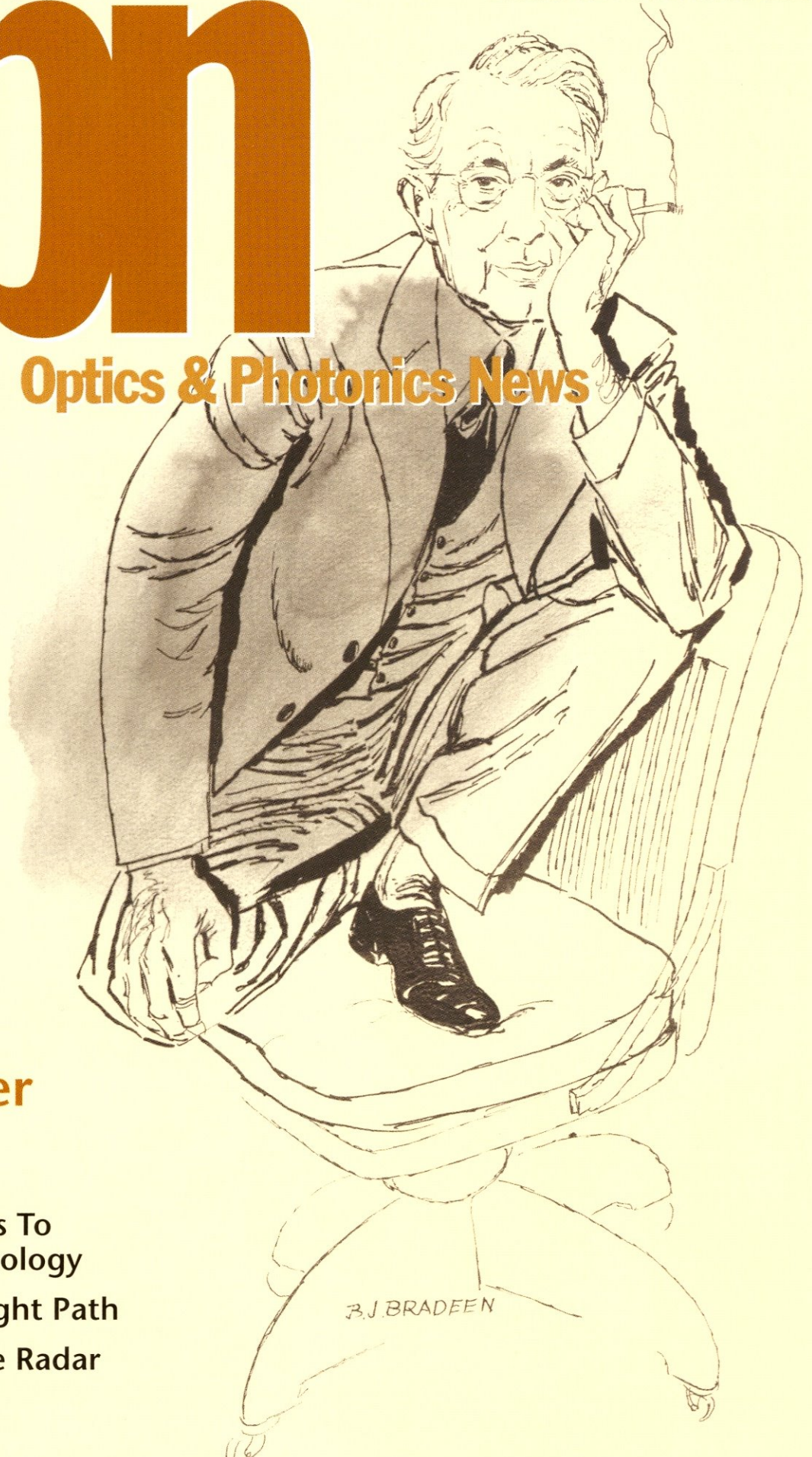


OPN

Optics & Photonics News



A Profile Of Edgar Derry Tillyer

CARS Microscopy

DoD Contributions To
Science and Technology

Polymers in the Light Path

Synthetic Aperture Radar

The Talbot Effect

The Amazing Career of Optics Pioneer Edgar Derry Tillyer

Tim Tillyer

The lives and scientific achievements of optics luminaries are highlighted in OPN's occasional column, "Profiles in Optics." Here, Tim Tillyer, grandson of Edgar Derry Tillyer, describes the career of the great scientist, who was one of the founders of OSA.

