Erwin Puts

LEICA LENS SAGA

evolution - optical design - evaluation - future

Berek's Legacy: the 50 mm lens for Leica rangefinder cameras

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1. Introduction

I am not interested in shooting new things - I am interested to see things new. - Ernst Haas

The fame of the Leica lens is built on the high quality of the pictures that have been made with the Leica camera. The Summicron lens is the finest example of all lenses, designed and made by the Leica company over a period of ninety years. This design has a long history, dating back to the Leitz Summar. The design of this lens is strongly influenced by its more modest predecessors, the Hektor and Elmar. The word ‘modest’ should be interpreted with caution. The Hektor type had the advantage of less glass-air surfaces than the Summar, giving the first lens the edge in definition. The many air-glass surfaces of the Summar, on the other hand, helped the correction of aberrations that were rather prominent in the original double-gauss design.

Why is the Leica lens held in such high esteem? There is undoubtedly a strong dose of myth involved in the evaluation of Leica lenses. A number of special optical characteristics are, however, real and can be related to the unique design methodology, that has been developed by Max Berek. His special method is derived from a comprehensive synthesis of the character of the design, derived from an intelligent analysis of the value of the Seidel coefficients at every surface of the lens elements comprising the optical system. The design of every standard lens for the M-system has been influenced by this overriding characteristic: the small physical size of the lens. Designing a high-speed, high-performance lens is not an easy task. Before describing the theory of optical design, the physical process of image formation has to be explained to understand what happens inside this lens. The theory of image formation and its practical application is a mixture of science and innovation. The search for this theory, including the discovery and description of aberrations and the development of the instruments that were invented in the course of this search spans about two centuries, beginning with Huygens and his experiments with lens grinding and ending with Berek and his development of the polarisation microscope.

This history sets the stage for the development of the photographic lens, culminating in the Elmar and Hektor design, rightly evaluated as milestone lenses for the compact precision-engineered miniature camera, the Leica camera, constructed by Barnack.

This book explores and explains how the standard lens for the Leica coupled rangefinder is being designed and why it performs as well as it does. The main idea can be described as follows: the evolution of Leica lenses has been made possible by the progress in lens design techniques and the progress in manufacturing technology. Both lines of development are connected to each other, although it is not possible to find a common cause. There is however a close interaction between the two lines of evolution. The performance or 'fingerprint' of the Leica lens for the rangefinder camera is determined by the physical constraints of the lens. These dimensional limits determine for a large part the design landscape for the lens. The final performance of the Leica lens is the function of the design methods, the manufacturing possibilities and the specific physical limits. In a nutshell one may call this complex interaction the opto-mechanical dimension.

Special attention will be given to the analysis of the development of the Leica standard lens from the original Elmar to the current Apo-Summicron-M 50 mm. There is a steady, almost evolutionary, progress from the original triplet design to the modern double-gauss derivative. This progress becomes even more understandable when design methods are integrated with the manufacturing technology. There exists, often disregarded, an intimate connection between the exactness of the design goals and the attainable manufacturing precision. It is possible to design a lens to a high level of precision, often to more than five decimal places. The machines needed to shape the surfaces of the individual lens elements are however not able to manufacture the optical and mechanical components to the same level of accuracy. Last but not least it is the human factor at the assembly stage that has to guarantee the required precision.

Some of the topics to address are:
(1) The special opto-mechanical characteristics of the Leica standard lens for the rangefinder camera and the explanation of the progress of the standard lens for the Leica rangefinder camera from 1925 to 2016;
(2) The optical design technology: the explanation of the processes of image formation by a lens and of the occurrence of aberrations;
(3) The techniques of the design of a Leica lens and its fabrication technology, because the tolerances of the machine tools and the accuracy of the assembly determine the final result;
(4) The metrology of the lens (the technical evaluation) and the subjective evaluation of the image quality.

The focus in the book is on Leica (mechanical) lenses for the coupled range finder (CRF) cameras. The Leica lenses with an f/2 aperture have been selected because they may be considered as the high-performance standard workhorse for most photographers. There is a simple logic behind this selection: the 50 mm started the Leica lens evolution and its physical restrictions (size and weight) forced the designers to extraordinary acts to provide outstanding performance within these physical constraints. The volume of the Zeiss Otus 1.4/55 mm, for example, indicates that the combination of small physical size and high optical performance is not self-evident. The Zeiss lens has a very impressive performance, but needs lots of lens elements, a large diameter and an extended length to deliver the quality.

Leica has always provided the photographer with a range of standard lenses from f/4 (the Tri-Elmar) to f/0.95 (the current Noctilux ASPH). The two most used lens lines are the Summicron and the Summilux designs, reflecting the universal trend for very high-speed lenses during the 1950s and 1960s. In those days the need for a fast lens could be met by the 35 mm system camera because of the relatively small weight and size in relation to the wide aperture. Both ranges are still the most popular today: the prestige button is for the f/1.4 design, while the f/2 design is shoved aside a bit in the public opinion. The most interesting designs have been proposed by Leica with the Summicron range from 28 mm to 90 mm.

The Summicron range offers undoubtedly the best performance-cost-ergonomics balance. It is true that the several Summarit, Xenon, Summilux and Noctilux designs have fired the imagination of reviewers and users alike, but its usability has been limited with one exception, the current Summilux-M 1:1.4/50 mm ASPH, which is a genuine general purpose lens.

