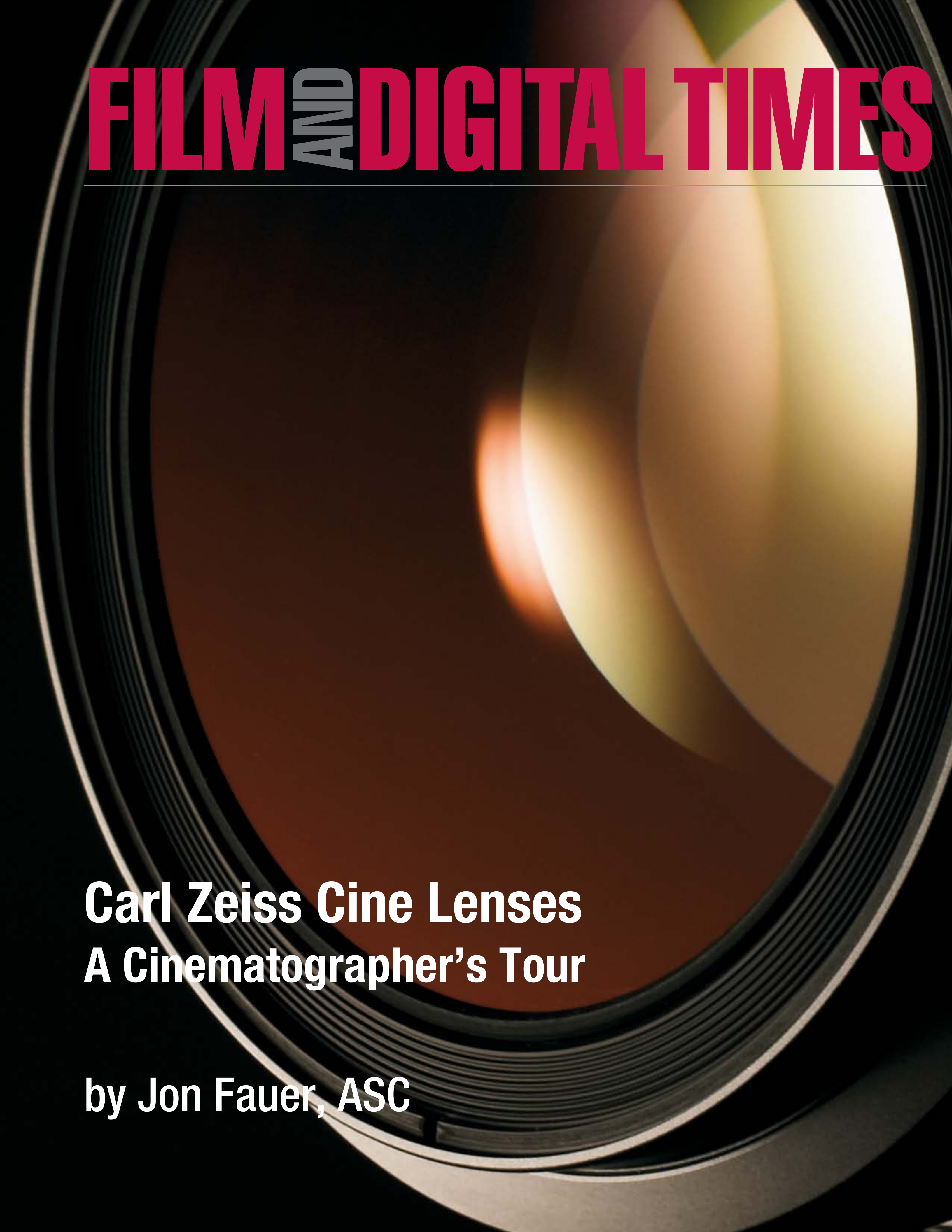
FILM AND DIGITAL TIMES



Carl Zeiss Cine Lenses
A Cinematographer's Tour

by Jon Fauer, ASC

Lenses

Dr. Winfried Scherle (below, left) is the Senior Vice President and General Manager of the Carl Zeiss Camera Lens Division. Coincidentally, his passion is photography, and he happens to be very good at it. I have a suspicion that what he really wanted to be was a National Geographic photographer.

I can only imagine what his colleagues at ZEISS thought when he announced, just weeks before the introduction of a new line of lenses (that we will learn about on the next pages), that he was heading off to Mt. Everest to do a little bit of climbing. Did they have insurance for this kind of thing? There's a famous story about John Huston heading off into the Congo while production was prepping *The African Queen*. Sam Spiegel, the producer, sent daily telegrams to Guy Hamilton, the Assistant Director. The telegrams asked, "Have you found locations yet? Stop." To which the unflappable Guy Hamilton replied, "No. Have not found locations yet. Stop. Have not even found Mr. Huston yet. Stop."

We are happy to report that Dr. Scherle has safely returned, and will be presenting the new ZEISS lenses at NAB.

The photos on this page were taken with his Sony Alpha 700 digital camera, using (what else?) a ZEISS Vario Sonnar and Sonnar 135/1.9. He writes, "These optics were not used in our new Compact Prime lenses, but of course are designed according our philosophy."

Foreword

by Dr. Winfried Scherle,

Senior Vice President and General Manager of the Carl Zeiss AG Camera Lens Division

If a "normal" person, perhaps a journalist or businessman, were to write about Carl Zeiss, a tour of the company would take them to offices and factories around the world, staffed by over 20,000 employees. On the other hand, a cinematographer, photographer or camera crew, in search of the origins of the ZEISS lenses they use, would visit our factories in two cities in Germany: Jena and Oberkochen.

Carl Zeiss AG is divided into Medical and Research Solutions, Industrial Solutions, and Lifestyle Products. Although we know that making movies is very difficult and demanding work, Cine Lenses are part of Lifestyle.

It is widely known that ZEISS produces millions of lenses for still cameras, binoculars, telescopes, cell phones and eyeglasses. But, it is not as widely known that 60% of all microchips are made using Carl Zeiss SMT (Semiconductor Metrology Technology) lenses. Our latest, high-tech plant in Oberkochen makes massive lenses that are used to etch microchips. The lenses focus a laser beam with a resolution greater than 5000 line pairs per mm (more than 20 times better than the best lenses we use in film or digital.) Some of what we learned from this science of nano lens technology went into the design and manufacture of our modern cine lenses: coating, aspherical polishing, assembly and rapid delivery.

Carl Zeiss SMT is a leading supplier, serving the global nano manufacturing and test equipment markets. We are dedicated to technical excellence—sustaining and facilitating growth in nano technologies.

Our leading-edge optical and e-beam expertise, based on core competencies, are key to our customers' success. Carl Zeiss SMT and its four strategic business units (Lithography Optics, Laser Optics, Nano Technology Systems and Semiconductor Metrology Systems) focus their operations on two main markets: Lithography Imaging Solutions and Process Control Solutions.

In 2008 more than 50 Million consumer and prosumer cameras were manufactured with ZEISS lenses: that's two cameras every second. These cameras included Sony, Nokia cellphones and Logitech. ZEISS makes SLR still lenses for Nikon, Canon and Hasselblad, and rangefinder lenses for M mount cameras (e.g. for ZEISS Ikon).

The ZEISS Cine Lens Division makes PL mount Master Prime, Master Zoom, Lightweight Zoom, Ultra Prime, Compact Prime, B4 DigiPrime and DigiZoom lenses.

Please join Jon Fauer as he takes us on a cinematographer's tour of our company. We hope you enjoy the journey.

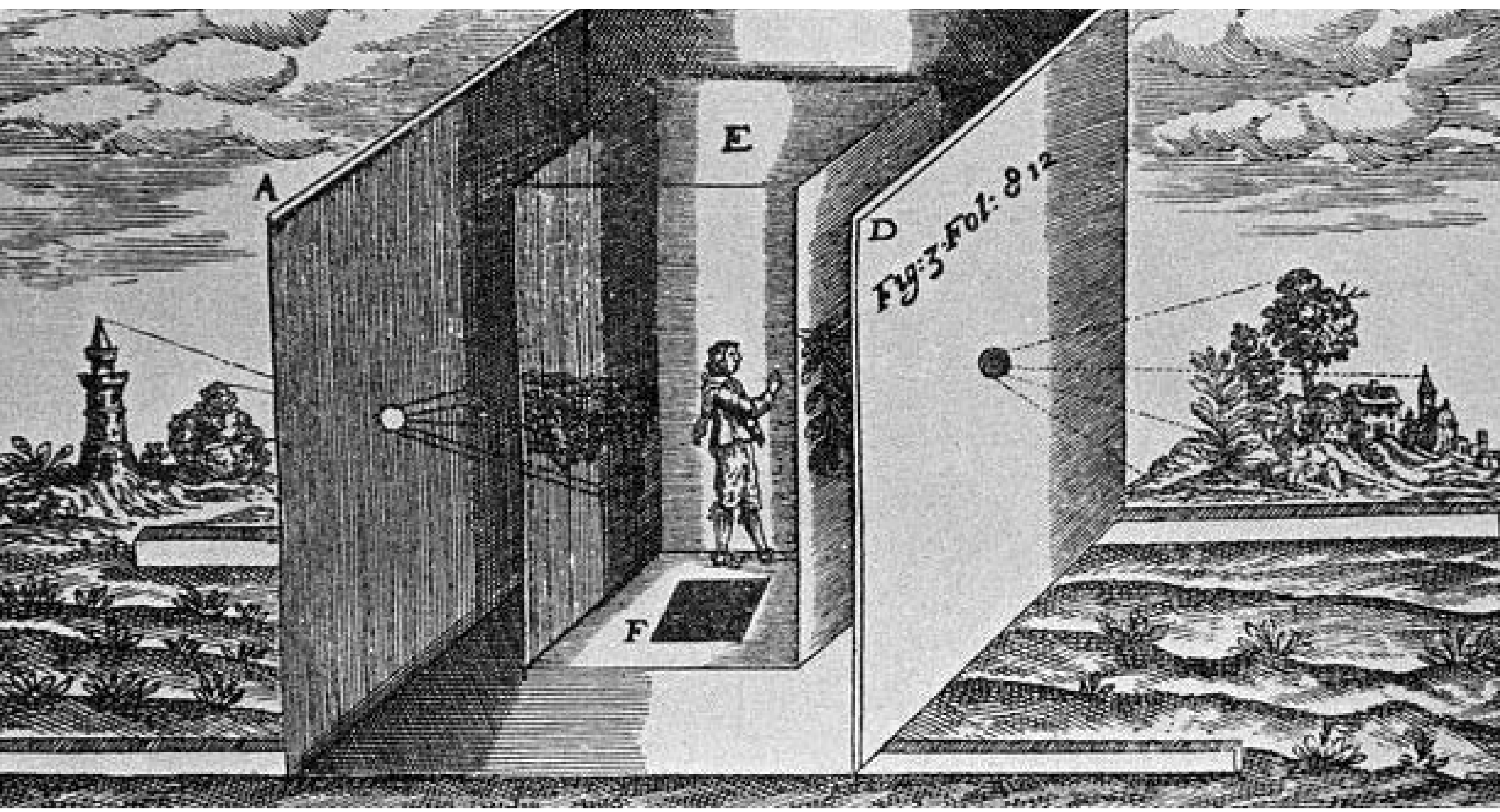
Cine and photographic lenses are improvements on the Camera Obscura and pinhole camera, but the theory is similar: light from the real world is focused onto a surface inside a light-tight box.

Not coincidentally, “camera” comes from Latin, meaning “chamber.”

Opposite, top: Prestwich 35mm Cinematographic Camera, J. A. Prestwich, Tottenham

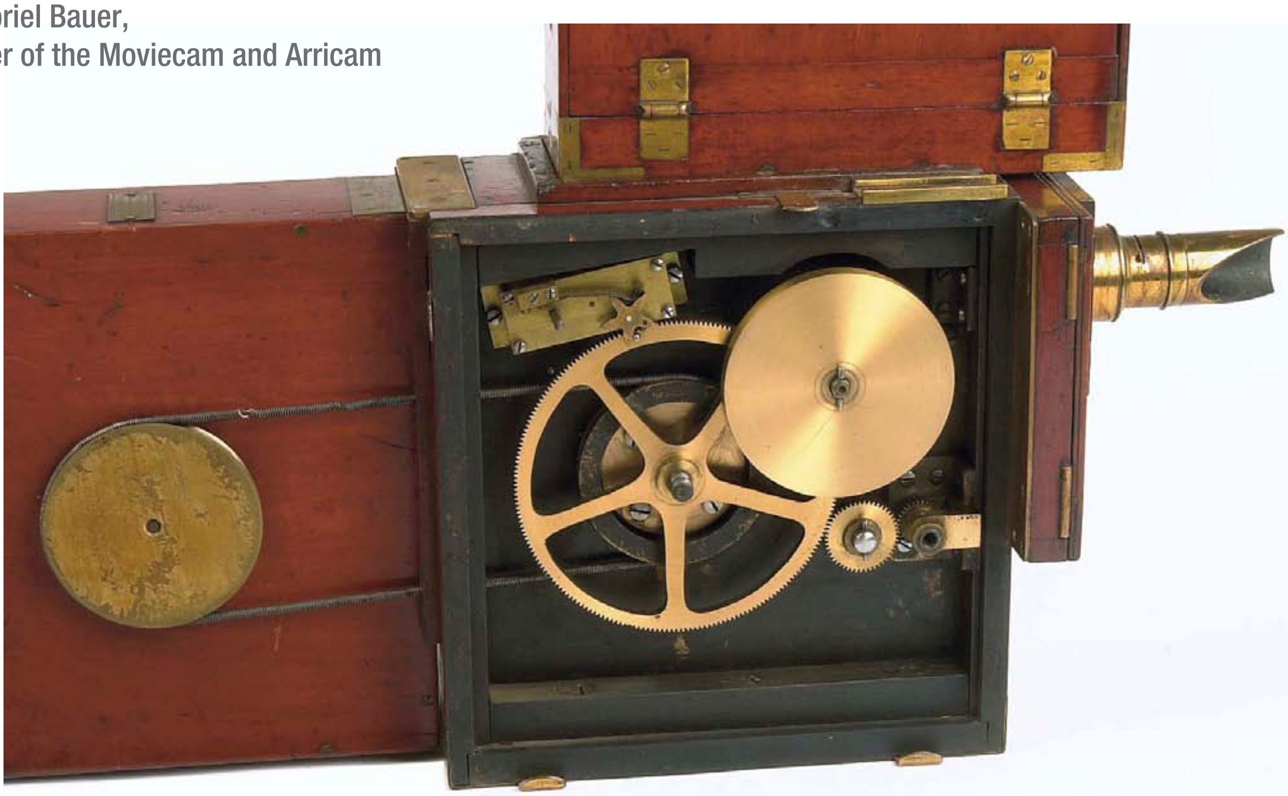
Opposite, bottom: Arricam body and inner mechanism