Edgar Derry Tillyer was one of the most productive inventors and scientists of the field of optics of the early and middle 1900s. The January 1940 issue of *Scientific American* featured him in its "Personalities in Science" section, noting that, "Every person who wears glasses owes to Dr. Edgar D. Tillyer, internationally known authority, a debt of gratitude so great that mere words cannot express it. His brilliant mind has contributed more than a hundred important developments in the field of optical science."

Doc, as he was known around the American Optical (AO) Company laboratories and factories in Southbridge, Mass., had 157 patents to his credit. Most were aimed at improving vision and protecting people's eyes during industrial processes. The majority of the patents were assigned to AO, a leader in research and development in the field of optics.

In 1911, when he was 30 years old, Tillyer was working as a mathematician at the National Bureau of Standards in Washington, D.C. It was there that he became intrigued by the problem of achieving proper eyeglass lens correction over the entire surface of the lens. The problem fermented in the back of his mind until Christmas Eve 1912. As his family was trimming the tree, a colorful glass ball slid off its hanger and shattered on the floor. When Tillyer observed the glittering ornament, he noticed the



Tillyer in a characteristic pose (sketch by B. J. Braddeen). In the office or lab, Tillyer always wore a gray suit with matching gray vest, tie and long-sleeved white shirt.

peculiar way the light was reflected off its curved surfaces. The phenomenon became the basis for the solution he was looking for. "What would happen if we used curved lenses?" he wondered. In 1915, he illustrated his ideas in a paper, "Axial Aberrations of Lenses," which would later be published in the Bureau of Standards publication, *The Bulletin*.

In 1916, George W. Wells, president of AO, read the paper and recruited him to head the company's research laboratory. Tillyer, his wife Florence and their three children (another son would be born in

1919) moved to Southbridge, where he started a career with AO that would last until 1970.

In 1917, he applied for a patent for the Tillyer principle of balancing oblique aberrations, which would come to be referred to later as the "effective power technique." A giant step toward achieving accurate lens correction, it was immediately incorporated into AO's Wellsworth lenses. It was not, however, a complete answer to the problem. For another decade, Tillyer would struggle with the challenges of translating his principle into a complete series of spectacle lenses.

During these years, he applied for 57 new patents and was awarded 44. One of his inventions, the lensometer, was patented in 1921, when he was 40. It allowed the first measurement of the effective power of a lens, answering the question optometrists and opticians had always asked, "How do I know if the lens created is accurate and exactly fills my prescription?" An article written in the February 1922 issue of the AO publication *Wellsworth Life* called it "... one of the greatest inventions in ophthalmic science," saying "all the instrument lacks to make it a real human eye is an optic nerve and a mind."

One of Tillyer's co-workers in the lab, A. Estelle Glancy, was nearly deaf. On her desk she kept a large electric box which resembled a radio and was equipped with a microphone and speaker to help her hear. Tillyer believed something more could be done. He contacted Lt. Col. Eugene McDonald, owner of Zenith Radio Corporation. McDonald, who was deaf himself, explained to him the state of radio art and the current theories on deafness. Tillyer soon invented a hearing aid that was designed for the individual's own particular hearing weaknesses. McDonald was so impressed that he sent Tillyer a new radio every year or two from then on.



(Left) Tillyer with AO lab staffers A. Estelle Glancy and John Davis.



(Right) Tillyer in the lab. His Tillyer lens provided for the first time both spherical and cylindrical error free corrections to the lens margin. The calculations on which the lens was based were done in pencil, filled 13 ledger books and took over 10 years to complete.

In 1926, he perfected the Tillyer lens, on the basis of his Christmas ornament experience and his work with effective power. The product was a lens that for the first time gave both spherical and cylindrical error free corrections to the very margins of the lens. The calculations and research on which the lens was based took over 10 years to complete; in Tillyer's own words the computations were "almost endless." Done in pencil in 13 fat ledger books, the computations were stored in a huge safe at AO. The invention would revolutionize thinking about spectacle design.