The very high-speed standard lens has always been the yardstick for the status of the lens range. Even now the performance of the lens with an aperture of f/1.4 (or wider) is a benchmark for the competences of the optical department and its status spills over the other lenses in the range. The element of prestige that the owner derives from such a high-speed lens is also well-known. Most f/1.2 lenses did not perform as well as their more common f/2 siblings, but showing/using one had and has its emotional value (including the undeniable artistic characteristics). The ergonomics do suffer when the lens dimensions are increased. The Noctilux-M 1:0.95/50 mm ASPH. has a size and weight twice the corresponding values of the Summilux-M 1.4/50 mm lens. This corresponds to more than twice the amount of energy that flows through the lens. The volume of the lens is 5482 mm2 and the weight is 700 grams. At maximum aperture the Noctilux is not as impressive as the Summilux design at its own maximum aperture, to be sure.

Apart from the aspects of ergonomics and performance, the lenses for the M-system are all mechanical constructions, because they are integrated into an opto-mechanical camera-system. Even the most electronic version of the M-range, the current M(240) has a limited list of mechatronic features.

The opto-mechanical lens construction may become an outsider in the current lens landscape.

Several recent optical designs that are made by Leica, are integrated in the digital system that comprises the camera, the optical construction, the embedded software and the interaction between all these components. These systems are characterized as opto-mechatronic devices and are very different from the classical opto-mechanical constructions. The comparison between the (opto-mechanical) Summilux-M 1.4/50 mm ASPH. and the (opto-mechatronic) Summilux-TL 1.4/35 mm ASPH. for the Leica T model illuminates the change of direction. The M version has a volume (length x diameter) of 2809 mm 2, a weight of 335 grams, eight elements and one aspherical surface. The T version (for a smaller image format!) has a volume of 5390 mm2, a weight of 428 grams, twelve elements and four aspherical surfaces. There is some justification for this increase in complexity and size. The aperture is electronically controlled from within the body. The distance setting is also controlled from the body that governs an integrated stepping motor in the lens mount. The new mechatronic designs set an elevated standard for optical quality (especially in the near distance range) and depart significantly from the classical mechanical designs for the M camera.

One can observe an evolutionary progression from the original Elmar design till the most recent Apo-Summicron-M 1:2/50 mm ASPH. The S, SL and T lenses on the other hand represent a new branch in the evolution of Leica lenses for photographic purposes. Due to the fact that they depart from the classical rule (small size – high performance) these lenses fall in a different category and will not be studied in this book (there is by the way too less information about these lenses for an in-depth analysis).

The standard lens for the Leica is now (mid-2016) more than ninety years old. This species of lens has experienced during its long evolution periods of slow progress, interspersed by leaps of improvement. Optical theory on the other hand has been rather stagnant: the method of ray tracing and the theory of the origin of aberrations was finalised at the beginning of the twentieth century. The main revolution came from the introduction of the computer and from the glass makers who produced glass with special properties. The calculations made possible by the computer produced a more comprehensive and more accurate tracing of rays. Specifically, the concept of the merit function revolutionized the art and science of optical design.
The Leica Optical Department however followed its own path that was originally spelled out in detail by Max Berek. He noted that a specific layout for optical designs possessed a character that made the design suitable for specific tasks. The exploration of this character did not require lengthy and accurate calculations. It sufficed to use the Seidel sums to study where aberrations originated and how to avoid them in the first place. From the start the Leica engineers and designers were well aware that an excellent design could be ruined by sloppy manufacturing. This conviction was a heritage from the microscope department.

The optical layout of the standard lens for the Leica rangefinder camera, restricted as it is by physical dimensions, can accommodate only a limited number of lens elements. A tilt or decentring of one element may jeopardize the image quality of the whole lens. A painstakingly accurate manufacture and careful assembly is a requisite to ensure that the calculated performance of the lens is realized during final assembly. Over the years the accuracy of manufacturing and assembly has been increased by a factor of ten, from a few hundreds of a mm to a few thousands of a mm. The automated manufacture of aspherical surfaces played a major part in the quest for narrower tolerances. When one compares the original Hektor 1:2.5/50 mm design with the Apo-Summicron-M 1:2/50 mm ASPH the number and layout of the lens elements provides only superficial information of the progress made. The MTF diagrams may help to illuminate the performance differences.

A real understanding of the task of the optical designer and of the true nature of a lens is only possible when one gains insight into the basics of image formation and begins to know what happens inside the lens. All ray tracing is based on Snell's Law and explained by Fermat's principle. The process of image formation was for a long period an object of intense scientific speculation and experimentation. What the general photographer takes for granted while taking a picture (if he does think about it in the first place), the process of the formation of an image, is not easy to explain. Why and how does a lens form an image at all? The answer for this question took several hundred years to emerge as a physical theory. The experiment with the pin-hole camera points to an exceptional model of image formation. Only after inserting a lens element in the pin-hole did the camera show what happens when the lens is used to bend the rays. The projection of an image (of a part) of the physical world by the lens onto the sensitive surface within the camera is a very complex physical process, the study of which occupied many great scientists and mathematicians during several centuries from the 17th to well into the 19th century. Against this background the design by Berek of the first lens for the Lilliput camera (by Barnack) can be rightly claimed as a landmark in optical design. Berek explained his approach in his book titled "Grundlagen der praktischen Optik" ("Foundations for practical Optics"), a title that is self-explanatory. Berek had several problems: the calculations were of necessity approximate, but he had also to consider the manufacturing techniques, the quality of the glass that was available and not in the least the commercial risks when the Barnack camera with its novel lens would fail in the market. Berek's approach to balance these often conflicting aspects became the standard for the design of photographic lenses for a long period.