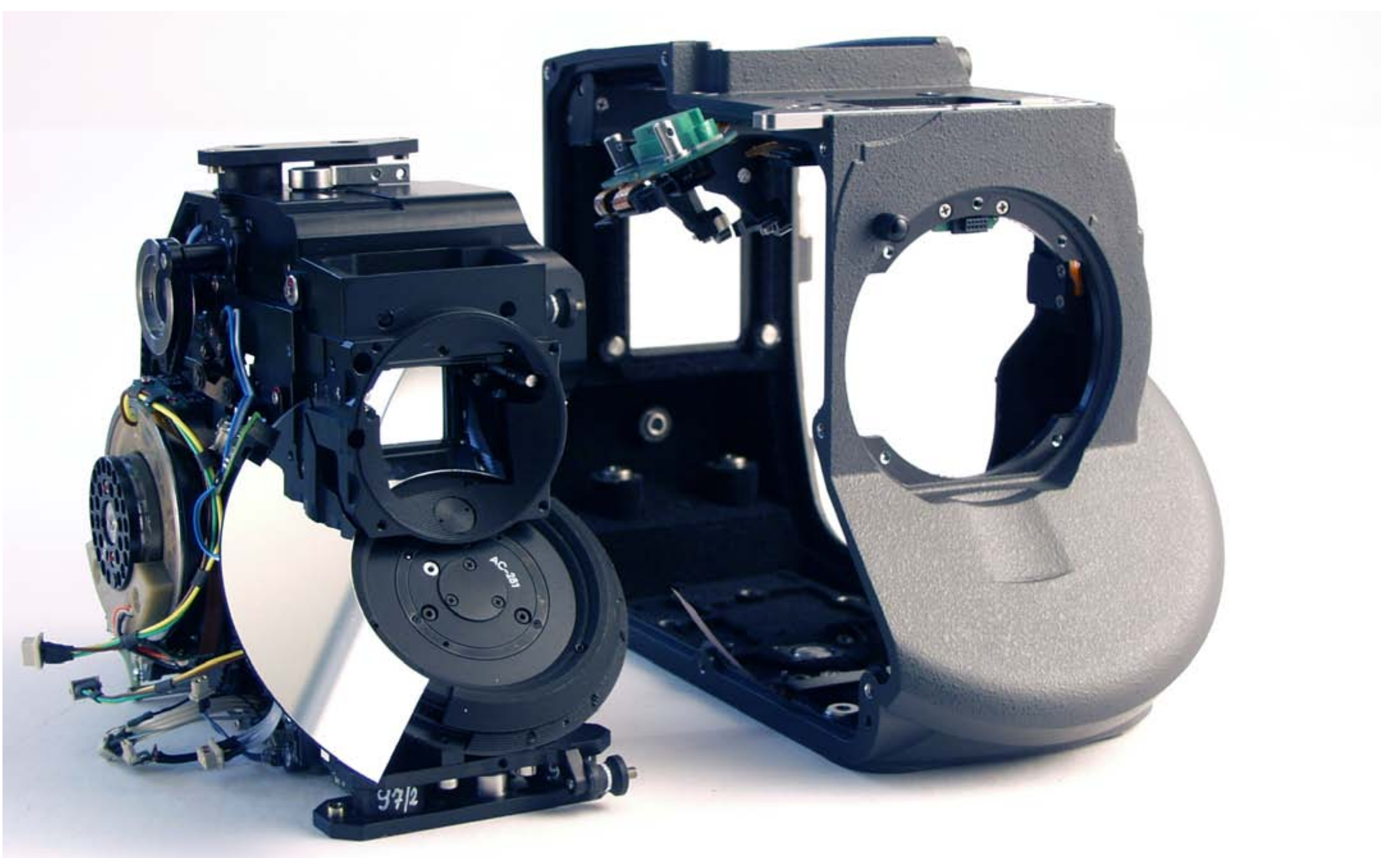
Below: Illustration from “Ars Magna Lucis Et Umbra” (Great Art of Light and Shadow), written in 1646 by Athanasius Kircher.

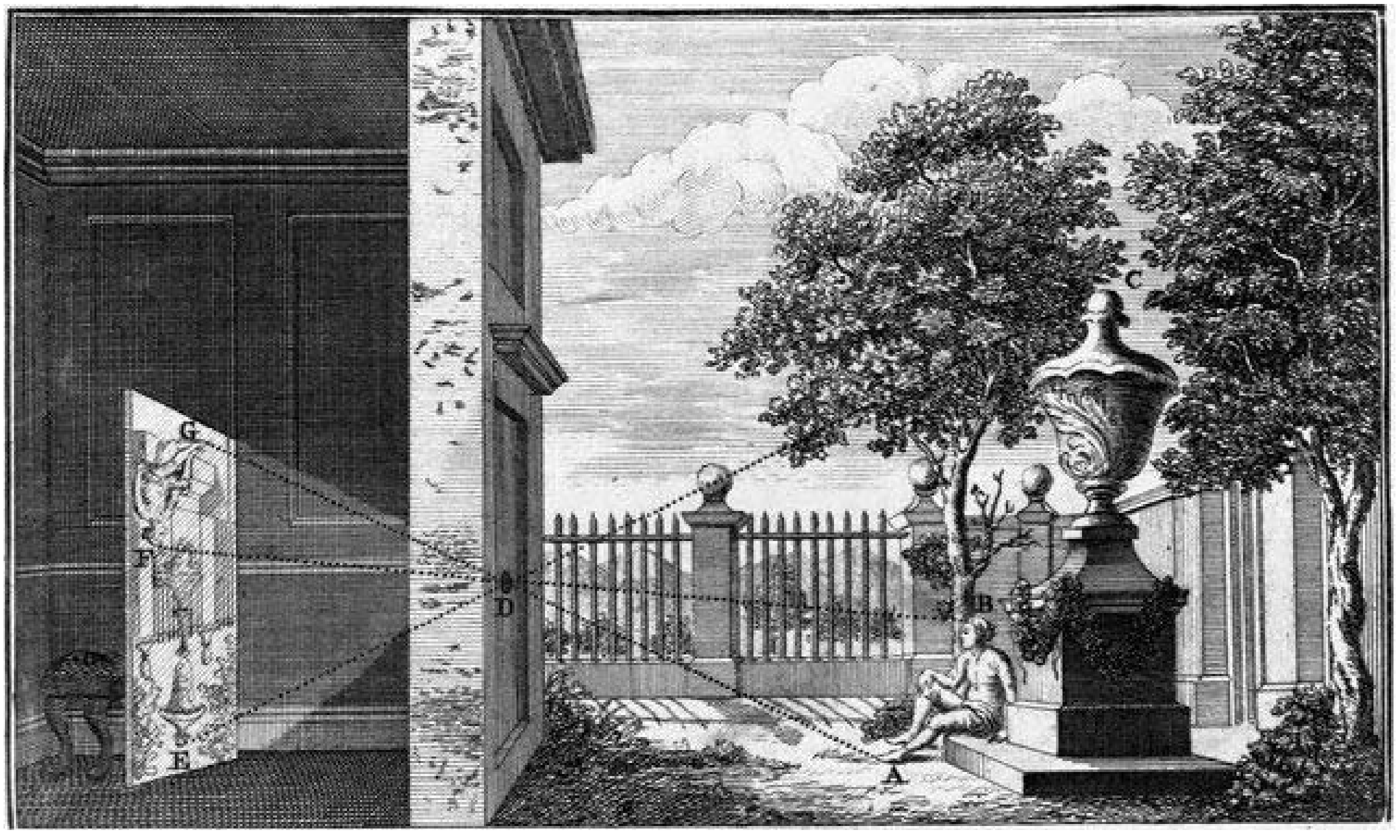


“Over the years the light-tight box, and the lens, became a little more complicated.”

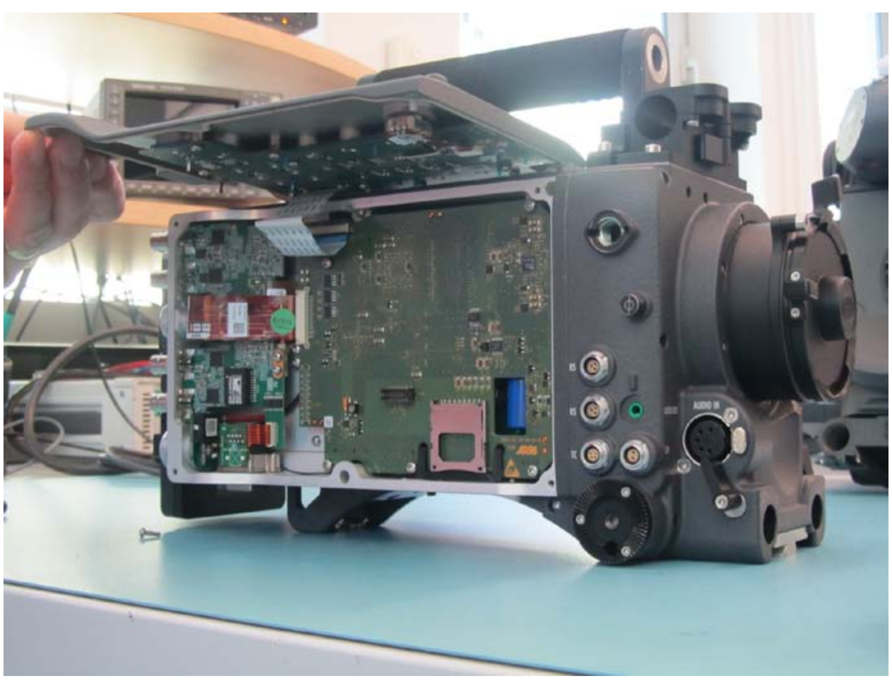
- F. Gabriel Bauer,
designer of the Moviecam and Arricam







Lumiere Cinematographe

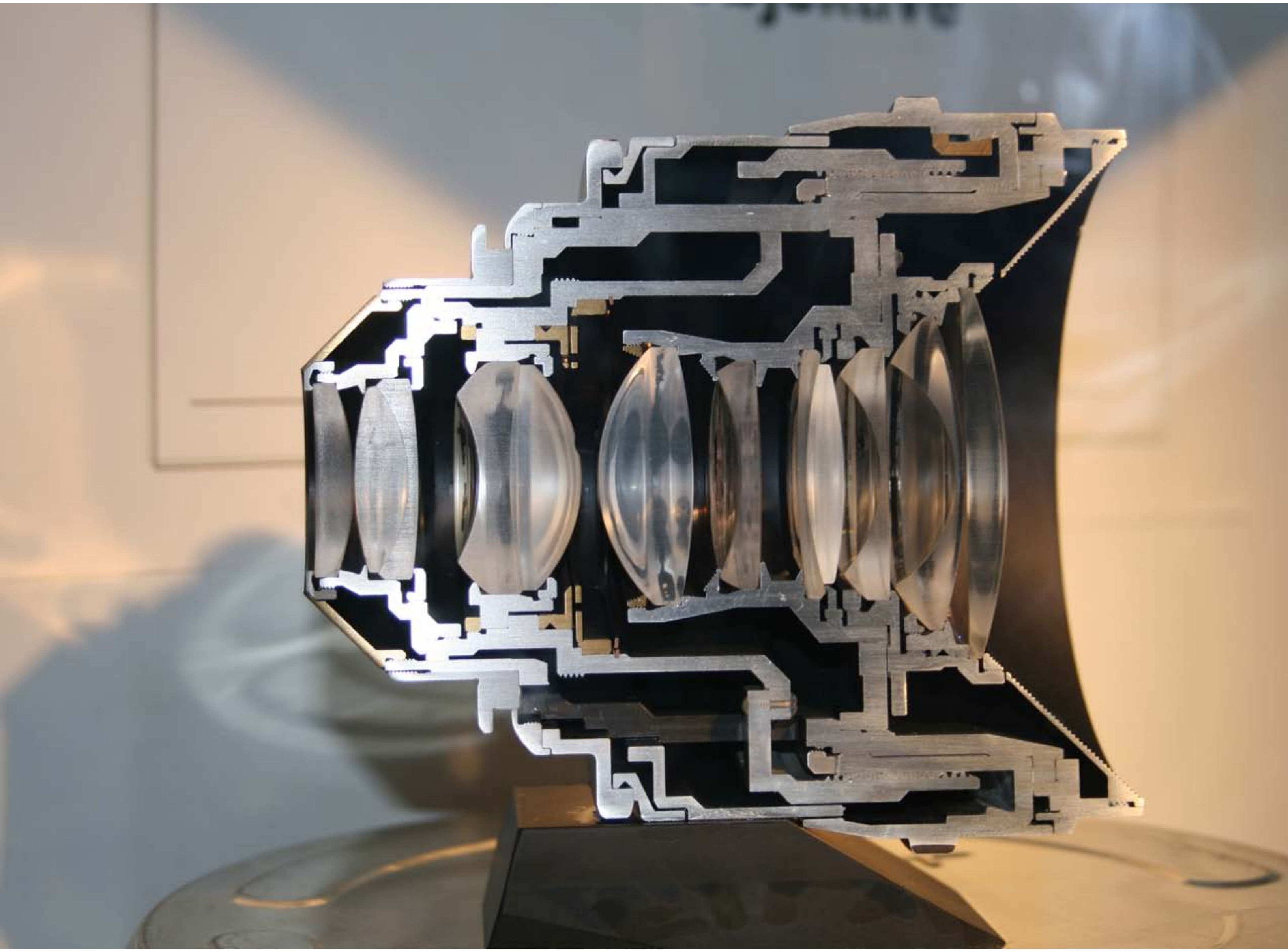


ARRI Alexa

...and the art of building cine lenses evolved from trial and error to highly sophisticated science,

from the workshop of Carl Zeiss in 1857 to the precision assembly areas in Jena and Oberkochen today.

A cine lens is a collection of glass elements, painstakingly cut, ground, polished and coated, held in a complex optical-mechanical (and now electronic) constellation of movable groups to maintain focus, aperture and frame size.



If a camera is the canvas, and lights are the paints, then the lens is the brushstroke of the cinematographer. Great camera design helps put the motion into motion pictures. Great lens design lets us translate ideas into images, bringing us closer to the ideal of being able to project our imagination onto the screen.