Tillyer's alma mater, Rutgers University, in New Brunswick, N.J., awarded him an honorary doctorate in 1928. The degree was awarded for: scientific achievements at the Naval Observatory and the National Bureau of Standards; service to the country in the form of the improvement of telescopic gun sights; invention of the Tillyer lens; authoring the standard periscope specifications for the Navy; and directing the leading optical research laboratories of the time. After he received the award, all of those who came in contact with him—even his children and grandchildren—began to call him "Doc." Interestingly, he never referred to himself "Doctor" Tillyer or used the title as part of his signature.

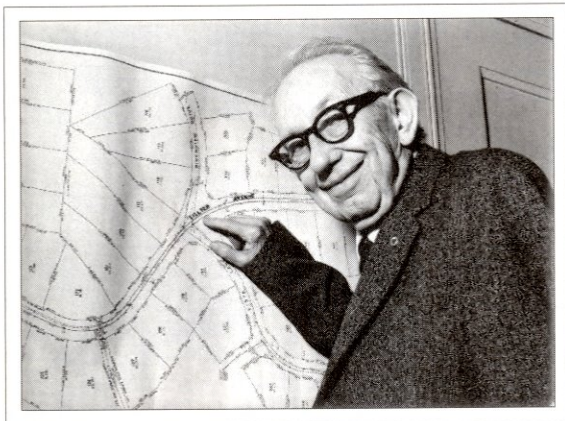
In 1936, Doc designed an Aphakia test for cataract surgery patients, along with a lens large enough to accommodate the post-surgical eye.

During World War II, both sides to the conflict were working to develop night vision equipment and weapons, but the optics used to gather the faint light was distorting the images so significantly that a corrector plate was required. The only plate known to be capable of achieving the required result had been developed in Germany in 1930 by Bernard Schmidt. Schmidt's method of creating the plates required exacting work and took weeks. Doc was challenged by AO and the U.S. military to develop a method to produce the plates quickly, easily and cheaply. He met the challenge: by 1942, corrector plates were being mass produced for the U.S. military, which helped the Allies win the war. After the war, the process was adapted for use in the production of television sets.

During World War II, Doc also played an important role in the development of the atomic bomb. The chemical uranium hexafluoride was used in the process. Since hexafluoride etches and dissolves ordinary glass, the beakers and other glassware in the labs were useless as far as this project was concerned. Tillyer was assigned the task of finding a glass that could be used to observe the chemical in action. He did this by replacing the sand in the glass mixture with the violently reactive substance phosphorus pentoxide. Surprisingly, when the explosive material was incorporated into the new composition, the result was a stable and chemically resistant glass. During development of the new glass, Harold Urey was a frequent guest in the Tillyer home. Urey had been awarded the Nobel Prize in 1934 for



Tillyer's alma mater, Rutgers University, awarded him an honorary doctorate in 1928.



(Left) Tillyer with a map of Southbridge, which honored the scientist by naming a street after him.



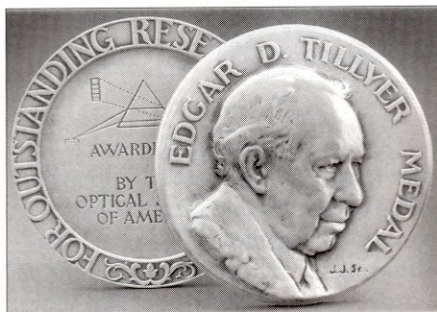
(Right) Tillyer and his wife, Florence, in their living room in Southbridge in the late 1930s or early 1940s.

his work in isolating deuterium, known as “heavy water.” As head of the gaseous-diffusion program for uranium separation, Urey was a vital part of the Manhattan Project to develop the atomic bomb in the early 1940s.

Tillyer’s 54 year career with AO was marked by inventions such as: a retinoscope (1923, with refinements in later years); the Calobar lens (1940); a contact lens (1937); an improved method for cutting crystals for use in radio oscillators (1930); an improved schematic eye (1926); several lens measuring devices (1922 and later years); a light bulb (1917); trial set lenses (1923 and later years); devices for improving sound reproduction in motion pictures and for heat shields for motion picture film (1917 and later years); neutralizing methods for lens measurements (1921 and later years); an ophthalmograph (1939); an ophthalmoscope (1926 and later years); phase microscope improvement (1949); the phoropter (1927 and later years); the Polaroid lens (CoolRay) for eyeglasses (1939); and many patents for improvements in radio and toric lenses.