The analysis of the evolution of the standard lens for the Leica rangefinder camera is at the same time a history of optical design techniques. The story of the steady progress in image quality from Summar to Summicron has been told very often and has been illustrated with MTF graphs, lens diagrams, glass types and patent details. What is still lacking in this story is the account of the tools that the lens designer had at his/her disposal and an explanation of the design techniques that were available. There is a vast difference between the tools and methods used by Berek and those employed by Mandler or Karbe. It is now easy to approach the Hektor design as a moderately successful attempt when comparing it to the recent Summarit-M 1:2.4/50 mm. The Hektor design was a tour de force for Berek. It was a formidable task, given the available choice of optical glasses and the large design landscape.

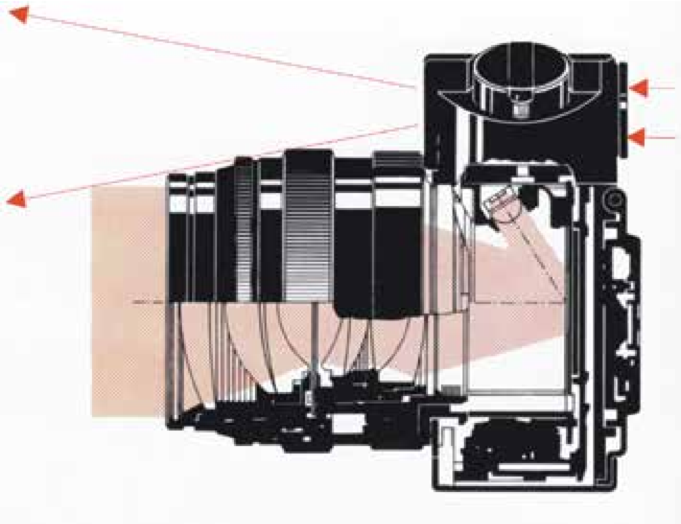
The interchangeable standard Leica lens for the rangefinder camera has an additional constraint. The physical size of the lens is limited by the diameter of the camera bayonet and the front lens diameter which has to match industry-standard filter sizes. The diameter and the length of the lens have to be chosen such that there is minimal obscuration of the viewing area of the viewfinder. With relatively simple designs like the Elmar or Summar this is not a great problem, but still a demanding one. When one wishes to increase the aperture to f/1.4 and/or wishes to improve the performance (Apo-Summicron-M 50 mm) then the physical limitations are becoming severe. These newer designs are only possible because of the progress made over the last thirty years.

This progress can be summarized as a (1) development of technology in manufactured components (optical glass, free-form surfaces like aspheres and thin film coatings) and (2) the application of this technology with the help of optical system design and optimization software. During the classical period of Leica lens design (1930 – 1960) the main goal was to create a design that minimized the important aberrations to combine high speed with high resolution for one specific image plane (most often the infinity position of the distance setting). It was accepted that the performance would be perceptibly lower over the near focus range from 1 to 2 meter. The inevitable extent of unsharpness was used to emphasize the plane of excellent sharpness, but a study of the behaviour of the lens in the unsharpness zones (the modern analysis of bokeh) was skipped.

The over- and under-correction of the spherical aberration was a matter of aberration balancing and not of a controlled approach to create special unsharpness effects. Modern lens design however has to cope with many more performance parameters than ever before.

More than ever before, science and art have to be two sides of the same coin.

2. The opto-mechanical properties of Leica CRF lenses



2.1. Introduction

The difference in performance between Leica lenses for the CRF M-camera is a theme that occupies the minds and emotions of most Leica users (and even non-Leica users), including the difference in performance, real or imagined, between lenses made by Leica and others and between lens generations within the Leica M scuderia. These differences are the result of a number of choices during the optical design process. The high-quality optical systems will therefore present a select profile of characteristics that may be called the fingerprint or the soul of the lens.

The reason for this difference can be found primarily in the different style in lens design. Tracing the origin of aberrations and finding solutions for the reduction or even elimination of aberrations is a very elaborate and creative process. There are many obvious solutions for the same problem and there are some hidden and uncommon solutions.

The final layout of the lens (number of lens elements, choice of glass, the radii of the surfaces of all lens elements, the spacing between elements) determines the way the lens will form the image on the plane sensitive surface.

This layout is not just a technical concept, but also a creation of the mind. One may refer to this alternatively as the ghost in the lens. To understand this soul or ghost, present in every Leica lens, requires an in-depth look at the design method, design process and production technique of Leica lenses. After this tour de force we are able to sense and appreciate the Leica “ghost in the glass”.

The exploration of the range of optical design techniques that are used for the creation of the Leica lenses since Berek designed the first lens for the Leica camera is a demanding one because a fair dose of mathematics is required to understand the topics of ray tracing and image formation. An understanding of what happens inside the lens and why it performs as it does, is a good point of departure for the discerning Leica user who wants to explore the subtleties of the performance provided by a specific lens profile.

