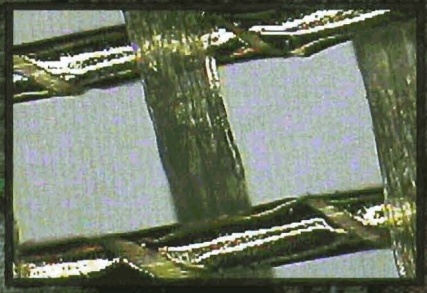
ELECTRONIC TEXTILES

"Wiring" the Fabrics of Our Lives

by Kathiann M. Kowalski

Once, the closest clothes came to electronics was when a music player or phone fit in your pocket. Now, scientists are fashioning fabric itself into electronics. One day, we might all be wearing our computers!



In this micrograph of silk organza, you can see copper foil wrapped around horizontal threads. LEFT: Don't think clothes can save lives? This LifeShirt can!

IT ALL BEGINS WITH THE WEAVE

The plain weave — the simplest, strongest, and most common fabric weave — takes two sets of threads and interlaces them at right angles to each other. It is used to make metallic silk organza, which Indian women have used since the 19th century

to make long, wrapped garments called "saris." Metallic silk organza is woven from some threads of ordinary silk fiber and other threads of silk fiber wrapped in thin copper foil or another metallic fiber. In essence, it contains metallic yarns, whose fibers are good conductors of electricity.

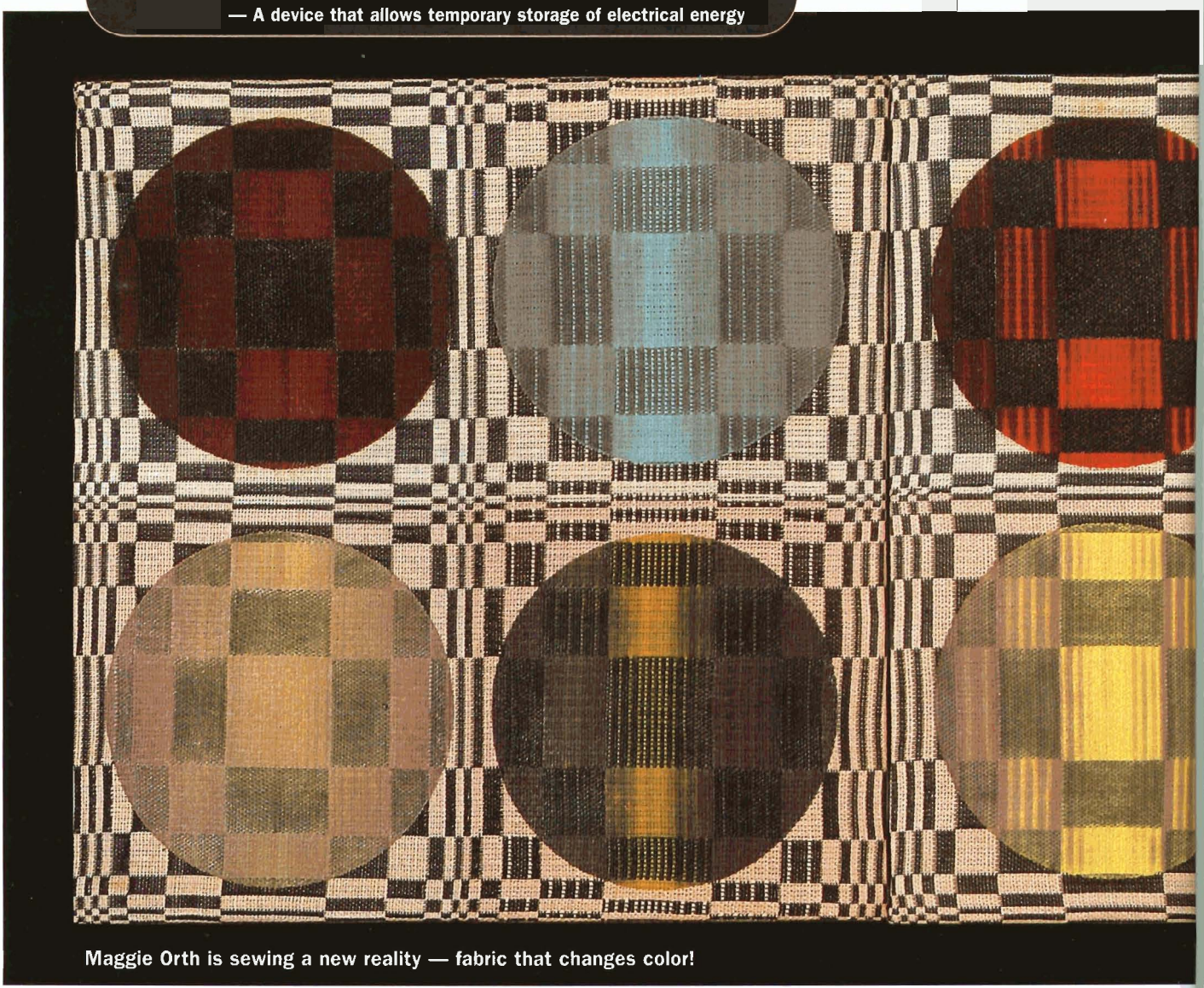
With that in mind, researchers at Massachusetts Institute of Technology's (MIT's) Media Lab set out to use that fabric to make computerized clothing. Imagine an insulated strip of that conductive weave functioning like a ribbon cable that connects a tiny computer's disk drive to its controller. Now sew some tiny ***resistors***, ***capacitors***, and coils directly to the conductive fabric. Then solder some little light-emitting diodes (LEDs) and other components to it. Clip a few other electronic components into the fabric. . .and *voilà!* You've got a lightweight, wearable PC without any external cords or gadgets. Just get dressed, and you're plugged in!

