips. The old-style imaging chips required costly, special-purpose production lines because they are custom made.

**DIGITAL DELIGHT.** Prices of chips that can capture images with more than one million picture elements, or pixels, have already dropped below \$40, says Peter Denyer, chief executive of the pioneering Vision Group PLC in Edinburgh, Scotland. The chips also use less battery power than the old-style imagers and produce the same image quality, Denyer says.

Many of the world's leading builders of electronic systems see digital imaging as the next big ticket to growth. That view is shared by makers of photographic film—notably Eastman Kodak Co.—and by camera companies. "There's not really a lot you can do nowadays to improve 35mm cameras," says Jeffrey L. Lengyel, marketing manager at Ricoh Corp.'s Consumer Products Group. "The excitement is focused on digital."

Even Polaroid Corp., which has built its empire on instant film, announced last spring that it is shift-



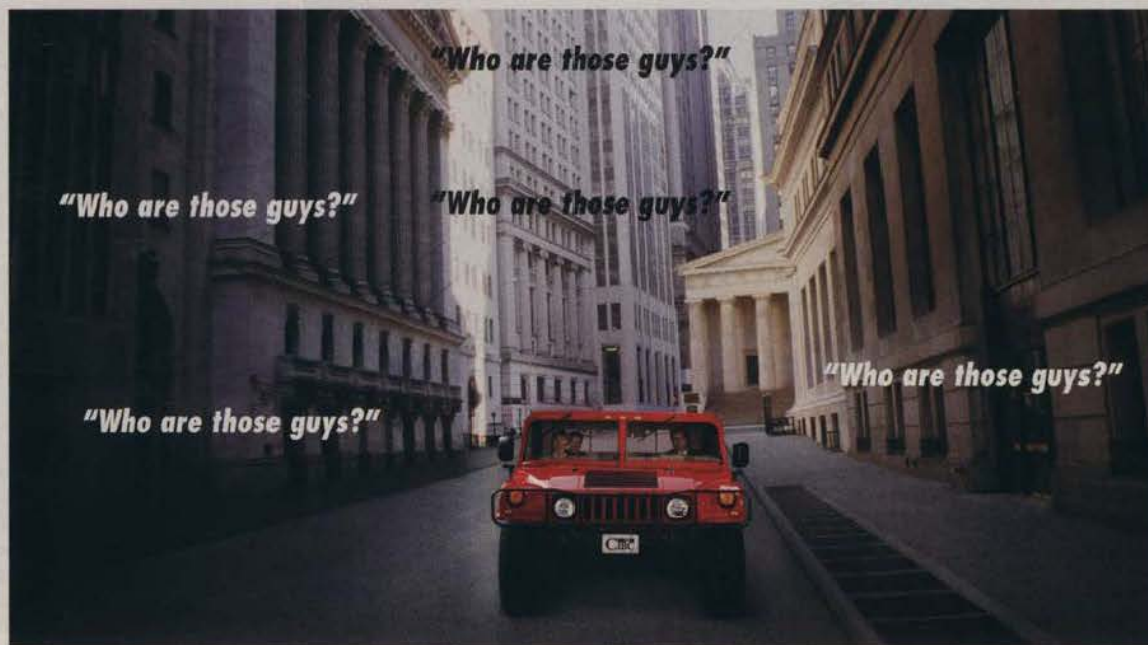
**THE KODAK DIGITAL CAMERA MAKES IMAGES OF FILM QUALITY**





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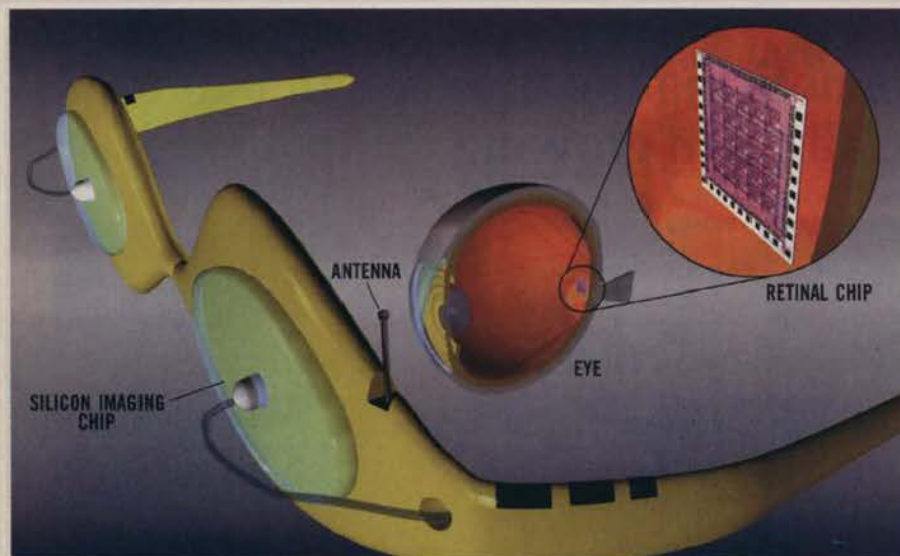
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## CAN A CHIP CURE BLINDNESS?