ZEISS Ultra Prime 8R in freefall


265m 5217
ARRI
ARRICAM ST
Master Zoom
16.5-110
Fisher


AATON
15.5-45


ND +2
ND +4
ND +8
270°
VIPER


ARRIMAG
60/200i
ARRI


ARRI


ARRICAM LT
ARRI
CSC


ARRI


ARRI
MASTER PRIME
25
Carl Zeiss
ARRIFLEX 235
ARRI
RUN
ARRI


ARRIMAG
60/200i
ARRI

Introduction to Carl Zeiss Cine Lenses

Jump cut to 2009, skipping over 100 years of ZEISS cine lens history (we'll get to that later.) In the contemporary world of ZEISS Cine Lenses, there are PL Mounts and B4 mounts, although this is blurring now in the new world of digital cameras. It's made even more interesting with renewed interest in having neutral or IMS mounts on cameras with Nikon, Canon, Leica and C-mount adaptors.

ZEISS PL mounted lenses have been distributed by ARRI, while B4 mounted lenses were distributed by Band Pro. Some of this has changed. It has confounded cinematographer, made even more confusing when some generations of lenses were named ARRI or ARRI ZEISS or just ZEISS. And why are they Master Primes (two words) but DigiPrimes (one word)? And why don't you see Band Pro's name alongside ZEISS on a DigiZoom (one word), but you see ARRI's logo below ZEISS on the Master Zoom (two words)?

It's a matter of strategic partnership and marketing. Let's say you want to sell a new set of lenses. Or what if you're a very wealthy sultan with a passion for photography and want a one-off telephoto lens with bragging rights of being the biggest and fastest in the world? If you're ARRI or a strategic partner in system development, you draw up a business plan, conduct customer surveys, make a wish list (sharper, faster, lighter, smaller) and then make compromises, since all lens design is a series of compromises, unless money, size and weight are no object or you are a sultan. ZEISS will then conduct the R&D and design the lenses, built prototypes, and when you approve the plan, go into production. ZEISS is the designer and manufacturer; ARRI is the distributor and marketer.


T
1.3
2
2.8
4
5.6


ARRI
MASTER PRIME
18
Carl Zeiss
ARRI
MASTER PRIME
25
Carl Zeiss
ARRI
MASTER PRIME
35
Carl Zeiss
MP
27

In the beginning, for me, there were ZEISS Standards and Super Speeds. On skiing, mountaineering and adventure sports films, ZEISS Standards were perfect. They were about the size of a tennis ball. You could protect them with your extra (clean) wool socks and carry an entire set in your backpack. At night, the Super Speeds, first T1.4, then T1.3, were revolutionary for shooting in low light, remembering always the operative word being "low" and not "no" — and that artful lighting was not rendered obsolete by these new lenses.

As film emulsions became faster and finer grained, and digital sensors were manufactured with higher resolution, ZEISS kept developing newer lenses that raised the bar in sharpness, resolution, contrast and performance.

Ultra Prime lenses were introduced in 1998 as the next generation "Standard" lens. They were quickly followed by LDS Ultra Prime lenses. The Lens Data System (LDS), developed with ARRI, consists of encoders inside the lens barrels that provide focus, iris, focal length and other information to the camera via gold-plated contacts in the PL mount. The Lens Data System has two jobs. It lets you monitor lens status (focus, iris, zoom) and depth of field information on your video assist monitor or on a dedicated Lens Data Display. The Lens Data System also provides continuous real-time lens information to the camera. This data is used to automate in-camera effects like speed/iris ramps or shutter/iris ramps without having to manually enter the data. Ultra Prime lenses mostly have a maximum aperture of T1.9 (8R is T2.8; 10mm is T2.1; 12mm is T2.1). The latest Ultra Prime, the 8R Rectilinear, was introduced at NAB in 2005.

Master Prime lenses were introduced at NAB in 2005. With a wide-open aperture of T1.3 for all, they can be considered the sons of "Super Speeds." Master Prime lenses were introduced with T-shirts that proclaimed, "Breathless!" and they truly are. When you rack focus, the image does not "breathe;" the image does not appear to zoom or change size as you quickly focus from near to far. To achieve this, Master Prime lenses have added elements that compensate, almost like a reverse zoom lens. They focus on cams, which are less stiff than the threaded Ultra Prime lenses. Master Prime lenses are sharper, have higher contrast and less flare. Internal baffles prevent random spill.

What does this mean for the cinematographer? Ultra Prime lenses are smaller and lighter. You may prefer them if you're shooting handheld or on Steadicam all day. But if the script says "EXT. CITY - NIGHT" or "Rack focus from ECU of scorpion in foreground to pirate ship on horizon," or "Car heads straight for camera, headlights blazing against darkened city," you'll save time, money and potential reshoots with Master Prime lenses.


18 / T 1,3
T* XP


T
1.3
2
2.8
4
5.6
8
11
16
22


DigiZoom™
17-112
DigiZoom™
6-24
Sharp Max™
DigiPrime®
135
DigiWide®
3.9


ARRI
MP
50

The new ARRI/ZEISS Master Prime 12 is an extreme wide angle lens. Its widest aperture is T1.3.

This 12 mm Prime shares the optical performance and straight image geometry of the other Master Prime lenses.

Here's a lens for wide establishing shots, sweeping vistas, chase sequences, POV shots, and shooting in cramped quarters.

Recent advances in high tech optics design, testing and manufacturing enabled ARRI and ZEISS to come up with the new and innovative lens design that makes the Master Prime 12 mm lens possible.

Master Prime lenses

Breathtaking, Breathless, No Breathing

Master Prime lenses are the latest top-of-the-line PL mount cine lenses from ZEISS for 35mm film and 35mm single-sensor digital production. All 15 Master Prime lenses have a maximum wide-open aperture of T1.3, which lets you shoot in low light, available light or night exteriors with previously unavailable sharpness, contrast, resolution and lack of flare. Opening up to T1.3 also gives your images a very narrow depth of field: sharp subjects and soft backgrounds. All Master Prime lenses have a front diameter of 114 mm (except the 150mm lens, which has a front diameter of 134 mm).

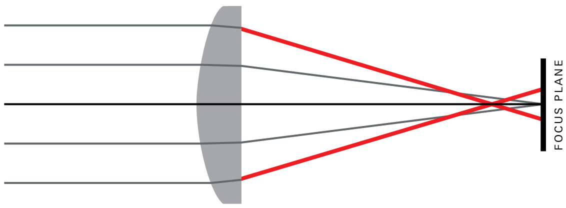
New design and manufacturing techniques, influenced by DigiPrime lenses and Microchip lenses, along with the use of aspherical glass elements came into play on the Master Prime lenses.

Master Prime lenses focus closer than Ultra Prime lenses, and are sharper, even wide open at T1.3. They exhibit minimal breathing (change in image size when focusing). In the past, the close focus performance of a lens could be improved with a floating element. However, this made it more difficult to control breathing, so the lens designers used a patented Dual Floating Elements technology, similar to the technology used in zooms. ZEISS virtually eliminated breathing in the Master Prime lenses while at the same time keeping excellent close focus performance. This enables focus pulls from ECU to infinity without image shift.

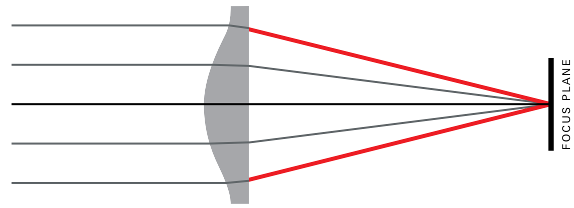
The improved T* XP anti-reflection coating provides a better light transmission and more uniform performance across the lens from optical center to the edges, resulting in higher contrast and deeper, richer blacks. Strategically blackened lens rims and special light traps combine to provide high resolution, high contrast, low veiling glare and minimal internal barrel flare.

Master Primes: Technical Details

SPHERICAL LENS



ASPHERICAL LENS



Aspheric Elements

ZEISS Master Prime lenses use aspherical glass elements. The illustration above shows the difference between the simple curve of a spherical element and the complex curve of an aspherical one. Spherical lenses (above, left) cannot focus all light rays onto the image plane. The image coming from the outer edges of the lens, having a longer distance to travel, often falls short. This is called "spherical aberration." Fast and wide lenses are more susceptible to this problem of softer edges because of their wide diameters. To compensate for spherical aberration, lens designers can add extra compensating elements, or they can use aspherical glass. Aspherical optics can make the lens lighter and smaller as well. In the past, they have been more expensive and more difficult to grind and polish. New technology helps this.

Edges

When checking lenses on a lens projector, you'll notice that many primes look darker around the edges and have less resolution. Master Prime lenses hold resolution and optical integrity from the center to all corners, at all apertures.

Color and Coating

Master Prime lenses use glass that reduces chromatic aberration (color fringing) and a new T*XP high performance optical coating. Of course, Master Prime lenses are color matched, so every lens of every set will intercut.

Geometry and Iris

Master Prime lenses have almost no visible geometric distortion: straight lines on location show up as straight lines on film. The iris leaves inside the Master Prime lenses consist of nine segments, which renders round and "organic-looking" out-of-focus specular highlights.

For Camera Assistants

The expanded focus scale has more space between focus marks. All focus scales are individually calibrated and engraved with an identifying letter, indicated by a small letter on the barrel. When shooting 3D, you can be assured of matching focal length by picking pairs with matching letters.

Lens marks are engraved and filled with large fluorescent numbers for better visibility in low light. Lens barrels ride on cams, which means the lens will not get stiff in low temperatures.

All Master Prime lenses have internal focusing; the front of the lens does expand or contract when you pull focus. Furthermore, focus and iris rings are in the same position. Your matte box, follow focus and lens motors can remain in the same position for each lens. Except for the 14 mm and 150 mm, all Master Prime lenses have a the same front diameter of 114 mm (4.5 inches).

For the Rental House

The focus ring of Master Prime lenses come from the factory engraved with accurate scales for both feet and meters. Rental house technicians can quickly switch from metric to imperial by removing and reversing the focus ring.

All gear rings have been specially hardened with a Permadur surface treatment, making them ten times tougher.

Various repairs can be done in the rental house shop without optical re-adjustment: replacing the front ring, replacing iris and focus rings and adjusting or replacing LDS components.

Ultra Prime lenses

Lighter, Smaller

Ultra Prime lenses are lighter, smaller, simpler, slower and slightly less expensive than Master Prime lenses.

When you want to bring both Masters and Ultras on location, but the budget or producer is compelling you to make a choice, here are some comparisons to help in your decision.

Ultra Prime lenses are not not “breathless” and most of them are 1 stop slower (T1.9). If you have to perform a critical rack focus without any apparent change in image size as you go from extreme close-up to infinity, you’ll probably pick Master Prime lenses over Ultra Prime lenses.

If you’re shooting night exteriors with lots of car headlights aiming at camera, the extra stop of the Master Prime lenses (T1.3) and their tolerance for flare reduction will weigh in their favor.

But if you need to travel light, pack into smaller cases, or have lots of handheld or Steadicam, you will probably pick Ultra Prime lenses.

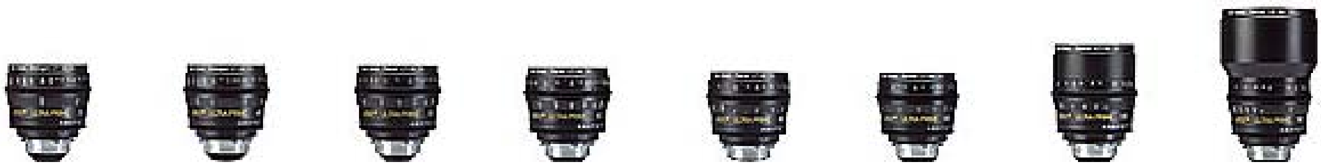
If you’re shooting in very cold places, the focus barrels of Master Prime lenses ride on cams. Ultra Prime focus barrels are threaded, and may feel stiffer on the North Pole.

Master Prime lenses are slightly sharper, especially around the edges, but if you’re shooting action, it may be hard to tell the difference.

All lenses in both sets are color matched, have internal focus and floating elements. All lenses cover full Silent Aperture (Big TV, Super 35 format).

There are currently 14 Master Prime lenses and 16 Ultra Prime lenses.

Ultra Prime lenses go wider and tighter than Master Prime lenses. The widest is the Ultra Prime 8R extreme wide angle rectilinear lens, and the longest is the 180 mm telephoto lens.



Floating Elements

Previous generation lenses like ZEISS Standards and Super Speeds were optimized for a particular focus distance, usually infinity. When focusing close, the lens performance can drop off, mainly because of image area curvature and increasing aperture aberrations. Because of this, most lens manufacturers limit the minimum close-up setting of their lenses to avoid users from moving too far into this area of lesser performance. We all remember "pulling the pins" of our lenses for close-focus table top product shots, and "breathlessly" waiting to see dailies the next day for confirmation that it really wasn't all that horribly soft.

With the Ultra Prime lenses, Carl Zeiss introduced Floating Elements, where lens groups move in relation to each other during focusing to correct image area curvature. Precise mechanical housings are just as important as the optical design when building lenses with floating elements. The result is better performance throughout the focus range, and this holds true for both Ultra and Master Prime lenses.

Internal Focus

Remember lenses whose front element and gears move back and forth as you focus? You dealt with this using rubber donuts between the matte box and the front of the lens, and with long gears to prevent the follow focus from jumping out of the focus gear ring. With the Ultra and Master Prime lenses' internal focus, the front element and lens barrels stay in the same position throughout the focus range. Instead of moving the entire internal optical assembly block with a large drive mechanism, the smaller, lightweight lens groups in the interior of the lens are moved. This also puts less torque on the focus barrel. The overall length of the lens is constant over the entire focusing range.

MTF

Ultra Prime lenses have an MTF value of over 90 % MTF for the rendering of 10 line pairs/mm.

Coating

Color fringing is absent and all lenses are coated with Carl Zeiss' proprietary T* anti-reflection coating on most of the lens elements. The newer 8R has the advanced T*XP coating used on all Master Prime lenses.

Iris

The iris on the Ultra Prime lenses have nine blades, except the 135mm which has a ten-leaf design. The edges of the iris are rounded.

Summary

- very high contrast and resolution over the entire focal range.
- uniform and constant position of the scales.
- the scales can easily and clearly be read from both sides, as can be the focal length.
- scales in m or ft can be easily exchanged in the shop.
- uniform overall length of the main focal lengths.
- uniform weight of the main focal lengths.
- service-friendly modular design with easily exchangeable front and back elements.

Rectilinear 8R

Manufacturers listen. Bill Bennett, ASC requested this lens at a users' group meeting in 2003.

