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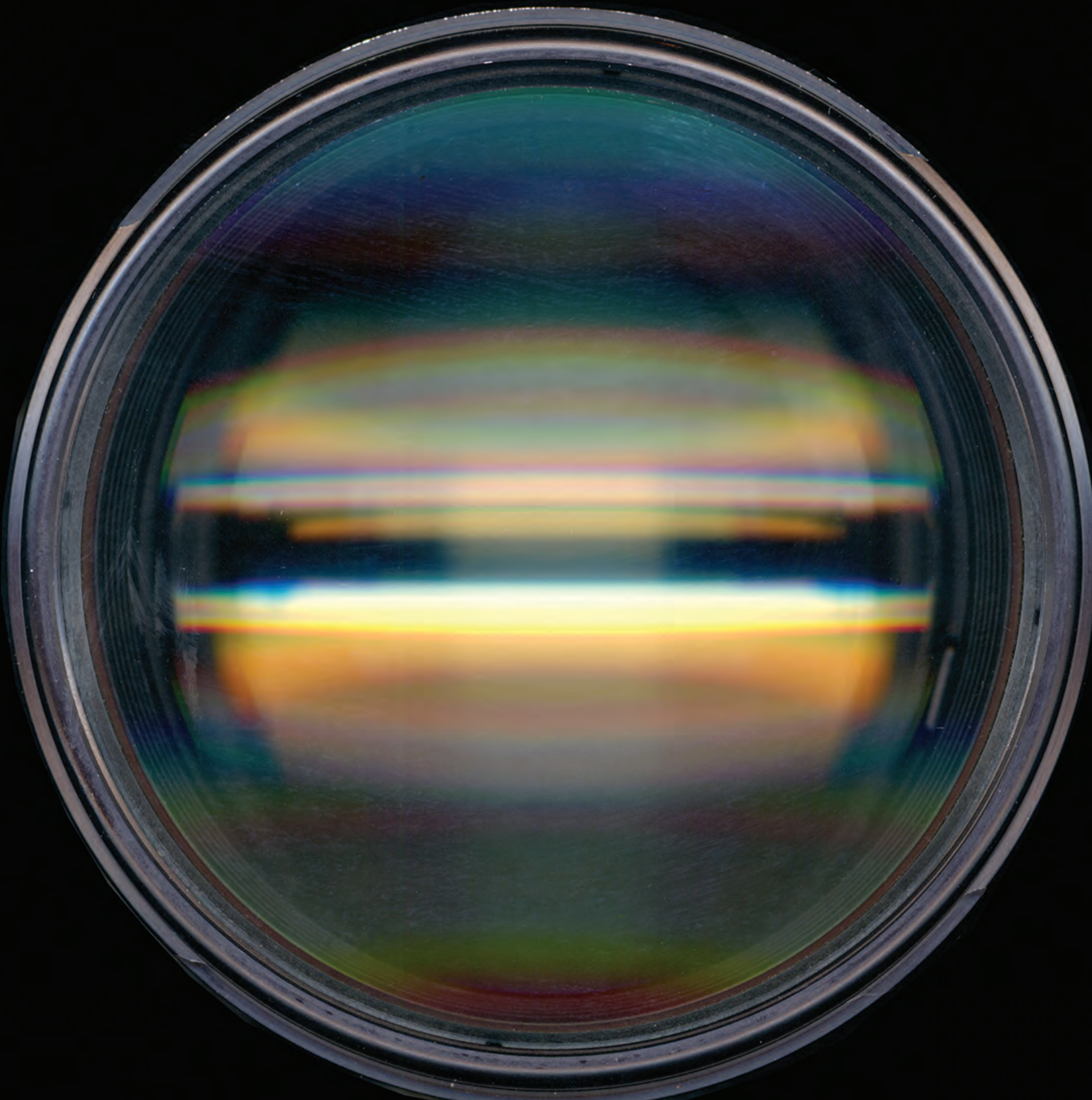

50 YEARS

LEONARDO
WHERE IDEAS
DON'T TAKE SIDES

REFRACTIVE FINGERPRINTS OF LENSES:
Explorations In Light Transformations

By Sheila Pinkel
artist, educator
spinkel4@gmail.com
210 N. Ave. 66, Los Angeles, CA 90042
323 256 1853

Abstract:

Searching for an apt visual metaphor for multiculturalism to form the cover of an exhibition catalogue in 2011, I scanned my Canon lens on a flat bed scanner and much to my surprise, found that the whole visible color spectrum was included in the resulting image. This serendipitous discovery led to my ongoing research project on the unique refractions of all manner of lenses.

