From the series of articles on lens names:

Distagon, Biogon and Hologon

by

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Retrofocus lenses – and why they were invented

In this third part of our series of articles on ZEISS lens names, I would like to present three different lens types. All share the final syllable *"gon"* in their name, which indicates that the lens has a large field angle. This part of the name is derived from the Greek word *"gonia"* (γωνια) which means *"angle"* and was also used by many other manufacturers of wide-angle lenses. One of the earliest examples is the famous *"Hypergon"* with its 130° field angle, which the Berlin firm Goerz introduced to the market around 1900.

However, the three lens types **Distagon**, **Biogon** and **Hologon** also display major differences along with this common feature. Examining these differences is particularly helpful to understanding the particular lens properties. Thus it seemed appropriate to discuss them in the same article.

In photography, the term *"standard lens"* is usually understood to mean a lens with a focal length about as long as the diagonal of the image field. The 24x36 mm image format has a diagonal of 43.3 mm, APS-C format 28.4 mm, the analog medium format is between 70 and 90 mm with its different versions and the digital between 55 and 60 mm.

With a *wide-angle lens*, the focal length is significantly shorter than the diagonal of the picture format. If it is about the same as the long side of the format, the lens is considered to be a *moderate wide-angle* lens. *Super wide-angle* lenses are those with focal lengths between the length of the short side of the format and half the diagonal. Those with even shorter focal lengths are often referred to as *extreme wide-angle* lenses, though the delineation between "super" and "extreme" is fluid, of course, and to some extent a matter of taste.

A lens with a shorter focal length can be derived from an existing one by reducing all its dimensions accordingly. This is similar to the principle of model railroads. Thus many small and medium format lenses look very similar, differing just in size. Of course, with this *"scaling"* of optical designs, a reduction of the image circle and of the distance of the lenses from the image plane is achieved, which is not always desired. Thus a usable wide-angle lens is not automatically obtained, and if the focal length and image circle are reduced by the same factor, the field angle remains the same.

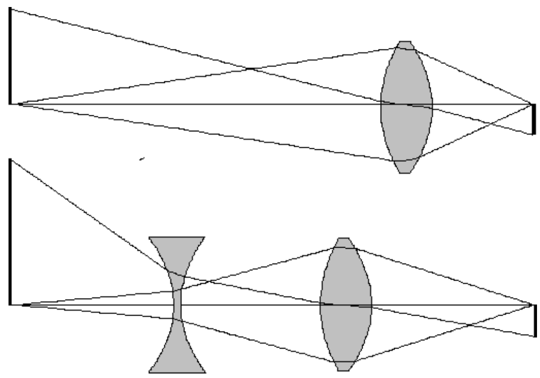
In fact, moderate wide-angle lenses have been made with the design structure of the conventional lens types like Tessar and Planar. However, if the field angle continues to be increased and good correction for the increasingly oblique incident rays of light is desired, these designs reach their limits. Wide-angle lenses have always required new ideas and are among the most difficult challenges in optics.

A particular problem of many cameras is that the ***distance of the last element*** in the camera lens from the image plane must not be less than a particular value, because some technical function still requires space between the lens and the image sensor. With an SLR camera that is the reflex mirror which redirects the image onto the focusing screen before the picture is taken. Also a beam splitting prism in cameras with three sensors for the primary colors or just the function for TTL light metering can require a large ***back focal length*** for the lens. In the 1930s, cine cameras often had a lens turret for changing the field angle quickly. This function also required that the lens was not extended too deeply into the camera.

In 1917, the *Technicolor* process for color motion pictures was introduced in the film industry. From 1932 on it was very successful, and in 1939 the film epic “Gone with the Wind” used it. The *Technicolor* camera used a splitter prism to produce first two, later three color partial images adjacent to one another on the strips of film. This prism required so much space between the lens and the film that the focal length of normally constructed lenses could not be shorter than 50 mm. Nonetheless, to film with this camera with larger field angle, despite these constraints, a new lens type was developed in those days, with a large negative element arranged in front of a standard lens.

In 1950, **Pierre Angénieux** in Paris and **Harry Zoellner** at Carl Zeiss Jena applied almost at the same time for a patent for the first lens for 35 mm reflex cameras based on this principle of the inverted telelens. The Jena lens was given the brand name **“Flektogon”**, and Angénieux named his lens **“Retrofocus”** to indicate that the focus was shifted backward.

This term originally introduced as a brand name ultimately became a generic name for all these lenses, known better today than the expression “inverted telelens”.

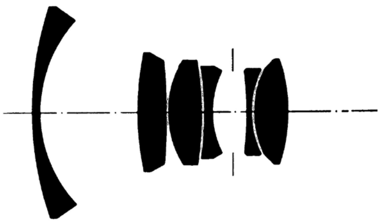


The principle of the inverted telelens, imaging of an object from left to right. A lens with negative refractive power in front of the positive refractive power of the base lens produces a greater field angle on the object side while increasing the back focal length, i.e. the distance of the last lens vertex from the image plane.

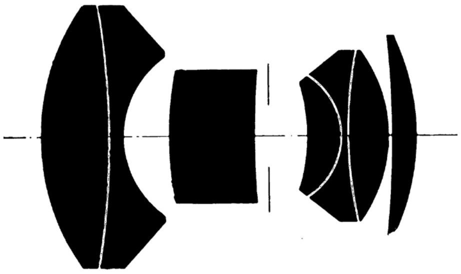
The diverging effect of this lens increases the field angle while slightly reducing the converging effect of the positive refractive power behind it, so that the rays do not intersect until a greater distance is reached. Thus the negative power front lens reduces the focal length and increases the back focal length. Because this arrangement of refractive powers is exactly the opposite of the telelens design principle, such a lens is also called an *inverted telelens*.

