DR. ESTELLE GLANCY – SEPTEMBER 1952

This personal account of the years from 1918 to 1951 might be entitled: The Evolution of A Lens Designer.

In July 1918 I entered the employ of the American Optical Company as a routine computer at Southbridge, Massachusetts. This company was then, as now, the leader in all that pertains to spectacle lenses and the associated professions. Design of lenses, their manufacture and distribution to optometrists and oculists, office equipment including optical diagnostic instruments and even grinding and polishing machinery were within the scope of the company's business. In 1918, the First World War was coming to a conclusion, but the computation for a gun sight was incomplete and so I thought my assignment might have some value. Ultimately, I would look on – the fundamental calculations which are the basis of the well-known Tillyer spectacle lens.

Perhaps I should preface the story of how I became a lens designer with some remarks about my background, including "near miss" during my junior year at Wellesley.

Mathematics and Astronomy served to be my best bet by the time I became a junior. However, for some unexplainable reason, I showed an uncooperative attitude in a course on the computation of comet patterns around the sun. Under Professor Ellen Hayes, a rare teacher and an independent thinker, she told me frankly that I could not follow up in the senior course. That left me high and dry, but my mathematics teacher, Miss Vivian, met me casually in the corridor of College Hall where we both lived and learned of my dilemma. Fortunately, for me, she interceded with Dean Pendleton in my behalf and I was admitted to Professor Hayes' class "on probation." Miss Hayes became the instrument of possible disaster and, at the same time, she was the making of me. From that time, it was my aim to redeem myself and keep going.

After an idle period of nearly a year and no success in selling my poor talents to an eastern observatory, I launched a far distant appeal to the Berkeley Astronomical Department of the University of California where I knew some large-scale calculations were in progress. I was invited to come as a computer provided I would also work toward a PhD degree; a thought which would never have entered my mind. However, once embarked upon this plan, it never entered my mind to stop part way.

So in 1906, a few weeks before the disastrous earthquake and fire, I arrived at Berkeley. Professor Deuschner, who was to be my mentor and guide for the next seven years, asked me with a twinkle in his eye: "What makes you think you can compute?" I answered that I thought I could learn, duly humble, knowing the great opportunity before me and very desirous of being accepted. Calculations gave me bread and butter, graduate courses led toward a doctorate and, during that time, a Lick Observatory Fellowship gave me experience in observational work at one of the world's famous observatories. Observations and theoretical work concerned comets and asteroids primarily. In 1913 I took my degree in Astronomy along with five others, one of whom was Phoebe Waterman, my roommate.

Phoebe said: "Let's get jobs at the same observatory." I answered: "Who would want two women?" "Maybe Dr. Perrine would take us," she said. Dr. Perrine was the American Director of the Argentine National Observatory at Cordoba. In a cooperative mood, I said: "Well, you can ask him." Lo and behold, he answered: "Come." So off we started in the fall of 1913. On board ship romance caught up with Phoebe and she only stayed three months.

Again, I was fortunate in my scientific associates. The two top men were Americans. No others on the staff had more technical training than I had, so I was accepted on equal terms and given a free rein, so long as I kept track of comets and asteroids and produced an occasional article for publication. In 1918, I took a year's leave of absence and returned home.

Knowing the lesser opportunities for women in observatories and my poor qualifications for teaching, I almost threw away my training by entering an airplane factory. But fate snatched me away and sent me to Southbridge.

I had no illusions about the difficulty of transfer from Astronomy to Optics, but knew also that there was no better background than computing in astronomical problems. So I elected to start once more from scratch. Trigonometry, calculus, the art of computing and something, which is best called insight, which developed under the inspired teaching of Professor Deuschner, was my stock in trade. In exchange, the new job could give me association with top-flight leaders and a chance to grow. My immediate superior was Dr. E. D. Tillyer, a widely known and acknowledged leader in the physical sciences and tops in lens design. Because he was formerly an Astronomer, we had a common understanding. His leadership through thirty-three years was always an inspiration and a challenge and the influence, which led to accomplishment.

When the war ended, I began the long and repetitious calculations on which the Tillyer spectacle lens is based. In principle, this lens aims to give marginal vision as nearly like vision through the center of the lens as possible. The larger part of ten years were occupied in this major project which no other company than the American Optical Company was ready to undertake.

There are many other types of ophthalmic lenses, such as bifocals, trifocals, cataract lenses, etc., all of which necessitate planning and calculation in preparation for manufacture. The purchaser of a bifocal has no idea of the many steps involved in the making of his lenses or of the standards of precision, which the company sets for itself. Some prescriptions cannot be supplied except by special calculation and individual grinding. All these came through my office.

Verification of lenses and establishment of standards of precision leads to physical measures; hence, it was part of my duties to use such instruments as the Lensometer, Spherometer, Spectrometer and Telescope. Physical optics and geometrical optics go hand-in-hand. Unless a person recognizes a good image of a bright point like a star and can call by name any of the five faults, which it may possess, he certainly cannot design a lens system relatively free from defects of imagery. It was a real satisfaction to know that with few exceptions there was no dead line on the accomplishment of a task. In other words, it was my business to be prepared on the "know how" rather than to produce. So I made it my aim to lay a foundation, one step always leading to another and inquisitiveness finding its own reward. As occasion arose, the publication of an article or application for a patent followed naturally.