During the fall of 2011 I discovered that when I scan lenses on a flat bed digital scanner, each lens has its own refractive "fingerprint." I became fascinated by the remarkable differences between the refractions of various lenses. Since then I have scanned lenses from the California Museum of Photography archive, the Canon Corporation office in Los Angeles, Freestyle Photographic in Los Angeles and from camera stores and private collections throughout Southern California.

To scan the lenses I originally used a Microtek Scan Maker 9800XL flat bed digital scanner. I tried a number of other scanners but found that this one gave me the greatest resolution. Recently I also started using a Canon 9000F Mark II digital scanner which has even higher resolution ability. To scan the lenses I have to make sure that the lens is placed in the horizontal center of the glass plate with the lid resting on top of the lens. I dim light in the room to make sure there is no additional light noise. The configuration of the final image is determined by the structure of the lens in combination with the structure of exposing system of the scanner, in this case a horizontal light bar that moves from top to bottom below the glass plate.

I found striking differences between the refractions of mid 19th century camera lenses used on the earliest cameras, and lenses subsequently developed in the 20th century. Early lenses prior to the use of lens coatings refracted light in colors that are similar to prismatic light refraction. I was especially interested in the potential of the scans to reveal the structure of the lens components. Thus, when possible, I scanned them in both their wide open and stopped down aperture settings (1). The configuration of lens elements (2) in front of or behind the aperture determines whether there is a great difference or little difference between the two scans (Color Figure 1).

In order to provide some background for my current work, I should say that in 1979, I read the book Goethe's Color Theory (3). I was intrigued by the possibilities of making visible color when a black, grey and white two or three dimensional artworks, sculpture or installation were viewed through a prism. The high contrast black and white graphics in Goethe's book became colorful when viewed through a prism, indicating that the brain can "see" colors that it cannot see without the aid of a prism. I became fascinated by the possibility of the addition of color based on whatever viewing device is used.

My interest in Goethe's ideas was from my vantage point as an artist, rather than as a scientist. I was and am not interested in the mathematical veracity of Goethe's work. Instead, I was fascinated by the transformative potential of a prism to make color visible in an otherwise black and white artwork, which the plates in "Goethe's Color Theory" demonstrated. In all of my artworks throughout my life I have tried to make visible the invisible in nature and in culture. The transformative potential of the prism to add color to high contrast images was in keeping with my larger artistic direction. This year I have revisited this prismatic investigation and continue to make graphics that explore prismatic light mixing.

The ideas of George Kubler, author of The Shape of Time, are relevant here. In this book Kubler distinguishes between the biological model and electro-dynamic model of history. In the former, historic ideas are born, grow, mature and then die. However, Kubler does not think that this is a true reflection of the historic process. In the electro-dynamic model of history, an idea emerges and continues to be viable as long as it enlivens the minds of people at a particular historic moment. When minds no longer find that idea useful, it goes dormant. However, when minds later in history are enlivened by it, that idea emerges as long as it is useful. In my case, I was fascinated by the transformative potential of light, and so when I saw colors emerge through the prism while looking at Goethe's plates, I became quite excited by the possibility of forming color in the mind that is not on the page. I began to explore two and three-dimensional possibilities for transforming monochromatic works into brightly colored works in which the color continuously morphs and intensifies in the mind's experience.