There were already certain predecessors of this at the beginning of the 20th century, where such negative elements were placed in front of projection lenses to produce large projected images in small rooms. Such front converters are still available today for permanently integrated lenses.

From the end of 1952, such wide-angle lenses were also developed at Carl Zeiss in Oberkochen, initially a 5,6/60mm for the Hasselblad 1000F. These have borne the brand name **“Distagon”** ever since, derived from “distance” and the previously mentioned Greek word for “angle”. Thus a Distagon is **a wide-angle lens with a large distance to the image.**

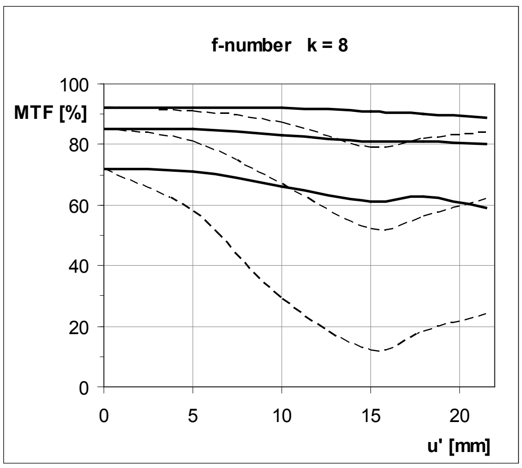


Lens cross-section of the first retrofocus lens from Carl Zeiss Oberkochen, the Distagon 5,6/60 for the Hasselblad 1000F (1954).



An improved version of the Distagon 5,6/60 from the year 1956. This optical calculation was "scaled" and produced as the Distagon 4/35 for the CONTAREX 35 mm camera starting in 1958. Since the spherical aberration increases as the fourth power of the aperture, for example, one can make the same lens design faster for smaller image formats.

The lens cross-sections show that these wide-angle lenses were not excessively complex in design with six or seven elements. And they were an example of modesty with respect to speed. Today, the thought of a maximum aperture of f/4 would provoke an amused smile, but at that time this was a wise limitation to ensure that the moderate wide-angle lenses offered more than just moderate quality.



Contrast transfer of the Distagon 4/35 at an aperture of f/8. In its day it was among the best of this focal length.

As simple as the basic idea of the retrofocus lens is, the calculation of the optics initially faced new challenges. This is because the strongly asymmetric design with respect to the distribution of the refractive power led to the occurrence of some aberrations to a far greater extent than with an approximately symmetrical lens, where the contributions from the front and back half of the lens compensate each other.

The problems which occur to a greater extent are primarily coma, distortion and lateral chromatic aberration. It was first necessary to learn how best to manage these aberrations. And because the early Distagon types were designed in the 1950s with little computer support, this set limits to the complexity of the optical designs.

Thus the advancement of the Distagon in the 1960s and 1970s was inextricably linked with the enhancement of the optical calculation which occurred at that time due to increasingly fast computers and improvements in programs, which gradually enabled automated optimization of a design. In Oberkochen, **Erhard Glatzel** was a primary force in the application of this new tool, which resulted in many excellent Distagon designs.

By the mid-1970s, this progress, supported by new optical glass types with properties not previously available, enabled such good, complex lenses such as a 3,5/15, 1,4/35 or 1,4/25 to be built for the 35 mm SLR.

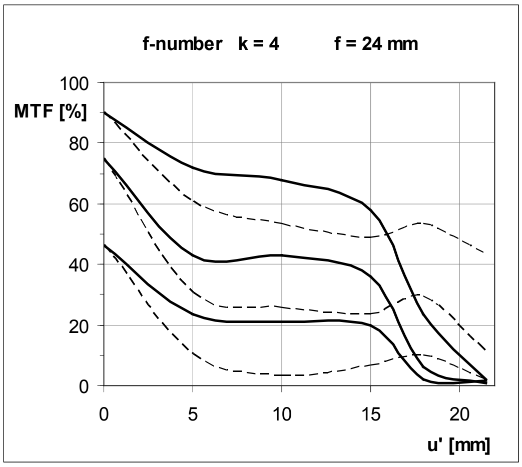
Today the Distagon type is one of the most important and best performing principles of design for our camera lenses, particularly if large field angles and a high maximum aperture are both required. Of course, the lens is then somewhat larger and more complex and thus also not cheap. But its good definition and image field illumination characteristics are worth the effort involved.

If the design conditions require extreme asymmetry such as in the 3-chip camera in the 2/3” format in which a color splitter prism with 48 mm length occupies the space between lens and sensors, Distagon designs have to be rather long compared to the focal length:

With the extreme wide-angle **DigiWide Distagon 1.7/3.9mm** (focal length is about one third of the format diagonal, i.e. corresponding to about 14 mm in the 35mm format), the overall length of the lens is about 60 times as large as the focal length.