The ZEISS Ultra Prime 8R is an 8 mm T2.8 - T 22 rectilinear, wide-angle lens with very little geometric distortion. It covers full 35 mm format Silent aperture. A rectilinear lens keeps vertical lines straight, whereas a fisheye lens "bend" vertical lines. The rectilinear lens compensates by making objects at the edges of frame appear wider, while the fisheye appears to bend vertical lines more at the edges.

Which lens would you use?

Rectilinear lenses are great for architecture and shots where straight lines have to stay straight (bottom, left) or a POV shot, facing forward to give the impression of great speed. Facing aft (top, left), you can increase the sensation of speed because the ground at the edge of frame goes whizzing by.

You'd probably want to use a fisheye (which ZEISS doesn't make...yet) to enlarge the center and reduce the corners.

To compare the Ultra Prime 8R and a Nikon 8 mm Fisheye, go to: http://archiv.arri.de/prod/cam/ultra_prime_r8/samples.htm

Because it has an aspherical front element, the Ultra Prime 8R is actually lighter and smaller than a 10 mm Ultra Prime.


Distagon 2.8/8R
T* XP
8R
ULTRA PRIME

Shot with Ultra Prime 8R

Notice the verticals and horizontals are straight, but the room looks deeper and larger.

Shot with Nikon 8 mm Fisheye

The edges are curved and distorted, but the rear of the room looks closer.


intel
ESSO
TOYOTA
TOYOTA


ARRI
TOYOTA

Master Diopters

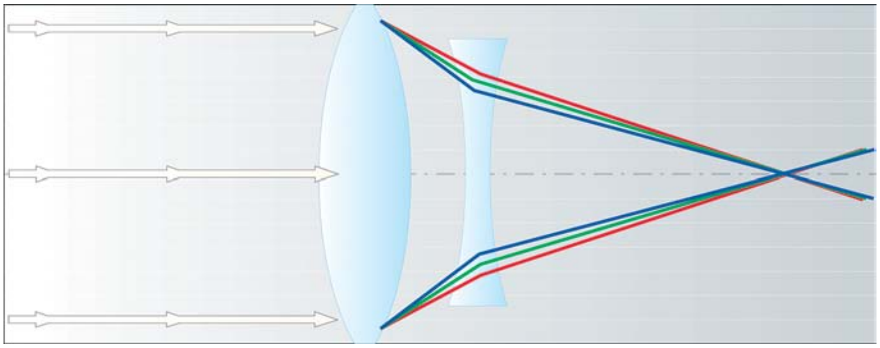
Diopters (also called Proxars or Close-up Attachments) attach to the front of your lens, and while not always optically wonderful in the past, they offered a fast and inexpensive way to film up to distances of 1:2 (a real-life size twice the width of the image area—about 48mm wide in 35mm format).

Master Diopters are a different story. There are three of them: +0.5, +1 and +2. They quickly clip to Master Prime lenses, Ultra Prime lenses, Ultra 16 lenses, Lightweight Zoom LWZ-1, LWZ.2, and many other lenses.

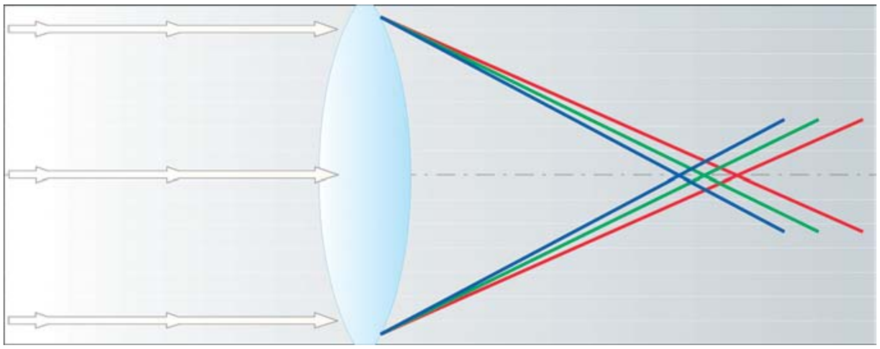
With the Master Diopters you can quickly shoot an extreme close up or get a wide angle shot with shallow depth of field, with superb sharpness and contrast, without changing lenses, and without the optical aberrations of traditional diopters.

For product shots, I like to use diopters on the long end of a zoom lens or a long prime. The main reason for the long lens is to narrow the field of view (the background) behind the product, which is usually a plexi sweep that never seems to be wide enough. The other reason is to give us room to get lights in place, because lights never seem to be small enough for product shots!

You can use a diopter on a wide angle lens to reduces the close focus distance by a small amount but throw the background way out of focus, to get a unique wide angle shot with shallow depth of field. This is especially helpful in 16mm and smaller formats.



Achromatic element of Master Diopter focuses all colors equally onto same plane



Conventional, single element diopter demonstrates color fringing and chromatic aberration because the different colors are focused onto different planes, especially at the edges.

Master Diopters are optically more advanced than regular ones, since the +1 and +2 diopters use an achromatic lens assembly and they all use the ZEISS T* coating that reduces glare and improves transmission for higher contrast.. The achromatic lenses greatly reduce color fringing and spherical aberration, common problems with traditional single element diopter designs.

In case you're reading this because the producer is breathing down your neck and you're in triple-time with meal-penalty trying to do an impossible product shot...here are some hints on using Master Diopters:

1. Master Diopters attach with a self-centering clamp ring that ensures quick, precise and safe attachment to the lens.

2. The concave side curves away from the lens (this is true for all diopters). Master Diopters can be stacked. The higher power diopter stays closest to the camera lens.

3. To calculate how close you can get your front element to the subject, divide the diopter number into 100 cm. For example, a +2 diopter will allow you to get 100/2 = 50 cm = 20 inches from the thing you're shooting, with any camera lens set to infinity. Of course, you will be able to get slightly closer when you focus the lens closer.

4. Reduction rings for different front diameters snap into the rear of the diopters. The 114 mm reduction ring allows them to attach to all Master Prime lenses, the Ultra Prime 180 or the Lightweight Zoom LWZ-1. Other reduction rings cover lens diameters of 95 mm, 104 mm and 110 mm, so the Master Diopters can be attached to most Ultra Prime lenses, LDS Ultra Prime lenses, Ultra 16 lenses and Cooke S4 lenses. This system puts the least amount of stress on the lens itself, while holding even a stack of three Master Diopters securely in place. Best optical results are achieved by using a single Master Diopter, but it is also possible to stack two diopters for a higher magnification ratio. Stopping your lens down may help image quality.

5. There is no discernible light loss when using the Master Diopters

Master Zoom

Available through the ARRI Rental Group, the Master Zoom 16.5 - 110 covers full Silent Aperture in 35mm format over the entire zoom range, while displaying very little breathing. The zoom is color-matched and shares similar image quality and characteristics with the Master Prime lenses. Special light absorption techniques and the ZEISS T* XP multi-layer, anti-reflection coating keep veiling glare to a minimum. Spherical aberration is reduced and the image geometry is free of distortions: straight lines stay straight, from infinity to close focus.

Summary

16.5 to 110mm zoom. T2.6 - T22

Covers full ANSI Super 35 image area over the entire zoom range.

Almost no geometric distortion, even up close

Virtually no breathing

ZEISS T* XP multi-layer, anti-reflection lens coating with minimal veiling glare

Holds effective aperture throughout zoom range. T2.6 reamins T2.6 from 16.5 to 110 mm.

Internal baffles restrict stray light and flare

A circular shaped aperture creates natural looking out-of-focus highlights.

Automatic temperature compensation holds focus and image quality over a wide range of temperatures

Built-in Lens Data System (LDS)

Reversible focus rings for easy switching at rental house between metric and imperial focus scales, like the Master Prime lenses.

Ultra 16 Lenses

There are nine Ultra 16 lenses: 6, 8, 9.5, 12, 14, 18, 25, 35, and 50 mm. They are all T1.3 - T16, cover the full Super 16 format and fit PL mounted cameras: Arriflex 416, 416 Plus, 416 Plus HS, Arriflex 16 SR and Aaton.

The Ultra 16 Prime lenses are the same size as the standard Ultra Prime lenses: 91.6 mm / 3.6" with a 95 mm / 3.7" front diameter and a weight of 1.0 kg / 2.2 lbs.

T* XP coating reduces flare. Image geometry is free of distortions even at wide angles. There is minimal chromatic aberration and minimal breathing.

Ultra 16 lenses are color matched to other ARRI/ZEISS Lenses: Master Prime lenses, Variable Prime lenses, Lightweight Zoom LWZ-1 and Master Zoom.

Like the Master Prime lenses, Ultra 16 lenses combine high speed with close-focus performance.

Optical Quality

The Ultra 16 lenses, like the Master Prime lenses, maintain uniform optical performance at all T-stops across the whole focus range. This was made possible through new manufacturing techniques, large diameter aspherical and radically shaped spherical glass surfaces. The Ultra 16 lenses exhibit high contrast, high resolution, almost no chromatic aberration (color fringing) and have a high resistance to flaring. They are designed as close focus lenses, and so retain their outstanding optical qualities even at minimum object distances.

Aspherical and Radical

Incorporating aspherical glass surfaces in a lens design requires ultra-high precision in manufacturing. The complex holographic measuring process was developed specifically for the Master Prime lenses, and now benefits all new ZEISS lens designs. The aspherical glass surface located close to the iris inside the 12, 14, 18 and 25 mm Ultra 16 lenses helps in reducing spherical aberration (the inability to focus all light rays from a point source onto a point on film). The aspherical front surface of the 6, 8 and 9.5 mm keeps the image free of geometrical distortions; straight lines stay straight, from infinity to close focus.

Radical Spherical Lens Surfaces

Old-style wide angle lenses are usually larger than their longer companions. The 6, 8 and 9.5 mm Ultra 16 lenses, however, have a revolutionary small form factor. This is made possible through a large diameter aspherical surface on the front and a radically shaped spherical surface with a very strong curvature on the inside. Radical spherical surfaces are cutting edge technology; they are difficult to grind, tricky to polish and demand precise attention during coating.

Thin Blue Line: Don’t use these on 35mm format

Ultra 16 Lenses have a thin blue ring in front of the PL mounting flange. This is to tell you, “Do Not Put Me onto a 35mm Camera.”

What happens if you do? These lenses only cover the Super 16mm image area, so what you’ll see is a peep-hole effect—an image circle not fully covering the 35mm frame.

What about the reverse—what happens if you put a Master or Ultra Prime on your 16mm camera? Well, we do that all the time. Note that the longest Ultra 16 is 50 mm. If you need a longer prime, feel free to use a 180 mm Ultra Prime or 150 mm Master Prime.

Will a 50 mm Ultra or Master Prime look any different than a 50mm Ultra 16 on your 16mm camera? The image area (field of view) and magnification will be the same. It’s a law of optics. A 50 mm is always a 50 mm, regardless of aperture size.

One thing you may notice, however, is that the 50 mm Ultra 16 may look sharper than anything else: because it has been optimized for the 16mm format.


Distagon 12/T1.3
T*XP
istagon 14/T1.3
ARRI ULTRA16


Carl Zeiss Distagon 6 / T1.3 T*XP
Carl Zeiss Distagon 9.5 / T1.3
Distagon 8 / T1.3 T*XP
Carl Zeiss Distagon 12 / T1.3
ULTRA16


ARRI
PAL
PUSH TO RELEASE
FIX
OPEN
LOCK
ULTRA
Carl Zeiss Distagon 14/T1.3


Carl Zeiss Planar 50/T1.3
Carl Zeiss Planar 35/T1.3
Carl Zeiss Distagon 18/T1.3
Carl Zeiss Distagon 25/T1.3
ARRI ULTRA 16
ARRI ULTRA 16
ARRI ULTRA 16
ARRI ULTRA 16


ARRI ULTRA 16
ZEISS


Distagon 14 / T1.3
m
0.3
0.31
0.32


15.5 - 45 / T 2.6
T* XP
ARRI
Zoom LWZ-1
15.5 - 45

Lightweight Zoom LWZ-1

The Lightweight Zoom LWZ-1 for the 35mm format was introduced at NAB in 2005. It was recently replaced by the LWZ.2.

It was ironic that, although film stocks and digital sensors were getting faster, we cinematographers were using bigger lights and heavier lenses. Steadicam and handheld camera operators were appalled.

The 15.5 mm - 45 mm, T2.6 Lightweight Zoom LWZ-1 weighs only 4.4 lbs (2kg). It is only 8 inches long. The front diameter is 114 mm: same as Master Prime lenses, so you can share matte boxes and filters. It also shares some of the optical technology used in Master Prime lenses and Ultra 16 Prime lenses, including smooth operation and a well-marked focus scale.

Like the Ultra 16 lenses, the Lightweight Zoom uses radical spherical and aspherical lens elements, advanced glass ingredients and the T* XP anti-reflection coating to ensure a sharp, high resolution image that covers the entire Super 35 frame and matches the other ARRI/ZEISS lenses.

This smaller and lighter lens is a good companion on the Arricam Lite and Arriflex 235 for handheld and Steadicam shots.

The Lightweight Zoom LWZ-1 is also helpful when you are squeezing into tight spaces like car interiors, jets, New York apartments or Tokyo subways, and when you need a zoom instead of a prime for action sequences, stunts, remote heads, car rigs, motorcycle rigs, bicycle mounts, body mounts and underwater shots.

The Lightweight Zoom renders a high contrast and high resolution image with almost no chromatic aberration or geometric distortion over the entire zoom range, at all focus settings. It covers the whole Super 35 frame at all focal lengths, while displaying minimal breathing, and stays a true T2.6 throughout the entire zoom range.

Radically shaped spherical glass surfaces are used—curved so much they are almost half-spheres. Some of the same optical components and techniques that go into the Master Prime lenses are used in the Lightweight Zoom, including large diameter aspherical lens elements.

The T* XP multi-layer anti-reflection coating reduces flare and internal reflections and creates a pleasing, gentle color balance, with higher contrast and deeper, richer blacks.

The lens' internal construction in combination with the T* XP coating ensures that it can easily handle tricky lighting situations like strong backlight, sunsets or car headlamps.

The round iris opening leads to organic looking, pleasing out-of-focus highlights.

The Lightweight Zoom has been Super Color Matched. Its optical and color characteristics have been optimized to create a pleasing color balance on modern film stocks and to precisely match the Master Prime lenses, Ultra Prime lenses, Variable Prime lenses and Ultra 16 lenses.

Lightweight Zoom LWZ-1

By using a set of matched lenses, the cinematographer is able to concentrate on creating a look rather than matching lenses in post.