Between 1980 – 1989, I made several "Goethe Gardens," that consisted of black, gray and white sculptural installations with strong directional light so that shadows were cast on the floor and walls as well as the sculptural elements. Wherever an edge appeared, colors of red, yellow and blue were visible when the installations and 2D artworks were viewed through a prism. When two edges are close together, light mixing occurs, adding secondary colors as well. When viewed longer than fifteen seconds colors seem to intensify in the mind's eye. In Figure 1, an installation done at Pomona College in 1989, a one point bright light source on the floor was

positioned to maximize shadows of the forms on the walls. A quote by Goethe, "Everything that lives strives for color" was visible in white letters on the floor. The edges of the letters, forms and shadows turned into brilliant color when viewed through the large prism placed in front of the installation.
When making "Goethe Gardens" I also experimented with polarizing filters and cellophane film that has a molecular structure in the shape of columns because of the color transformation of a black, grey and white sculpture when viewed through polarizing film viewer. When I place cellophane film throughout sculptural monochromatic installations and view them through a spinable polarizing film wheel, very colorful interference patterns become visible. In my final "Goethe Garden" installation viewers first saw the monochromatic work and then its transformation through the prism and a second transformation through polarizing film, allowing them to personally experience the dynamic non-static color possibilities of the work and transformative potential of light as experienced by the mind.

This brings me to my current work on lens scans where I was surprised to once again encountered Goethe's prismatic phenomena. Early lenses reveal refractive light bending at the edges of each lens element similar to prismatic bending of light in Goethe's high contrast drawings (Figure 2). These early lenses were composed of relatively simple combinations of glass lens elements made from crown glass or flint glass. As scientists continued to better understand the subtleties of light transmission and amplification, they were able to combine lens elements with greater precision. After WWII they also began to use extra high refractive index rare earth optical glass that resulted in even better clarity and light transmission.

Some of the approaches to combining lens elements included gluing them together as was done in the Turner Reich lens manufactured in the early 20th century (Figure 3). Because the glue degraded over time, it became visible at the edges of the lens scan; this actually enhanced the beauty of the scan.

Later in the 20th century, refractive coatings for lens surfaces were developed to enhance their light transmission ability. A major problem for lens manufacturers is light reflection that reduces the intensity of light transmission by 4 – 8% at each glass-air interface. Thus, as the number of lens elements increases, light transmission decreases. By 1935, Zeiss had perfected a single coat deposition of a very thin layer of magnesium or calcium fluoride to suppress surface reflections (4). This coating allowed the transmission of very precise wavelengths of light. Scans of these lenses reveal the structure of the lens elements in combination with the coating on the lenses, which in most instances reveal an intensity of color normally not visible.

Dr. Alma Zook, a physics professor at Pomona College, recently told me that her father had been given the challenge during WWII to develop lens coatings for periscope prisms to enable more transmission of light so that navy personnel could better see enemy submarines at dawn and dusk. In this case the lens coating reduced reflections of light from the prism, enhancing transmission of light. After WWII, multiple coatings were perfected by Asahi Optical Company, Ltd. that enabled the design of complex lenses with many lens elements.

Recent conversations with physicists at Pomona College and Harvey Mudd College have helped me understand the language of refraction that was unfolding. For instance, when two adjacent lens components have slightly different curvatures, interference patterns result, appearing as alternating dark and light lines in the refraction, visible in the Leitz Wetzlar Noctilux lens scan (Color Figure 1).

The oldest lenses I scanned date from 1840 when the lens elements were relatively simple. Among the lenses I scanned from the 19th century were multiple lens cameras, like a stereo Palmos camera whose twin Zeiss Tesar lenses, when scanned, look like eyes (Figure 4), and nine lenses in a lens board used to take portraits in commercial 19th century portrait studios (Figure 5). The refractions from this set-up are reminiscent of holography in that each image is formed from a slightly different vantage point.

As lens manufacturers began to add coatings to the surface of the lenses to enhance light transmission, the refractions became much more colorful in most instances (Color Figure 1). One physicist explained that because the color green is in the center of the human visual light spectrum, in more efficient lenses the ultimate goal of the coatings is to transmit green as fully as possible. Thus, the most efficient lens coating is one that delicately reflects in the pink/purple range and transmits green and most of the other light waves. This lens turned out to be a Zeiss lens on a Hasselblad camera, with the most subtle refractions of the lenses I scanned. Most of the other lens coatings resulted in more colorful scans indicating that more of the light was reflected than in the more efficient lenses.

