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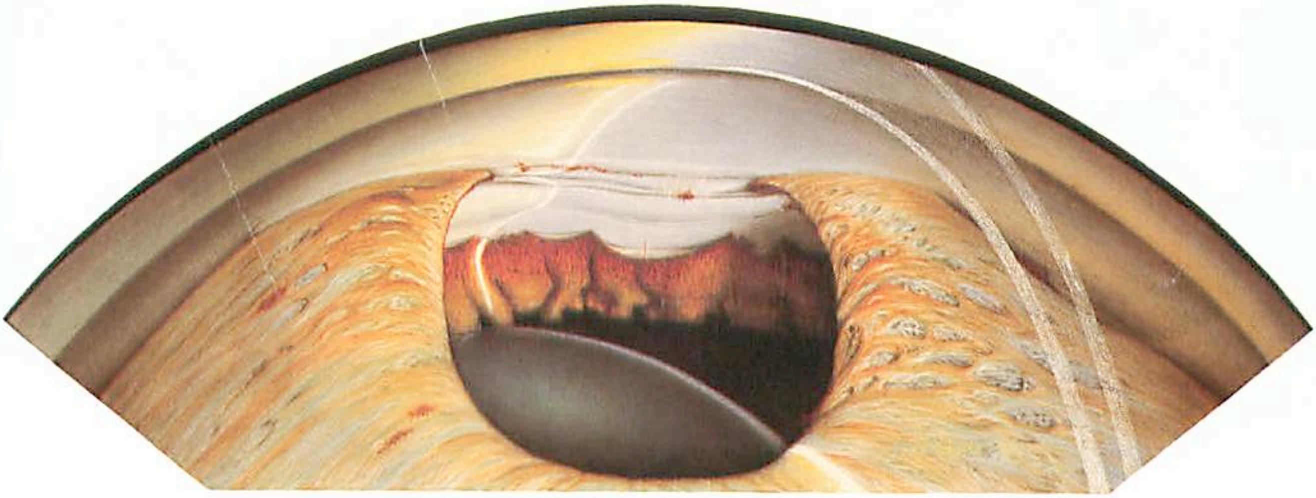
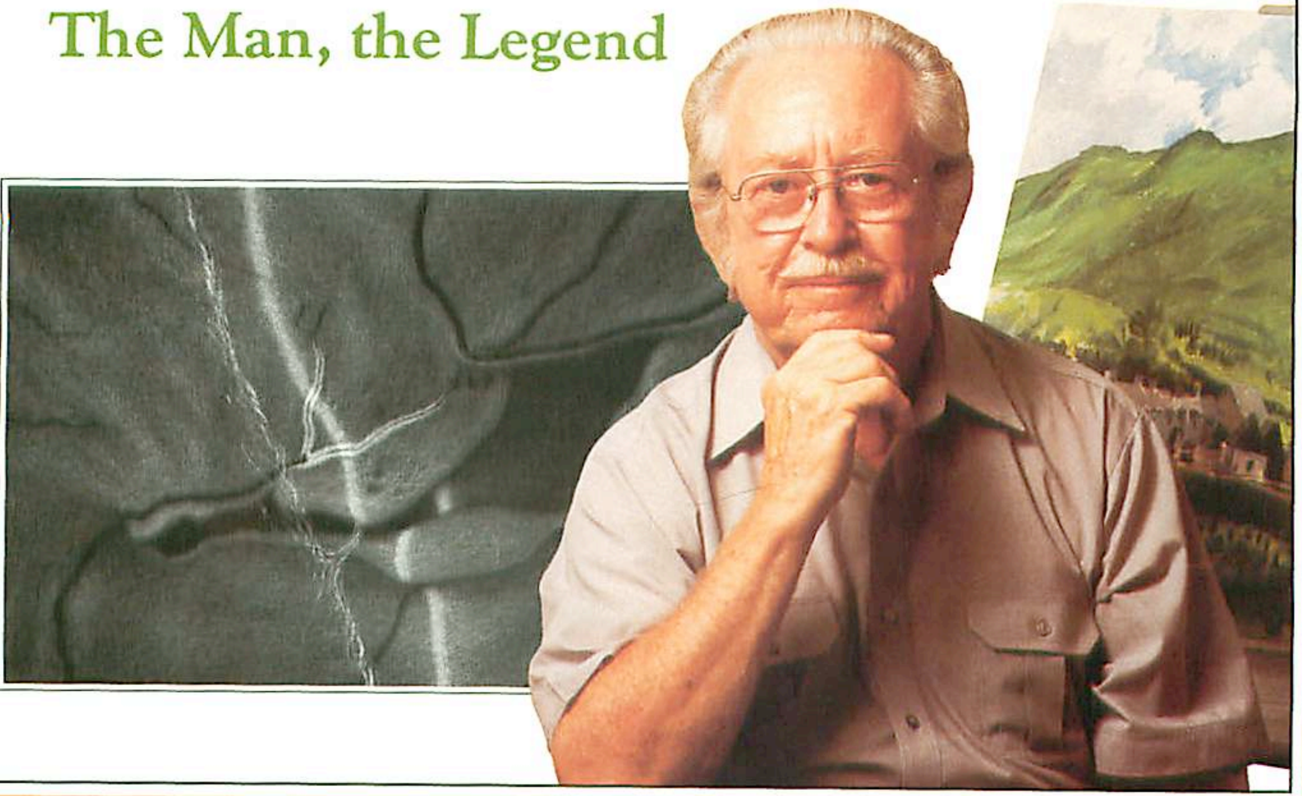


Lee Allen

The Man, the Legend



To Lee Alward
with best wishes Lee Allen

Lee Allen

The Man, The Legend

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> *The highway of health is lined with memorials erected to those who have advanced the art and science of medicine. Every discovery in medicine and surgery is commemorated, some by large imposing structures, others by small tablets; but to the historian every one recalls important facts, so that this avenue is life's most famous road.*[1]
>
> Authur J. Bedell, M.D.

Every once in a while, a rare individual comes along to leave a meaningful mark on his chosen profession. Lee Allen is such a person, and we who are engaged in ophthalmic photography at this time are privileged to be considered his contempories.

Lee Allen personifies achievement. He appears able to master any challenge that he chooses because of his intense determination. A natural curiosity combined with an ingenious mind and creative talents have made Lee an innovator, not only in ophthalmic photography, but in ophthalmic medical illustration, ocular prosthetics, and ophthalmology itself. His achievements become even more amazing when we learn that Lee knew nothing of ophthalmology until as a young man he undertook ophthalmic medical illustration in order to support his family.

Edwin Lee Allen's first nine years were spent in Muscatine, Iowa, a small city on the Mississippi River, where he was born on September 16, 1910.[a] In 1918, Lee's mother contracted and died of double pneumonia from the "war flu" that followed the end of World War I. The next year Lee's father remarried and moved to Des Moines, Iowa, where Lee was to spend his formative years, being raised and educated and learning his love of art, and being ingrained with deep-seated values of perseverence and self-reliance. Lee's father, a self-taught, innovative engineer, had a workshop in the basement of their home. Here Lee learned many crafting techniques using a metal lathe, milling machine, band saw, and other woodworking tools. Lee was destined to carry his "lessons of childhood" throughout his life, as integral components of his numerous achievements.[b]

Art

The first hint that Lee had artistic abilities came after his eleventh Christmas, when he received an oil painting set from his father. This gift resulted in Lee becoming so enthralled by art that by the time he was in high school, he knew that he wanted to be an artist (Fig 1). Lee's natural talent became obvious early on, when he began receiving awards in local art shows and competitions for his oil painting, water colors, etchings and lithographs.

Figure 1: Lee, at age 16, began winning awards for etchings, oil paintings and water colors in the Iowa State Fair Salon.

Lee's father didn't anticipate the passion his gift would unleash and tried to dissuade his son from becoming an artist, because it held an uncertain future for him. He wanted Lee either to follow in his own footsteps as an engineer, or consider becoming an architect, which might satisfy his artistic needs. But Lee persisted in his intentions to become an artist, a source of contention between himself and his father that was to become a moving force in Lee's professional destiny.

Lee's conviction to obtain an education emerged at an early age. His father believed that after finishing grade school (8th grade), a person should begin working to support himself; if someone wanted to learn more, he could study in a library. Despite these strong pressures from his father to quit school, Lee was supported by his stepmother who fought for his individuality and right to more than an eighth grade education, which helped Lee persist in his ambitions to graduate from high school and pursue a career in art. Although he was allowed to live at home while in high school, Lee was no longer given full financial support. He was expected, moreover, to undertake extensive household chores in return for his room and breakfast. Although this treatment seemed harsh at the time, Lee later credited his father with having instilled in him a strong sense of self-discipline.[c]

To cover his expenses throughout his high school years (1924–28) Lee delivered messages by bicycle after school for Western Union, working from 4:00 p.m. until 10:00 p.m. every night. These duties brought him into contact with members of the art department of the *Des Moines Register & Tribune*, one of the midwest's most prominent daily newspapers of that time. Lee began watching the artists work there, often returning after finishing his shift at Western Union. The artists would demonstrate for him some of the techniques with pen and ink and air brush, and show him composition and retouching procedures.

Another important person in Lee's life at the time was his high school art instructor, Harriet Macy, whose influence was to play a key part in shaping Lee's adult personality. With her philosophy that people do not use more than one tenth of their potential abilities, she encouraged her students to make greater use of their talents. She fired his interest in broad experiences and education, guided Lee into the world of art and encouraged him to attend the University of Iowa Art School, exhibit his work in the State of Iowa, Iowa Art Salon, and to do anything else he wanted, or felt the calling to do. This teacher inspired the self-determination that propelled Lee's pursuit of knowledge and excellence throughout his career.

In 1928, Lee won a First award in oil painting in the Iowa State Fair Salon. Another major winner in the show was a young man by the name of Grant Wood. Although Wood was nineteen years older than Lee, the two young men became friends, and would remain close until Wood's death in 1941. In his career, Wood became a nationally prominent regionalist artist, and his approach to fine art became a strong influence in Lee's artistic style.

Following high school, Lee attended the Cummings School of Art in Des Moines for a short time. During the summer of 1929 he worked in a factory to earn tuition and expenses for his first year at the University of Iowa. That fall, Lee enrolled as an art student, intending to major in fine arts. His costs were at first partly defrayed with jobs in a school cafeteria, and later he worked as a designing artist for a local company that decorated large halls for school dances at various midwestern universities.

During holidays from school, Lee would visit his family. It was on one such visit that Lee made an astounding discovery. Rummaging through a trunk in the attic, Lee discovered a yellow and faded certificate that was a First Prize Award for crayon portraiture earned by his father in a county fair competition many years earlier! Confronted with the award, Lee's father confessed that he had tried to support himself by doing crayon portraits for three years, but couldn't make a living at it, and so became an engineer instead! Lee could now understand why his father was so against Lee's choice to become an artist.