All mechanical parts have been engineered for smooth and durable operation. Precision ball bearings ensure easy focusing and zooming at all temperature and humidity conditions. Chamfered precision gears mesh smoothly with the gears on follow focus units and lens motors. The interior of the lens is a lightweight yet sturdy inner skeleton with special weight reducing construction.

The design of focus, zoom and iris scales has been matched to the other ARRI/ZEISS lenses, so that assistants can work with familiar controls. The front diameter of 114 mm is the same as that of the Master Prime lenses, and an ergonomic, rubber zoom ring provides a comfortable grip for manual zooms.

When you need to get closer than the close focus distance of 0.45m/18 inches from the film plane, the Lightweight Zoom accepts the Master Diopters (+0.5, +1, +2) that can be quickly attached and removed from the lens, delivering excellent sharpness and contrast without optical aberrations.

And, yes...you can use the Lightweight Zoom on your Super 16 cameras. It becomes a mid-range zoom in the 16mm format—good for portraits and interviews. Remember the laws of optics: 15.5-45 mm is always 15.5-45 mm, but on a 35mm format camera is considered wide, while in 16mm format, is considerably tighter because the 16mm aperture is half the size of the 35mm frame, and so is effectively "seeing" only half the image width of the 35mm frame.

Lightweight Zoom LWZ-1

ZEISS Lightweight Zoom LWZ.2

Focal Length Range	15.5 - 45 mm
Focal Length Ratio	3:1
Aperture	T2.6 - T22
Close Focus (1)	0.45 m / 18''
Angle of Focus Rotation	337°
Angle of Zoom Rotation	120°
Length (front to PL mount flange)	209 mm / 8.2''
Front Diameter	114 mm / 4.5''
Weight	2 kg / 4.4 lbs
Horizontal Angle of View (2)	at 15.5 mm: 90.2°
	at 45 mm: 40.0°
Front Element	Radical aspherical lens
Lens Coating	Carl Zeiss T* XP
Coverage	The complete ANSI Super 35 image area 24.9 mm x 18.7 mm (0.980" x 0.7362")
Camera Mount	PL, Canon EF, Nikon F, Sony E, Micro 4/3 mount

ZEISS has added a zoom to their line of lenses with interchangeable mounts. With the Carl Zeiss Lightweight Zoom LZW.2 15.5-45, they are reintroducing a design originally available only in PL.

The new-generation Lightweight Zoom by Carl Zeiss comes with interchangeable mounts that allow the lenses to be used with a wide range of cameras, from traditional cine to HDSLR systems. Three different mounts are available: PL, EF and F mount. The LWZ.2 covers the ANSI Super 35 image area (24.9 x 18.7mm / 0.980” x 0.7362”).

Weighing around two kilograms, the LWZ.2 is comfortable handheld, on Steadicams, with cine cameras and also HDSLRs.

The LWZ.2 uses radically shaped spherical glass surfaces with a very strong curvature, which guarantee high optical performance. Large-diameter aspherical lens elements keep the lens lightweight while reducing spherical aberrations and keeping the image free of distortions. Straight lines stay straight, from infinity to close-up and over the entire zoom range. The T* XP multi-layer coating reduces flare and internal reflections, resulting in pleasing and gentle colors, high contrast and deep blacks. www.zeiss.com/cine

(1) Close focus is measured from the film plane.

(2) Horizontal angle of view for an ANSI Super 35 Silent camera aperture aspect ratio 1:1.33,
dimensions 24.9 mm x 18.7 mm
0.980" x 0.7362"

ZEISS Compact Primes CP.2

ZEISS Compact Prime CP.2 lenses now come in 18, 21, 25, 28 35, 50, 50 Macro, 85, and 100 mm Close Focus. They are available with interchangeable mounts: PL, EF (Canon) and F (Nikon)—and coming soon, Micro Four-Thirds and Sony E-mount. ZEISS CP.2 lenses cover the full-frame still format (24 x 36 mm) without vignetting (except the 18 mm).

CP.2 lenses have 14-blade irises. They all share the same barrel diameter (except 50 Macro), industry standard gearing for follow-focus and aperture control.

The CP.2 lenses come with a helpful manual and focus chart that explain how to easily swap lens mounts. Download the CP.2 lens manual: http://tiny.cc/zeiss-cp2

Lens	Type	Aperture	Close focus	Horiz Angle Full Frame	Horiz Angle ANSI S35	Horiz Angle N35	Length	Front diam	Weight
18 mm	Distagon T*	T3.6 - 22	0.3 m / 12"	-	69°	62.5°	80 mm / 3.15"	114 mm / 4.5"	0.9 kg / 2.0 lbs
21 mm	Distagon T*	T 2.9 - 22	0.24 m / 10"	80.8°	60.9°	54.8°	80 mm / 3.15"	114 mm / 4.5"	1.0 kg / 2.2 lbs
25 mm	Distagon T*	T 2.9 - 22	0.17 m / 7"	71.3°	52.5°	47°	80 mm / 3.15"	114 mm / 4.5"	0.9 kg / 2.0 lbs
28 mm	Distagon T*	T 2.1 - 22	0.24 m / 10"	65.2°	47.4°	42.3°	80 mm / 3.15"	114 mm / 4.5"	1.0 kg / 2.2 lbs
35 mm	Distagon T*	T 2.1 - 22	0.3 m / 12"	54.0°	38.5°	34.3°	80 mm / 3.15"	114 mm / 4.5"	1.0 kg / 2.2 lbs
50 mm	Planar T*	T 2.1 - 22	0.45 m / 18"	39.0°	27.3°	24.2°	80 mm / 3.15"	114 mm / 4.5"	0.9 kg /2.0 lbs
85 mm	Planar T*	T 2.1 - 22	1 m / 3'3"	23.9	16.7°	14.8°	80 mm / 3.15"	114 mm / 4.5"	0.9 kg / 2.0 lbs
100 mm	Planar T* Close-Focus	T 2.1 - 22	0.7 m / 2'6"	21.0°	14.7°	13.1°	132 mm / 5.19"	114 mm / 4.5"	1.49 kg / 3.3 lbs
50 mm Macro	Makro-Planar T*	T 2.1 - 22	0.24 m / 10"	39.0°	27.3°	24.2	132 mm / 5.19"	134 mm / 5.3"	1.35 kg / 3.0 lbs

Close focus distance is measured from the film / sensor plane. Horizontal angle of view for a full-frame camera aperture (aspect ratio 1:1.5, dimensions 24 mm x 36 mm). Horizontal angle of view for a Normal 35 Academy camera aperture (aspect ratio 1:1.37, dimensions 22 mm x 16 mm). Length is Front to PL mount flange.

DigiPrime and DigiZoom Lenses

All of the lenses we've looked at so far in the previous pages have PL mounts, and are made for 35mm motion picture and single-sensor digital cameras. While the film world standardized on ARRI PL (along with Mitchell, Panavison PV, and assorted other mounts), the video and digital world agreed on the B4 mount for ⅔" 3 CCD cameras.

The image area (aperture) in a PL mount camera is 18mm high x 24mm wide. (4:3 aspect ratio, aka 1.33:1)

The image area of each CCD in a ⅔" camera is 6.6 mm high x 8.8 mm wide (4:3 aspect ratio).

There are many technical details which will follow, but the main thing to point out here is that the DigiPrime and DigiZoom lenses have to do a lot more "heavy lifting" than their PL mounted brethren for several reasons: they have to cover a smaller image area, they have to deal with a prism separating red, green and blue onto three separate CCD sensors, and they have to be more telecentric—meaning the image has a longer distance to travel from the rear of the lens, through filters and prism, to the image plane.

for 2/3" 3 CCD Cameras

DigiPrime and DigiZoom Lenses

Specifically built for the three 2/3" CCDs and beam splitting prism optical system found in current digital cinematography cameras, DigiPrime lenses exceed 90% MTF value for the rendering of 56-line pairs/mm. Additionally, the perception of sharpness is made possible by uniform contrast and brightness across the entire image area. DigiPrime images are free of color fringing across the focus range and color matched.


Carl Zeiss Vario-Sonnar 1.7 / 17 - 112
DigiZoom™
17-112
ZEISS
Sharp Max™
Back Focus Alignment Device
Carl Zeiss
DigiPrime®
70 CF
DigiPrime®
40
DigiPrime®
28
DigiPrime®
10
DigiPrime®
14
DigiPrime®
5
DigiWide®
3.9

DigiPrime Lenses

When do you use a Zoom or Pick a Prime?

Every cinematographer is different, but the zoom lens is usually my workhorse, because we don't have to slow down to change lenses. It's also helpful because we can subtly creep in our out to adjust frame size if an actor misses a mark or we need to avoid something in the background. For documentaries, changing frame sizes every time an interviewer asks a question helps the editor avoid jump cuts.

We use primes when we need a wider aperture: at night or to throw the background out of focus. We'll also use primes for handheld shots, for wide-angle views and in tight locations.

DigiPrimes are smaller and lighter than DigiZooms. They employ fewer optical elements.

Uniform Size & Balance

Each DigiPrime's lens barrel has a common diameter. Focus and iris gearing is uniformly positioned from lens to lens so changing lenses is easy. Because of their uniform size and shape, motors, matte boxes and rod-mounted accessories don't need to be repositioned. Every DigiPrime lens in the family from the 70mm to the wide angle 5mm have a common 95mm front diameter. With a design that puts the center of gravity near the lens mount and keeps it there throughout the focusing range (thanks to their internal focus design), DigiPrime lenses work well on Steadicam and remote heads.

Internal Focus and Floating Elements

DigiPrime lenses have internal focusing, uniform, center to corner, over the entire focusing range. There is no movement of the front exterior housing. Focusing the lens moves small light-weight lens groups within the DigiPrime lens' interior. This floating element design moves lens groups precisely in relation to each other during focusing to correct image area curvature, optical aberrations, eliminates field and edge distortion, and yields sharp, high-resolution images across the entire field of view—down to the closest focus.

Accurate & Visible Markings

The expanded DigiPrime lens barrel features large, easy-to-read focus marks engraved and filled with long-life bright yellow enamel, highly visibile in low light. Focus and iris marks are easily and accurately readable from either side of the lens.

DigiPrime lenses have about 300° of barrel rotation. The expanded scales are individually calibrated for each lens. The standard focus ring, engraved in feet and inches, can be quickly changed to meters by your rental house or repair facility. The iris scales are marked in ⅓ stop increments.

Uniform Iris and Focus Gears

The geared rings on DigiPrime lenses are positioned in the same place on each lens. Positioning external lens motors and follow focus is simplified. Lens changes are simple and fast.

Breathless Focus

DigiPrime lenses, like Master Prime lenses, have been designed to be free of breathing, backlash or play. When focusing, the image remains perfectly centered. There is no tilt, rotation, or shift. Each DigiPrime lens is designed to be virtually free of image shift, and focusing does not influence image size.

Absolutely Precise Back-Focus

Precision back-focus is critical to properly calibrated focus scales and properly focused images. DigiPrime lenses were designed with a rugged back-focus mechanism that ensures accurately maintained focus scale calibration across the entire focusing range. Back-focus scales are clearly engraved for exact repeatability. Once desired back-focus is achieved, the dependable locking feature fastens the mechanism securely in place.

Nine-Bladed Iris

The iris design is free from lag, slop or backlash, and uses nine blades to deliver circular diaphragm geometry. This results in organic and natural-looking specular highlights in out-of-focus areas of the image.

Wide Open

DigiPrimes all open to a maximum aperture of T1.6. In low light situations, DigiPrime lenses provide rich contrast with minimal flare, veiling glare or internal reflections.

Construction and Service

DigiPrime lenses are designed and built at the Carl Zeiss camera lens headquarters in Oberkochen, Germany by the same teams who build PL mounted lenses: Master Prime lenses, Ultra Primes and Zooms.

The DigiPrime lens barrel is rugged enough to accommodate clamp-on accessories like matte boxes, lens motors, clamp-on shades, filters, ring lights, encoders and motors without squishing the barrel, distorting the image or impacting optical performance. Scales and indices are carefully engraved for long-term accuracy and durability. Modular constrution streamlines service and maintenance.

T* Coating and Color Matched

The individual elements of DigiPrimes receive the Carl Zeiss proprietary T* multiple layer anti-reflectin coating. Further-more, all lenses are color matched so each one intercuts not only with every other DigiPrime and DigiZoom, but also with all other current generation Carl Zeiss cine lenses. This becomes a huge time-saver, for example, when doing a Digital Intermediate with scenes shot with on F23, F35 and motion picture cameras.

6-24 mm T1.9 DigiZoom

Carl Zeiss Digizoom 6-24 mm T1.9

At just 9.8" (249mm), the Carl Zeiss DigiZoom is compact. It is also light weight: 6 lbs (2.75 kg). It's good for handheld, remote and Steadicam work. With familiar cine-style layout, the zoom lens works in studios, with matte box, bridgeplate, as well as focus, zoom, and iris motors, or bare-bones for documentary-style handheld.

Common Advantages

The 4x zoom offers industry standard pitch zoom, focus and iris gears and brightly-marked oversized windowed focus scales, readable from either side of the lens. Focus scales are individually calibrated to each lens. Like the rest of the family, the Carl Zeiss DigiZoom features a 95mm front diameter.

Precision Back-Focus

The DigiZooms use the ZEISS proprietary back-focus mechanism to ensure accurately maintained focus scale calibration across the focusing range. The zoom is fully compatible with the ZEISS Sharp Max Universal Back-Focus Alignment device.

Internal Focusing Design & Close Focusing

This zoom employs Internal Focusing Design to ensure top performance—center to corner—over the entire focus and zoom range, a consistent center of gravity, minimum balance shift, and no breathing. Like most ZEISS DigiPrime lenses, the 6-24mm zoom focuses to just 22" from the image plane. That's a close-focusing 11" from the front of the lens. ZEISS DigiZoom uniquely offers the ability to focus tightly on objects as small as 66mm x 117mm. So, even objects as small as a business card can fill the frame in precise focus.

9 Blade Iris

Both ZEISS DigiZoom™ and DigiPrime® lenses utilize the same innovative iris design for unequaled performance, free from lag, slop, or backlash.

Low Light Friendly

Like DigiPrime lenses, the DigiZooms have been engineered for optimum performance in low light situations with the aperture fully open, for excellent contrast control, and with minimized flare, veiling glare, and internal reflections. It also offers superior relative illumination and high resolution over the entire screen edge-to-edge, throughout the focal range. Users will appreciate that the ZEISS DigiZoom does not ramp.

Perfect Color Match

For exceptional color characteristics, Carl Zeiss carefully selects superior quality optical glass, then applies proprietary coatings. Naturally, ZEISS engineers have designed the 4X zoom to accurately color match and seamlessly intercut images made with the DigiPrime family.

