Light at the End of the Fiber

Persistence, collaboration and pure determination led U-M scientists to revolutionize endoscopic procedures. BY JAMES TOBIN

IT WAS NEVER, NEEDLESS TO say, anyone's favorite procedure to insert a stiff tube into a patient's rectum to search for cancer. In the early 1950s, it was the duty of Basil I. Hirschowitz, M.D. (Residency 1956), a young gastroenterologist at University Hospital, to perform these rudimentary endoscopies by the hundred. The results were often incomplete. With the scopes then available, even the most skilled examiner could see only part of the patient's bowel.

It wasn't much better when the gastroenterologist lowered a scope down a patient's throat. Even with a semi-flexible instrument, the esophagus, the duodenum and much of the stomach simply couldn't be seen. The miniature light bulbs never gave enough light. And of course the patient found the procedure all but unbearable unless he or she possessed "a compliant anatomy approaching that of a sword swallower," as Hirschowitz put it. Endoscopy remained a good idea in search of a truly practical device.

Hirschowitz was a South African trained in gastroenterology and endoscopy at British hospitals. He came to the U-M for a fellowship under H. Marvin Pollard (M.D. 1931, Residency 1933), head of the Section of Gastroenterology. Each week, Hirschowitz and a few colleagues would meet over beer to commiserate about the sorry state of their science. In those early days of television, one of them speculated that patients might someday swallow a miniature TV camera.

Then, early in 1954, as Hirschowitz was paging through the latest issue of *Nature*, he found two brief articles way in the back. Both described the transmission of images through a bundle of flexible glass fibers, with possible applications in medicine. The authors of one of the articles — Harold Horace Hopkins and his assistant, Narinder Singh Kapany — were at Britain's Imperial College of Science.

Hirschowitz put down his copy of *Nature* and booked a trip to London.

A century earlier, an Irishman named John Tyndall had demonstrated that it was possible to transmit light through a stream of water poured from a pitcher. That led to a series of efforts to send both light and images through glass tubes. Hopkins and Kapany appeared to have taken important new steps, but Hirschowitz soon learned they were far short of producing a practical medical scope.

In London, the Brits showed Hirschowitz how an image of newsprint could be seen through their 13-inch bundle of fibers.

"The definition was good enough to read large print," Hirschowitz recalled later, "but the color was green, and light loss was so great as to make long fiber bundles impractical. Nevertheless, it was flexible and did transmit an image, and that was enough to set one dreaming."

Back in Ann Arbor, Pollard connected Hirschowitz with C. Wilbur Peters, an optics expert in the U-M physics department. They tried to bring Kapany to Ann Arbor to help them, but he went to Bausch & Lomb instead, figuring a big company would have the inside track on fiber optics.

"Considering the facts — we had no lab, no money, no background, no commercial interest to spur us on, and no personnel — he was quite right,"

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Hirschowitz using an early gastroscope

Hirschowitz wrote later. "Because of the illogicality of scientific invention, he was wrong."

Hirschowitz and Peters recruited a sophomore from one of Peters' physics classes, Larry Curtiss — an "illogical" choice who would prove to be a godsend. In the basement of Randall Laboratory on East University Avenue, the three went to work.

The first necessity was good glass fiber, but the stock they ordered from England arrived in a snarled mess. When they got it untangled, they found the glass wasn't pure enough. And when they bundled fibers together, light would leak from one fiber to another — a phenomenon called "cross-talk" — producing muddy light and garbled images.

From the Corning Glass Works, they ordered high-quality glass rods. Using a tiny furnace, they would heat a rod, then pull a minuscule thread of glass from the end, then wind the cooling fiber on a drum made from a cardboard "Mother Oats" box.

Light came through these fibers cleaner, not so green. But images were still muddled by "cross-talk." Somehow each fiber had to be protected — insulated — from the fibers around it.

Curtiss observed that when a single glass fiber stood alone, light passing through it remained wholly inside the fiber — a phenomenon called total internal reflection. But another fiber pressing close, or a speck of dirt or grease, drained the light away. So, to take the place of the insulating air, Curtiss proposed that they coat the fiber with a skin of even purer glass. Insulating glass with glass preserved total internal reflection in each strand, even when bundled together.

"When he first proposed to melt a rod of optical glass inside a tube of lower-refractive index glass and pulled the two together into a composite fiber," Hirschowitz remembered later, "all the wise men in the physics basement lunch group laughed at him. Fortunately, he persisted and produced the fiber on which today's fiber optics is based — the glass-coated glass fiber."

In late 1956, the collaborators pointed a camera through a bundle of glass-insulated fibers and photographed a clear image of Abraham Lincoln on a 15-cent postage stamp. Two months later, they assembled what they hoped would be a working, fully flexible gastroscope. Hirschowitz decided he must be his own first subject.

"I looked at this rather thick, forbidding but flexible rod, took the instrument and my courage in both hands, and swallowed it over the protest of my unanesthetized pharynx and my vomiting center," he recalled in a 1979 memoir. "No lights were turned on and to my present recollection no bells rang."

Days later, he peered through the same scope at an ulcer in the duodenum of the wife of a dental student. She had a successful gastrectomy.

FOR A TIME, THERE WERE skeptics. One called Hirschowitz's fibers "illuminated spaghetti." But by the 1970s, fiberoptic endoscopy had reinvigorated the field of gastroenterology, transformed the diagnosis and treatment of diseases ranging from esophageal cancer to Crohn's disease, and led the way to today's array of arthroscopic and noninvasive surgeries. [M]

COURTESY OF BASIL HIRSCHOWITZ