TEXTILES ON GUARD

Why mess with wires and uncomfortable health monitors if you don't have to? The LifeShirt is even comfy enough for sleeping. Or, wearers can work, play, or exercise as it tracks breathing, heart rate, blood pressure, and other conditions. LifeShirt is

— A device that inhibits the flow of electricity for purposes of control, operation, or protection

— A device that allows temporary storage of electrical energy

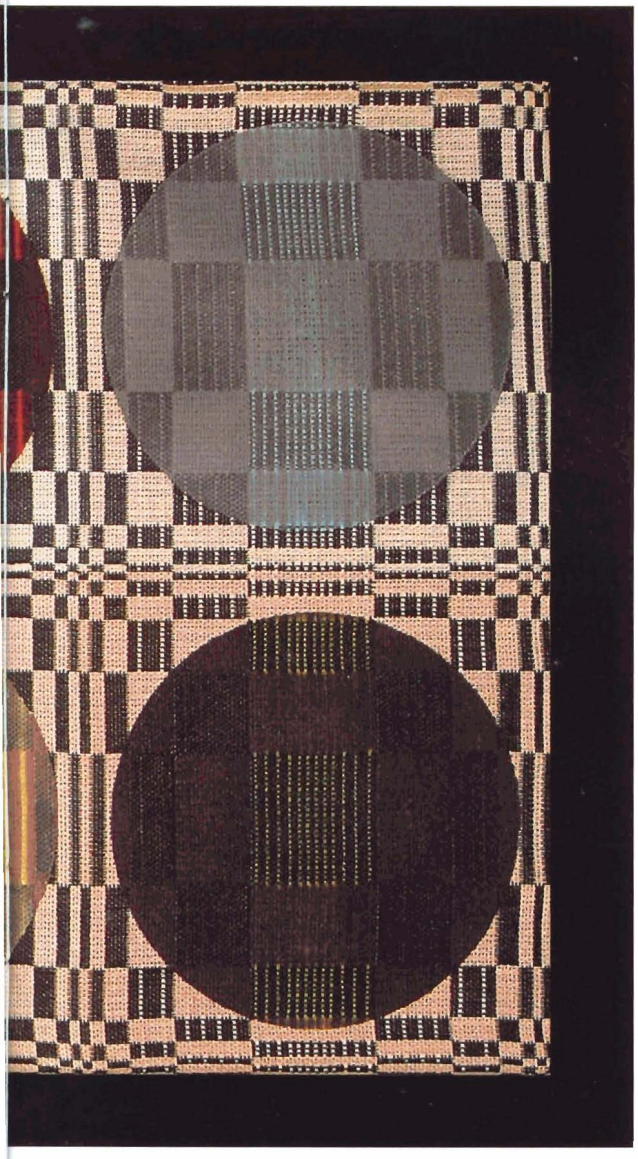


Maggie Orth is sewing a new reality — fabric that changes color!

already helping scientists to research conditions ranging from asthma to the prevention of SIDS (Sudden Infant Death Syndrome). And, as you read this, German astronaut Thomas Reiter should have one on the International Space Station for a study on sleep in space.