As I continued to scan I began to recognize specific manufacturers of the lenses. The combination of the optical structure plus the lens coatings by the same manufacturer began to emerge as its own recognizable "fingerprint." I inadvertently scanned the same kind of Canon lens in two collections. Both scans are identical indicating that the refraction from identically structured lenses is the same. Scans of more recent lenses reveal very different structures that older lenses reflecting new concepts in lens construction.

I made prints of these many lenses and discovered that when people look at them they talk about how the images look like eyes or like planets (Color Fig 2). I am fascinated that they are able to find analogies that give the images meaning to them. Interestingly, the prints are precisely clear where the lens front touches the

glass surface of the scanner and are slightly fuzzier in the area where light is coming through the lens and into the scanner. This is because the depth-of-field (5) of the optical scanning element results in less clarity as the lens elements move away from the scanning surface. This contrast between the physical lens elements and light phenomenon in the final print is experienced as the difference between the enduring presence of the lens housing itself and the temporal experience of the light coming through the lens, as if light is being transmitted in real time. Scans of the lenses sometimes include the camera itself. Details of the equipment and the color phenomena of refraction become 'delicious' to look at for their own sake when printed.
Recently G. Ray Hawkins, a photography dealer and collector of cameras used by preeminent photographers, allowed me to scan lenses of world famous photographers, including Man Ray, Ansel Adams, Edward Curtis, Dmitri Baltermants and Paul Outerbridge. The scans of lenses that produced seminal images in the history of photography add another level of meaning to this project. Especially noteworthy is the Dallmeyer soft focus lens used by Man Ray that is exceptionally beautiful (Figure 6). The care with which early lenses and their mounts were designed add an aesthetic dimension to this body of work.

So far I have scanned hundreds of lenses, including telescope and enlarger lenses. I still have a great deal to learn. In a perfect world I would love to scan Louis-Jacques-Mande Daguerre's and Henry Fox Talbot's lenses as well as the history of Kodak, Zeiss, Canon and other manufacturers' lenses. I remain passionate about scanning lenses because I can never anticipate what will be revealed.

Footnotes:

(1) Wide open and stopped down aperture settings: The diameter of the opening of a lens is known as the aperture. Wide open aperture means that the lens is at its largest diameter setting, letting in the most light, but less of the image is in focus. A stopped down aperture has the smallest diameter, lets in the least light but more of the image is in focus.

(2) Lens elements: Lenses are built by combining convex, biconvex, planoconvex, positive meniscus, negative meniscus, planoconcave, biconcave pieces of ground glass. The glass lens elements in the 19th and early 20th centuries were made from low refractive crown glass and/or high refractive flint glass. After WW II light transmission was improved with the use of extra high refractive index rare earth optical glass. Source: https://en.wikipedia.org/wiki/History_of_photographic_lens_design

(3) R. Matthaei, arranged and edited by, *Goethe's Color Theory* (New York, Van Nostrand Reinhold Company, 1971) 275 pages.

(4) Source: https://en.wikipedia.org/wiki/History_of_photographic_lens_design

(5) Depth of field: The amount an image is in focus as a result of the aperture of the lens or exposing apparatus.

Brief Bio: Sheila Pinkel is an emerita professor of art from Pomona College where she taught from 1986 – 2111. Her work has been exhibited nationally and internationally, most recently at Higher Pictures Gallery in New York City and the Los Angeles County Museum of Art. She has been an international editor of Leonardo since 1984.

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Pinkel Fig 5.tif: Multiple lenses were used on large format cameras for portraits after 1860. Abraham Lincoln was the first person to run for president using the distribution of his photograph as a campaign tool.

Pinkel Fig 6.tif: Dallmeyer Soft Focus Lens used by Man Ray.

Color Image Captions:

PinkelColorFig 1.tif: Leitz Wetzlar Noctilux 50mm, left view F 16, right view F 1.2. This was Leica's first extremely low light lens, designed in 1966.

PinkelColorFig 2:Frontispiece.tif: Canon 200 mm zoom lens