ESTELLE GLANCY

An Optics Pioneer

Over the course of her career, Estelle Glancy was the only female scientist in eyewear lens design. Forty years after her death, she is finally gaining recognition for her innovations.

Dick Whitney

(Facing page) Estelle Glancy at work at the American Optical Company.
Carl Zeiss Vision International GmbH / (Above) Getty Images

Estelle Glancy with the Lensometer she helped develop.
Carl Zeiss Vision International GmbH

In a career spanning three decades, Estelle Glancy made numerous innovations across the field of optics. Yet she still fell victim to the "glass ceiling" facing women in many professions—or, in Glancy's case, what might be called an "eyeglass ceiling."

A brilliant mathematician and dedicated researcher, Glancy helped create the most significant advance in vision correction of the 1920s, the Tillyer Lens, a development that benefited literally millions of consumers. In addition, she developed a breakthrough camera lens that snapped sharper, clearer pictures—a project that required 200 pages of handwritten calculations. Her work also contributed to advancements in telescopes, eye exam equipment and military optics. In television, experts drew on her research to create larger screens.

Yet only recently have her pioneering contributions—in eyewear lens designs and other fields—begun to receive the attention they deserve. Here, we examine the career and life of a true optics innovator.

Early promise

As a student at Wellesley College in Massachusetts, USA, Glancy planned to train as an astronomer. But she ran afoul of the astronomy professor at Wellesley, who felt she showed an "uncooperative attitude." Her mathematics professor offered more encouragement, and Glancy eventually chose that field as her major. Years later, her mathematical training would serve as the foundation for her innovations in optics.

Glancy later admitted that, the year after her graduation, she fell upon an "idle period," and had little success in finding a career. No observatory in the eastern United States was willing to hire her. She sent "a far distant appeal to the Berkeley Astronomical Department of the University of California," where she knew large-scale calculations were in progress. In response, the university invited her to "come as a computer," provided she "would also work toward a Ph.D. degree."

A century ago, the term "computer" referred to a person, not a machine—specifically, humans who would grind through laborious pages of calculations by hand to support scientific investigation and technical innovation. (The books *Hidden Figures* and *The Glass Universe* have recently thrown the spotlight on how women in this role helped underpin 20th century scientific efforts at U.S. institutions such as NASA and the Harvard Observatory.) But although amply trained in the math required for computation, the thought of seeking a doctorate had, she later wrote, never entered her mind. Once on that path, however, "it never entered my mind to stop part way."

From Berkeley to AOC

So Glacy moved to the west coast of the United States, and settled in Berkeley—only a few weeks before the celebrated 1906 earthquake that destroyed much of San Francisco, just across the bay. Surviving in a disaster zone, however, was only a portion of the challenges she would now encounter almost daily. At the time, no woman had ever received a doctorate in astronomy from the University of California, Berkeley. But here, as in so many phases of her life, Glancy pushed ahead with the conviction that she could succeed where others had been deterred.

Glancy later wrote that her mentor throughout the course of her Ph.D., a Professor Deuschner, asked "with a twinkle in his eye, 'What makes you think you can compute?' "I answered that I thought I could

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A brilliant mathematician and dedicated researcher, Glancy helped create the most significant advance in vision correction of the 1920s.

learn, duly humble, knowing the great opportunity before me and very desirous of being accepted. Calculations," she noted, "gave me bread and butter, graduate courses led toward a doctorate and during that time, a Lick Observatory Fellowship gave me experience in one of the world's famous observatories."

After earning her Ph.D. at Berkeley in 1913, Glancy continued to encounter obstacles as a woman in a field dominated by men. Even when she found employment at an observatory in Argentina, she realized her best career options weren't in astronomy. Seeing men without her training and credentials get better jobs, while she was excluded from consideration, Glancy despaired of ever using her scientific talents in astronomy, and even mulled taking a job in an airplane factory.

In 1918, however, an unexpected opportunity came from the American Optical Company (AOC) in Southbridge, Massachusetts, USA, then the largest supplier of eyewear in the United States, and synonymous with vision-related innovation.