Sensors sandwiched between layers of Lycra or Coolmax fabric relay data to a PDA (personal data assistant). "The challenge was in miniaturizing the sensors to be unobtrusive [not noticeable]," says Elizabeth Gravette at the shirt's maker, VivoMetrics, Inc.

Part of what makes T-shirts and some sportswear so comfy and formfitting is their knit construction. "Knits just inherently have a lot of stretch and recovery," explains Stacy Burr at Textronics, Inc. Knitting uses patterns of interlocking loops to make yarn into fabric. While most woven fabrics stretch only on the bias, or diagonal, knit fabrics generally stretch lengthwise and crosswise, too.



Knits' inherent stretchiness helps the electronic fabric patches on the NuMetrex sports bra by Textronics stay in contact with wearers' skin. The patches also use a yarn that combines fine metal with stretchy fibers. This makes the patches electrically conductive, so that they can pick up electrical signals that the heart naturally sends out when it beats. A tiny transmitter in the bra then sends the data to a watch so that exercisers can monitor their heart rates.

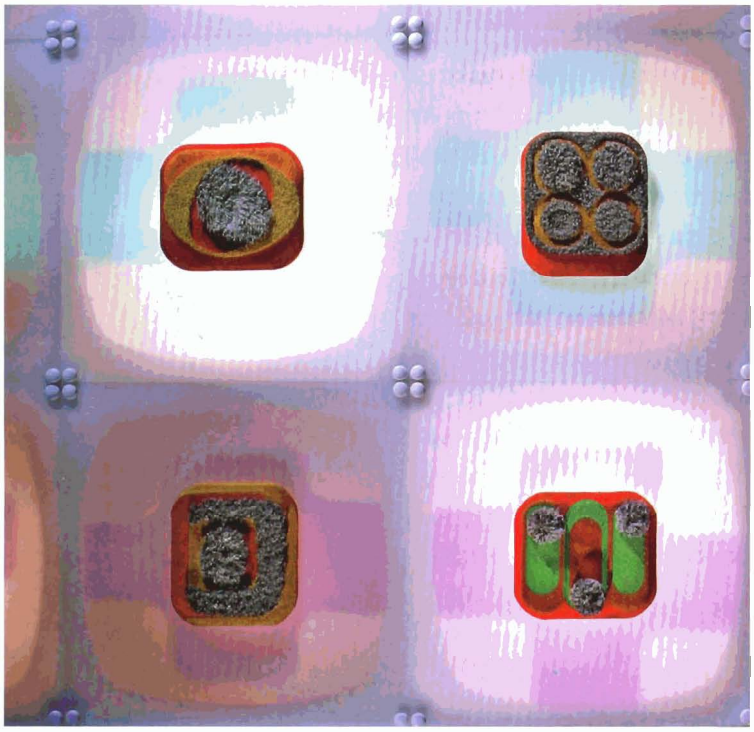
Knitted hats' stretchiness makes them comfortable.

Yarns in some e-textiles have short metal fibers twisted with polyester. Others combine nylon and metal. Still other e-textiles coil fine metal around yarns, as in the wearable PC mentioned earlier. Conductive yarns that carry an electric current can become sensors or heaters. Or, they can form resistors, capacitors, or switches.

ILC Dover used silver-coated polyester in a shirt that can sense where a soldier is wounded. Another project to detect tiny punctures in an inflatable lunar habitat involves etching an electrical circuit onto a layer of the habitat's fabric that resembles a potato chip bag lining. "We've actually screen-printed a lot of circuits as well, just as in the T-shirt screen-printing process," says ILC Dover's Dave Cadogan.

TEXTILES FOR CONTROL

Touching the wrist area on ILC Dover's "smart" space suit can signal a rover vehicle to come, go, or do other maneuvers with Bluetooth, the wireless technology that lets computers, mobile phones, and other devices interconnect at short distances.