Figure 2: Lee, at age 25, working on a fresco panel immediately after returning from Mexico, copied from a watercolor he entitled "Pyramid of the Sun in Mexico."

While at the university, Lee befriended and eventually roomed with another, more advanced art student, Emil G. Bethke. Emil became the first medical illustrator in the Department of Ophthalmology at the University of Iowa.[d] Many nights, Bethke would return to the hospital to finish a drawing and Lee, being curious about the work, would go with him. Lee prevailed upon Emil to demonstrate his techniques of ophthalmic illustration, as well as those of the direct ophthalmoscope and slit lamp, and soon Lee began making his own retinal drawings. When he resigned his position in 1935, Bethke asked Lee if he would like to take over, but Lee declined because he wanted to continue with his goal to be an artist.

Thus, Lee pursued his painting for the next few years. He spent part of the summer of 1935 in Mexico City where he studied briefly with the famous muralist, Diego Rivera, and other Mexican fresco painters. Observing Rivera's mural painting technique served Lee well later. After returning to Iowa, he briefly practiced fresco painting (Fig 2). Lee's friend Grant Wood had become famous in the 1930s for his painting *American Gothic* and, in 1933, was named Regional Director of the Public Works of Art Project (P.W.A.P.) under the U.S. Government's Works Progress Administration (W.P.A.). Lee worked with a group that transferred Grant Wood's designs onto large linen canvas for installation in the Library of the Iowa State University in Ames, Iowa (Fig 3).

Near the completion of that three-year project, the U.S. Treasury Department awarded Lee a commission for a mural painting (oil on canvas) for a new Post Office Building in Onawa, Iowa. His subject was soil conservation. About a year later he was awarded another commission for a mural on wild life, intended for the new

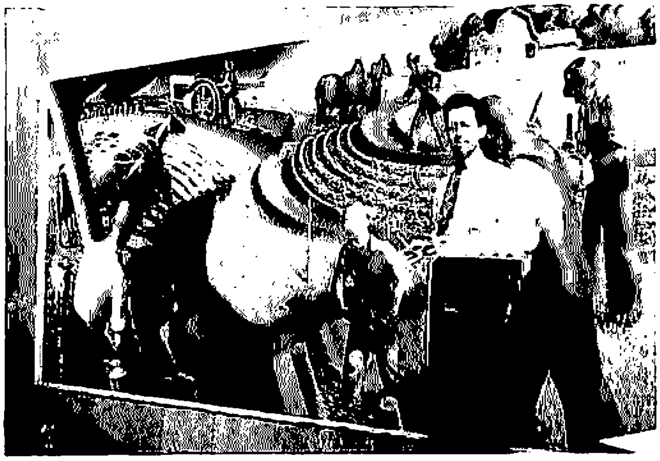


Figure 3: At age 26, Lee painted murals with Grant Wood in the W.P.A. Two of Lee's murals are exhibited in Post Offices in Emmetsburg and Onawa, Iowa.

Post Office in Emmetsburg, Iowa. Both of these murals still reside in their respective locations. The color preliminary painting for the mural exhibited in Emmetsburg is part of the permanent collection at the Smithsonian Institute in Washington, D.C.

Medical Illustration

In 1937, when the medical illustrator was leaving the Eye Department at the University of Iowa, Lee was once again asked to take over. Lee hesitated because he preferred the world of fine art and he had no medical education. But Lee had married the previous year, and the financial realities of his wife's expecting their first child caused him to reconsider, and so a new career was launched. However, Lee continued to paint, sketch, and sculpt in his free time, giving most of his art work away.[e]

With the adoption of his new profession, Lee faced monumental challenges. Not only did he need total familiarity with the anatomy and physiology of the normal eye, but also of the disorders and diseases of the abnormal eye. Trips to the operating room to diagram new surgical procedures were another necessity. From this practice, he acquired a working knowledge of some of the standard surgical procedures, the instruments used, and the techniques of the surgeons. The pressure of having to learn all of this new material was amplified by the requirement to start producing work immediately. That the illustrations were to be anatomically accurate and of high technical quality was unequivocal. Only the most gifted of persons could have managed those tasks alone. Lee Allen did more.

Recognizing the obstacles Lee faced, Department Chairman Dr. C.S. O'Brien, not only encouraged him to audit the lectures and courses scheduled for the ophthalmology residents, but also gave Lee his full support to devise his own projects within the department. Lee received full credit for the work in subsequent publications, and eventually became first author on many articles.[f]

> *"The department wanted him to learn. He himself had a desire to know all he could."*[32]
>
> David Bulgarelli
>
> **Describing how Lee Allen acquired multidimensional expertise.**

Lee's progress through ophthalmology was very circuitous, continuously bringing him into contact with new challenges, many of which were delegated by the director or members of the medical staff of the Department of Ophthalmology, but in several cases, Lee voluntarily undertook projects out of genuine scientific curiousity. One of these projects established Lee as an expert in three-dimentional imaging.

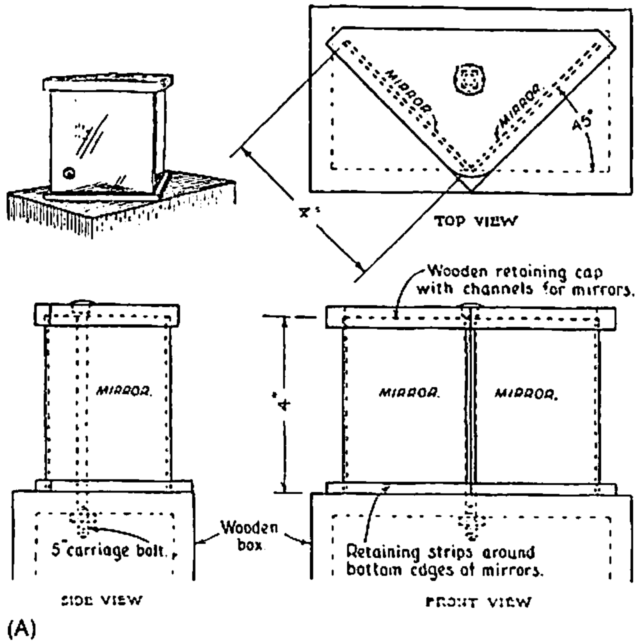
STEREO ILLUSTRATION

Early in his career, Lee developed an intense interest in stereopsis, which he later applied throughout his professional art and photography. He made disparate pairs of drawings which could be mounted into stereo mounts to be viewed in a stereo hand-viewer. In 1940, he also designed and produced a scientific exhibit on neuro-ophthalmology which was shown at the American Medical Association Annual Meeting in New York City.

The impressive exhibit, entitled "Stereoscopic Drawings of Neuro-ophthalmology" (by P. J. Leinfelder and L. Allen), consisted of a long bench, at the opposite ends of which were mounted two identical, but disparate, drawings facing each other. A Wheatstone stereoscope (Fig 4A), a device consisting of a pair of 4″x4″ mirrors mounted into a box-like base at 45° to one's line of vision, was placed in the center of the long bench. The observer sat before the stereoscope and viewed the drawing on the left through the left-hand mirror with the left eye, and the drawing on the right through the right-hand mirror with the right eye (Fig 4B).

Serial pairs of drawings of the brain as it relates to ophthalmology,[g] in its entirety as well as in cross section, were produced using a special stereoscope drawing technique: for each pair of drawings, Lee pinned two sheets of art material to his board, first occluding his right eye and drawing the brain as seen with his left eye, then occluding his left eye and drawing the brain as seen with the right eye (Fig 5). Thus, when viewed in the Wheatstone stereoscope, the two disparate images could be easily fused by the observer's brain to appear three-dimensional.

To achieve this effect, however, strict attention had to be paid to the exact duplication of all vertical and lateral lines and points within the subject, from one drawing to the other. In this way it was possible to provide an accurate representation of the height and depth relationships of the various parts of the subject. Errors in these dimensions would result in points appearing closer or more distant than they actually were. Also, errors in the vertical meridian would place undue strain upon the observer's eyes—all corresponding lines



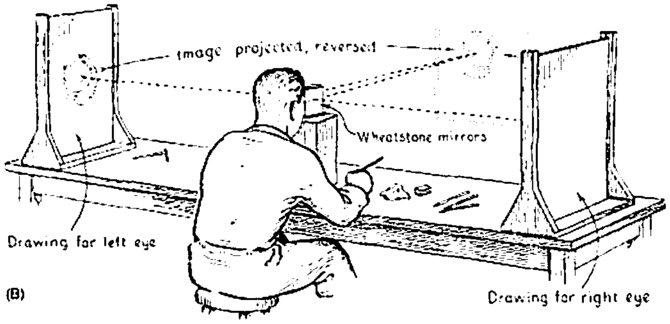


Figure 4A: Plans of a homemade Wheatstone stereoscope. **B:** Viewing drawings with the Wheatstone stereoscope, designed and produced by Lee [Reproduced from L. Allen: Stereoscopic drawing techniques. *Medical & Biological Illustration*, 1(4): pp. 186 and 187, 1951.]

had to be of the same width through the entire drawing. Moreover, all the labels and legends used on the drawings had to be done in reverse, in order to appear correct when seen in the stereoscope. Any mistakes had to be painstakingly corrected.

The discipline of this and similar experiences developed in Lee a meticulous attention to detail and single-minded obsession for accuracy. Lee subsequently published his techniques in the biomedical literature.[2] Coupled with his fascination with depth-perception, this expertise would come to play an important part in Lee's contribution to ophthalmic photography two decades later.

Gonioscopy

In 1941, the Eye Department sent Dr. James H. Allen (no relation to Lee) to learn the techniques of gonioscopy from Dr. M. Troncoso, one of the few American ophthalmologists who was studying the anterior chamber angle (in living humans) by gonioscopy.[3] Troncoso's technique consisted of using a Barkan lens, which had a steep curve on its anterior surface, combined with a water chamber between the goniolens and the cornea of the eye to provide optical continuity. Gonioscopy would be performed with a loupe and penlight and, after only about a half-minute, the water would leak out from between the goniolens and cornea, thus breaking optical continuity.

Although imperfect and difficult to use, Troncoso's technique was the best method of gonioscopy available at the time, and Iowa's Eye Department was interested in replicating it. With only Dr. Allen's description of the technique he had observed, Lee was able to duplicate this lens for their department, and put it into use. The awkward technique, however, proved to be very discouraging to doctors and patients alike.