17-112 mm T1.9 DigiZoom

Carl Zeiss Digizoom 17-112 mm T1.9

The longer zoom in the Carl Zeiss family of DigiZoom lenses is the Telephoto DigiZoom 17-112mm T1.9.

It is compact (300mm / 11.8" long) and lightweight (7.8 lbs, 4 kg / 9 lbs).

The Telephoto shares common ergonomic and optical designs with the 6-24 DigiZoom and the other DigiPrime lenses: industry standard pitch zoom, focus and iris gears, and brightly marked oversized windowed focus scales The lens has a 95mm front diameter.

The new 6.5x zoom focuses to just 30 inches from the image plane. Like the rest of the ZEISS DigiPrime and DigiZoom family, the 17-112mm has been engineered for optimum performance in low light situations with the aperture fully open.

ZEISS engineers have designed the new 6.5x zoom to accurately color match and seamlessly intercut images made with the DigiZoom 6-24mm T1.9 as well as the DigiPrime family.

Carl Zeiss DigiDiopter

The DigiDiopter line of achromatic diopters are currently available in +0.5, +1 and +2 magnifications.

DigiDiopters are designed to work in conjunction with the ZEISS DigiPrime and DigiZoom series, as well as all other high-end ⅔" HD lenses. Carl Zeiss DigiDiopters are intended for extreme close ups or wide angle shots with a shallow depth of field. They attach easily to the front of the lens to provide increased close-focus range and magnification capability.

DigiDiopters employ a unique, achromatic dual-lens assembly to minimize color fringing and spherical aberration, common problems with traditional single lens diopters. The ZEISS optical design ensures a high-resolution, high-contrast image with consistent precision anywhere in the frame. Carefully selected optical glass elements and the ZEISS proprietary T* anti-reflective coating—the same coating applied to their DigiPrime and DigiZoom lenses—reduce light loss and flare, while improving transmission for crisp images with saturated colors and accurate blacks. DigiDiopters are designed to optically match the DigiPrime, and DigiZoom's color balance, contrast, and overall image quality.

Weighing about 10 ounces (285g) each, ZEISS DigiDiopters can be attached to the camera lens, or to each other, with a single thumbscrew. A unique self-centering clamping mechanism maintains a proper distance between diopter and lens and keeps them parallel to each other, ensuring optimal image quality. This mounting system puts the least amount of stress on the lens itself, while keeping the DigiDiopters securely in place. It also enables stacking the diopters on the front of the lens. The +0.5 can be placed on top of the +1 DigiDiopter to provide a +1.5 magnification or on top of the +2 DigiDiopter to offer a +2.5 magnification.

Sharp Max Universal

The ZEISS Sharp Max Universal is your lifeline, a field instrument to adjust and align back-focus on both standard definition and high definition B4 mount lenses. With Sharp Max Universal there's no need to light a chart or move the camera. First, the lens is set to its infinity mark with the iris wide open. Next, Sharp Max Universal is held up to the front of the shooting lens and the power button is pressed. Finally, the back-focus ring is adjusted for the finest focus in the center of the internal back lit Siemens star and the back-focus ring is locked. That's it. Infinity focus is set and the focus scales are accurately calibrated.

Weighing only 2.2 lbs. (1 kg), with a size of just 83.5mm in diameter by 280mm long, the Sharp Max Universal should be part of every camera package. A set of nine adapter rings ranging from 80mm to 130mm ensure that Sharp Max Universal will work with nearly all lenses available in B4 mount.

Back Focus

by Michael Bravin

One of the areas of digital production that often bewilders crews coming from the film world is back focus. "Why do you have to adjust the back of the lens in the field?" they ask. Back focus on a digital camera/lens system is similar to flange focal distance on a film camera/lens system. The main difference is that flange focal distance and depth on a film camera usually are adjusted in the shop, and once set, should not have to be changed again unless something has changed drastically, like the camera was dropped or the lens bounced on the ground.

On a film camera, the lens and camera mount are usually made of stainless steel: very strong and precise. The metal is "dimensionally stable," which means there is little expansion or contraction as temperature changes. They are also made of complementary metals so that when they do change under dramatic environmental conditions they change together. Remember, with a film camera, focus is often decided with a tape measure and set on the lens, so scale accuracy is very important.

The lens mount on a High Definition camera was originally designed to be as lightweight as possible. The mounts on camera and lens are made of non complimentary metals so dimensional stability is an issue and the mount geometry can change with extremes in temperature. This can result in calibration errors (eyefocus no longer matches index marks on the focus barrel.) In a video imaging system where the resolution is limited and the material captured is shown once on television, small misalignments and errors are barely visible and therefore are acceptable. Also traditionally, with electronic cameras, focus was done by eye through the eyepiece.

With the advent of Digital Cinematography where HD cameras are used in productions where images may be blown up and shown on a big screen, or transferred to film, or become part of an extensive post production process, these errors are magnified and become a problem.

Among the manufacturers who make lenses for Digital Cinematography, Carl Zeiss was one of the first to design and manufacture a precision back focus mechanism for their DigiPrimes. To help combat the problems caused by back focus misalignment, calibrated focus scales and a precision back focus mechanism with index marks are used. Fortunately, the other manufacturers have followed suit and offer their versions of a calibrated back focus mechanism. Clairmont Camera actually redesigned and modified the lens mount on their Sony F900 using a steel alloy that was complementary with the stainless alloy materials used in the ZEISS lens mount, which allows for dramatic temperature changes with no change in back focus..

With a video system, there are two ways to check back focus: a back focus chart or a handheld collimator such as the ZEISS SharpMax. Back focus is accomplished by adjusting the rear element group mechanism farther or closer to the image plane.

The SharpMax and similar portable collimators are used to adjust the back focus system for infinity. When the lens is properly back focused, the infinity mark on the focus scale and the optimum focus of the Siemens star chart are achieved.

Collimation involves expanding or concentrating a beam of light into a parallel beam. When adjusting lenses, collimated light is light that is focused at infinity so that all the rays are parallel or a in column. Basically this is calibration for infinity. Once infinity calibration is accomplished, then the focus scales should, in theory, be accurate throughout their range. It's always good to check close focus as well, by comparing eye focus and taped focus.

Check back focus often: at beginning of day, after shipping or changing locations, and whenever the temperature changes enough so that you have to remove or add clothing to stay comfortable.

Setting back focus with the SharpMax and similar portable collimators

1. Mount the lens on the camera and set the lens focus scale to infinity.

2. Open the lens aperture as wide as it goes.

3. Turn down the peaking circuit in the viewfinder and make sure the viewfinder eyepiece is focused.

4. Turn on the light that illuminates the Siemens star chart and focus the image using the mechanical back focus ring on the lens.

5. Adjust the back focus by rocking the back focus knob forward and back, paying attention to sharpness in the center of the chart.

6. If using a zoom, zoom the lens from wide to telephoto throughout the range and insure that focus tracks (focus stays sharp throughout the range, and the image does not shift to one side or another.

7. Tighten the back focus mechanism firmly, and the lens should now have accurate focus scales as well as a calibrated infinity focus.

After you have done this several times it should take no more time than what one would use when checking and cleaning the gate in a film system.

One common misunderstanding is that back focus causes focus errors when focusing by eye through the eyepiece. It does not except for infinity focus. Otherwise there is merely an inaccuracy of the focus scale up to infinity and no ability to get any focus at infinity. Of course, if you're using a tape measure and your back focus is off, you're doomed.

With a back focus chart on a lit set

Set up a back focus chart; usually it is a Siemens star, which is a popular pattern because it "pops" in and out as you check focus. Make sure the chart is lit to a low level, so that the lens can we worked at a wide open aperture. It's a good idea to view the chart on a good studio monitor: its resolution is usually better than the camera's eyepiece.

1. Set up your camera 10 ft from the chart and set the lens focus scale to 10ft. (or similar close range that has a definitive focus scale mark.

2. Open the lens aperture as wide as it goes.

3. Turn down the peaking circuit in the viewfinder and make sure the viewfinder eyepiece is focused.

4. Adjust the back focus knob, as above, #5.

5. If using a zoom, check tracking (as above, #6)

6. Tighten the back focus mechanism firml.

7. To reconfirm, check the focus against the scale reading at several distances to insure proper calibration.

It is a good practice to check and touch up the back focus whenever changing lenses and whenever there is a wide change in temperature.


5
7
DigiPrime
10
14
DigiPrime
20
DigiPrime

DigiPrime®
Sharp Max™
Carl Zeiss Vario-Sonnar
DigiZoom™
17-112
Carl Zeiss
DigiPrime®
135
40
DigiPrime®

Places in History

Cine Lens Days and ZEISS Tour

ZEISS Cine Lens Days

Every few years, when the planets and stars align properly with Cinec and cinematographers' calendars, invitations to the highly sought-after Cine Lens Days are sent out. For a cinematographer, this is like being invited to the Oscars or getting a table at Melisse.

It is usually scheduled in September between IBC and Cinec, usually in Oberkochen.

The event has traditionally begun with an interesting event and superb dinner in a mischievously planned, previously secret location. These have included an optical illusion museum and a castle inhabited by huge raptors. There's always an angle, of course. Raptor in flight are best seen through high-powered ZEISS binoculars and scopes, conveniently available to demo.

The next day has typically been convened in a lecture hall at ZEISS headquarters, to learn about the latest in optics, followed by a tour of the manufacturing facilities.

I thought it might be a good literary device to pretend you, dear reader, are with us on a ZEISS Cine Lens Day, as we visit the two cities where the lenses are made, Jena and Oberkochen, and where we discover the fascinating history of the company.

Cast of Characters

The 1531 portrait of Johann Friedrich I, Elector of Saxony, also known as Johann the Magnanimous, by Lucas Cranach the Elder, oil on wood (51 x 57 cm) hangs in the Louvre. Johann the Magnanimous established a school in Jena, Germany in 1548. It was opened as the University of Jena in 1558 by Emperor Ferdinand I. By the end of the 17th century, the University of Jena had become one of the most prominent in Germany.

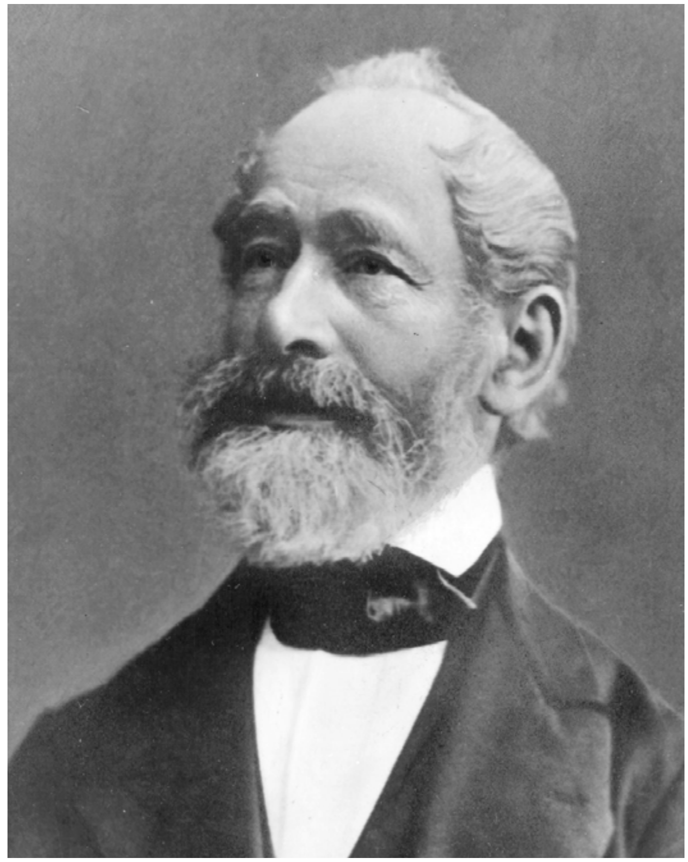
Gottfried Wilhelm Leibniz was a student of the scientist Erhard Weigel in Jena in 1663.

Friedrich Schiller was a professor of history at Jena University 1789 – 1799. At the same time, Johann Wolfgang von Goethe, then state minister of Saxe-Weimar, supported the University and spent much time in Jena.

By 1800, Jena was the heart of classical German philosophy. Friedrich-Wilhelm Joseph Schelling attended in 1798 and Georg Wilhelm Friedrich Hegel was there from 1805-1807.

In 1841, Karl Marx submitted his Ph.D. dissertation to the University of Jena, fearing repercussions in Berlin where he was studying.

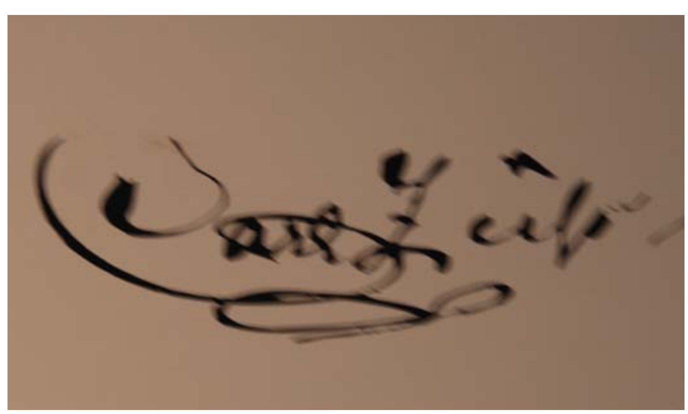
The University of Jena was the focal point for the meeting of three unique individuals: Carl Zeiss, Ernst Abbe and Otto Schott. Forty years after Napoleon won the battle of Jena (1806), Carl Zeiss set up a workshop that would turn Jena into a "city of optics."