Maggie Orth's new take on light switches — they're fuzzy!

In this case, it lets the space suit's fabric pad work like a remote control for the computerized rover vehicle.

Another pressure-sensitive area on the space suit's chest would let astronauts display information on a small computer screen inside their space suit helmets. "You have a little heads-up display in the space suit, and you touch your chest, and move the mouse and double click just like you would on a laptop mouse pad," explains Cadogan. This feature lets astronauts reference pages from technical manuals while repairing spacecraft or other equipment. After all, it's hard to memorize everything, and you can't easily flip through a big book while wearing space suit gloves.

Some pressure-sensitive controls work with piezoelectric materials. Crystals in such materials emit energy when pressed. Other devices use a concept called quantum tunneling. Squeezing rubbery material brings metal particles inside closer together. While the metal bits don't actually touch, some electrical energy gets transmitted across the barrier of rubbery stuff that separates them. This happens because at the atomic and molecular level of quantum physics, things we typically think of as objects also tend to act like waves. Although it's not exactly on point, you might think about how you can sometimes get a small static shock the instant before actually touching something when you're wearing wool socks.

COOL AND CREATIVE

A fabric-wrapped pom-pon light dimmer by International Fashion Machines senses someone's touch with capacitive fibers. To turn a light on or off, just squeeze the pom-pon. Hold it longer, and the light dims or brightens. "When you touch it, you draw a little charge off the fabric, and it goes to ground," explains designer Maggie Orth. In simplest terms, going to ground means finding an electrical path that leads to the lowest point, which is usually Earth. So connecting with the capacitive fiber doesn't hurt you. It just lets you control the lights. Plus, says Orth, "it's very, very soft and fuzzy."

According to Orth, "one of the real challenges in electronic textiles is connecting them" to a power supply or other parts of a system. Electrically conductive glue connects the pom-pon to the rest of the dimmer, which attaches to a home's electrical wiring.

Orth's other projects include color-changing fabrics. A computer chip's program sends electric current to certain conductive yarns. Heat from the current makes inks on their surfaces change color. Orth has also designed light-up fabrics and clothing. Her technology holds promise for flashy dresses, cool shoes, home decorating designs, and more.

IN THE BAG

While she was at MIT's Media Lab, Gauri Nanda designed a purse that could tell someone that she forgot her keys or wallet. In dim conditions, the bag could also light up to let someone see inside. System parts were small blocks attached inside the bag with Velcro-like material made

from silver-coated nylon. "Essentially, we made tiny computers about an inch wide and a few millimeters thick inside each of the blocks," explains Nanda. "Each of these computers has a brain that can figure out what to do based on the signals it receives from neighboring blocks." Signals between and among the blocks tell the bag what to do.

"They're not just physically attached. They're talking to each other," emphasizes V. Michael Bove at MIT's Media Lab. Plus, individual parts are reprogrammable. "Using Bluetooth, you could download a new function into this in the same way that you download a new ring tone into your phone." Patches could even be made into a new device, such as a music-playing scarf.

Not your average glove. Robotic controls are embedded in this space-suit glove developed by ILC Dover for NASA.

That's an e-textile control pad on the astronaut's arm.

PRACTICAL, TOO!

Remove the tiny battery or PDA, and the NuMetrex bra, the LifeShirt, and other products are easily washable. "These systems have to feel good," stresses Burr. "They have to look good. They have to be easy-care."

Cost is a concern, too. As this magazine goes to press, the NuMetrex bra, transmitter, and heart rate display watch cost $115. Orth's fuzzy switches are available online for $129. This is pricey for a lot of people, but it's not out of range for early adapters — folks who tend to buy new technology right away. Also, over time, prices on new technology tend to come down. Just look at the history of electronic calculators, DVD players, and portable music players.

"Textiles make up about 70 percent of the surfaces that people touch on a daily basis," adds Burr. With electronic textiles, the fabrics of our lives will become more fun and functional.

Kathiann M. Kowalski sews many of her own clothes in between writing for *ODYSSEY, Cobblestone,* and other publications. She'd love to see e-textile pajamas that act like a silent alarm clock, waking one person without disturbing a roommate.