Goldberg subtitled his book about camera technology the ‘dark side of the lens’ (1992). He discussed the engineering of that part of the camera that is located behind the lens and is responsible for the production

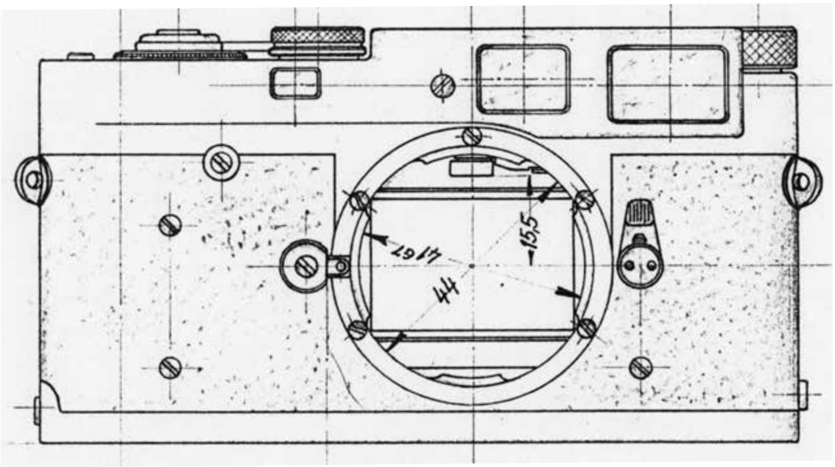
of a technically perfect photograph. His approach was to explain all mechanisms that are normally not discussed, but in reality determine the level of perfection of the image. The same approach can be applied to the analysis of the Leica M lenses. The designer of Leica M lenses faces a battle on two fronts:
(1) the correction of the aberrations inherent in a high-speed lens to the maximum possible (to achieve maximum fidelity and maximum informational content) and
(2) achieve these goals within the physical constraints of the rangefinder concept: compactness and mechanical accuracy. For a long period, it was the goal of most optical designers all over the world to create physically compact lenses. The classical designs for the Olympus OM camera were among the smallest on the market. The approach by Zeiss for the Contarex system was rather different. Their developers designed lenses that were as voluminous as was deemed necessary at the time of the computation. The Leica designs were and are closer to the Olympus philosophy. It is no coincidence that Olympus wanted to designate its nimble reflex system, the Olympus M, but were stopped by Leitz and then changed the name to Olympus OM.

2.2. Opto-mechanical limits

There are two reasons for the drive to compactness. They address the physical constraints and ergonomic arguments. The size of the lens should suit the size of the body and the camera/lens combination, while no longer as portable as the original Leica camera with collapsible lens, has to be an unobtrusive companion for the photographer. A larger lens is also a heavier lens and this disrupts the balance of the camera and its ease of holding. The standard M lens has a narrow bayonet diameter, a short overall length and a short back focus (rear clearance between the lens and the image plane). The camera is a rangefinder type and the photographer looks through a viewfinder above the lens. The free field of view through the finder must not be obstructed by the lens and this requirement limits the length and thickness of the lens.

This picture of the M8.2 with Noctilux-M 1:0.95/50 mm ASPH shows clearly the limit of the size before the view through the finder will be blocked. The situation would be even more problematic when the lens is fitted with a lens hood. Several modern Leica lenses have retractable lens hoods, that are less effective than add-on versions, but at least they do not block the view through the viewfinder.

A detailed sketch of the physical dimensions of the Leica lens attached to the camera body is the starting point for the design of the lens.
The normal high-speed 50 mm lens with an aperture of f/2 is used as example. The physical front diameter of the lens is 39 mm, a size that is prescribed by the standard filter sizes. The back diameter is limited by the diameter of the bayonet throat that has a maximum size of 41.67 mm.
On the right side the camera facts are sketched: the film or sensor plane with its maximum diameter of 43.6 mm, the bayonet flange to image plane distance of 27.8 mm and the diameter of the bayonet throat: 41.67 mm.
On the left side there is the lens. This diagram is derived from the original version of the Summicron (II) lens 1:2/50 mm as example. The focal length is exactly 52.08 mm and is reckoned from the film plane (or image plane) and the principal plane, which is located somewhere in the lens.
The back focal length is a measure from the surface of the last lens element to the image plane. The lens unit or optical cell is enclosed by the front lens with a diameter of 25.6 mm and by the back lens. The optical cell has to be mounted in a physical mount that is limited at front by the filter size and at back by the bayonet throat.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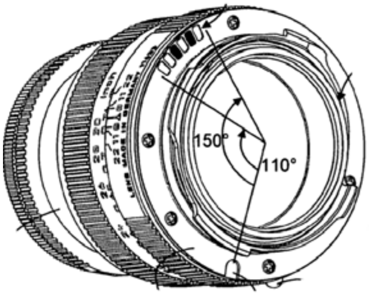
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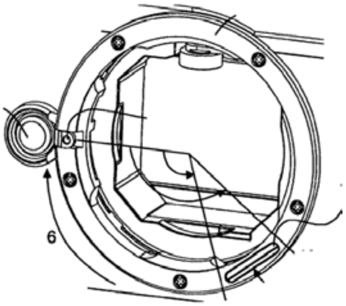
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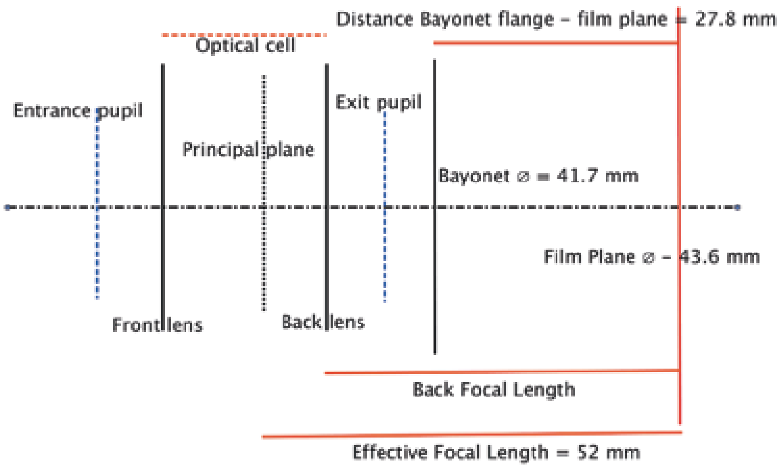
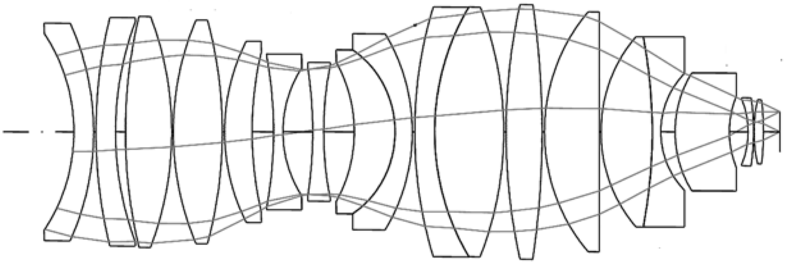