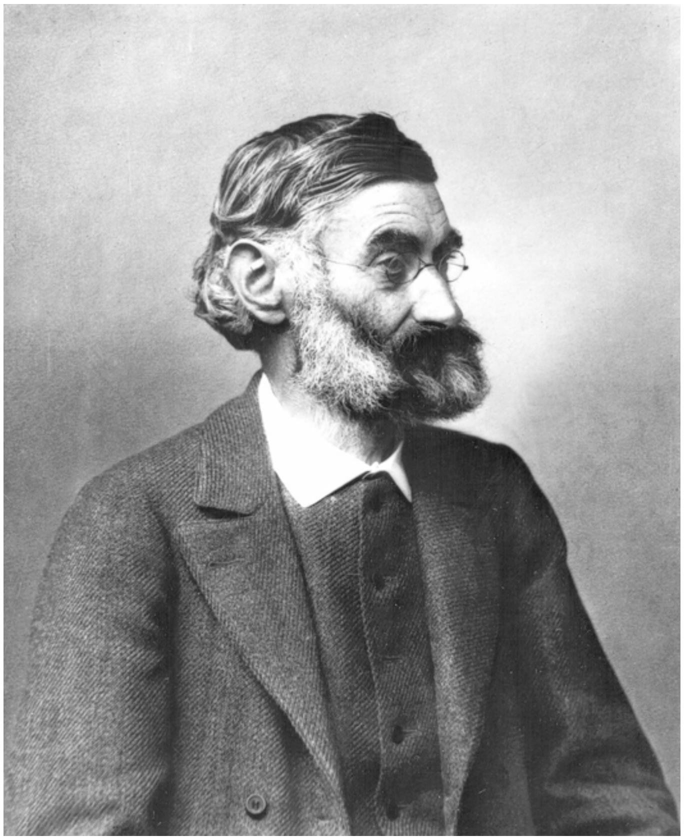


Carl Zeiss (1816-1888) was born in Weimar, the fifth of twelve children. From 1835 to 1838, he attended lectures at the University of Jena.

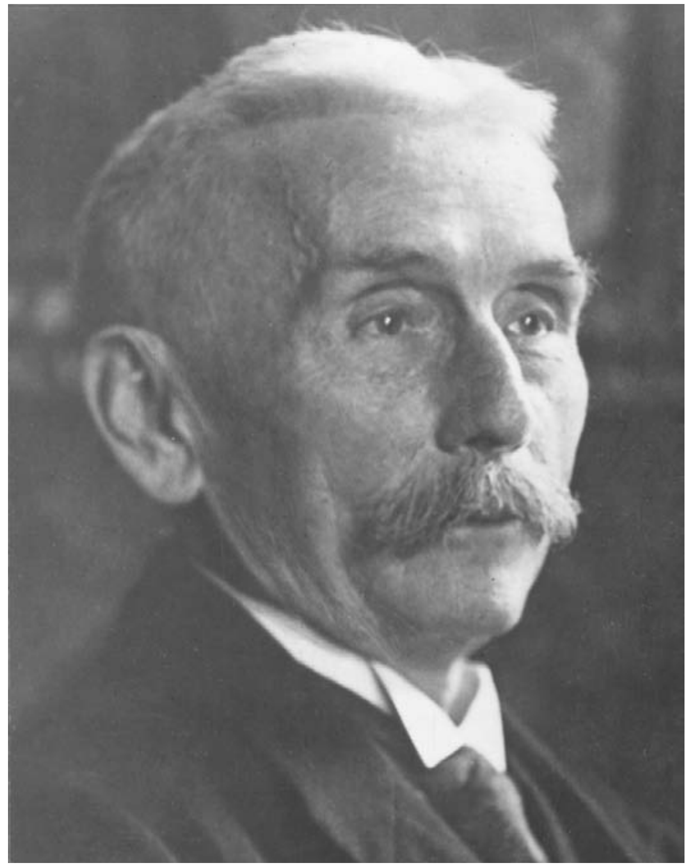
In 1846, Zeiss set up a small workshop in Jena to build and maintain scientific instruments and microscopes at the University. Like his successful contemporaries of the industrial revolution, Carl Zeiss recognized the importance of science, precision and mass production in the manufacturing process.

After Carl Zeiss died, Ernst Abbe became the owner of the company.



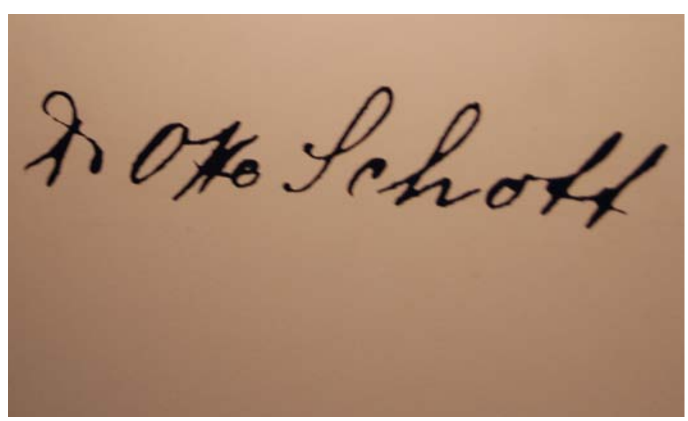


Ernst Karl Abbe (1840-1905), professor of mathematics and physics at the University of Jena, joined Carl Zeiss in 1866. He replaced the trial and error manufacturing process with a scientific approach based on math and physics. Abbe is remembered as a social reformer. In 1889, he restructured the company as a Foundation, and by 1900 established the 8-hour workday, minimum wages, medical coverage and pensions for all workers. His visionary social policies and recognition of the rights of workers led to the creation of the Zeiss Foundation, where all employees share, to this day, in the success of the company.

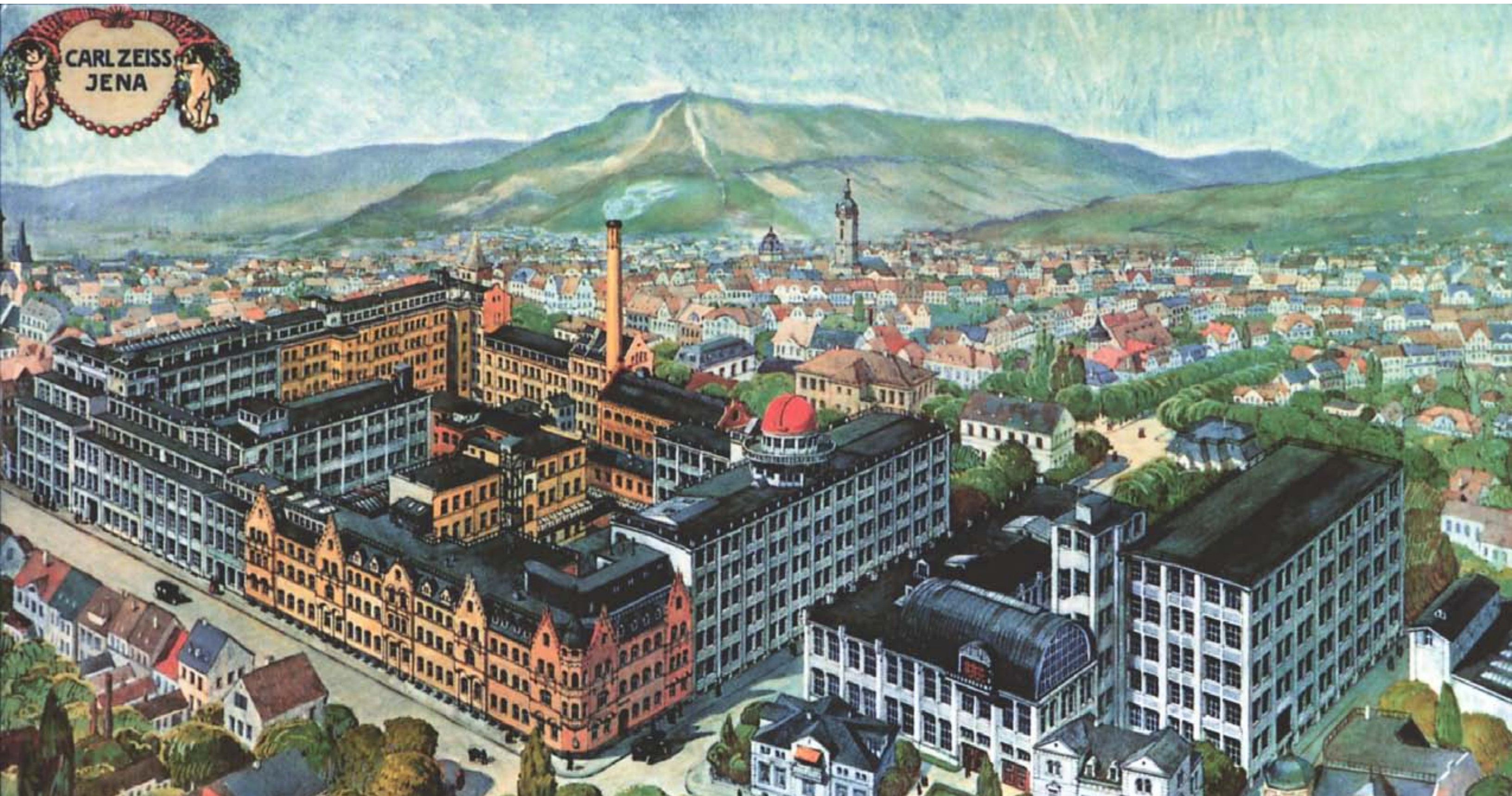


The third member of the Optical Triumvirate was Friedrich Otto Schott (1851-1935), son of a window glass maker, who received his doctorate in glass chemistry at the University of Jena. In 1884, he partnered with Zeiss and Abbe to found the optical glass-making factory Schott und Genossen.

Jena became one of the major centers of industrial optics, paralleling Leicester, England and Rochester, NY.



Jena: Today, 1850 and 1900


CARL ZEISS
JENA

ZEISS Cine Lenses are manufactured in Jena and Oberkochen.
Jena is about 260 km southwest of Berlin (2.5 hours).
Jena to Oberkochen is 358 km southwest (about 3.5 hours).
Oberkochen to Munich is 184 km southeast (2 hours).

If you go, use Google maps: maps.google.com
In the example above, A is for Jena for B is for Oberkochen.

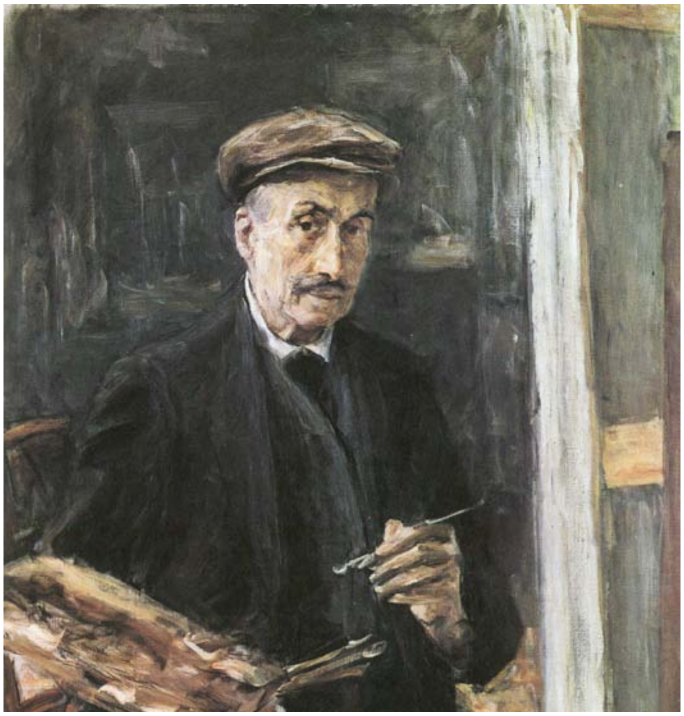
Below, right: The rounded rear of the Steigenberger Hotel Esplanade in Jena, seen from Intershop Tower observation deck. The Jena Optical Museum is across the street from hotel.

Steigenberger Esplanade
Carl-Zeiss-Platz 4
07743 Jena, Germany

Phone +49 3641 800-0
Fax +49 3641 800-150
www.steigenberger.com

Bottom, right: Scala Restaurant on top of Intershop Tower.

Cinematographers' Tour begins



Max Liebermann, self portrait. 1925.
112 x 890 cm. Oil on canvas. National Gallery, Berlin

Our Cinematographer's Tour of ZEISS begins in Berlin if we're flying in from far-off places. We'll rent a car, drive to Jena, then on to Oberkochen, and end in Munich.

I suggest spending a couple of days in Berlin, visiting the magnificent museums and impressionist Max Liebermann's beautiful villa. Stay at the historic Kempinski, and have dinner at Reinhard's in the hotel.

Try the "Secret of the Kaiserhof," a juicy steak whose sauce is almost as classified as the secret kitchen of Crustacean in Beverly Hills. The steak was a favorite of a regular customer, Max Liebermann, the same famous painter whose summer house we have hopefully just visited earlier in the day. Max Liebermann was a prolific artist, proponent of the German Impressionist movement, the avant-garde Berlin Secession movement, and became president of the Prussian Academy of the Arts. He was born in 1847, one year after Carl Zeiss set up his first workshop in Jena.

Rent a car from Sixt, and set the GPS for the Steigenberger Hotel Esplanade in Jena. It's an easy two and a half hour drive southwest on the Autobahn.

The Steigenberger Hotel Esplanade is in the center of Jena. It is modern, comfortable, and attached to a shopping center where you can purchase the toothbrush and toiletries you forgot in Berlin.

Room with a View

Make reservations at Scala Restaurant on the top floor of the Intershop office building two blocks away, and step onto the observation deck for a great view of Jena.

The restaurant is a block away from 32 Wagnergasse, where Carl Zeiss established his second workshop.

Impressionist view of Helmut Lenhof at Scala Restaurant, taken with a mobile phone camera that clearly could have benefitted from a ZEISS Lens.