Though famous for its eyeglasses, AOC (now part of Carl Zeiss Vision) was a high-tech company that produced everything from precision machinery to military optics. (One of Glancy's first projects on joining the company was to improve the performance of gun sights used by soldiers.) The company would eventually branch out into contact lenses, film technology, polarized sunwear, automotive accessories and more.

Reflecting upon this career transition, Glancy later said, "I had no illusions about the difficulty of transfer from astronomy to optics, but knew also that there was no better background than computing in astronomical problems."

A new lens

When Glancy arrived at AOC, the company's 17-acre headquarters complex dominated the town, and thousands of employees showed up there each day for work. Like many other scientific companies of its time, however, the laboratory was just as male-dominated as the boardroom, and no woman had ever held a leadership position. Presumably, Glancy's arrival must have shocked many of her new colleagues.

A photo of Comet Morehouse taken by Estelle Glancy in 1908.
Wikimedia Commons/Astrophysics Journal

Yet one important figure at AOC, the eminent Dr. Edgar D. Tillyer—who had also trained as an astronomer—recognized Glancy's extraordinary talent, and believed she could advance the company's

Dr. Estelle Glancy and Dr. Edgar Tillyer (circa 1930).
Carl Zeiss Vision International GmbH

key research projects in ophthalmic lenses. While Tillyer would later become famous in the field, few knew that the mathematical work behind his breakthrough lenses was the work of the only woman on his project team—Estelle Glancy.

That Tillyer was hailed as the revolutionary mind behind the novel lens was ironic, as Tillyer had never actually received a doctorate degree. Instead, he received an honorary doctorate degree from Rutgers University in New Jersey, USA. (To learn more about Tillyer, see "The Amazing Career of Optics Pioneer Edgar Derry Tillyer," OPN, November 2004, p. 18.)

Glancy's work helped solve a problem that had long plagued eyeglass wearers. Even with fine optics at the center of a lens, a noticeable distortion, called marginal astigmatism, compromised the wearer's peripheral vision—a stubborn issue that not only caused discomfort, but compromised the wearer's safety. And the larger the lens, the worse the distortion.

Glancy aimed to create an improved lens that would "give marginal vision as nearly like vision through the center of the lens as possible." In doing so, however, she would also need to ensure that the finished technology didn't require processing labs to keep an excessive number of lens types in inventory. Previous attempts to solve this problem had involved hundreds of different lens-blank variations, but AOC wished to limit the range to fewer than ten standardized blanks. According to Glancy, this constituted a "major project which no other company than the American Optical Company was ready to undertake."

Her work on the new Tillyer lens filled 13 volumes of painstaking ophthalmic design and ray-tracing calculations; she later noted that the single project "took the greater part of ten years." Modern scientists, who have ample computing power at their disposal, can scarcely imagine the perseverance and dedication required for such a breakthrough in the 1920s.

Yet Glancy's devotion to science was matched by an equal degree of humility. When the new ophthalmic lens launched, it was known as the "Tillyer Lens"—not the "Glancy Lens." The name became more not just a scientific label but a consumer brand, so effectively

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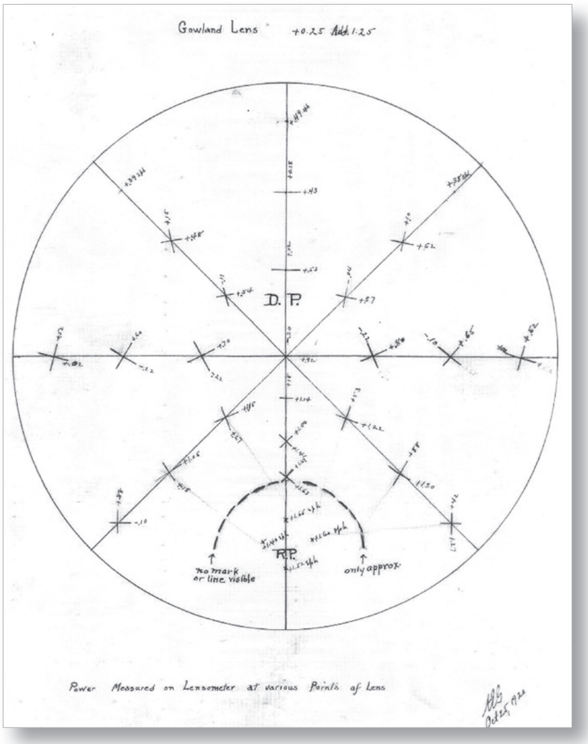
marketed that it not only sold millions of lenses but made Tillyer a widely known public figure. The company even secured Norman Rockwell, arguably the most popular American painter and illustrator, to create custom paintings for use in the advertising campaign. Amid all of the publicity and the acclaim showered on Tillyer, there is no record of Glancy ever complaining about the lack of public visibility for her contributions to the project—or for the many others during her long career.