GONIOPRISMS

Dissatisfied with this method, Lee believed that gonioscopy did not require a deep fluid chamber between the goniolens and cornea, so he fashioned an entirely new type of examination lens. Using the skills that he had learned in his father's basement machine shop, Lee designed a small lens that did not extend onto the scleral area of the eye, but rather contacted the cornea only, and maintained optical continuity by a capillary film

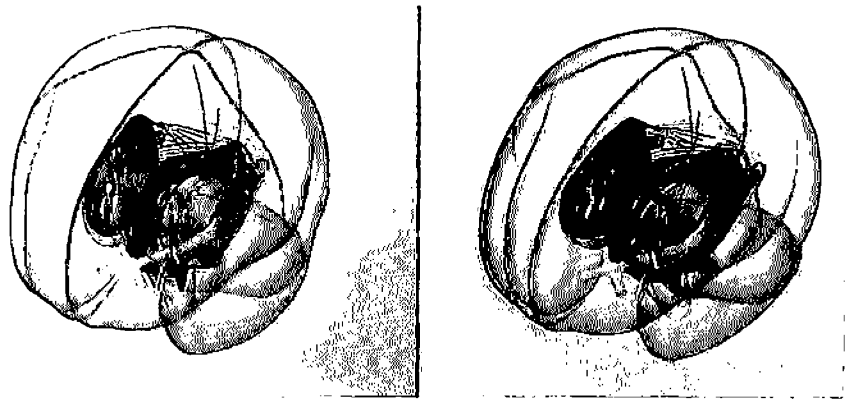


Figure 5: One of Lee's stereoscopic pairs of brain illustrations for the scientific exhibit "Stereoscopic Drawings in Neuro-ophthalmology" at the American Medical Association Annual Meeting, New York City, 1940.

of tears. Lee took the lens to the Eye Clinic and asked one of the staff, Dr. P. J. Leinfelder, to help test the new device. Leinfelder, assisted by a patient and with a drop of topical anesthetic on the eye, placed the lens on the cornea. Lo and behold, there was the chamber angle! With this new lens, the anterior chamber angle could be examined more easily than anyone had ever thought possible.[h]

Although the new lens was an immediate success, enabling the department staff to visualize the chamber angle without any difficulty, Dr. O'Brien advised Lee that the new device would not be practical unless it could be placed on the eye and remain in position by itself. Lee continued perfecting the lens, designing several models until he finally succeeded in mounting the gonioprism onto a speculum that could be positioned under the patient's eyelids (Fig 6).[4,5] With the aid of this lens, the members of the department began to study the chamber angles of every glaucoma patient. Eventually, with the collaboration of Dr. Harvey Thorpe, an ophthalmologist from Pittsburgh's Montefiore Hospital, the lens evolved into a four-mirrored device, which they named the Allen-Thorpe Gonioprism,[6] which was patented by Bausch & Lomb Optical Company.

In the beginning, as designer of the lens, for some time Lee was called upon to apply the instrument and study each patient before the doctor did his examination. In so doing, he rapidly became an expert on gonioscopy.[i] Unlike previous instruments, this lens could be so comfortably and firmly positioned under the eyelids that examinations could easily be done with the patient seated at the slit lamp, thus permitting the time to make new observations on the anterior chamber. As a result, Lee began to spend most of his medical illustration efforts doing drawings of the anterior chamber angle (Fig 7).

Figure 7: Example of Lee's slit lamp gonioscopy drawings. Carbon dust, pencil and ink drawing of peripheral anterior senecia, showing lens, zonule and ciliary body.

THEORY OF DIFFERENTIAL GROWTH

As Lee's familiarity with the anatomy of the angle grew, questions about the formation of the chamber angle began to intrigue him. Why did the chamber angles look as they did? Why did some look like the chamber angles of cows, and others like those of cats or pigs?

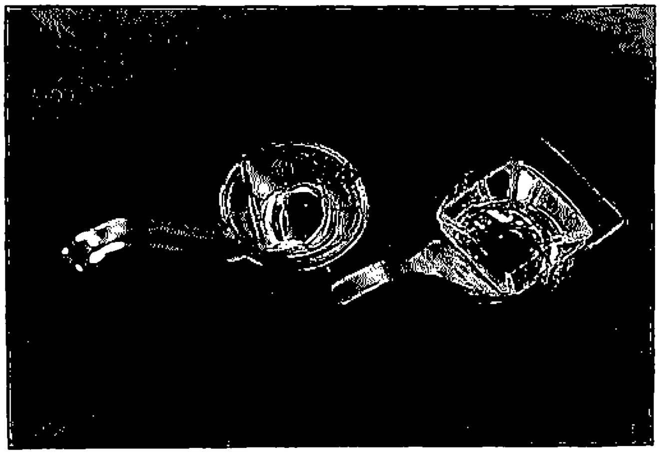


Figure 6: Two of the first goniolenses ever made by Lee: a single- mirrored, and a later four-mirrored model.

For the answers, Lee began reviewing the literature on anatomy of the chamber angle. One translated paper by the European expert, Dr. R. Seefelder, proposed the prevailing theory that the angle of the anterior chamber opened in embryonic and fetal life by a process of atrophy and resorption of tissue.[7]

Doubting the validity of this theory, Lee pursued a more plausible explanation. First, he consulted an expert comparative anatomist at the University's Zoology Department, asking if there was any place in the bodies of humans or lower-order species where cavities opened up by a process of atrophy and resorption. The anatomist's answer was that, to his knowledge, all cavities developed through the *increase* of the number of cells surrounding the cavities, giving them greater surface.

Dr. Alson E. Braley, the second head of the Eye Department who was a bacteriologist and pathologist, suggested that Lee might resolve his questions by microscopic research of the embryonic, fetal, and adult chamber angles. Responding to this suggestion, Lee embarked on a study that took all his spare time for nearly a year, looking at thousands of histologic sections, studying every eye in the ophthalmology department's pathology lab, including counting the mesodermal cells of the trabecular zone and the ciliary body, and studying the changes in form, volume, and space relationships.

Lee garnered substantiating histopathologic evidence demonstrating that the two cellular layers forming the embryonic angle separate, in part due to a diverse rate of growth: he found that the scleral spur moves forward at a greater rate than the tip of the ciliary body, resulting in a rotation that pulls apart the layers of cells, thus forming a common junction. Hence, contrary to Seefelder's theory of cellular diminution, during development a con-

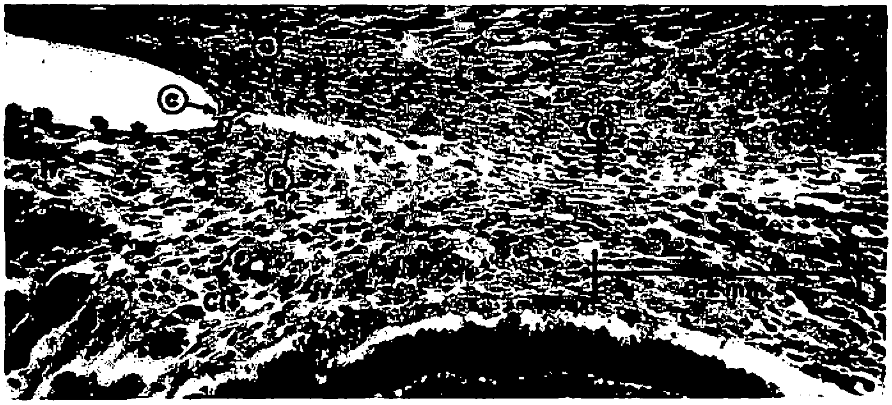


Figure 8: Histologic section (Mallory stain) through the chamber angle of a 220 mm fetus. Note: long parallel collogen fibers to the right side of cleft. "Cleavage is occurring first between the inner surface (*a*) of the uveal trabecular tissue and the anterior surface (*b*) of the iris-ciliary body mass." [8] Lee theorized that the angle is formed when two layers comprising the embryonic angle separate, in part due to a diverse rate of growth. [Reproduced from Allen L., Burian H.M., and Braley A.E.: A new concept of the development of the anterior chamber angle. *Archives of Ophthalmology*, Vol. 53, No. 7, page 5, 1955. Reprinted with permission from the American Medical Association.]

tinual *increase* in the number and differentiation of cells was responsible for the formation of the anterior chamber angle (Fig 8). Thus, Lee conceived of an **entirely new theory of the embryonic development of the anterior chamber angle** that was in direct contradiction with current accepted theory!

The published work on this new theory[8] initially caused controversy among physicians and anatomists alike, but Lee's concept eventually became recognized as more feasible than that of Seefelder. Over a period of years, Lee produced a series of drawings of the anterior chamber angle for patient records, publications, and teaching, many of which have become recognized as classic illustrations and paintings of these structures.

TRABECULOTOMY AB EXTERNO

As a natural extension of this research, Lee investigated the abnormal development of the chamber angle that is often associated with glaucoma. Perhaps it was Lee's fine art background that gave him an experimental edge that was needed at the time to develop new ways of looking at medical techniques and instruments. He subsequently devised a **new surgical procedure** with which to treat these conditions, trabeculotomy ab externo,[9] [j] and made the first instruments to be used to perform the operation.[10] His collaborator, Dr. Hermann M. Burian, was first to use this procedure and he reported on his success in numerous publications and lectures in the United States and Europe.

ERG ELECTRODE

Doctor Burian, who was also known worldwide for his electrophysiological studies of the eye, approached Lee for help in designing a better contact lens electrode than was currently available for electroretinography (ERG) studies. The ERG electrodes then in use consisted of large contact lenses that fit under the eyelids. Eye movement in response to the bright flashes of light during the test were causing false peaks in ERG responses. Dr. Burian thought that Lee, with his new ideas, might be able to create a more satisfactory lens for ERG testing.

Extrapolating from the basic configuration of his lid speculum for gonioscopy, Lee experimented with various designs until finally constructing a contact lens electrode that was mounted flexibly on a spring within a speculum, thus preventing lid movement from interfering with the eye's electrical response to the testing light (Fig 9). This solution proved highly satisfactory. The design was submitted in 1954 to Mr. Ken Hansen, a skilled optician in Iowa City, to produce these lenses for the department.[11] The combination of Lee's imaginative design and Mr. Hansen's expert craftmanship has made Burian-Allen ERG electrodes popular worldover, not only for clinical testing of humans, but also for ERG research on a vast variety of animals and birds.[k]

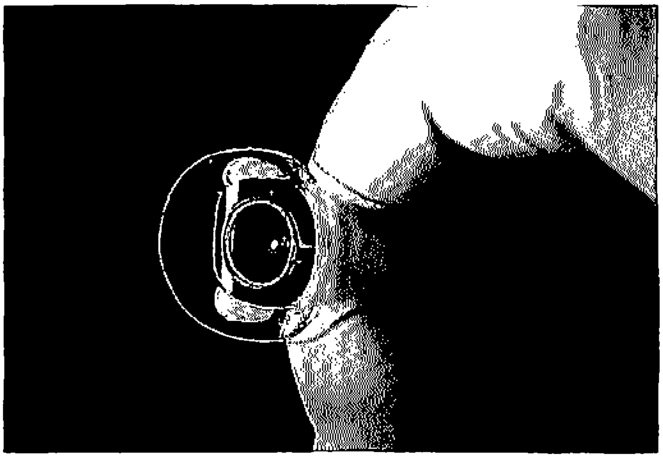


Figure 9: Burian-Allen ERG Electrode, designed and made by Lee and subsequently manufactured by Ken Hansen, Ophthalmic Development Laboratory.