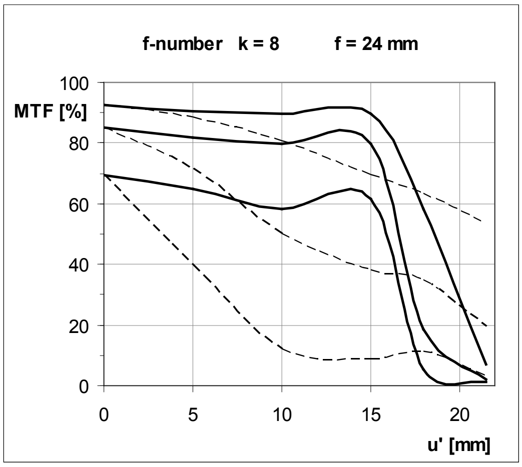
With this camera, a Distagon also isn’t necessarily a wide-angle lens: the **DigiPrime Distagon 1.5/70mm** has the field angle of a 280 mm lens for the 35 mm format, yet it is a retrofocus lens due to the large back focal length demanded by the prism and the telecentric design – but the topic of beam angle will be discussed later.

Modern high-performance lenses of the Distagon type can be quite complex; 12 to 16 elements are not uncommon. Our **Ultraprime Distagon 2.8/8mm** for 35 mm motion picture with a 130° field angle is constructed with 24 elements. A few examples can illustrate what a long road this was from the very beginning to this complexity:

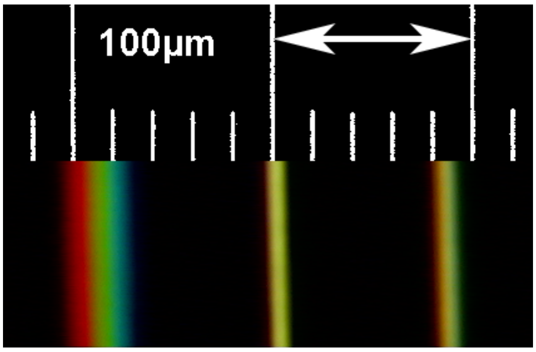


Contrast transfer of a retrofocus lens 4/24mm from the 1950s, here measured fully open. The curves nicely illustrate the typical difficulties to make a good wide-angle lens: only a small area in the middle shows good image quality, but already at 5 cm distance from the centre the contrast drops to values, which are typical for very fast lenses in the old days. Edge and corners are overall very poor.

Since a wide-angle lens often shows a wealth of details rather small in an image, the natural tendency is for the eye to have rather high expectations for the image quality of the lens. At the very least, this lens would have to be stopped down enough to increase its performance:



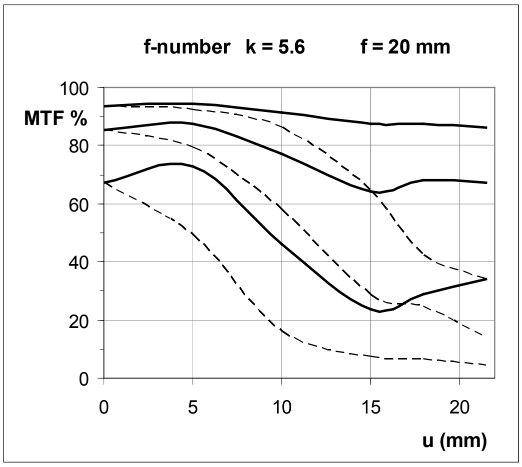
4/24 mm at an aperture of f8; the contrast and sharpness are relatively good for sagittal structures up to 15 mm image height but then still drop abruptly. The well-corrected image circle is actually too small, edge and corners remain to look poor. Most of all, however, it is evident that the dashed curves for tangential structures fall sharply in the middle from high values. The cause of this is the large lateral chromatic aberration.



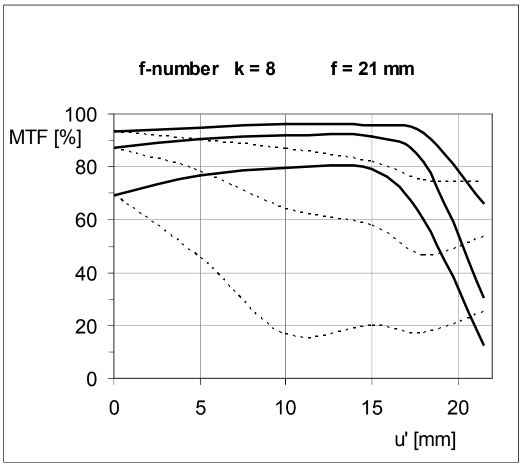
Microscope photographs of the tangential line image of three camera lenses at 10 mm image height and f/8 aperture, from left to right:
the 4/24 above, the Distagon T 2,8/21 for the Contax and the Biogon T* 2,8/21 ZM.*

With the 24 mm lens from the 1950s, the tangential line image is 30 to 40 µm wide, i.e. somewhat more than the circle of confusion (CoC) limit for low enlargements. Thus particularly well-defined images could not be expected from this lens, and at edges with great differences in brightness it showed color fringes. The two line images to the right of that are examples of perfect image definition, which are achieved by particularly high glass complexity in case of the **Distagon T* 2,8/21**, while the **Biogon T* 2,8/21** relies on its symmetric design.