Patient and helpful with those he considered fellow scientists, Doc was open in sharing his theories and discoveries. He worked closely with optics pioneers such as Edwin Land, developer of the Polaroid process, George Eastman of Eastman Kodak and John Jacob Bausch of Bausch & Lomb.

One lunchtime in the lab, two of Doc’s employees were discussing electrical designs for radios. The discussion became increasingly deep and theoretical, and soon they realized that their lunch



In 1953, OSA inaugurated its biennial Edgar D. Tillyer Medal for outstanding research in vision by awarding it to Tillyer.

hour had been over for some time. Fearing Doc would “raise the roof” when he saw that they were so late, they quickly gathered their papers and stood to leave. It was then they realized Doc had been standing behind them listening to their discussions and observing their diagrams. He did indeed “raise the roof,” but not because they were late; the object of his concern was the fact that they had misunderstood the principles they were discussing. Doc sat down with them and conducted an impromptu class in radio theory. His characteristic pose was perched on the desk, sitting on his heel.

Doc was, however, impatient with non-scientists. During his involvement with the atomic bomb, FBI agents appeared at the front door of his house one day. They wanted to interview him to make sure he wasn’t a security risk. Doc reluctantly allowed them to enter, but after they had posed a few personal questions, he grew weary of the intrusion. When they asked, “What are your politics?” Doc retorted, “None of your goddamn business!” and ushered them out.

While at the National Bureau of Standards, Doc redesigned the optical system used in the naval submarine periscope. Years later, he was touring a naval facility with his son, Lynd, during an open house at the naval yard. When they visited a submarine, they were invited to look through the periscope by the proud ship’s captain. Doc did and detected a smudge on the image. “Yes,” the ship’s captain said, “We’ve noticed it but we can’t figure out where it is.” Tillyer took a magnifying glass from his suit pocket and after studying the device he looked at the captain and said, “You’ll find the problem on the lens right about here,” pointing to a spot on the periscope tube. The officer was astonished: the periscope’s optical system was top secret. The captain asked Doc how he knew. Doc grumbled back, “I invented the goddamn thing.”

Doc received many awards during his lifetime. One, however, he valued more than others. In 1953, OSA inaugurated its biennial Edgar D. Tillyer Medal for outstanding research in vision by awarding it to Tillyer. The medal, a tribute to the achievements of Doc Tillyer, continues to be awarded to this day.

There is no doubt that Edgar Derry Tillyer led an outstanding career in the research of vision and other sciences, and that his creativity benefited mankind. To quote *Scientific American* again, we owe a debt of gratitude to Doc so great “... that mere words cannot express it.”

Tim Tillyer (jtillyer@cox.net) is the grandson of Edgar Derry Tillyer. Tim retired seven years ago from the San Diego County, Calif., Department of Public Health after 34 years of service. He now provides daycare for two of his grandchildren.

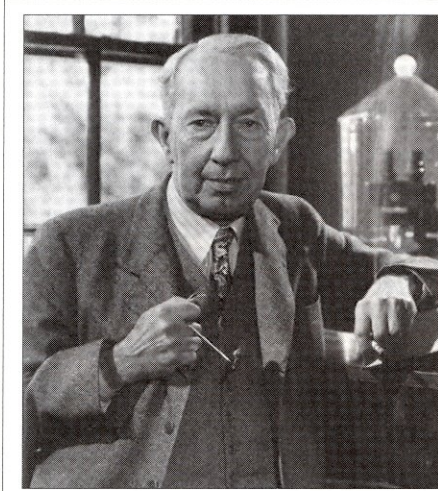
A Biography of Edgar Tillyer

Edgar Derry Tillyer was born in 1881 in Dover, N.J. He was an only child, and a small one at that. As a child, he was taken along on house calls by his uncle, William Derry, a physician. The two would discuss diseases or conditions, along with the appropriate treatments. Edgar was a “tinker,” who spent much of his youth in the backyard shed inventing gadgets. As a teenager, with the help of a friend, he installed electric lights in the local high school.