Ophthalmic Photography

In 1939, two years after he started working at the university, Lee turned his attention to ophthalmic photography. He recognized that with the introduction of Kodak's new Kodachrome color transparency film that year, photography could possibly exceed the illustrator's capabilities in documenting ocular disorders. Lee purchased a $12 Kodak 35 mm camera, removed the camera lens, remounted it on an extension, and began taking close-up (1:1) pictures of the external eye and anterior segment. By using ordinary flashbulbs, he could stop down the camera aperture in order to achieve good resolution and depth of field. Lee thus established ophthalmic photography as an integral part of the ophthalmology department.

FLUORESCEIN ANGIOGRAPHY

With the use of this equipment, Lee captured the first color photographs ever taken of sodium fluorescein dye as it flowed through the anterior chamber. In 1940, Dr. Kenneth Swan, a staff ophthalmologist, wanted to measure the transit time for pilocarpine, atropine, epinephrine and other drugs to flow through the bloodstream into the aqueous from the posterior chamber of the eye. Working with rabbits, they injected fluorescein into an ear vein, and watched the passage of the dye through the aqueous. After several attempts, Lee finally obtained on Kodachrome film the first photographs of fluorescence following the injection of fluorescein dye, demonstrating the dye's transit. Because the fluorescent images recorded with this homemade 35 mm system were so small, a color composit drawing was used to represent some of the photographs when the results of these experiments were published.[12]

FUNDUS PHOTOGRAPHY

The new possibilities of color photography impelled further experimentation in ophthalmology. In 1949, Lee and one of the ophthalmology residents, Dr. Nicholas Douvas, decided to use this new medium for fundus photography. They retrieved an old Zeiss-Nordenson carbon-arc fundus camera that had been stored in the corner of Lee's darkroom for several years. When purchased for the department in 1928, this instrument recorded fundus pictures on black-and-white glass negative plates. Dr. O'Brien, however, felt that fundus morphology should be documented in color, which had led him to hire a medical illustrator. Thus, the camera gradually fell into disuse and was ultimately placed in storage. With the new availability of Kodachrome, perhaps this instrument could be of some value after all.

Replacing the glass plate holder with a hand-made adapter for Bantam size, 828 Kodachrome film, Lee and Douvas soon learned how to use the instrument well enough to begin to substitute color fundus photography for retinal illustration. They also discovered that this instrument was useful for anterior segment photography as well, and published the first paper on this technique.[13]

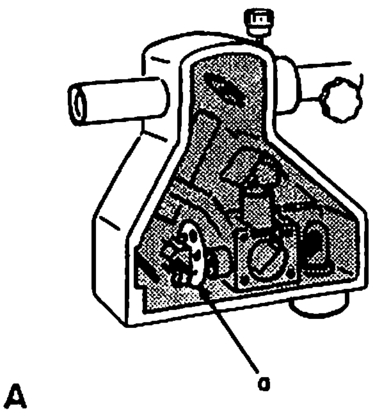
During the 1950s, a Cooperative Study of the Long-term Effects of Hypertensive Drugs was set up in ten VA hopitals and fundus photography was being used as one of the research criteria. Dr. Walter Kirkendall, a professor of internal medicine at Iowa, was a participant in the study. The quality of the early photographs being submitted by the participating institutions, however, was proving to be of little or no value because of artifacts in alignment, focus and exposure.[f] In many cases, photographers were taking an entire roll of film on each eye, in their attempt to obtain at least one good photograph for the study.

Being familiar with the quality of Lee's fundus photography, Dr. Kirkendall asked him if he would prepare a photographic protocol for the study photographers to follow, outlining the steps necessary to obtain consistently good fundus photographs using the Zeiss-Nordenson camera. Lee did this, and agreed to help evaluate the results. Thus for several months afterwards, Lee served as a reader for the study, receiving films from the study photographers in the mail, evaluating them, and returning them with comments on how improvements could be made.

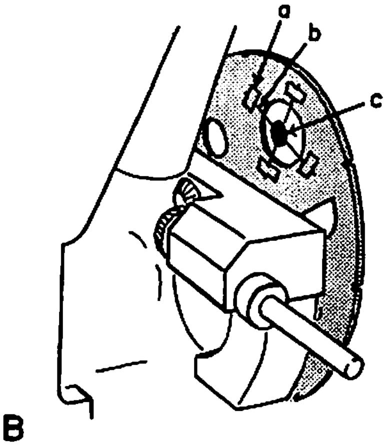
> *"You can't imagine how good he was. He touched so many people's lives every day."*[34]
>
> Dr. Alson E. Braley
>
> Commenting on Lee's work at University of Iowa.

Thus, in addition to all his other duties as medical illustrator, instructor, and participant on numerous types of research, Lee undertook the responsibility of providing the expanding volume of photographic services for his department. Lee now needed a multi-talented assistant. In 1964, he hired a skilled machinist and tool maker, Mr. Ogden Frazier, to assist in both the photography and the production of the devices Lee

Figure 10: Lee and Ogden Frazier (behind camera), at the Ophthalmic Photography Laboratory of Iowa's University Hospital in 1965.



Camera with side cover removed exposing aperture wheel.



Accessory mask (Allen Dot) placed on aperture.

would design. Ogden eventually assumed the role of Chief of the Ophthalmic Photographic Service. In addition, occasionally when Lee had an idea for a new instrument, he would take the concept to Ogden, who would often make the device entirely by himself. In the ensuing twelve years of collaboration with Mr. Frazier, the photographic section of Iowa's Department of Ophthalmology achieved international prominence (Fig 10).

In 1964, Lee published an expanded version of the guidelines he had established (for the collaborative hypertensive study) in an extensive paper that described the technique of fundus photography with Zeiss's first electronic flash model camera. The article, "Ocular Fundus Photography. Suggestions for Achieving Consistently Good Pictures and Instructions for Stereoscopic Photography" ultimately served to help a new generation of photographers standardize their techniques. It also introduced one of Lee's important innovations to ophthalmic photography, which came to be known as the "Allen Dot," and clarified the technique of stereo fundus photography as well.[14]

ALLEN DOT

Soon after acquiring the new Zeiss fundus camera with electronic flash (first introduced in 1957), Lee began encountering problems in obtaining critical alignment with this instrument, resulting in a bright meniscus on one side of the picture, or an overall haze. He realized that, in one case, he was getting reflections from the cornea, and in the other, reflections from the iris and tissues on the inside of the eye.

While examining the optical system of the new fundus camera, Lee noticed that Zeiss had a black dot painted on one of the camera's lenses in the illumination system, the function of which was to cast a shadow through the entire anterior segment of the eye to prevent stray light from being reflected directly back into the lens that would form an image. Guessing that the camera's designer had based this design on the average, or ideal eye, and did not take into full consideration differences in corneal curvature, or depth of the anterior chamber, Lee found a simple solution: make the shadow slightly wider and longer in order to project from the level of the iris deeper into the eye (Fig 11C).

In the aperture wheel, comprised of a number of openings of different sizes and shapes, Lee found a place in the camera's illumination system where he could place another opaque circle from which the shadow could extend slightly farther than the original Zeiss dot. Lee cut, by hand, a 6 mm circular mask out of ordinary black illustration paper, and secured it in one of the aperture wheel's circular openings with suture material painted black (Fig 11B). Eventually the Zeiss Company incorporated Lee Allen's mask, or "dot" into all of its fundus cameras, and named the innovation after its inventor. But in 1964, Lee's landmark article helped improve ocular photography with existing equipment by explaining in detail how photographers could make and insert these masks for themselves.

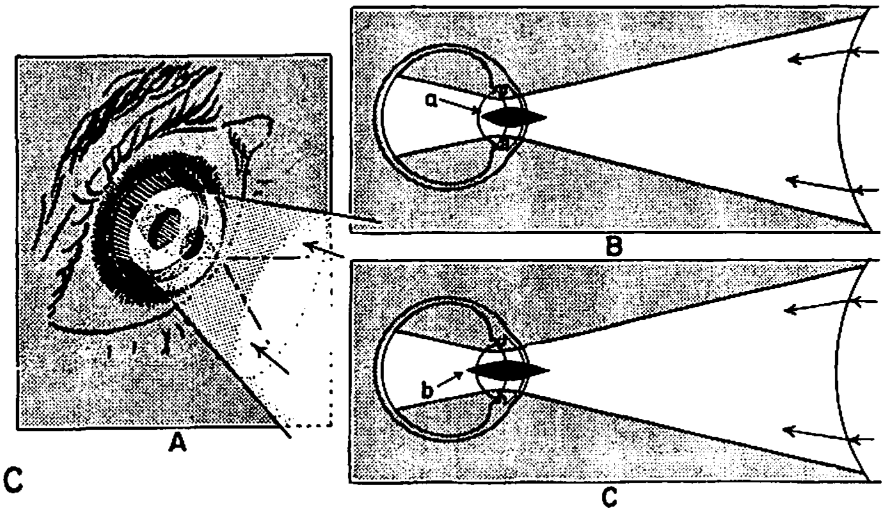


Figure 11: Schematic drawings (by Lee Allen) showing modification of Zeiss fundus camera to lengthen nonilluminated central area of camera's illumination. C: Illustrations showing (*A*) cone of light properly directed and focused; (*B*) traversing eye with excessive illumination of central lens cortex, capsule and vitreous; and (*C*) lengthened nonilluminated area. (Reproduced from, Allen L.: Ocular fundus photography. Suggestions for achieving consistently good pictures and instructions for stereoscopic photography, *American Journal of Ophthalmology*, Vol. 57, pp. 16 and 17, 1964. Published with permission from *The American Journal of Ophthalmology*. Copyright by The Ophthalmic Publishing Company.)