However, these two 21s are really exceptional lenses. The following performance curves are typical of the majority of the retrofocus super wide-angles for SLR cameras, clearly illustrating the efforts required to solve the problems of asymmetry:



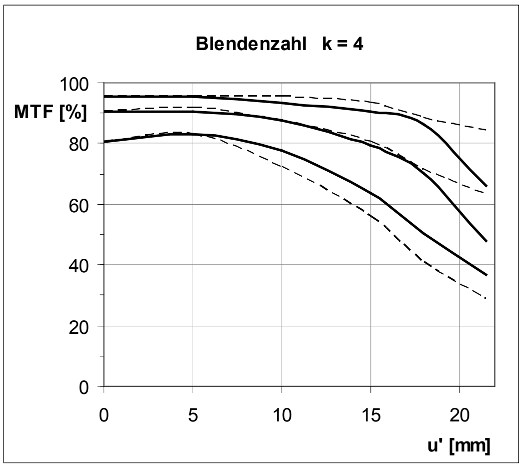
*MTF curves of the **Flektogon 2,8/20** from Carl Zeiss Jena at aperture f/5.6*



MTF curves of an otherwise excellent 4/21 which also shows the low tangential values toward the edge of the image due to lateral chromatic aberration.

In 1992, **Karl-Heinz Schuster** at Carl Zeiss developed the **Distagon T* 2,8/21** for the Contax/Yashica system, a retrofocus superwide-angle lens which was at least as good as the best symmetric types with respect to image sharpness. The 2.8/21 even had a related lens, the **PC Apodistagon 3,5/25**, with a larger image circle, which unfortunately was never produced in series due to its high manufacturing costs.

Lens cross-section of the Distagon 2.8/21 for the Contax SLR, a relatively complex lens with 15 elements in 13 groups. However, it had no aspherical surfaces. Its performance, particularly the perfect correction of lateral chromatic aberration, was achieved solely by the combination of very special (and expensive) high-index glass types with glass types displaying extremely high anomalous partial dispersion.



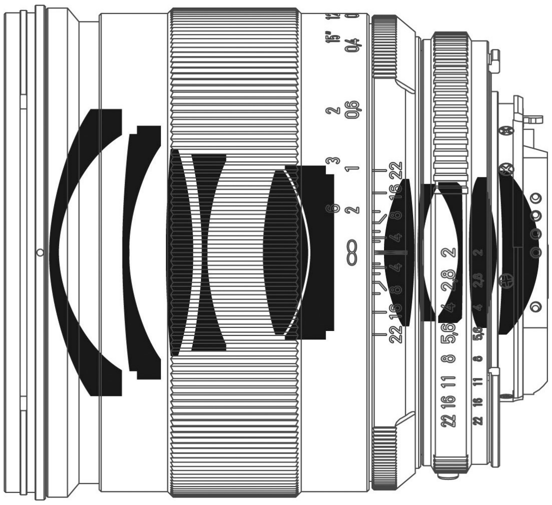
Already at aperture f/4, the Distagon T 2,8/21 achieved superb image quality; thus it is no wonder that its price on the pre-owned market often exceeded the original price after it was no longer produced.*

The **Distagon T* 2/25 ZE** or **ZF.2** is a **new** wide-angle lens for SLR cameras which also offers excellent overall performance. To achieve compactness despite the higher maximum aperture, the design of this lens is not quite so complex, consisting of 11 elements in 10 groups. However, these also include three elements made of glass types with a high anomalous partial dispersion, achieving chromatic correction which is not quite as good as with the legendary 2.8/21, but which produces almost no visible color fringes in most cases.

What is **"partial dispersion"**? This mysterious-sounding technical term is appearing with increasing frequency in brochures. If, for example, a negative and positive lens are combined to correct chromatic aberration, then the element with the lower refractive power must have the higher dispersion so that the color dispersing effects of both lenses compensate for each other without also canceling the refractive powers of both elements.

But Nature works in such a way that the refractive index of glass does not change uniformly with wavelength, but the variation becomes greater and greater at shorter wavelengths. Thus the graph of these dispersions over wavelength is not linear; it is curved. Normally, the dispersion curves for glass types of higher dispersion show greater curvature. This is why the compensation of the color dispersion effects described above does not work perfectly. A small chromatic aberration remains because the curvatures do not match.

Glass types with anomalous partial dispersion deviate from the normal relationship between dispersion and the curvature of the dispersion curve. For them, the ratio of the change in refractive index between blue and green to the change between green and red differs from that of normal glass, allowing better chromatic correction with these glass types.



Optical design of the new Distagon T 2/25 ZF.2*

The next to the last element of the lens has two aspherical surfaces. These contribute to better correction of the spherical aberrations and coma caused by the higher maximum aperture, and they have a favorable influence on distortion. Thus the 2/25 no longer displays the wavy distortion sometimes criticized in the 2.8/21.

In focusing, the front and back part of the lens are moved differently (using floating elements) to maintain high image quality even at close range.

In particular, it is a general characteristic of asymmetric lenses that they are more sensitive to changes in scale if no particular countermeasures are taken. The older Distagon T* 2,8/25 focuses by means of an overall movement without variable air spaces, and therefore it cannot be seen in any way as a macro lens despite its very near short focus.