Occasionally, we had requests for small telescope objectives, which are usually a combination of two kinds of glass and require a different mathematical treatment from ophthalmic lenses. Eventually, this experience led to a new type of objective having certain improvements over the regular crown-flint cemented type. The calculations, which were voluminous, resulted in the issue of a U. S. Patent. It was important, not because such an objective was constructed and put into service, but because it influenced one of the finest American Lens Designers. Dr. Frank Ross of the Mt. Wilson and Palomar Observatories was working on the design of an auxiliary lens to be used with the giant new Palomar mirror and he had run into trouble. The publication of my theoretical work gave him an idea, which helped him out of his difficulty. That any work of mine could be useful to such an experienced designer was thrilling indeed.

Now and then, we received a request for a simple camera lens system. The design of camera lenses is a field itself and offers a lifetime of study, so I only scratched the surface. With the exception of the very cheapest camera lens, the system consists of elements of two or more kinds of glass and fast cameras are very complex. Starting from scratch, I learned how to handle simple cases and then studied more complex ones. It might be asked if the procedure cannot be found in books. The answer is both "Yes" and "No." Various authors have developed each his own method of attack and each prefers his own notation. We adopt the procedure, which has the most appeal, but it is far from adequate because design is accomplished by understanding, ingenuity and infinite patience. From a mathematical point of view, we have to solve a group of equations which cannot be expressed in workable form and have no absolute solution. Optical design is a compromise within the limits of what the eye will call good. When the final figures are used to make a sample, then comes the test of performance and it is not remarkable that, after months of work on paper, performance can be expected to verify the figures substantially.

One of the most important articles which I published in the Journal of the Optical Society concerns an original method for getting the best design from the given glass components after the approximate design has been found. This problem concerns the derivation and solution of a set of differential equations expressing the residual five faults of imagery, which it is desirable to remove as far as possible. The need to do this theoretical work presented itself when I was asked to design an f/4.5 camera lens. This accomplishment was the culmination of some thoughts, which had been in my mind since the days when I was a student under Professor Deuschner who taught us to make a differential correction of an approximate comet orbit. But only near the end of my career did I find myself ready and competent to attack the problem. A sample f/4.5 lens system has been made and pronounced satisfactory.

Probably a definition of Aniseikonia is in order. It sometimes happens that the retinal images in the left and right eyes are not the same size and, although the difference is a small percentage, headaches and other anomalies may ensue. Some years ago, Dr. Adelbert Ames discovered the cause of this trouble and at Dartmouth College a clinic was established. The American Optical Company was selected to manufacture these special iseikonic lenses. The inequality of size may be the same in every meridian or different if different orientations and such a heterogeneous fault greatly complicates matters. So a whole new branch of ophthalmic optics was opened up and, as might be expected, pioneer work preceded the promotion of a new kind of spectacle lens. Notwithstanding the work at Dartmouth, Dr. Tillyer and myself did considerable spadework on theory and measurement of lenses. In this connection, a U. S. patent was issued to me for a system of three separated lenses, which could be used to measure aniseikonia.

During the Second World War, certain new optical devices incorporated “aspheric” lenses to increase the light-gathering power. Such a lens is convex in the center, concave near the rim like a mound surrounded by a valley, but the departure from a flat surface is small and great precision and new techniques of manufacture were demanded. Such a lens had been described for astronomical use and the difficulty of making one was not insurmountable. It’s great usefulness had been retarded because up to the time of the war, it could not be produced in quality.

The American Optical Company found a unique way. So, again I did some spadework on a new branch of optics. It is to be understood that what little had been published was inadequate in the new circumstances.

After the war, television surged forward on the strength of what had been accomplished under the stress of war. Television optics also requires the use of “aspheric” lenses or “corridor” lenses, as they are called the larger radio companies began experimenting and the American Optical Company took a leading part. The earlier theoretical work was limited in scope and it was time to develop the theory for the general case. This, I did and applied the formula to a special invention of Dr. Tillyer. The mathematical theory was published in the Journal of the Optical Society.

Now that my scientific work is terminated, I can view this period impersonally and analyze the factors, which led to success. Necessity and opportunity meet hand-in-hand. Inspiring leadership blessed all my thirty-nine years in astronomical and optical pursuits. If this leadership had been wanting, I could probably have succumbed to a natural inertia, which sometimes takes possession. Another important factor in my career has been progressive deafness. The forced aloneness which deafness imposes was compensated in part by freedom from distraction and the ability to concentrate. Diversity of talents was not one of my assets, but rather the capacity for digging down deep and persistently and advancing one step at a time, looking for an occasional nugget among the pebbles. And in every career, good fortune plays an unobtrusive part. Opportunity knocked at my door. It might have been someone else.