STEREO PHOTOGRAPHY

Lee applied his expertise in three-dimensional perception to the techniques of stereo fundus photography. He extrapolated from Dr. Authur J. Bedell's technique of moving the camera laterally and realigning it at a different angle while keeping the patient's fixation constant,[15] added his own theories of stereopsis, and developed the idea of shifting the axis of the camera's optical system from one slope of the cornea, to the peak of the cornea, and across to the opposite slope. In this way, one could take advantage of the opposing "prismatic" effects (Fig 12). The technique, which he named cornea-induced parallax, and described in his 1964 paper, produced effective stereo photography, however the degree of stereopsis was not well-controlled.

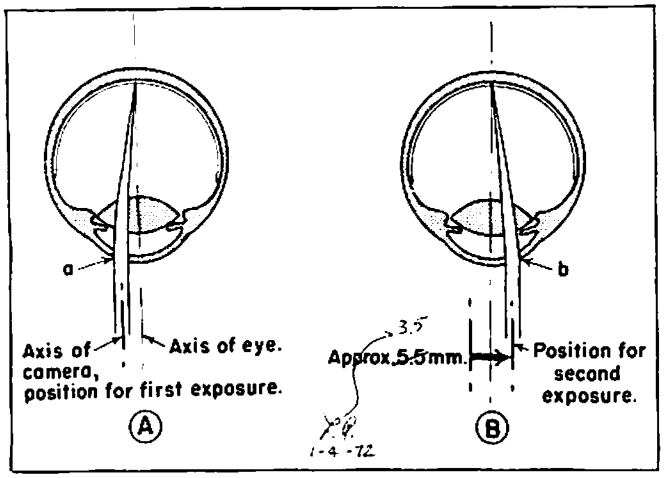


Figure 12: Diagrams of principle of "cornea-induced parallax" permitted reproducible stereo fundus photography. Originally published in Allen L.: Ocular fundus photography. Suggestions for achieving consistently good pictures and instructions for stereoscopic photography, *American Journal of Ophthalmology*, Vol. 57, p.25, 1964. (Published with permission from *The American Journal of Ophthalmology*, Copyright by The Ophthalmic Publishing Company.) Lee subsequently corrected the estimated shift of axis of camera.

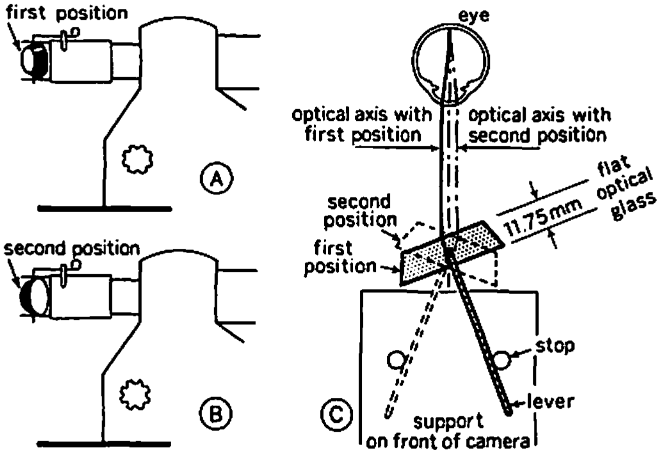


Figure 13: Prototype of stereo-separator. First published in Allen L., Kirkendall W.M., Snyder W.B. and Frazier O.: Instant positive photographs and stereograms of ocular fundus fluorescence, *Archives of Ophthalmology*, Vol. 75, p. 75, February 1966. Copyright 1966, American Medical Association. [Reproduced with permission from the American Medical Association.]

Lee did not stop there, but sought a reliable, reproducible method of stereo photography. He fashioned a prototype mechanical stereo accessory[16] by framing a piece of plano glass plate with heavy-gauge picture wire. The framed glass was then hung on a hand-made bracket that was secured over the front barrel of the fundus camera. Over the top of this device he secured another wire, which was bent back toward the photographer to serve as a handle (Fig 13). To obtain stereo photographs, two pictures were sequentially taken of the same field, with the glass plate tilted in one position for the first photograph, and then tilted in the second position for the second photograph. The glass plate diverted the light rays emanating from the fundus camera to opposite sides of the dilated pupillary area (and thus to the opposite slopes of the cornea). Along the same paths but in reverse direction, the disparate images of the fundus returned to the camera through opposite sides of the cornea to produce stereopsis. Thus a systematic parallel shift was effectively produced without having to move either the camera or the patient's gaze, and the resulting stereopsis was nearly reproducible.

By 1970 the Zeiss Company had produced a motorized version of this stereo device.[17] This automatic power-driven unit, which was named the "Allen Stereo Separator," made it possible to take stereoscopic pairs of fluorescein angiograms in rapid succession (Fig 14). Moreover, the reduced interval between exposures resulted in closer control of qualitative stereopsis.[1] Expert use of this device resulted in new revelations in ophthalmic diseases which were reported in a two-volume set of books published by Dr. Frederick Blodi, Lee, and Ogden Frazier.[17,18]

Lee later applied stereo photography to slit-lamp biomicrography by installing beam splitters before each ocular of his Zeiss photo slit-lamp camera and mounting one 35 mm camera body on each (Fig 15). With this method, he could obtain full-frame stereo slit-lamp photographs. As with their exemplary work in fundus photography, Lee and Ogden's stereo photography of anterior segment eye disease set new standards of excellence in the emerging profession of ophthalmic photography, resulting in the publication with co-authors, Dr. Alson E. Braley and Dr. Robert C. Watzke, of a two-volume set of manuals.[19]

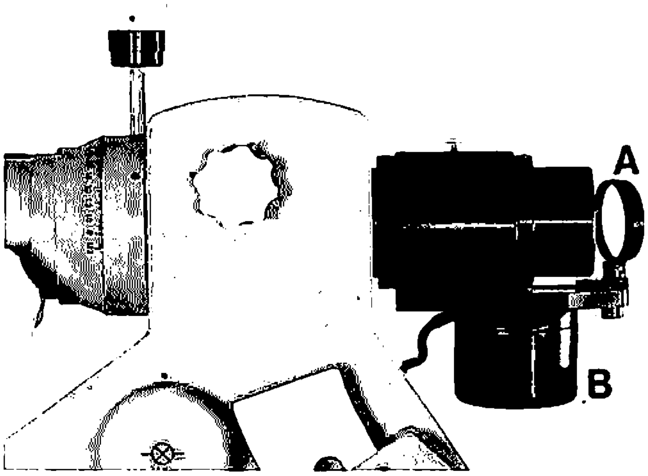


Figure 14: The motorized Allen Stereo Separator, produced by Carl Zeiss, Inc.

POLAROID INSTANT ANGIOGRAPHY

Once fluorescein angiography became a routine clinical procedure at Iowa in the 1960s, Lee realized the potential advantages of a system that could provide immediate stereo photographic results. In typical fashion, he attempted to create one. In 1964, Lee had reported the design of a Polaroid film holder applied to his system for color fundus photography, and use of a Wheatstone type stereoscope for studying the resulting paired photographs that were trimmed and mounted

Figure 15: Lee Allen at age 60, at his Zeiss photo slit-lamp camera, equipped with beam splitter for full-frame 35 mm stereo photographs.

for viewing.[20] Two years later, he reported an improved system, designed to immediately obtain stereoscopic fluorescent images.[16] The new system consisted of a "split-back" that could be shifted from one side to another, permitting two images to be obtained, side-by-side, on a single Polaroid print. For stereo angiography, first the Polaroid back was set to record the left image of the stereo pair on the left side of the print. Then the glass plate of the separator moved laterally and the Polaroid back shifted across to the right position, and a second picture was taken on the right side of the print. After one minute development time, the stereo angiogram could be studied while the patient was still seated at the camera.

After photographing several patients utilizing the conventional Wratten gelatine filters 47 and 15, however, Lee was dissatisfied with the image quality obtained with Polaroid's 3000 ASA positive print film. The images were oftentimes so faint that only the brightest fluorescent areas would be recorded. Even after substituting the Wratten 47A with the higher transmittance, the variations in image intensity were still occasionally unusable. Unlike 35 mm negative film, the development of Polaroid's instant film could not be manipulated for image enhancement.

Frustrated by these limitations, Lee sought solutions to this problem—a process that ultimately did not resolve his quest for immediate angiographic results, however it did help to revolutionize the quality of ocular fluorescein angiography worldwide.

BROAD-BAND FILTERS

The dilemma of insufficient light transmission during fluorescein angiography led Lee to think critically about the filters being used then (in the mid-1960s). He had tried the wide-band Wratten filters for his instant photography experiments (to optimize light transmission), but they yielded insufficient images. Moreover, filters for fluorescein angiography with 35 mm film were changing, but not necessarily for the better.

Following Novotny and Alvis's 1960 experiments in photographing fluorescein as it circulated through the human retina, most early clinical angiography was initially done with the use of their Wratten 47 and 15 filter combination. Although successful, these filters were not well-suited to the task because their broad transmission curves permitted serious overlap, allowing an excessive amount of reflected blue light to pass back to the film, which resulted in falsely dense negatives and confusion in the interpretation of the angiogram, a phenomenon known as pseudofluorescence.

Recognizing this as a serious problem, early investigators sought an exciter filter that transmitted a very narrow portion of the spectrum so that no overlap would occur with the transmission curve of the barrier filter. By the late 1960s, the Baird Atomic B4 narrow-band interference filter had replaced the original Wratten 47 gelatin filter and use of other combinations of narrow-band interference filters subsequently followed.[21,22] Most practitioners using the new diagnostic medium felt the narrow-band interference filters, with sharp cut-offs between the blue exciting and yellow barrier wavelengths, were providing sufficient light to record pertinent information. But Lee realized that both the early gelatin filters as well as the new generation of narrow-band interference filters were all performing inadequately.