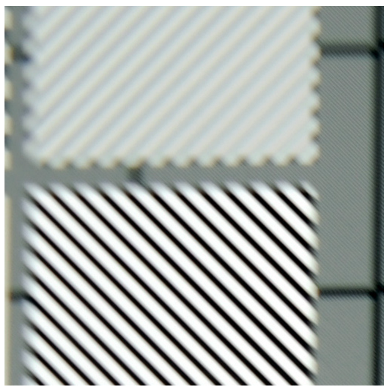


Image corner (500 x 500 pixels from 24 MP) with the Distagon T 2,8/25 at a distance of 25 cm, stopped to aperture f/8.*

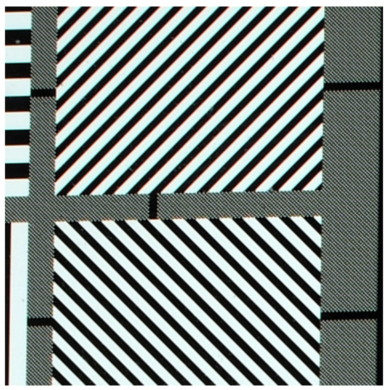
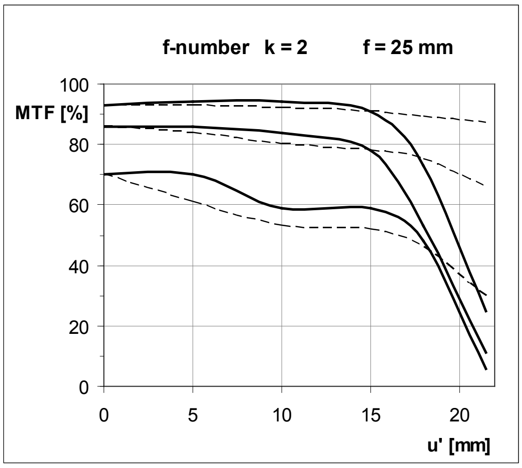
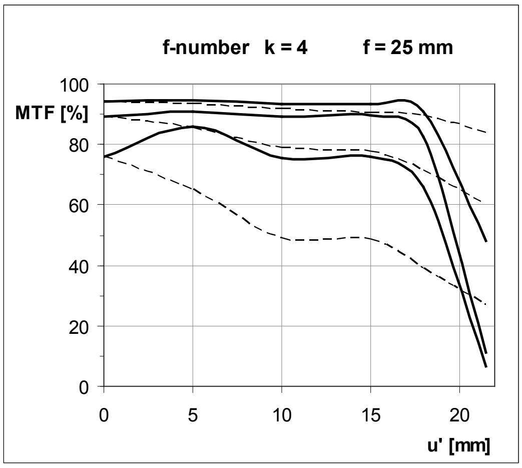


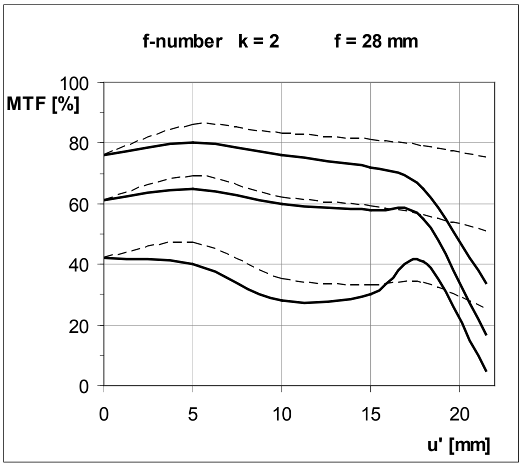
Image corner (500 x 500 pixels from 24 MP) with the new Distagon T 2/25 at a distance of 25 cm, stopped to aperture f/8.*



MTF data for a Distagon T 2/25 ZF.2 at full aperture. A large part of the image area displays high, uniform quality, a brilliant picture with excellent reproduction of details. Stopping down is only necessary if the outer edges are important or greater depth of focus is desired.*



The Distagon T 2/25, stopped down slightly.*



Comparison with the Distagon T 2/28 for the Contax from 1974 shows the improvement achieved.*

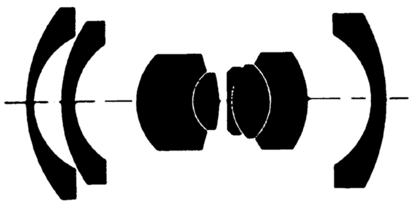
The other approach to outstanding picture quality: symmetrical wide-angle lenses

If the design of the camera permits elements of the lens to be placed also fairly close to the image, i.e. if a short back focal length is possible, then image quality equaling the best Distagon lenses can also be achieved at much lower effort by constructing an approximately symmetrical lens.

In **1946** the first patent for a new kind of symmetrical wide-angle lens was applied for by the Russian lens designer **Michail Roossinov**. It looked as if two retrofocus lenses had been combined with the rear elements together and thus had a symmetrical arrangement of positive refractive powers close to the aperture, surrounded at the front and back by strongly negative menisci.

As of **1951**, **Ludwig Bertele** carried this idea further and designed the legendary **Biogon** on behalf of Zeiss. At that time, it always had a maximum aperture of 4.5 and was built with various focal lengths for a series of image formats: 21 mm for the 35 mm format, 38 mm for the 6x6 medium format, 45 mm for the 6x7 format, 53 mm for 6x9 and 75 mm for the 9x12 large format. There was also a 2.8/38 test prototype for the medium format and a Biogon 5.6/60 for photogrammetry, which was developed for NASA.

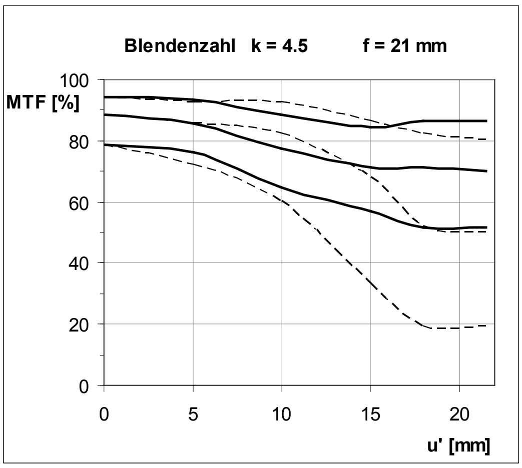
The cameras used with these lenses were rangefinder cameras such as the Contax from Zeiss Ikon or special housings in the system such as the Hasselblad Superwide or flat-bed cameras or special technical cameras.