Distance Bayonet flange – film plane = 27.8 mm
Optical cell
Entrance pupil
Principal plane
Exit pupil
Bayonet ⌀ = 41.7 mm
Film Plane ⌀ – 43.6 mm
Front lens
Back lens
Back Focal Length
Effective Focal Length = 52 mm

The two important connections are the bayonet flange on the camera (top) and the diameter of the lens at the back (bottom). The size of the bayonet diameter on the camera determines what the maximum diameter of the back of the lens can be. In the above diagrams the connections are indicated. The bottom diagram is the most important.
The blue lines represent the entrance pupil at front and the exit pupil at the back. All the light energy that is coming from the object and limited only by the boundaries of the field of view of the lens has to be squeezed through this narrow optical pipe and will finally be captured by the sensor or film emulsion at the back of the camera. At the same time the optical design must also fit within these physical boundaries. The number of lens elements and the maximum diameter of the lens element is defined by these simple physical conditions. You can only pack a limited number of elements into a physical mount of a certain length. It is well-known that the image that any optical system produces is not a perfect copy of the objects that are being projected on the capture medium, but this image is marred by lens faults or aberrations. There is a close connection between the number of lens elements and the possibilities for correction of these aberrations. The designer of lenses for the Leica rangefinder camera seems to be in a complex situation: the physical dimensions limit the number of lens elements and the goal of excellent image quality requires the use of as many elements as possible.
A four-element lens (like the original Elmar 1:3.5/50 mm) may suffice when the major lens specifications (aperture and focal length) are modest. The situation becomes demanding when the specifications are quite ambitious (like the current Apo-Summicron-M 1:2/50 mm ASPH FLE).
A lithography lens shows what can be accomplished when there is no limit to size or number of elements. The illustration below shows one example with eighteen elements.

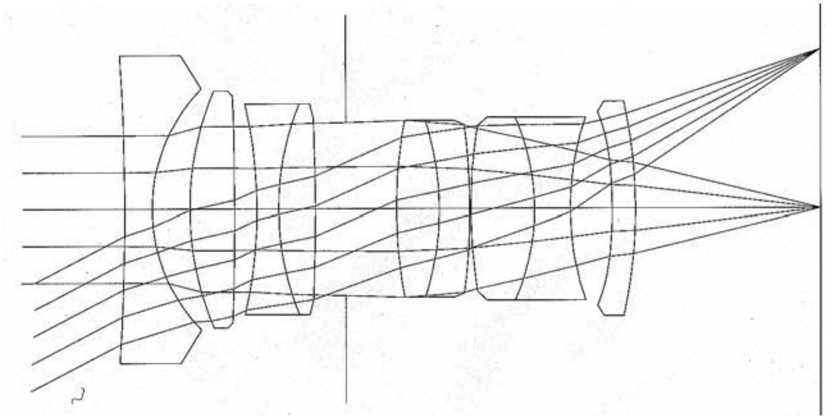


The importance of this diagram lies not in the optical lay-out, interesting as this may be, but in the demonstration how the light rays are traced through the system. The basic law of optical ray tracing is Snell's law which specifies the relation between the angle of the incoming ray on a surface and the amount of bending of this ray after leaving this surface. This relation depends on the angle of the incoming ray, the amount of curvature of the lens surface and the index of refraction of the glass type of this lens.

The amount of bending is also an indication for the existence of aberrations. The steeper the bending, the more impact the aberrations will have. The diagram of the lithography lens shows clearly that the light ray will move very smoothly through the system. This is what a designer would like to accomplish.

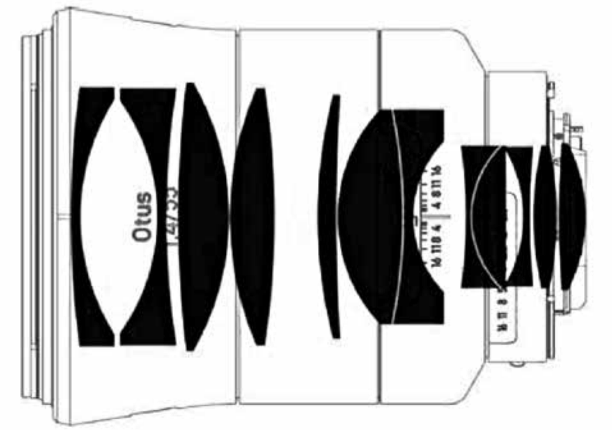
The diagram below of the original Summicron-M 1:2/28 mm ASPH shows that the Leica designers in this case have reached this goal.