Having been interested in the spectrum and transmission of light energy since he was first drawn to art and photography in his early teens, Lee knew that there was a considerable gap between the end of the excitation filter transmission curve and the proximal end of the barrier filter curve which was possibly restricting

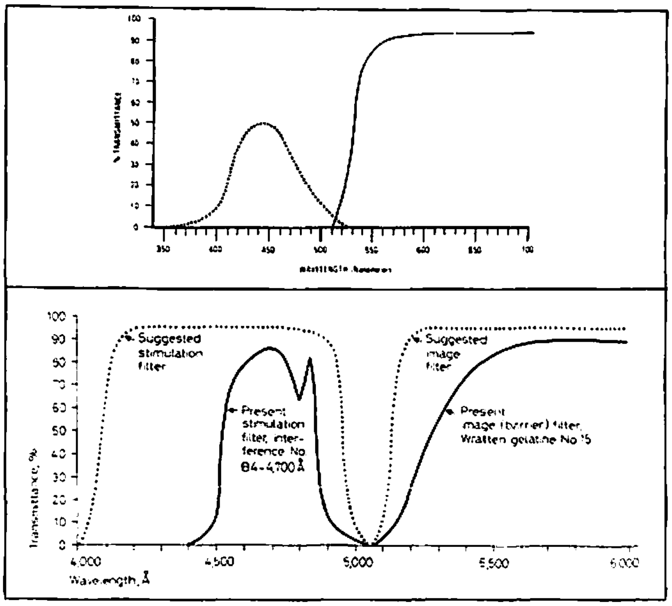


Figure 16: Transmittance curves for early fluorescein angiography. (*Top*) Kodak Wratten filters no. 47, blue (dotted line) and 15, yellow (solid line). [Reproduced from D. Wong: *Textbook of Ophthalmic Photography*, Birmingham, AL: Inter-Optics Publications, Inc., 1982, p. 85.] (*Bottom*) The narrow-band Baird Atomic B-4 interference filter, which limited the amount of blue light used to excite fluorescence, and the Kodak Wratten no. 15 (a commonly used filter combination in 1969). [Reproduced from Allen L. and Frazier O.: "Evidence Favoring Wide Band Filters for Fluorescein Angiography." In, Amalric P. (ed): *Proc First Int Symp Fluorescein Angiography, Albi, 1969*, Basil: Karger, 1971, p. 4.]

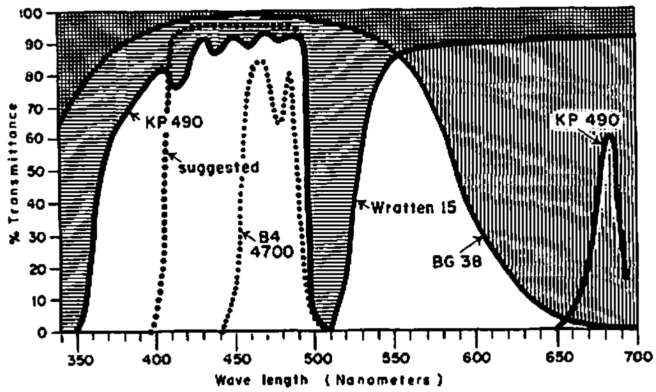


Figure 17: Diagram of transmittance curves of filter combination suggested by Lee to capture peak emissions of fluorescence with widely different wavelengths of exciting light while still omitting pseudofluorescence. [Reproduced from Frazier O. and Allen L.: Fluorescein angiography—tests on a broad-band filter combination. *Journal of Biological Photographic Association*, Vol. 42, p.51, April 1974.]

useful information as well as additional light transmission. The wavelengths of blue light beyond the end of the excitation interference filter could also excite fluorescence, which could amplify the fluorescent image. If an interference filter could be made to extend the transmittance beyond both ends of the current narrow-band filters, a considerably greater amount of energy would be available to stimulate emission of fluorescence.

Lee also believed that fluorescein in different individuals might require different excitation wavelengths to elicit optimal fluorescence. Some investigators had already published evidence that peaks of light emission from blood-fluorescein mixtures vary with varying conditions such as hemoglobin content and pH. If this were true, a narrow-band filter combination clearly would not perform as well as filters with broader ranges of transmission.

In order to prove his theory, in 1965 Lee asked Dr. John Chambers, an ophthalmology resident at Iowa, to run in vitro tests on fluorescein in blood. The measurements, done using very sensitive instruments in the university's physics department, resulted in confirmation of Lee's theory! Lee subsequently presented these results in a theoretical paper at the First International Symposium on Fluorescein Angiography in Albi, France, coordinated by Dr. Pierre Amalric in 1969 (Fig 16).[23]

Lee attempted to find an exciter filter that would have very high transmittance of all wavelengths between 400-495 nm, with a sharp cut-off at 500 nm. The perfect barrier filter should be matched to this and not transmit wavelengths shorter than 500 nm so that there would be no overlapping with the excitation filter, but all wavelengths over 510 nm would have high transmittance. After considerable research, Lee ended up with a combination of four filters for angiography: the KP 490, a broad bandpass blue filter made by the Leitz Company for fluorescence microscopy that has a transmission range from 350-500 nm and a second transmission range from 650 nm to a little over 700 nm; a Schott BG38 filter to absorb the red wavelengths that appeared in the second peak of the KP 490 exciter filter; a Wratten 2B filter to absorb ultraviolet light passed by the KP 490; and a Wratten 15 barrier filter (Fig 17).

Lee and Ogden Frazier reported their successful use of these filters at the Third International Symposium on Fluorescein Angiography held in Tokyo by Dr. Koichi Shimizu in 1972.[24] Their paper, demonstrating how the greater quantity of exciting wavelengths from the new filters offered advantages over the previous filters, was hailed by world leaders in ophthalmology as being a considerable advancement."[m]

"I began to hear the name "Lee Allen" repeated in conversation. It was obvious that here was a man who was a legend in his own time."[26]

Johnny Justice, Jr.

OPHTHALMIC PHOTOGRAPHERS' SOCIETY

In 1969, a group of photographers working in ophthalmology convened during the annual meeting of the Association for Research in Ophthalmology, and decided that it was time to form an independent society exclusively devoted to the burgeoning profession of ophthalmic photography. Biomedical photographers being drawn into serving in ophthalmology were finding it difficult to obtain the specialized training they needed to recognize eye diseases or to utilize the unique equipment required to photograph the internal aspects of the eye. The implementation of educational programs devoted exclusively to techniques and diagnostic interpretation of ophthalmic photography, as well as other objectives motivated them to take the bold step of forming their own professional organization, which they named the Ophthalmic Photographers' Society (OPS).

In order to achieve credibility as an organization representing a specialized profession, the leading organizer, Mr Johnny Justice, Jr., suggested that their first president should be someone with international recognition for his achievements in ophthalmology. The selection was unanimous. In a brief synopsis of the establishment of the OPS, Johnny described how he first heard about Lee:

> Shortly after arriving at the Bascom Palmer Eye Institute, I began to hear the name, "Lee Allen" repeated in conversation. It was obvious that even though I had not met him, here was a man who was a legend in his own time. He not only enjoyed an outstanding reputation as a photographer, but also as a medical illustrator and as an ocularist.[26]

By the late 1960s, in addition to being recognized as a pioneer in ophthalmic photography, Lee Allen had gained recognition thoughout ophthalmology, as a scientist who had contributed to ocular anatomical theory; a teacher of gonioscopy; an exceptional artist; and an

Lee Allen's Contributions to Ophthalmic Photography

(A partial list)

Date first reported	
1940	Performed fluorescein angiography of the anterior chamber angle[12]
1950	Employed Nordenson Retinal Camera for anterior segment photography[13]
1954	Created 4-mirror gonioprism later used for goniophotography[6]
1964	Published treatise on techniques of fundus photography; modification called the Allen Dot; and introduced concept of corneal-induced parallax for stereo photography of the eye[14]
1964	Adapted Polaroid camera back and films for stereoscopic color fundus photography[20]
1966	Invented Allen Stereo Separator which automated and standardized stereoscopic fundus photography[16]
1969	Served as first (interim) president of the Ophthalmic Photographers' Society
1969	Reported theoretical evidence supporting use of broad-band filters for fluorescein angiography[23]
1972	Established optimal combination of interference filters for fluorescein angiography[24]

innovator of ophthalmic instrumentation. The prestige of having such an accomplished celebrity represent the new society could facilitate achievement of their goals.

Lee was invited to serve, and he agreed to act as interim-president, until the society had its first formal election of officers. Despite his numerous commitments, Lee supported the fledgling organization in many ways, giving the OPS the benefit of his experience and creative thinking through its formative years.

Lee's guidance and counsel were immensely helpful to the organizers. He orchestrated the society's first annual educational program, and, together with Johnny Justice, established the annual scientific exibit (photographic competition) that has since been displayed at the annual meetings of the American Academy of Ophthalmology. In his Keynote Address at the Society's First Annual Meeting in Las Vegas in 1970,[27] Lee shared some of his personal convictions and envisioned goals for this new alliance of ophthalmic photographers. When characterizing the relatively new profession of ophthalmic photography, he aptly described his own personal experience: "Ophthalmic photography is a collection of arts which have developed in different areas of activity of ophthalmology. They have developed out of different needs at different times and at different rates. Some came from clinical ophthalmology, some from pure research and some from the fields of ophthalmological education. Some relate to records of patients conditions, some to diagnosis, some to study of pathology and some to records of treatments." And while many ophthalmic photographers at the time were also engaged in general medical and scientific photography, Lee mirrored his own absolute commitment when he recommended that ophthalmic photographers "... must look to Ophthalmology for our origins, and our future, because this is where our responsibilities lie ...." Above all, Lee said, "I believe that the quality of ophthalmic photography will depend in all cases upon the degree of dedication to this one field on the part of the photographer."

In Lee's perspective of the profession, not only must the ophthalmic photographer be skilled in the handling of the cameras and films and understand the arts of lighting, perspective, composition, etc., but also "...in... preparation for ophthalmic photography, trainees should know the anatomy of the eye .... They should be exposed to as much other knowledge in ophthalmology as possible. Pathology, physiology, microbiology, neurology, etc. are areas to be studied .... A fundamental part of training should be the comprehensive study of all the methods of visual examination of the eye. They cannot know too much about the handling of direct and indirect ophthalmoscopy and the eight basic types of illumination used in slit-lamp biomicroscopy. They must become facile in applying, manipulating and viewing through the various accessory instruments used by the ophthalmologists for special types of examinations. These include contact glasses for gonioscopy and slit-lamp gonioscopy, slit-lamp examination of the central fundus and slit-lamp study of the peripheral fundus. Only after the trainee has learned to see what the ophthalmologist sees with these (or any) instruments, can he find and recognize the features he is asked to photograph. Finally, when this comes easily to him, he can incorporate the camera into the system and learn how to best represent the various subjects in pictorial records. As far as I know, these things are not yet taught in any formal manner to our ophthalmic photographers"[27]

On these principles an organization devoted to education and advancement in ophthalmic photography was founded. And so it was that the Ophthalmic Photographers' Society aspired to provide instruction in these disciplines. Within a span of just two years, the society presented its first course of instruction at the 1972 Annual Meeting, and has since become internationally recognized for its educational programs and workshops.

In recognition of all the innovations and progress that he contributed to the field of ophthalmic photography, and for his guidance in the establishment of the society, Lee was awarded an Honorary Life Membership, and in 1982 was selected for the society's highest honor, the OPS Outstanding Contribution to Ophthalmic Photography Award (Fig 18).

Figure 18: Lee at age 70, receiving the Outstanding Contribution to Ophthalmic Photography Award at the 11th Annual OPS Meeting in Chicago, 1980, from Don Wong (right), and President, Csaba Martonyi (center).