Serial innovator

Even though she never achieved the wide recognition enjoyed by Tillyer, those who worked with Estelle Glancy well knew her formidable skills. Even after more than three decades at AOC, as her career was drawing to a close, she was still the only woman in the field of eyewear lens design. By then, she was more than a pioneering woman in science—she was also a catalyst for the innovations of others. Her papers were studied at universities, her patents advanced the field of optics, and her know-how laid the foundation for further improvements in vision correction for millions of people.

In eyewear, she anticipated many innovations long before they entered the marketplace. She filed a patent on progressive lenses in 1923—a half century before they became widely accepted as a superior alternative to bifocals and trifocals. The progressive lens is sometimes referred to as the "no-line bifocal," though that hardly captures the technology's full significance. The lens not only removes the unsightly dividing line in a multifocal lens, but also allows a smooth transition from near to distant vision in a single pair of eyeglasses. In work on other eyewear technologies, for instance, her work in aspheric lens design and lens manufacturing techniques was used not only in ophthalmic optics, but was adapted to improve telescope designs. Her improved methodology for telescope lens designs was eventually also used in camera systems; both were the subject of a *Journal of the OSA* technical paper in 1948.



A page from Glancy's calculation notebook.
Carl Zeiss Vision International GmbH

At the time of her patent, the value of this bold innovation was hardly recognized. When Glancy retired from AOC in 1951, it wasn't even mentioned in tribute articles about her career. Yet in 1978, three years after her death, AOC introduced its first progressive lens, called the Ultravue. Today, the progressive lens is considered the gold standard for aging eyeglass wearers who require different optical correction for near, intermediate and distance vision.

The lensometer, now a standard piece of equipment to measure the power of a spectacle lens in optical dispensaries, was also a Glancy product. Introduced in 1921, it provided a means to verify the degree of correction in an eyeglass lens relative to what was prescribed. When an improved model was introduced in 1938, Glancy wrote its manual and authored papers on its use. Today, high-tech versions of her invention

> “It’s really very simple—two things. First, don’t ever take a job for money. Second, only work at what you enjoy.”
>
> *—Estelle Glancy*

Ads depicting the Tillyer Lens.
Carl Zeiss Vision International GmbH

are used in almost every eyecare practice.

She also made flying safer with her work on pilot goggles. In the 1930s, those goggles tended to cause headaches, so Glancy focused on the use of a prism in uncorrected lenses that had a large wrap or face form. Her work concluded that the headaches were from prismatic imbalance errors, due to the high curvature of the lenses. These distortions were corrected by her work, and the improvements were incorporated in AOC’s flying goggles.

This concept became commonplace in consumer eyewear during the 1980s and 1990s, when wrapped lenses gained widespread popularity. Now, celebrities and sports figures are frequently seen wearing stylishly curved sunwear—fashion products embodying optics pioneered by Glancy. As with the progressive lens, she led the way for features and designs taken for granted today.

Glancy was just as dedicated in her efforts to solve problems affecting only a small number of people. Only a few eyeglass wearers suffer from aniseikonia, a condition that causes objects to look larger or smaller depending on which eye is used. Yet for this small group, the condition is a big issue, leading to headaches or more severe problems. Glancy took on the challenge of helping these patients. In the process, she wrote, “a whole new branch of optics was opened up,” as the work required a “considerable spadework on theory and measurement of lenses.” It also resulted in another Glancy patent.