The path of the rays to the centre of the image is very smooth and the path of the rays to the edge of the image has only a few kinks, although quite strong.



Note that all rays through the last cemented doublet are straight, indicating that the task of this element is to control the chromatic aberrations. Designing such a compact construction is not a simple task. When one would ask the computer to suggest solutions for a certain optical design, there is a big chance that the final result will be a long lens with a very short back focus and thick lens elements. A large diameter reduces the amount of vignetting and a long lens with ample space between the individual lens elements simplifies the correction of

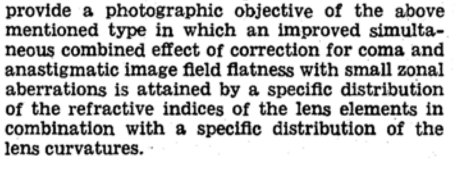
aberrations. The lens elements in the Leica high-speed standard lenses are located very close to each other. The logical conclusion would be that such a lens should have a higher level of aberrations, because of the difficulty to control the effect of the aberrations. It is a fact that there is a strong relationship between the amount of lens variables (element powers, element shapes and element air spaces) and the amount of optical properties that can be controlled. Optical properties are not only the aberrations but also the physical properties like focal length, total length and so on. One needs one variable to control one property. There are seven basic aberrations and therefore we need at least seven variables to control them. A three-element triplet lens has eight variables and can in principle control all the aberrations plus the focal length. Such a control however is not perfect and the more variables (lens elements) there are in a system, the better will be the control of the residual aberrations. One cannot squeeze any number of elements into a short tube. The current Sigma 1.4/50 mm employs thirteen elements (including one aspherical lens) in eight groups and has a length of about 100 mm with a filter size of 77 mm. The Zeiss Otus 1:1.4/55 mm provides an additional example.
This lens has twelve elements and needs a length of 125.3 mm to accommodate these elements, including their thickness and distances between the elements.



The Leica Summilux-M 1.4/50 mm ASPH FLE has a length of 52.5 mm and space for eight elements, including the critical distances between elements. When the designer has to operate within a small space, the tolerances of the dimensions become very critical. Accurate manufacturing and careful assembly of all parts become a premium requirement. Leica has always stressed the importance of precision engineering and precision manufacturing. The classical slogan that Leica works at the limits of the technologically feasible is a bit overdone, but has a grain of truth.

Why is it so difficult to design a high-quality, high-speed lens with compact dimensions? The physical mount of the Leica lens can be interpreted as a light tube with a relatively narrow front diameter and a narrow back diameter (the lens has to be coupled to the bayonet flange of the camera). The angle of view of the standard lens is about 46 degrees and light rays from an extended object enter the front of the tube. The rays have to be angled quite steeply to pass through the relatively narrow tube and are again steeply angled when leaving the last surface of the lens. Steep angles introduce high amounts of aberrations and should be avoided. One method is to use high-index glasses which are very expensive and often difficult to manipulate in the fabrication process. With high-index glasses the curvatures of the lens elements can be made flatter which reduces the effect of aberrations. Thicker elements are another method that can be used.

The issue was well-known by classical designers, like Tronnier. He filed a patent in 1950 for a high-speed lens with improved correction of aberrations, based on the specific distribution of lens powers.



The main object of the present invention is to provide a photographic objective of the above mentioned type in which an improved simultaneous combined effect of correction for coma and anastigmatic image field flatness with small zonal aberrations is attained by a specific distribution of the refractive indices of the lens elements in combination with a specific distribution of the lens curvatures.

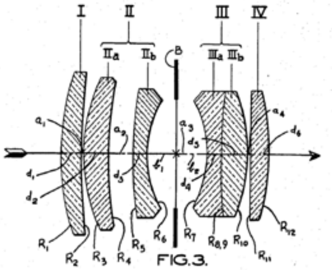


FIG.3.

The dilemma becomes clear: with a limited number of lens elements, closely packed together with limited space between the elements a large amount of aberrations has to be controlled. Every lens element is among others characterized by the refractive index of the glass. The refractive index determines partly the power of the lens or its power to bend the rays. The power of the lens is also its focal length, measured in dioptres. The focal length that is given as an attribute of the photographic lens (for instance 50 mm or 75 mm) is in fact the sum of all focal lengths of the individual lens elements. The distribution of these powers over the lens elements is an important topic in the design process. Abrupt changes from one element to the next one will introduce strong kinks in the trajectory of the light ray and by definition will also generate aberrations. Most photographic lenses have curved surfaces that are part of a sphere. The lens has therefore a natural tendency to produce a curved image plane. The surface of a digital sensor and a film emulsion is a flat field. The designer has to make a special effort to flatten the field and a measure for his success is the so-called Petzval sum. The bad news is that one of the more troublesome aberrations (astigmatism) is difficult to correct at the same time as the reduction of the Petzval sum. Here we are already in the midst of the design process, where art and science and computer optimization programs meet. The physical restrictions have not limited the designers in their goal to provide the critical Leica user with lenses of impressive quality. This quality was needed to demonstrate to a reluctant photographic community that the Leica system was worth investing in.