Ocular Prosthetics

Despite the satisfaction of his numerous contributions in ophthalmic medical illustration and photography, an even more compelling challenge was destined to become the most ardent commitment in Lee Allen's career: the creation of motility implants and ocular prostheses.

World War II had left hundreds of soldiers with eye injuries, facially disfigured and blind, often with little hope of having normal appearance restored. In the 1940s, although great strides were being made, reconstructive surgery and the techniques for crafting artificial eyes were laden with difficulties.

EARLY ARTIFICIAL EYES

Before the 1940s, artificial eyes that were used following enucleation were prone to numerous problems: The eyes were simply thin glass shells, containing a vacuum. The cell-like shells were fragile: they broke easily, or even imploded from changes in atmospheric conditions, thus requiring frequent replacement. The average "life" of glass eyes was only two years. Moreover, because methods of making impressions of the eye sockets had not yet been developed, their hollow back surfaces and uniform shapes did not conform to the tissues behind the eyelids, resulting in pressure points that caused open spaces within the socket that would allow troublesome mucous and bacteria to collect. The shells' improper fit caused discomfort, extrusion, and infection, as well as an unrealistic appearance. The alkalinity of tears caused etching of the surface of the glass until the resulting roughness made continued use intolerable for the patient. Furthermore, besides having an artificial appearance to the iris, these early prosthetic eyes possessed no controllable quality of movement.

MOTILITY IMPLANTS

In 1937, Mr. Fritz Jardon, a dental technician in Kansas City, acquired from Europe a new plastic, devised a way of making plastic eyes, and patented the first plastic eye. The material, methyl methacrylate, (now commonly called acrylic), was relatively unbreakable and could be molded into complex shapes more easily than glass. Word of this advancement spread, and eventually other dental technicians put Jardon's method to use.

Seven years later (1944) Dr. Norman Cutler, an ophthalmic surgeon in the armed forces, applied these new techniques to design *orbital implants* (devices implanted after enucleation for substituting not only the eye but also portions of the orbit), thus providing volume and support for the remaining tissues behind the eyelids. Before this innovation, orbital implants were simply spheres of glass or hollow glass, or gold balls, charred bone or autogenous dermal fat, rarely capable of providing adequate, natural movement to the artificial eyes. Dr. Cutler applied the durable new plastic to construct orbital implants that could be directly integrated with artificial eyes by means of square pegs on back of the eyes fitting into square holes in the front of the exposed implants, thus transmitting *motility* from the four rectus eye muscles through a positive connection between the implant and the plastic eye.

The procedure for orbital implantation evolved into a two-phased technique of first surgically inserting an enucleation implant into the orbit, (attaching the rectus muscles to it), and approximately one month after surgery, fitting a prosthetic eye to the socket. Compared to all previous solutions for eviseration and enucleation, the motility of these prosthetic eyes was exceptional. Yet, despite these advancements, severe problems were being encountered in both these phases, namely infection and extrusion.

While still a professor at the Eye Department at University of Iowa, Dr. James H. Allen, was at that time a Major serving in the Air Force, in charge of a section of the Air Force Base Hospital at Scott Field, Illinois, that included the Dental Laboratories. After hearing of Cutler's implant, Dr. Allen felt further development would be needed to perfect these implants, and urged the Eye Department at Iowa to become involved in the development of artificial eyes and integrated implants. He also recommended that Lee assume responsibility for this work, considering his knowledge, artistic ability, and talent with tools. As a result, Lee was sent to learn the techniques for handling methyl methacrylate at the Dental Laboratory at Scott Field. Lee was to learn, however, that the use of plastic was only the first step toward successful fabrication of artificial eyes. There were still several frustrating challenges to conquer.

The staff at Scott Field had made nearly fifty attempts to satisfactorily finish artificial eyes, but all had failed because the oil paints used to color the surface of the iris would lift and run over the white sclera during application of a protective covering of transparent plastic. Moreover, the processing time for the eyes was cumbersome, requiring several hours of drying time. (Much later, it was learned that the paint needed to dry four times longer than they expected (four days and nights) before the protective plastic covering could be applied.)

After returning from Scott Field, Lee experimented with different art materials other than oil-based media, such as ink, colored pencil, and show-card colors. None were satisfactory until he tried a varnish-like solution made by dissolving the powder form (polymer) of methyl methacrylate into the liquid form (monomer) and mixing dry powdered artists' pigments into it. Lee found that this preparation, called mono-poly, made with the same acrylic as the eyes, solved the problem. Moreover, it could be dried in just ten minutes under the warm flow of air from an ordinary hair dryer.

The discovery of successfully adhering iris coloration to artificial eyes turned out to be only the beginning. Lee's dedication to creating not only the appearance, but the *effect* of "living tissue" for ocular prostheses, would become an obsession for more than forty years.

ALLEN IMPLANT

When Dr. Allen returned to Iowa from the Air Force, he described the kind of motility implant he wanted to develop: one with a stainless steel peg that protruded forward in an opening left through Tenon's capsule and conjunctiva. The peg would fit into a hole in the back of the artificial eye and the four rectus muscles would be passed through tunnels in the implant (rather than around it), and the ends of the muscles would be sutured together around the peg. This would be the first implant to employ tunnels for the rectus muscles (Fig 19).

Lee expressed concern that eventually foreign materials, bacteria, and viruses would invade the openings between the implant and the orbital tissues, causing infection and inflammation. He suggested that a completely buried implant would prevent those problems as well as transmit good motility to the eye. Nevertheless, work continued with the first design.

The new prostheses, named the "Allen Implant" (after both Dr. Allen and Lee) was retained better than its spherical predecessors.[28,29] However, although motility of the eyes from this implant was excellent, after a number had been implanted, infections and discomfort eventually required their removal, which caused the Head of the Department to terminate the motility implant program.

IOWA IMPLANT

After a year-and-a-half of cajoling, Lee's persistence in favor of a buried implant paid off. It was August of 1948 when he finally convinced the department to try his completely buried muscle cone implant design.[29] The implant still incorporated Dr. Allen's concept of passing the rectus muscles through tunnels, which gave excellent motility to the eye, but the shape of its front surface was now a smooth, flat ring which permitted the implant to be *completely buried under Tenon's capsule and conjunctiva.* These implants were hand-made, of top quality, solid, transparent, factory processed methyl methacrylate resin which was used to avoid the possibility of burying volatile remnants, plasticizers or other impurities which might cause eventual extrusion. Although this new implant reduced the possibility of contamination, its smooth design did not always present

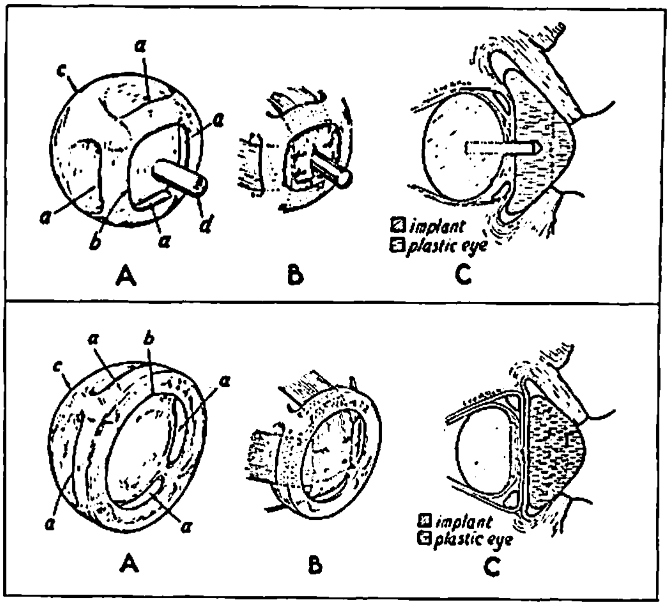


Figure 19: (*Top*) Early integrated muscle cone implants used tunnels to allow the four rectus muscles to be sutured to each other: (A) shows implant with tunnels (*a*); (B) schematic of method of suturing muscles; and (C) cross section of implant with prosthesis. (*Bottom*) Subsequent tunneled hemispherical, completely buried implants provided large opening (*b*) in the anterior surface for suturing of muscles. Schematic cross section (C) shows implant and prosthesis in relation to completely closed Tenon's capsule and conjuctiva. [Reprinted from Allen J.H. and Allen L.: A buried muscle cone implant. 1. Development of a tunneled hemispherical type. *Archives of Ophthalmology*, Vol. 43, pp. 880 and 883, May 1950, American Medical Association. Reproduced with permission from the American Medical Association.]

enough irregularity to "lock" into any overlying orbital tissues, which consequently sometimes resulted in undesirable movements of the prosthesis.

Improvement in motility was finally achieved when, in 1957, Lee designed the "Iowa Implant," with four low, rounded mounds positioned around the intersection of the four rectus muscles, imbricated across the front of the implant and resting in two crossed "valleys" between the mounds (Fig 20). Drs. Edward C. Ferguson and Alson E. Braley helped perfect the surgery of its implantation.[30] Yet despite the superior motility and retention qualities of this new design, many surgeons have continued to use spherical implants, some because they were concerned that the mounds of the Iowa Implant would erode through the tissues, or because spherical implants were easier to implant.”

As a natural progression from this work Lee began making and fitting artificial eyes for the Eye Department. One persistent problem was that some stock shapes would not stay in certain eye sockets. Lee believed that if the shape of the front surfaces and edges of the prosthesis were changed, enhanced comfort and cosmesis could be achieved. He proceeded to design a system for modifying the shapes of artificial eyes, and in 1953, together with his associates Howard Webster and Dr. Alson Braley, published a paper, "Problems in Ocular Prosthetics".[31] Lee also produced a scientific exhibit for the department demonstrating this work. The exhibit won first prize awards at the annual meetings of the American Academy of Ophthalmology and Otolaryngology and the American Medical Association.

Lee also changed the method of fitting plastic eyes and, together with his associate Howard Webster, in 1969 reported a new modified impression method that resulted in better fit and alignment of artificial eyes by correcting distortions in eye sockets and eyelids resulting from trauma, disease, and different surgical techniques of eye removal.[32] This method is still widely used.

AMERICAN SOCIETY OF OCULARISTS

In 1957, Lee was asked by two ocularists, Mr. Hugh Laubheimer and Mr. Charlie Erickson, to become a charter member of an organization which was being formed to advance the craft of ocular prosthetics, the American Society of Ocularists. Ever since, Lee has been a moving force in this society, holding key positions on the governing body, teaching in workshops, lecturing, contributing new techniques and publishing them for future reference, and establishing the National Examining Board of Ocularists and an accredited method of certification in this profession.

Figure 20: Iowa implant and conformer.

