19th-century tourmaline tweezers from the UNIL-EPFL Collection of scientific instruments.

LIGHT TOUCH

Raphael's Tourmaline Tongs

Stephen R. Wilk tells the story of a historical optical tool with a peculiar name.

Chapter 6, verses 5 to 7 of the biblical Book of Isaiah tells of a vision by the book's title character, in which he objected that he could not be a prophet because he had "unclean lips." At this, an unnamed angel—later identified with the archangel Raphael—took a glowing coal from the altar of sacrifice with a pair of tongs and used it to cleanse Isaiah's lips, rendering them clean and meet for prophecy.

I introduce this story to explain why, in *The Chemist-Optician*, a 1908 handbook of optical practice and dispensing written for pharmacists, there is a figure labeled "Raphael's Tourmaline Tongs." There has been, as far as I am aware, no notable optical scientist with the surname Raphael. The item in question is obviously named after the archangel by analogy with the tong-wielding angel of Isaiah's vision. It would not be the first time biblical characters have been invoked to name a scientific or technical apparatus. The name Jacob's Ladder, for instance, has been applied to a kinetic construction and an electrical-arc demonstration device.

Tourmaline tongs

And what are "Raphael's tongs"? More commonly called "tourmaline tongs" or "tourmaline pincettes," they were a 19th-century optical device whose place has since been taken by more efficient polariscopes and colmascopes.

It was Jean Baptiste Biot who discovered by 1815 that tourmaline crystals, when cut so that the face was parallel to what is now called the *c* axis of the crystal, acted as a very effective polarizer of light. David Brewster found that agate behaves similarly. Both these crystal polarizers

were inconvenient, though, because it was hard to find large, clear crystals, the polarization itself was wavelength dependent and the crystals tended to be colored.

A real breakthrough came when William Nicol figured out a way to saw a crystal of Iceland spar into two pieces and glue them back together with balsam cement in such a way that the altered crystal separated rays with two different polarizations by a much greater angular distance than the unaltered one did. The Nicol prism had a relatively large aperture and was very nearly colorless and transparent. For the next century or so, polarizers and polarimeters for careful laboratory work either used reflection from glass surfaces or Nicol prisms.

But for applications outside the laboratory, such equipment was bulky and unwieldy. Alexander Bryson, a Scottish scientist, constructed a pair of polarizing spectacles in 1849 using two Nicol prisms. The prisms were both aligned so that they only transmitted vertically polarized light. This fulfilled Bryson's desire to construct a device that would eliminate the glare caused by the sun's reflection from the surface of water, thus allowing one to see into the water. But it must have been relatively large and costly. The obvious improvement was to replace the Nicol prisms with some other, lighter polarizing item, and the best of these was tourmaline. It wasn't long after Bryson's paper relating his results that we find tourmaline spectacles.

Whose invention?

In an 1872 issue of the magazine *Hardwicke's Science-Gossip: An Illustrated Medium of Interchange and Gossip for Students and Lovers of Nature*—an absolutely wonderful

Woodcut engraving of the archangel Raphael holding a glowing coal with a pair of tongs, after a drawing by Julius Schnorr von Carolsfeld, published in 1877.

Getty Images

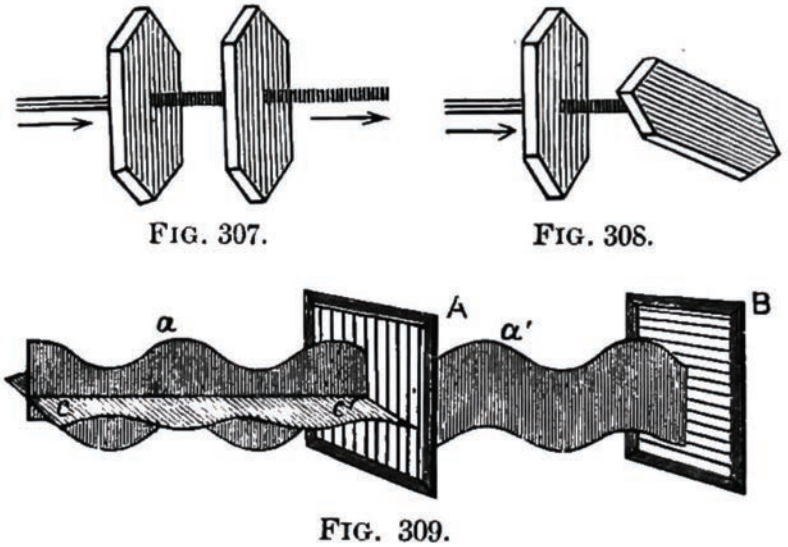
"Tourmaline tongs" or "tourmaline pincettes," were a 19th-century optical device whose place has since been taken by more efficient polariscopes and colmascopes.