2.3. The search for perfection

The lenses, made for Leica CRF cameras, have a legendary status. Ever since Prof. Max Berek designed his first lens for the Leica camera, the Anastigmat/Elmax 1:3.5/50mm, in 1924, the optical capabilities of Leica lenses have been intensively studied and discussed. Some reviewers have declared that Leica lenses are the standard against which others are to be judged. Others have expressed the view that Leica lenses may have a different fingerprint in image recording, but bottom line are as good as comparable lenses from the other two or three top-class optical firms in the world. Among Leica users and collectors, the topic whether the newer lenses have lost some of their magical qualities by using modern design techniques is a hotly debated item even today. One recent theme has overshadowed this older discussion topic. The widespread use of digital M cameras and the close interaction between solid-state image sensors (“imagers” or “FPA”(focal plane array)) and the surprisingly effective imaging processing algorithms have brought renewed interest in the method for evaluation of and the criteria for image quality. It is evidently the case that current highly efficient image enhancement programs are challenging the traditional parameters for image assessment.

The technical analysis of the lens quality relates to the ideal of perfect imagery as defined by Maxwell: a point is projected as a point; the image has a flat field and exhibits no distortion. This ideal may not conform to the expectations of the average human observer. I described in the companion volume (Leica Practicum) that the human visual process operates differently and reconstructs or even builds an image from the data the retina receives as a random pattern. This is the main reason why there are so many different and even conflicting reports about the performance of a Leica lens when one version has been compared to another one.

Notorious in this respect is the discussion about the performance of the Dual Range Summicron and the Rigid Summicron of the same age. Reports based on photographs of outdoor scenes have also to be looked at critically. The observation that under very specific conditions a modern Leica lens can exhibit flare may be certainly true in the specific situation when the photograph was taken. That specific location and time frame and the photographer's position, might be not representative of the general performance of the lens.

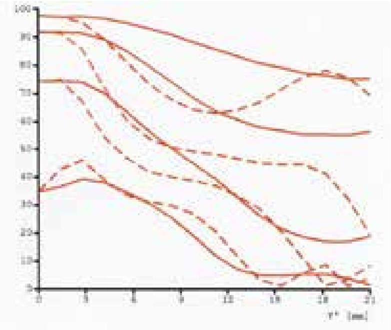
The equipment in the optical laboratory (MTF bench) gives a verdict without taking into account the human perception. The result is a measure of the amount by which the lens degrades the contrast of a test target (most often the edge of a bar-line pattern). Contrast degradation is a measure of the image quality, but it has no information about the content of the image. The software program that determines the level of contrast at the edges of fine detail has also no idea what this detail represents and it is at this point that the eye becomes important.
The remark that “beauty is in the eye of the beholder” (Margaret Wolfe Hungerford, 1878) is certainly appropriate and probably valid when discussing image quality.

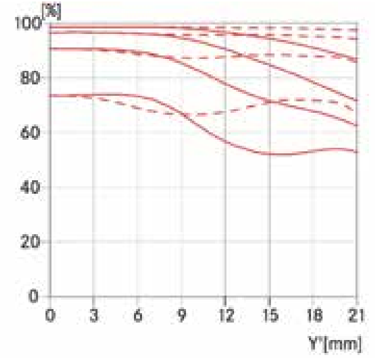
Leica lenses have always been associated with high image quality. The definition and evaluation of the concept of image quality is not a simple one. The issue of image quality can be approached from a technical or optical viewpoint and from an artistic or emotional perspective. All these viewpoints have an intrinsic merit; there is no viewpoint that is inherently superior to any other. This discussion about the validity of the subjective (photographic) and the objective (technical) evaluation criteria should be re-framed as a gradual scale between two positions, the communications and fidelity yardstick.

The appreciation of Leica lenses in particular (and this applies to a slightly lesser degree also to Zeiss lenses) is however and unfortunately often distorted by a good deal of myth and historical misrepresentation. There are countless stories that add to the legendary status of Leica lenses. There is the story of a famous photographer who carefully selects one specific lens out of a batch of twenty pieces because this specific one suits his demands best. There is another photographer who claims that his famous photograph could only be made with a Leica lens. And there is now an incalculable amount of reviews floating around in cyberspace that are imbued with buzzwords like amazing, wonderful, perfect while discussing and admiring the smoothness, crispness and contrast of the photographic image made with a Leica lens.

In the final analysis any lens is the result of a series of steps from the calculation of the design to the manufacture of the mount. In this respect a Zeiss lens, a Voigtländer lens or a Sigma lens follow the same

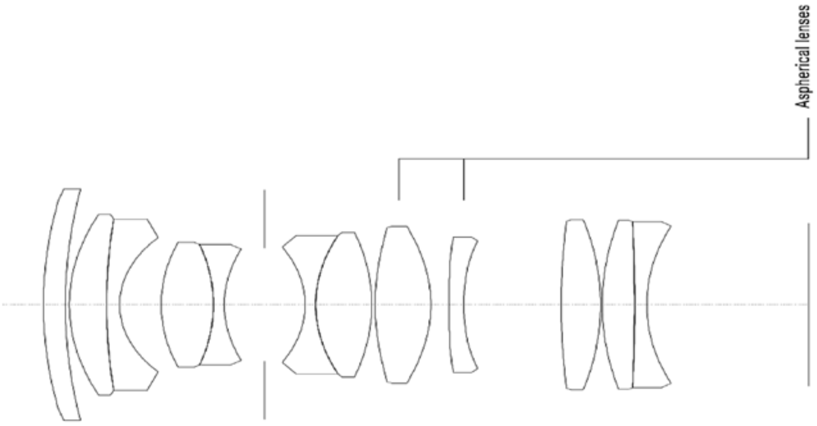
strategy from design to production. Between 1970 and 1980 there raged a battle among the top camera companies who could produce the most prestigious lens. The most important and influential reviewer of that period, Geoffrey Crawley, wrote that the prestigious four companies of that time (Canon, Leica, Nikon, Zeiss) had the same goal, but different opinions and methods to reach this goal of absolute image performance. He wrote a series of articles about Leica lens design in 1982, in connection with the then new Leica M4-P, and placed into perspective this aim of optical perfection. He commented that this goal must be related to the contemporary state of the art of optical design.
If one would only look at the measurable results that have been achieved during the last century, the progress is indeed impressive. A comparison between the Summar 1:2/50 mm left)and the Apo-Summicron-M 1:2/50 mm ASPH (right) leaves no doubt which lens has the better performance.
It is, by the way, amazing that there is a period of more than 80 years between both designs. This long period can be interpreted in two ways: the designer of the Summar did a great job or optical progress is a slow process. In reality both views are equally valid. The increased control of aberrations and the precision of manufacture are the decisive features.