◆ ◆ ◆

In 1976, after nearly 40 years of service to the Department of Ophthalmology at the University of Iowa, Lee retired from his position and received Emeritus Member status of their faculty. He continued to dedicate himself to manufacturing and improving ocular implants and to strive to establish accredited certification standards for the profession of ocularistry (Fig 21).

Now, fourteen years later, at a time when many others have long since retired from their chosen professions to spend their days in leisurely activity, Lee has come full-circle, back to his first love, fine arts painting (Fig 22). His days are now filled with the pleasures of sitting quietly for hours, painting outdoor scenes, yet he is still actively giving of his talents, engaged in the fitting and

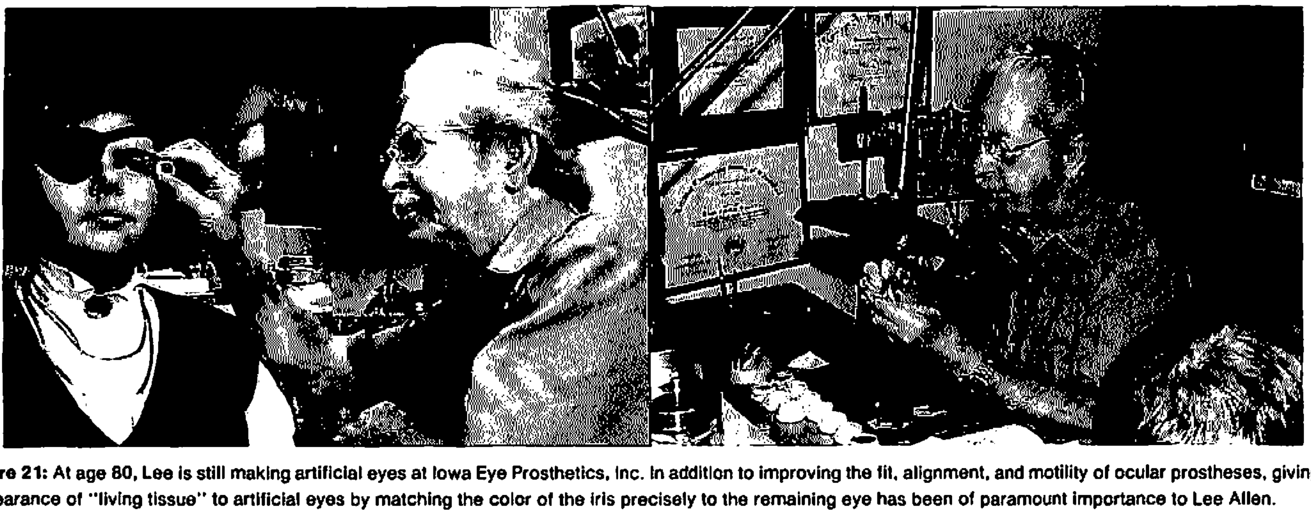


Figure 21: At age 80, Lee is still making artificial eyes at Iowa Eye Prosthetics, Inc. In addition to improving the fit, alignment, and motility of ocular prostheses, giving the appearance of "living tissue" to artificial eyes by matching the color of the iris precisely to the remaining eye has been of paramount importance to Lee Allen.

producing of artificial eyes for those very special patients who still need him.[o]

Lee Allen has spent over fifty-two of his eighty years in professional endeavors far afield from his earliest ambitions. Through sheer determination, perseverence, and a dedication to excellence, he not only has mastered ophthalmic illustration, ophthalmic photography, and ocular prosthetics, but also has contributed meaningful advancements in each of these fields. Through his endeavors have come a new theory of the embryonic development of the anterior chamber angle; a new surgical procedure for the treatment of glaucoma; five new goniolenses and prisms; nine surgical instruments and research apparatuses; the design and construction of five ocular implants; a new systematic approach to the fitting of plastic artificial eyes; creation and production of life-like plastic facial prostheses and three-dimensional plastic models of eyes; innovative changes to ophthalmic photographic instrumentation (two of which bear his name); a total of ten books; illustrations for four other books; scientific exhibits that were shown at thirty-three major ophthalmologic and medical meetings, fourteen of which won awards; and ninety-three scientific papers. In addition Lee has found the time to hold active memberships in no fewer than eleven organizations, accepting key positions on governing bodies and serving as president of three.[p]

Figure 22: Still winning awards for his works of art, Lee Allen is shown here standing next to his acrylic/alkyd painting, "Willows in the Wind," which won an Award of Merit at FLORA '90, the third biennial exhibition of contemporary artwork at the Chicago Botanical Garden, on January 20, 1990.

The wealth of these achievements notwithstanding, perhaps Lee's most profound contribution has been his abiding commitment to helping others learn and improve their craft. Lee embodies the true spirit of the dedicated investigator. All he has learned he has published and demonstrated for the benefit of others and the advancement of science. These efforts have had enormous impact, not only on several professional spheres, but on innumerable people as well.

Lee Allen is, indeed, a rare individual, and it is our privilege to know and honor him.

NOTES

a. Lee had a younger sister, Mary Gertrude Allen, who is now deceased.

b. Numerous people played important roles in Lee's life. Lee especially credits the following persons for their help and encouragement: Herman Clyde Allen; Bessie Burkholder Allen; Richard L. Anderson, MD; James H. Allen, MD; Emil G. Bethke; Frederick C. Blodi, MD; Alson E. Braley, MD; David M. Bulgarelli, BCO, FASO; H.M. Burian, MD; Edward C. Ferguson, MD; Ogden Frazier, FOPS; Ken Hansen; Frederick Kent; P.J. Leinfelder, MD; Harriet Macy; Jeffrey A. Nerad, MD; Cecil S. O'Brien, MD; Bruce E. Spivey, MD; David T. Tse, MD; Howard E. Webster; and Grant Wood.

c. After graduation from public grade school, Herman Clyde Allen had to go to work because his parents were poor. While working for Northwestern Railroad as a machinist, Lee's father educated himself by going to the library at night to study, and later registered for correspondence courses in engineering. It is therefore of interest to note that he was a completely self-made man. He later went on to devise important improvements on several pieces of equipment, such as an acetylene torch and a multicolor offset machine for which he held patents.

d. Since the earliest days of science, drawing has been the perennial method of graphic demonstration of scientific observation and documentation. Photography was applied to medicine as early as the mid-nineteenth century, and the first fundus photography was in 1862 on a rabbit eye. However, ophthalmic photography did not develop fully until much later because of several factors: the very slow photographic emulsions available at the time, the lack of easily processed color film, inadequate equipment, and availability of experienced photographic personnel. Prior to the 1970's, illustration was an essential component of ophthalmic residency training because drawing was the only readily available means of documentation. Although this training is still required in most teaching programs, particularly for the purposes of familiarizing surgeons with the important features of the fundus prior to performing retinal surgery, reliance upon photographic documentation has supplanted its emphasis.

e. Lee did portraits of staff members of the medical school, including bronze bas relief studies of the first three heads of the Department of Ophthalmology. Five of Lee's works were donated to the permanent collection of the University of Iowa Museum of Art. Among his many artistic contributions to ophthalmology has been the design of the Proctor Medal for outstanding achievement in basic science, conferred annually by the Association for Research in Vision and Ophthalmology.

f. Cecil S. O'Brien, MD, was the first chairman of the Department of Ophthalmology at Iowa. He granted Lee the privilege to experiment in many areas of ophthalmology, even to the point of doing his own basic research. In contrast to the customary practice of not giving credit in publications for work done by artists and technicians, O'Brien permitted Lee to be first author or sole author on reports of projects which Lee initiated (a gesture of acknowledgement in medical literature to a non-physician that was almost unprecedented prior to that time). His support and friendship had far-reaching impact on the course of Lee Allen's career.

g. One of the brain drawings represented the vascular supply to the structures most involved with vision; a second showed the structures at the base of the brain and brain stem, including the optic radiations and their relationship with the brain as well as some of the major tracts going from the cortex to the lower portions of the body; and the third showed the same view of the base of the brain in higher magnification, for better detailed study of relationships.

h. On this and many subsequent goniolenses that Lee designed and made, intricate skill was required, not only to position mirrors critically enough within the lenses to permit obtaining a view of the angle and other interior structures of the eye, but also to hand-polish the lens surfaces to such a high optical quality that visualization of the fine details of these structures was possible.

i. Lee traveled to Pittsburgh's Montefiore Hospital to help Dr. Thorpe in similar instruction. In 1959, Lee and Dr. Thorpe were invited to teach gonioscopy at the annual meeting of the American Academy of Ophthalmology and Otolaryngology. In 1984, Lee received the Senior Honor Award from the American Academy of Ophthalmology for twenty-five years of instructing gonioscopy at their annual meetings.

j. Trabeculotomy ab externo is still considered one of the procedures of choice in the treatment of infantile glaucoma.

k. Ken Hansen later established a separate laboratory to produce ERG electrodes. These devices may still be purchased from the Ophthalmic Development Laboratory Inc., P.O. Box 613, Iowa City, Iowa 52244.

l. Carbon-arc illumination was extremely cumbersome for the photographer: unless one constantly adjusted the carbons to optimum burning position, exposure and quality of illumination would suffer.

m. During discussion of the papers presented at the Third International Symposium on Fluorescein Angiography, Dr. Edward Norton, of the Bascom Palmer Eye Institute (Miami, Florida) credited Lee and Ogden's paper as being one of only two that marked any considerable advance in fluorescein angiography. Subsequent to this fundamental modification of angiographic filters, Dr. Francois Delori introduced in 1976 the SE40, SB50 transmission filter series which became the standard filter combination for fluorescein angiography for several years.[25] Interestingly, even though the origins of these new filters were associated with the use of the Polaroid attachment, the new filters were primarily used for photography on 35 mm color transparency and black-and-white negative film from that time. 3000 speed Polaroid film fell into disuse at Iowa except as a convenient demonstration tool for meeting workshops.

n. In 1987 Lee reported yet another quasi-integrated implant, the "Universal" implant in the hope that more surgeons will come to accept it because it can be used following enucleation, eviseration, or as a secondary implant. Drs. Richard Anderson, David Tse, and Jeffry Nerad helped devise the surgical procedures of its implantation.[32]

o. In 1976 Lee and a colleague, David Bulgarelli, B.C.O., F.A.S.O., established their own company for the manufacturing and fitting of ocular prostheses (Iowa Eye Prosthetics, Inc., in Coralville, Iowa). In 1987, Lee sold his part of the business, although he still works in the laboratory on a free lance basis.

p. Lee has served as president of the Association of Medical Illustrators (1959); the American Society of Ocularists (1969); and the Ophthalmic Photographers' Society (1969–70).

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