title—we find an advertisement for "W. Lark of Oxford Street, London, Practical Optician." While the ad claims Mr. Lark was the inventor of "the invisible and tourmaline spectacles," I don't know if he was indeed the first to use tourmaline-crystal lenses to make polarized glasses as a commercial item.

But he was probably among the first, and definitely not the last. There are numerous mentions of polarized glasses in the last third of the 19th century, chiefly as a tool used by fishermen, who benefit from penetrating the glare of the water's surface. In these cases, as with Bryson's Nicol prism spectacles, the filters transmitted vertical polarization, since the effect of reflecting from a horizontal or nearly horizontal surface would be to polarize the light in a horizontal direction.

There was another, much more widespread use of tourmaline polarizers in the 19th century. At that time, many spectacle lenses were made from sawn discs of rock crystal—silicon dioxide, better known as quartz. The common and misleading name given to this naturally clear substance was "pebble." It was preferred over glass for several reasons: Glass manufacture was still in a relatively primitive state, and thicker pieces required for lenses often contained bubbles, imperfections and impurities that added color to the glass. Manganese in the glass might not at first be apparent, for instance, but with long exposure to sunlight the glass would gradually darken and turn purple.

"Pebble," on the other hand, looked clear and uniform, wasn't discolored and wouldn't darken with exposure to sunlight. It was



Images from *The Principles of Physics* by Alfred P. Gage, 1895, showing how tourmaline slices (top) and gratings (bottom) affect the polarization of light passing through.

stronger and less likely to shatter, and many people felt that it was cooler and protected their eyes from heat. Some eyeglass specialists said they could distinguish between glass and pebble lenses by the color or by putting it to their lips. But there was one infallible test: using the tourmaline tongs.

Some sources claim that Biot invented a tourmaline polariscope after discovering the polarization property of the gemstone. Others claim that Brewster constructed one using polarizing agate. I haven't been able to corroborate either claim—the polarimeter most commonly used by both scientists exploited reflection polarization from glass. One contemporary source credits German crystallographer Karl Michael Marx with inventing tourmaline tongs in 1827.

A quick sorting tool

Whoever invented them, the tongs—or pincette, as the tool was also called—looked like an oversized pair of tweezers or a test tube holder, with a large circular optical element at the end of each arm. Each contained a slice of tourmaline crystal in the center, cut and affixed in such a way that it polarized light passing through it. One slice was generally fixed in place; the other sat with its polarization perpendicular to the other one's or, in some cases, had a rotatable polarization.

The tongs thus acted as a quick and easy way to distinguish between natural quartz lenses and glass lenses. That's the reason they came to be called "pebble triers."

With the polarizers crossed, no light would be transmitted by both filters if there was nothing between them. When placed between the crossed polarizers, glass, being a homogeneous material unless stressed, would not affect the polarization state, so the view through the tongs would still be dark. But crystal quartz is birefringent, with different indices of refraction along different crystal axes. Unless the axes lined up with the directions of the polarizers, the linearly polarized light from the first tourmaline crystal would become elliptically polarized by passing through the quartz, so some light would be transmitted by the second polarizer. The tongs thus acted as a quick and easy way to distinguish between natural quartz lenses and glass lenses. That's the reason they came to be called "pebble triers."

The tongs were a quick and compact form of polariscope or colmascope—smaller and lighter than reflection-based or Nicol prism–based units, though not as accurate. They were probably no good for measuring degrees of polarization or looking at stress patterns in improperly annealed glass. But they could very quickly distinguish between glass and pebble, and could be used to demonstrate the difference to customers (who might question judgments based on color or apparent temperature).

Despite the tong-like appearance of the device, they were not used to pick up or hold anything. An eyeglass seller who actually did clamp the "jaws" of such tongs onto a lens being tested would soon find it scratched and useless. But the urge to call the device "tourmaline tongs" must have been irresistible. OPN

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For references and resources, go online: **optica-opn.org/link/tourmaline-tongs**.

References and Resources

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