In 1898, he entered Rutgers in New Brunswick, N.J. A slender youth who stood a mere 5 feet, 5 inches tall, he had blazing blue eyes and an impressive sweep of dark hair. In college, he excelled at mathematics and applied physics. His youthful appearance and apparent small town innocence hid his brilliance, allowing him to easily earn spending money by playing cards.

He soon realized that he would need a master’s degree; he could not, however, afford the tuition. In 1901 or 1902, just before he was to graduate, he heard that the National Almanac Office in Washington, D.C., was giving an examination to college seniors, with first place being appointment there as a computer. Tillyer took the exam, in which he competed against many Ivy League seniors. He received the highest score and took the position, moving to Washington soon after his 1902 graduation from Rutgers. While working there, he was able to attend George Washington University, from which he earned his master’s of science degree in differential equations and functional theory in 1903. Speaking later of his career at the Almanac, he said, “I learned to compute there, which is what the ordinary individual doesn’t know how to do. Most people are afraid of it.”

In 1904 or 1905, he returned to Rutgers, where he was awarded a master’s of science degree in 1905. He felt it would be a waste of time to stay on for a doctorate: he had no need for titles and thought people who remained in school



were often afraid to venture out into the world of research.

In 1905, he married Florence Louise Lynd, daughter of William Lynd, the mayor of Dover. That year he went to work at the U.S. Naval Observatory in Washington, where he stayed until 1911. While at the observatory, he became involved in the congressional investigation aimed at determining whether Peary or Cook had discovered the North Pole first. His task was to analyze each one’s log books. He later told his son, Lynd, that Peary’s figures checked and that Peary was “too goddamned stupid to rig the data anyway.”

While at the observatory, he received the first public recognition of his work. In 1909, he presented a paper, “The Clock Vault of the U.S. Naval Observatory,” at the 10th annual meeting of the Astronomical and Astrophysical Society at Yerkes Observatory in Williams Bay, Wisc. The paper described the innovations he had made to the clock vault that contained the official U.S. Master Clock. The changes were to the temperature-regulating device so that a constant precise temperature could be maintained. As a result of the presentation, he was elected to the society in 1910. At the observatory, he was responsible for developing the calculations used in the creation of a huge astronomical telescope lens. The lens had a 110-inch focal length and was 10 inches in diameter. The design of the lens required 600 days of pencil and paper

calculations that were then reduced to a formula.

In 1911, Tillyer went to work for the National Bureau of Standards (NBS). His work was so respected that he became the arbitrator of disputes between the Army and the Navy over optical requirements. He was also charged with creating a calibrated set of master lenses to verify optical surfaces in labs around the country. The lenses bore the valued NBS certification and the initials of the examiner, in this case, “EDT.”

In 1915, when he saw the need for an optics association to further the exchange of ideas and information, he and some associates formed OSA. The same year he published a paper “Axial Aberrations in Lenses,” that was read by George W. Wells, president of AO. In 1916, Tillyer was hired as director of the research laboratory at AO. He would work there until his death on Christmas Day 1970.

In addition to inventions in optics, “Doc,” as he was called, was responsible for a number of inventions involving radio in the 1920s and 1930s. Many of his patents were sold to RCA. Doc once told his son how he had put one over on either RCA or AT&T, explaining that he had sold an obsolete patent and used the money to buy a Buick.

Doc went to the office every day until about a week before he died. In later years, younger staff found him a nuisance and a meddler, but older staff knew his background and treated him with respect. Although he had formally retired years before, AO always kept a corner office for him. He used it for reading or as a base for wandering the halls and peering over people’s shoulders to see what was going on.

Doc has been described as a Renaissance man because he was well versed in all the arts and sciences. His skills ranged from glass technology to crystal oscillators, and from growing exotic flowers to mechanical design.

For a complete biography of Edgar Derry Tillyer including his childhood, personal life and a description of each of his patents, please contact his grandson, Tim Tillyer, 1129 Viewmont Dr., Escondido, Calif. 92027