Optical design of the Biogon lens f/4.5

The name **"Biogon"** was used for the first time in 1936 for a 2.8/35 mm lens for the Contax rangefinder camera, also designed by Ludwig Bertele. Its name also includes the final syllable "gon", referring to the angle. Of course, the syllable "bio" had a different meaning than today, which is often associated with foodstuffs in Germany and elsewhere. At that time it was often used to express the possibility of very dynamic photography and referred to quite different technical properties of the lens. We are already familiar with the **"Biotar"**, with a high speed which made dynamic photography possible.
A super wide-angle lens with a 90° field angle makes one think more of a camera which captures the subject with a perspective which, with appropriately high final magnification, gives the viewer the impression of being in the middle of the action.

The image quality of the Biogon was sensational in the 1950s, and its combination of a large field angle and nonetheless perfect definition up to the corners led to a real boom in wide-angle photography. Even today, these lenses offer credible performance:



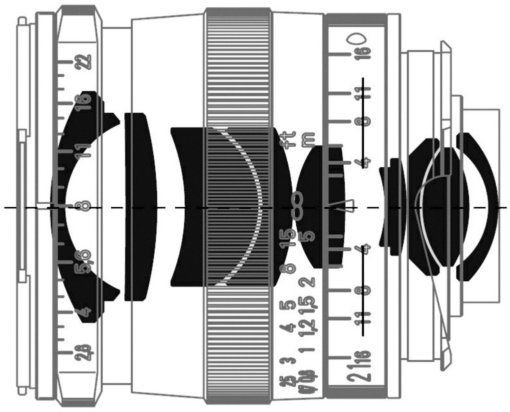
MTF curves of a Biogon 4,5/21 from 1956, measured at full aperture.

In addition to excellent contrast and definition properties, these lenses also offered perfect image geometry with almost no distortion. For the Biogon 4.5/21, the maximum radial deviation was 40 µm. That is less than 0.1%, i.e. nothing compared to the 2 to 4% typical of retrofocus lenses with the same field angle.

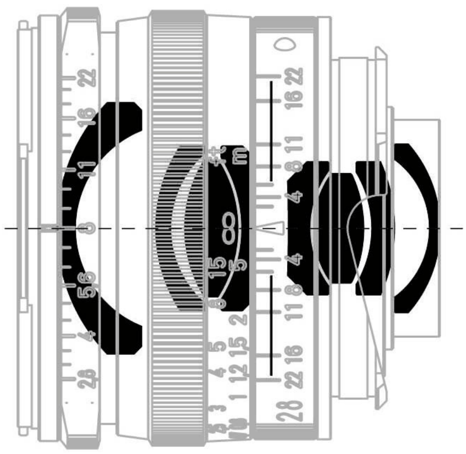
Thus it is understandable that these lenses also continued to be used for a time in SLR cameras with a flipped-up mirror and attachable viewfinder. Convenience was deliberately sacrificed in the interest of image quality, because composing an image on the viewing screen is of course simpler and better than with a conventional viewfinder.

This comparison of a Distagon 2,8/25 (right) with a Biogon 4,5/21 (left), both mounted for the Contarex from Zeiss Ikon, demonstrates once again the great differences in the two designs. The Biogon is nearly as long, but disappears for the most part into the camera; this of course brings its mirror to rest.

The new Biogon lenses designed in recent times have a somewhat larger back focal length to facilitate exposure metering through the lens with modern cameras as well. A lens mount extending to directly in front of the focal plane shutter could conceal the measurement cells to be used to meter the exposure from the light reflected by the shutter. Whereas the back focal length of the Biogon 4.5/21 was only 9 mm, in the Biogon 21 for the Contax G it increased to 12 mm. In all ZM series lenses, the shortest back focal length is 15 mm. For this reason, the distortion is also slightly greater, but still almost indiscernible. One might say that a few Distagon "genes" have been incorporated in today's Biogon lenses. Ultimately, this slightly blurs the distinction between the two types. The even shorter focal lengths of the ZM series are thus called "Distagon", but nonetheless there are enormous differences between a Distagon for the SLR camera and one for a rangefinder camera. This is because the 35 mm SLR requires a back focal length of at least 38 to 40 mm to move the mirror. With a moderate wide-angle lens (35 mm for small image, 24 mm for APS), the back focal length is thus about the same as the focal length and clearly requires a design of the Distagon type.



Optical construction of the Biogon T 2,8/21 ZM; compared to the original Biogon designs, it has a back focal length increased to 15 mm for TTL exposure metering.*



Biogon T 2,8/28 ZM; the simpler it is to meet the back focal length requirement, the greater the similarity of the design to the classic Biogon.*

Wide-angle lenses and digital sensors

Even if the camera has no mirror or other "obstacles" in the image space, the design of a wide-angle lens can have great importance, particularly when the camera has a digital sensor – which it nearly always does today. This is attributable to a property of lenses that can be recognized from the exterior appearance of the lens without any knowledge of its internal design:

***Entrance** pupils of the Biogon T* 2,8/21 ZM and Distagon T* 2,8/21 ZE. The virtual images of the aperture seen **from the front** appear the same size to us, because the focal length and f-stop are the same. The f-stop is the ratio of the focal length to the entrance pupil diameter.*

***Exit** pupil of the Biogon T* 2,8/21 ZM and Distagon T* 2,8/21 ZE. The virtual images of the aperture seen **from behind** are of various sizes. Since the f-stop is also the ratio of the exit pupil diameter to its distance from the image plane, this figure shows that the exit pupil of the Distagon is farther away.*

Incidentally, the entrance pupil is the projection center of the lens for central perspective imaging. For panorama photographs, one must swivel around the entrance pupil if the position of foreground details with respect to the background is to be the same in adjacent pictures. Thus this point can be seen rather simply. By the way, in some lenses it is either in or even behind the image plane, but not in those discussed in this article.