This quantum leap in optical performance is clearly visible disregarding what criteria for image quality are applied. Every manufacturer, however, has its own definition of what ‘perfection’ means. The Zeiss Otus 1:1.4/55 mm approaches the ideal of perfection as Zeiss currently defines this goal. Some decades ago, the same goal might have been formulated differently. The Summilux-M 1.4/50 mm ASPH is Leica's statement of perfection for a very high-speed lens. A truly perfect lens does not exist and even when it might be constructed this design would not be suitable for photographic purposes. (A lens for lithographic purposes weights a ton, has an immense size and is only suitable for one specific wavelength).

This is the background for the remark by Berek when he was asked what were his motives for designing the Elmar 3.5/50 mm and not a higher speed lens. In his short answer he referred to the critical issue of focusing accuracy with such high-speed lenses. The Summar lens that was offered by Leitz some years later in an interchangeable mount gave improved image quality based on a six element design that differed substantially from the Hektor three-element construction. From then on there was a steady progress in the line of the Leica high speed lenses with aperture f/2. The current paradigm shift in lens design can be inferred from the lenses designed for the T, Q and SL lenses.



The incorporation of autofocus mechanisms in the optical system has changed the classical assumptions. The ideas within the Leica design department about the value of autofocus are clearly formulated: autofocus must be fast and accurate. Both requirements can be met when the moveable element is small and featherweight. A moveable element however is a big problem for the optical system. The design of an optical system usually prescribes a fixed distance between the lens elements.

A loose element would degrade the performance. For focus setting the whole optical system moves, disregarding for the moment the older front focus lenses.

When one lens element, somewhere inside the optical system, is used for (auto) focus movement, the optical calculation cannot cope with this movement, unless the optical design optimizes the group of lens elements before the autofocus element. When there are no aberrations left when the light energy is about to hit the autofocus element, this element can freely move because it will have no additional impact on the aberration content. This design automatically implies more lens elements and a bigger physical size for the whole system.

2.4. Spot diagrams of early Leica standard lenses

These topics are far removed from the world of optical constructions that Berek had to consider. A small point image was theoretically the best approach for high image quality. A geometrical point is an abstraction and in reality we can only consider sources of radiant energy. Such a source must have some physical extension because otherwise it would be impossible to emit some energy.

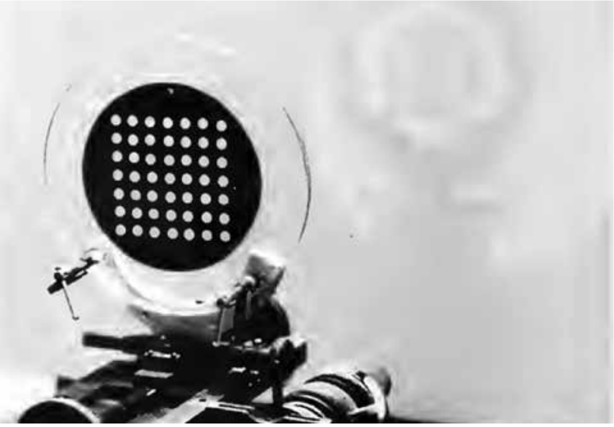
The task of technical optics consists of an effort to concentrate all this radiation into one point in image space. Because of diffraction and other defects, this radiation will be concentrated in a very small, but finite area. The distribution of the radiation in an image of the object point (with a very small area) is called the point spread function from which can be derived the well-known family of MTF graphs as a description of the performance of an optical system.

The flow of the radiation from on object point (in fact small object area) can be represented by a bundle of rays (straight lines) from this point. One can compute the paths of the rays of this bundle and make a graph to represent this image spot or one can use some laboratory equipment to produce the bundle of rays and the corresponding image spot.

In the laboratory, ingenious instruments had to be devised to test a lens when spot diagrams were used as a measure of optical performance.

Imagine an opaque plate with a number of small holes in it that is placed in front of the lens. Light from an object point is passed through the holes in the plate and will form an image on the focal plane.

See illustration below.



The illustration below shows a large amount of rays coming from two object points, one on the axis (O_1) and one off the axis (O_2). When the lens is perfect all rays from O_1 and O_2 will converge in point P_1 and P_2 and in this hypothetical situation all light energy from O_1 (and O_2) will be concentrated in P_1 (and P_2). In reality some light rays will be aberrated (ab errare = to go astray) and will end up somewhere in the small rectangle surrounding the points P_1 and P_2. The pattern of the distribution of the image points that are connected to one object point and intersect the focal plane is called a spot diagram.