In experiments begun last year, a camera on eyeglass frames sent images to an implanted chip. The blind patient could see a large letter

Wilmer Eye Institute, a totally blind patient saw a large letter when data from a simulated imaging chip was wired to the retinal neurons of one eye. But questions remain. Can the technology provide sufficiently detailed vision to be useful? And will the body's immune system tolerate a silicon implant? Further research will be needed to answer those questions.

In the meantime, Intel is betting big on the future of the new imaging chips. The chip behemoth says it has spent hundreds of millions on digital imaging R&D in the past two years, and Chairman Andrew S. Grove says the investment "will be even more substantial as time goes on." Intel plans to sell imaging chips to link cameras and other products to its Pentium microprocessors. "This is a potentially explosive opportunity," says Peter J. Green, general manager of Intel's digital peripherals division. **"UBIQUITOUS FEATURE."** Toshiba Corp. also hopes to capture a large share of the market. It is now one of the top suppliers of the old-style CCD chips, but it also plans a huge investment in the new chips. Takeshi Enya, a Toshiba marketing manager, expects the market for both kinds of chips to grow rapidly but says the market for the new chips will grow faster. Of the 55 million imaging chips his company plans to sell in 2001, half will be of the newer CMOS variety. Enya figures that the old-style chips will be used primarily for printers and scanners, while the new chips will prevail in mobile computers and digital cameras.

Bryan Ackland, a research manager at Lucent Technologies Inc.'s Bell Labs—where all this started—believes imaging chips are destined to follow in the footsteps of digital clocks. Initially, digital clocks were costly stand-alone devices. Today, they're taken for granted on a range of products. Tomorrow, says Ackland, imaging chips will be "a ubiquitous feature of everyday life."

A new chapter in the silicon saga is unfolding. Computers and other devices are getting silicon eyes. Everywhere you go, machines will be watching.

By Geoffrey Smith in Boston, with bureau reports

close the shutter on conventional cameras within the next decade. Film is convenient and cheap, one-hour photo-finishing shops are everywhere, and old habits die hard. Still, Kodak Chairman George M.C. Fisher, whose company has perhaps the most to lose, acknowledges that there "will be an explosive market." So he's diving into digital imaging. The results are mixed so far; Kodak sells more digital still cameras than anyone but has yet to turn a profit on the technology. Fisher says, however, that he will continue the emphasis on digital cameras.

**SEEING-EYE CIRCUITS.** The arrival of the new chips has triggered frenzied efforts by makers of the old-style CCD chips to protect their turf. Despite the inherent manufacturing difficulties, suppliers have been improving resolution while cutting prices. "CCD makers realize that if they don't drop their prices fast, they'll be vulnerable," says William H. Boles, who until July was head of marketing at Olympus America Inc. Last year, 20 Taiwanese companies announced plans to make digital cameras. Ten dropped out before joining the fray. Even Sony, which makes the

world's best-selling digital camera—the \$500 Mavica—wonders whether the bloodletting is worth it. "We have to consider whether we should continue to put out new and better products if we have to lose money," says Shizuo Takashino, president of Sony Personal A&V Products Co.

The new imaging chips also have important applications in medical markets. Endoscopic surgical devices—thin tubes that enable a surgeon to see inside a patient—are fast being made disposable, in order to eliminate the need for sterilization. So manufacturers are switching from stainless steel to plastic tubes and replacing expensive old-style imaging chips with the cheaper new chips.

There's even a chance that digital imagers may serve as artificial retinas and help blind people see. Two decades ago, researchers showed that the brain's optical nerves can be electrically stimulated by optical sensors on a credit-card-size circuit board.

That enabled a blind person to discern very crude images. Given the advances in silicon technology since then, the National Eye Institute sponsored a study last year at Johns Hopkins University to explore the feasibility of implanting chips in or behind a person's eyes.

According to Dr. Mark S. Humayan of Johns Hopkins

## CHEAPER CHIPS

Nintendo offers a \$50 camera option that slips into the cartridge slot in its Game Boy