A lasting impact

A 1948 article on Glancy’s scientific achievements noted that although AOC employed 5,000 people, probably only a half-dozen could understand the nature and depth of her research. Yet millions of people have benefited from her work and continue to do so.

Her scientific contributions might be easier to measure, however, than her impact on those around her. Contemporary reports include multiple examples of how she inspired and mentored others—usually by example, but sometimes through pointed advice.

Her colleague Fred Joslin remembered his surprise when she intercepted him in the hallway, asking, “Young man, would you like some advice from an old lady?" The duo went into Glancy's office and sat down, where she smiled and said, "It's really very simple—two things. First, don't ever take a job for money. Second, only work at what you enjoy." Says Joslin, "I have found that to be great advice and have tried to live my life that way."

Glancy faced many obstacles in her career, and overcame most of them. But she couldn't overcome one: her gradual, irreversible hearing loss. Still, she managed to find a positive side even to that affliction. "The forced aloneness which deafness imposes," she wrote, "was compensated in part by freedom from distraction and the ability to concentrate." She added, "Diversity of talents was not one of my assets, but rather the capacity for digging down deep and persistently and advancing one step at a time, looking for an occasional nugget among the pebbles. And in every career, good fortune plays an unobtrusive part. Opportunity knocked at my door."

Today, few people know about Glancy. In contrast, her university roommate, Phoebe Waterman Haas—who gave up science when she married the chemist Otto Haas, a few months after earning her degree—has an observatory at the Smithsonian's National Air and Space Museum named in her honor. Haas and Glancy received their doctorates on the same day, the first women at Berkeley to earn doctorates in astronomy, but only Glancy pursued a career as a scientist. (Haas did, however, maintain a lifelong interest in astronomy, and in 2012, Haas' son gave the Smithsonian US$13 million for a public observatory named in her honor.)

Looking at their respective contributions, it is hard to understand how Glancy, with so many innovations to her credit, remains virtually anonymous.

At the time of her death in 1975 at age 91, Glancy had been retired from AOC for nearly a quarter of a century. By then, the evidence of her impact could be seen everywhere, from the progressive lenses that were finally gaining acceptance as the best vision solution for presbyopia, to televisions and other screens in homes and workplaces. Forty years after her passing, she is finally gaining notice and respect for her scientific achievements and her pioneering role in optics. OPN

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American Optical's Southbridge Facility as it was in 1965.

Carl Zeiss Vision International GmbH

A Personal Connection

The author of this feature, Dick Whitney, has some personal connections that give Glancy's story special resonance. Here, he shares a few memories.

My father, Don Whitney, was hired by Dr. Tillyer's lens design department in 1947, and was trained by Estelle Glancy. He conducted ray-tracing calculations with a slide rule. Glancy instructed him and supervised his progress. Today, these calculations could be solved quickly with a computer. Back, then, however, they typically took two days to complete.

My father and a colleague would work on the same lens calculations and, if both came up with the same answer, they would be satisfied that the results were correct. For Glancy, however, two days to solve a single math problem was considered beginners work! Her own projects, according to my father, involved far more complex and detailed calculations. And she probably did not have the luxury of dual error checking, as my father and his colleague did, when designing the Tillyer lens series. Her own work simply had to be perfect.

Glancy's pioneering work is also part of my own personal vocation. I joined American Optical in 1974, the year before her death. She had already retired at that point, but her influence could still be felt in the company's R&D operations, and my own career was shaped by her indirect influence. Much of what I learned from my father and others originally came from Glancy.

Now, as keeper of the American Optical Company historical collection and in my role as executive director of the Optical Heritage Museum, I have an added reason to preserve and promote Glancy's legacy. Within the Optical Heritage Museum archives are numerous examples of Glancy's inventions and innovations in ophthalmic optics. She is one of the great pioneers in our field.