The position of the pupils relative to the principal planes from which the focal length is to be measured can also be identified by their size ratio:

With symmetric lenses, the entrance and exit pupils are the same size; this is the case for the old Biogon lenses as well as the Planar types for the rangefinder camera. The Biogon types slightly modified for TTL metering display slight asymmetry of the pupil ratio (for example, entrance pupil to exit pupil = 7.7 / 10.3 mm for the Biogon 2.8/21 ZM, 9.9 / 10.9 mm for the Biogon 2.8/28 ZM). This is also the case for Planar lenses for the SLR camera, which also tend slightly toward Distagon characteristics, because the refractive powers in the front part of the Gaussian type lens are somewhat smaller to achieve a sufficiently large back focal length.

If the entrance pupil is significantly smaller than the exit pupil, then you have a Distagon-type lens. (For example, entrance pupil to exit pupil = 7.5 / 22.6 mm for the Distagon T* 2,8/21, 17.6 / 35 for the Distagon T* 2/35.) For the telelenses with a shortened back focal length, such as a **Sonnar**, it is exactly the reverse.

The exit pupil is the area from which all rays of light headed for an image point appear to come. If it is far removed from the image, then rays toward the edge or corner of the image have a lower angle of inclination with respect to the image plane. Lenses in which this angle is made as small as possible are referred to as **"telecentric"**, because the exit pupil is very far removed from the image.

However, telecentric lenses require very large bayonet diameters, so the mechanical dimensions of the camera set limits.

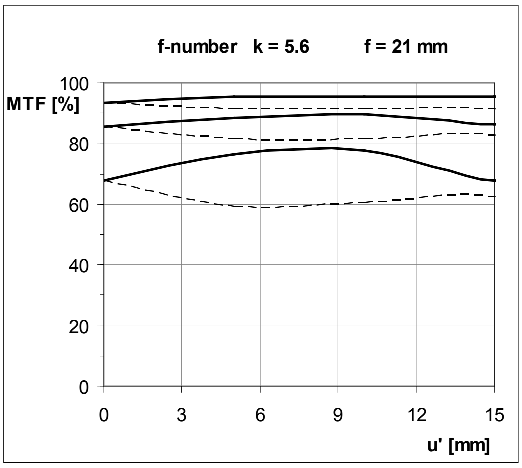
It is also not at all the case that all rays of light strike the image plane perpendicularly in telecentric lenses. In all lenses, the aperture angle of the ray cone depends only on the f-stop and is identical at the same aperture – regardless of where the exit pupil lies. With telecentric lenses, the angles change less in the image field only.

But in any case, symmetrical wide-angle lenses are exactly the opposite of telecentric ones, because their exit pupil is close to the image. That has three important consequences:

1)
The greater beam tilt at the edge causes a greater natural fall-off of light as per the $\cos^4$ law in which the change in distance between the pupil and image from the middle to the edge and the photometric effect of the oblique projection is expressed. Usually these lenses only have a little artificial vignetting from the edges of the mount, and the uniformity of the brightness distribution in the image changes little with changes of the f-stop.
The situation is different for Distagon types; in that case the artificial vignetting is dominating at full aperture, and as it disappears when stopping down, the image brightness becomes much more uniform. When stopped down, the Distagon has brighter corners.

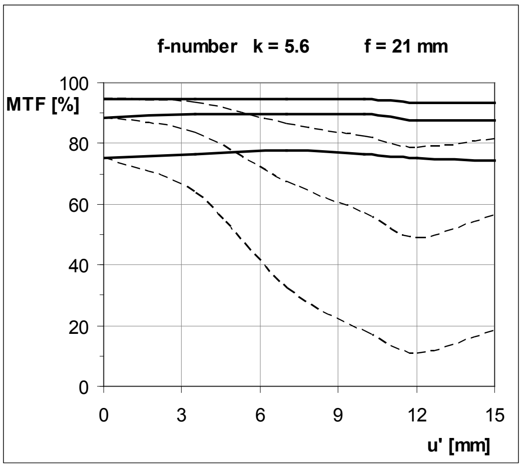
2)
Digital sensors do not respond very well to very oblique incident rays of light. At the very least, they become more inefficient or require compensatory measures such as a suitable shift of the light-gathering microlenses relative to the pixel grid. That was not necessary with film, as it was essentially independent of direction.

3)
Lenses with a very large beam tilt react in a much more sensitive manner to a change of refractive index in the image space caused by filter plates in front of the sensor (such as low pass and IR-blocking filters). If the filter plate is not considered in the design of the lens, the edge definition will suffer. The effect of the additional path through the glass grows exponentially with the beam inclination. A Distagon which never achieves more than 20° beam tilt in the corner of the image reacts more tolerantly than a symmetrical wide-angle lens, which might reach a 45° tilt. This is why filters in digital Leicas are very thin – to remain compatible with older optics.



MTF curves of a Biogon T 2,8/21 ZM, shown in the APS-C format – ideal quality and uniformity up to the corners. But unfortunately these curves apply only to the thin Leica filters, and not for all cameras to which this lens can be attached.*

If the filter is significantly thicker, the contrast transfer for the image edge becomes worse for tangential structures. In the graph of the curves, this looks like the old retrofocus lenses but is caused by astigmatism rather than lateral chromatic aberration. The focus is shifted to greater distances for tangential structures by the additional path through the glass. If the best edge definition is to be achieved, then all that can be done is to stop down further.



MTF curves of the same lens as above, but with a thicker filter in front of the digital sensor.

The two types of wide-angle lenses discussed in this article thus each have very specific advantages and disadvantages:

Advantages of nearly symmetrical wide-angle lenses:

- *Small size and low weight*
- *Very good, uniform definition despite moderately high effort required*
- *Usually excellent freedom from ghost images*

Disadvantages of nearly symmetrical wide-angle lenses:

- *Cannot be used with every camera*
- *Require specially matched digital sensors*
- *More sensitive to the change of optical parameters in the image space*
- *Greater natural fall-off of brightness toward the edge of the image*

Size comparison of nearly symmetrical and retrofocus wide-angle lenses with the same focal length and maximum aperture.

Advantages of asymmetric wide-angle lenses:

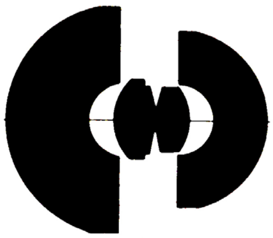
- *Usable for all cameras in principle*
- *Favorable characteristics for digital sensors*
- *Very uniform image field illumination at medium apertures*
- *High maximum apertures possible*

A legend among camera objectives

The importance of the beam inclination angle described above is the reason why a comeback of some great legendary objectives is hardly imaginable. The **Hologon** from **1966** was an extreme wide-angle lens with a 110° diagonal field angle, which was popular for its high definition up to the corners of the image and its complete absence of distortion. Thus it's no surprise that we are asked time and again when it will be reintroduced. Unfortunately, we must disappoint its fans, because a beam inclination of about 55° in the corner of the image is not compatible with digital sensors, at least not today.

The name of the lens is derived in part from the Greek word “*holos*”, meaning “everything” or “complete”. It was built from just three elements, two highly curved, very thick negative meniscus lenses on the outside and a positive lens in the middle. One might describe it as an inverse triplet.

However, the simple appearance of its design does not mean that it was easy to make. The precision requirements for the shape of the lenses and their centering are extremely high. Because of the difficulties of production, the Hologon 16 mm for the Contax G, which came later, had five lenses, a technical “trick” to simplify manufacturing, with the cemented elements made of the same types of glass.



Optical design of the Hologon 8/15 mm for the 35 mm format. Its back focal length was only 4.5 mm.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Some members of the family of wide-angle lenses:

1. Distagon T* 2,8/15 ZM	for 35mm rangefinder camera
2. Distagon 3,5/15	for CONTAX 35mm-SLR
3. Distagon 2,8/25	for Contarex 35mm-SLR
4. Distagon 5,6/60	for Hasselblad 1000 F 2¼ x 2¼ ”
5. Distagon 4/50	for Hasselblad 500 C 2¼ x 2¼ ”
6. F-Distagon 3,5/30	Fisheye-lens for Hasselblad V-System
7. Distagon 4/40 IF	for Hasselblad V-System 2¼ x 2¼ ”
8. Distagon 4/40	for Hasselblad 500 C 2¼ x 2¼ ”
9. F-Distagon 3,5/24	Fisheye with circular image for Hasselblad
10. Distagon 2,8/21	for CONTAX 35mm-SLR
11. Distagon T* 2,8/21 ZE	for Canon EF-mount
12. Distagon T* 1,4/35 ZF.2	for Nikon F-mount
13. PC-Distagon 2,8/35	Shift-lens, automatic diaphragm (CONTAX)
14. PC-Distagon 4/18	Shift-lens for 35mm motion picture camera
15. Hologon 8/16	for CONTAX-G electronic rangefinder camera
16. Biogon 4,5/21	for Contarex 35mm-SLR
17. Biogon 2,8/21	for CONTAX-G electronic rangefinder camera
18. Biogon T* 2,8/21 ZM	for 35mm rangefinder camera
19. Biogon 4,5/38	on Hasselblad Superwide 2¼ x 2¼ ”
20. Biogon 4,5/38	in NASA-version for space photography
21. Biogon 2,8/38	Prototype of 38mm Biogon with higher speed
22. S-Biogon 5,6/40	for close distance copy applications
23. Biogon 4,5/76	9-lens version for 114x114 mm aerial photo
24. Hologon 8/110	for large format 13x18 cm
25. Distagon 12/T1.3	for 35mm motion picture camera, PL-mount
26. Distagon 8/T1.3	for 16mm motion picture camera, PL-mount
27. Distagon 2/10	for 35mm motion picture camera, PL-mount
28. Distagon 2.8/8R	for 35mm motion picture camera, 130° field
29. Distagon 1.7/3.9	for 2/3“ 3-chip camera
30. Distagon 1.5/70	for 2/3“ 3-chip camera (not a wide-angle!)
31. P-Distagon 3,5/75	Projection lens for 2¼ x 2¼ ”