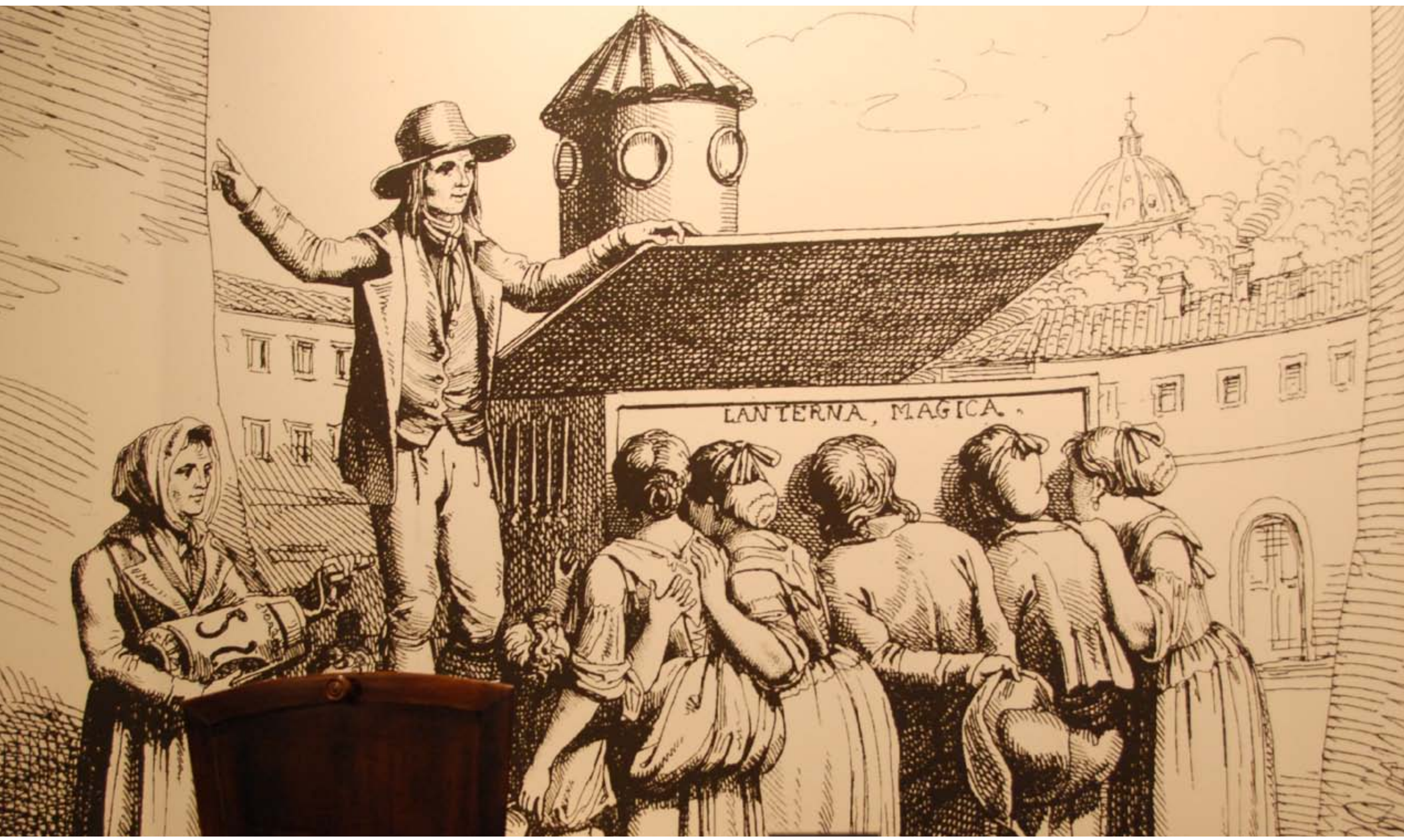
Carl Zeiss Workshop

From the Scala Restaurant, walk a couple of blocks to Wagnergasse.

Carl Zeiss' second workshop (from 1847 to 1857) was in this building, Number 32 Wagnergasse. It's now a musical instrument shop.

Above: Wagnergasse in foreground, with University and today's Zeiss factory in background.

CATOPTRICA.
2. DIOPTRICA.
3. MICROSCOPIUM.
4. LATERNA MAGICA.
Die Optic ist ein Künst, so Uns mit Aüg ünd Sehen
Aüf die ünd dise Weis mit vortheil lehrt ümgehen,
Wie inder Lüfft ünd sonst dürch lieber Soñen Krafft
In Farben, Schein ünd Glantz Gotts Wünderdinge schafft
Catoptric widergellt empfangne Soñen-Stralen,
Dioptrica auch den Schein im dünklen thüt bemalen,
Das Microscopium zeigt alles grösser an;
Das Magisch Liecht entwirfft vorüber jedermañ.



LANTERNA, MAGICA.

Jena Optical Museum

Jena is a company town. ZEISS, Schott and other optical companies are there. The city is clean and charming: perhaps a result of social welfare policies initiated by Carl Zeiss and Ernst Abbe—who shared profits with their workers.

Across the street from the Steigenberger Hotel Esplanade is the Jena Optical Museum. Call well in advance to schedule time to visit the replica of the 1860 Carl Zeiss workshop (*www.optischemuseum.de*). Five centuries of cinema, pre-cinema and optical devices are on display, as well as a remarkable display of etchings and art whose characters are shown with early lenses, glasses and telescopes.

What brought Carl Zeiss to Jena? The University. Zeiss was born in Weimar in 1816. From 1835 to 1838, he studied physics and optics at the prestigious, ancient and nearby (15 miles east) University of Jena. Karl Marx submitted his doctorate three years later.

In 1846, Zeiss set up a small "mechanical-engineering workshop" in Jena, mostly to build and maintain scientific instruments at the University. In 1847, he moved to a second workshop at Number 32 Wagnergasse. Business was good: all those medical students, botanists, biologists and scientists at the University of Jena needed microscopes.

By 1866 he had sold 1000 of them. It was a tedious, trial-and-error process assembling the optical elements, but that was the current state of the art.

The company that would later grow to over 30,000 employees was still small. Carl Zeiss supervised the small workforce from his office perch, with its interior window onto the workshop. The workers were mostly young men with good eyesight and steady hands, often grinding lenses by candlelight.

Enter Ernst Abbe, a tutor in math and physics at the University. Abbe was born in 1840, 60 miles west of Jena, in Eisenach, to a poor family. His father worked in a textile mill, often sixteen hours a day, without break. In 1857, he arrived at the University of Jena. There were 382 students at the time.

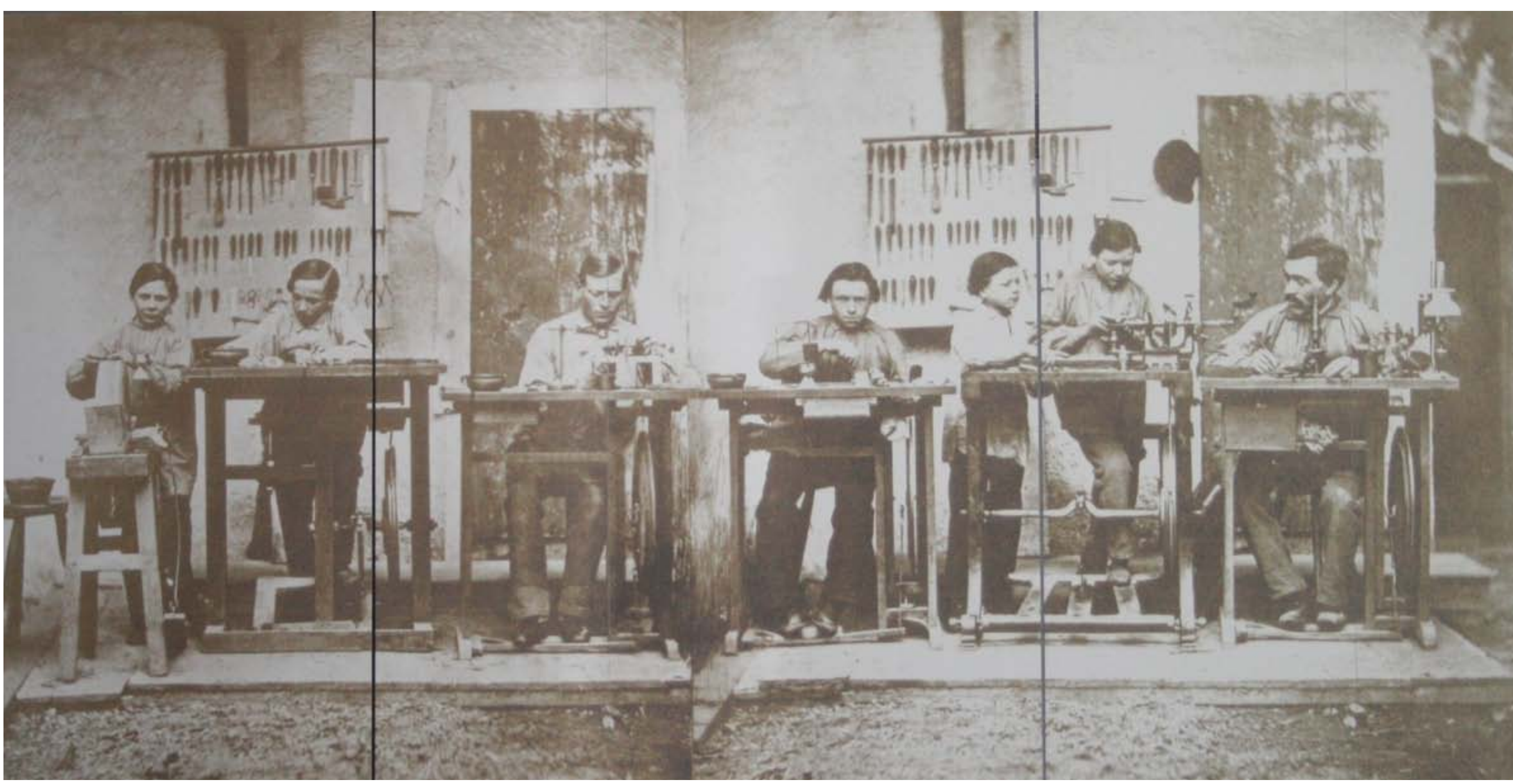
Abbe joined Zeiss in 1866, applying research and science to the art of lens grinding and pairing. After extensive research, his theories on microscope image formation and diffraction of light contributed not only to the field of optics but were major influences on the later development of camera lenses.

At ZEISS, Abbe developed measurement and test instruments, including thickness gauges, refractometers, and spectrometers. As a famous manufacturer said, "if you can't measure it, you can't make it."

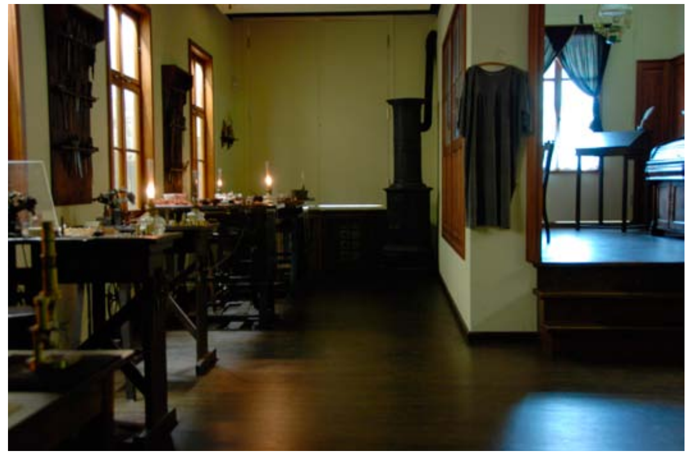
The original optical workshop was lit to a level of five candle power: five candles on the workbenches lit the room, which could not rely on sunlit windows during long, dark winters.

In fact, the workers in the photo, below, had to move their work stations onto the street in front of number 32 Wagnergasse because it was too dark inside for a properly exposed photograph.

The replica of Carl Zeiss' workshop is meticulously recreated in the Jena Optical Museum. Advance reservations are required, and it is well worth the trip.



Replica of Carl Zeiss Workshop



Top group of four large pictures, clockwise, from Upper Left: 1. Entrance to replica of 2nd Zeiss workshop. 2. The workshop as it would have looked in 1860: Carl Zeiss's perch overlooking workers from his office. 3. Cutting, grinding and polishing of lens elements. 4. Location of workshop at 32 Wagnergasse is marked by a plaque. The workshop has been moved to the museum.

Bottom Left: One of the microscopes from the Zeiss workshop. Bottom Right: polishing optical elements.

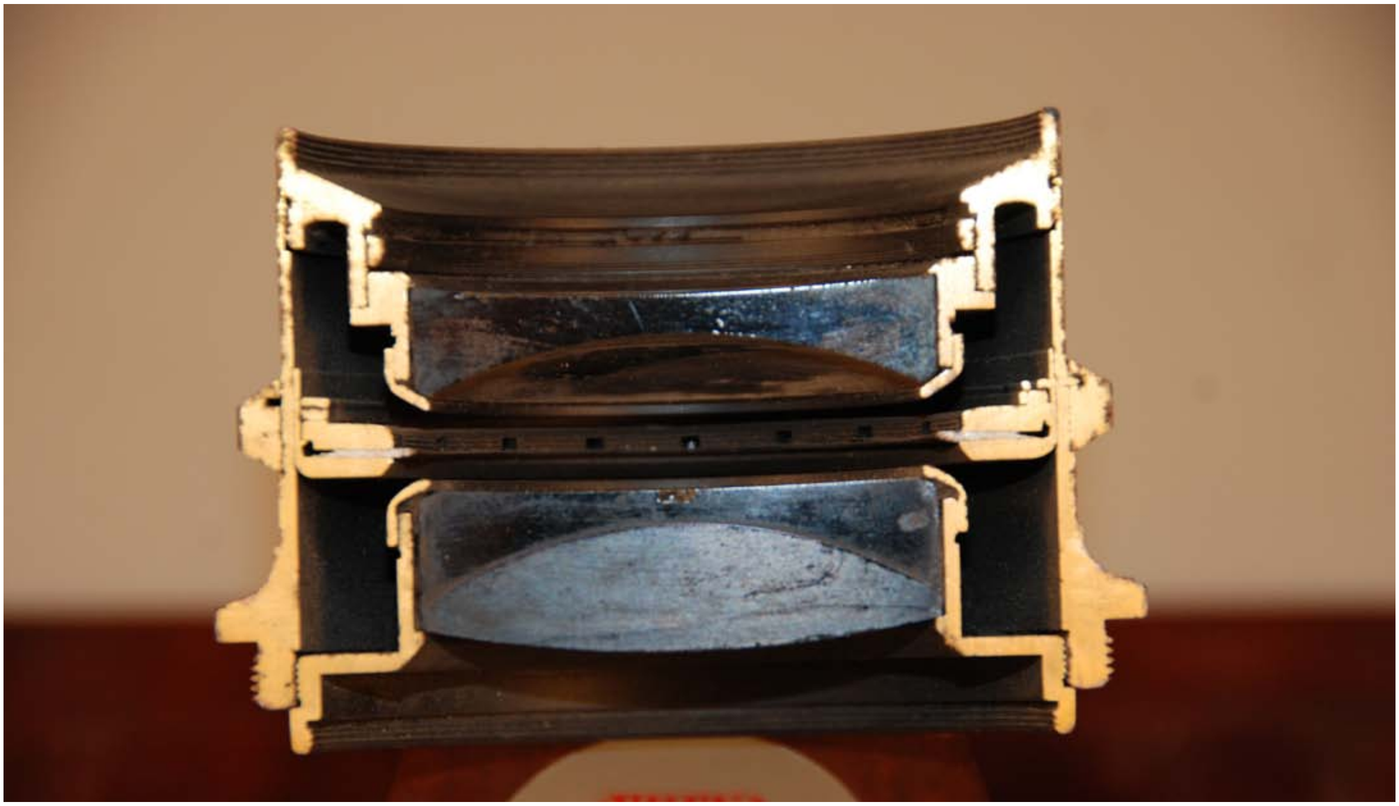
Microscopes to Camera Lenses

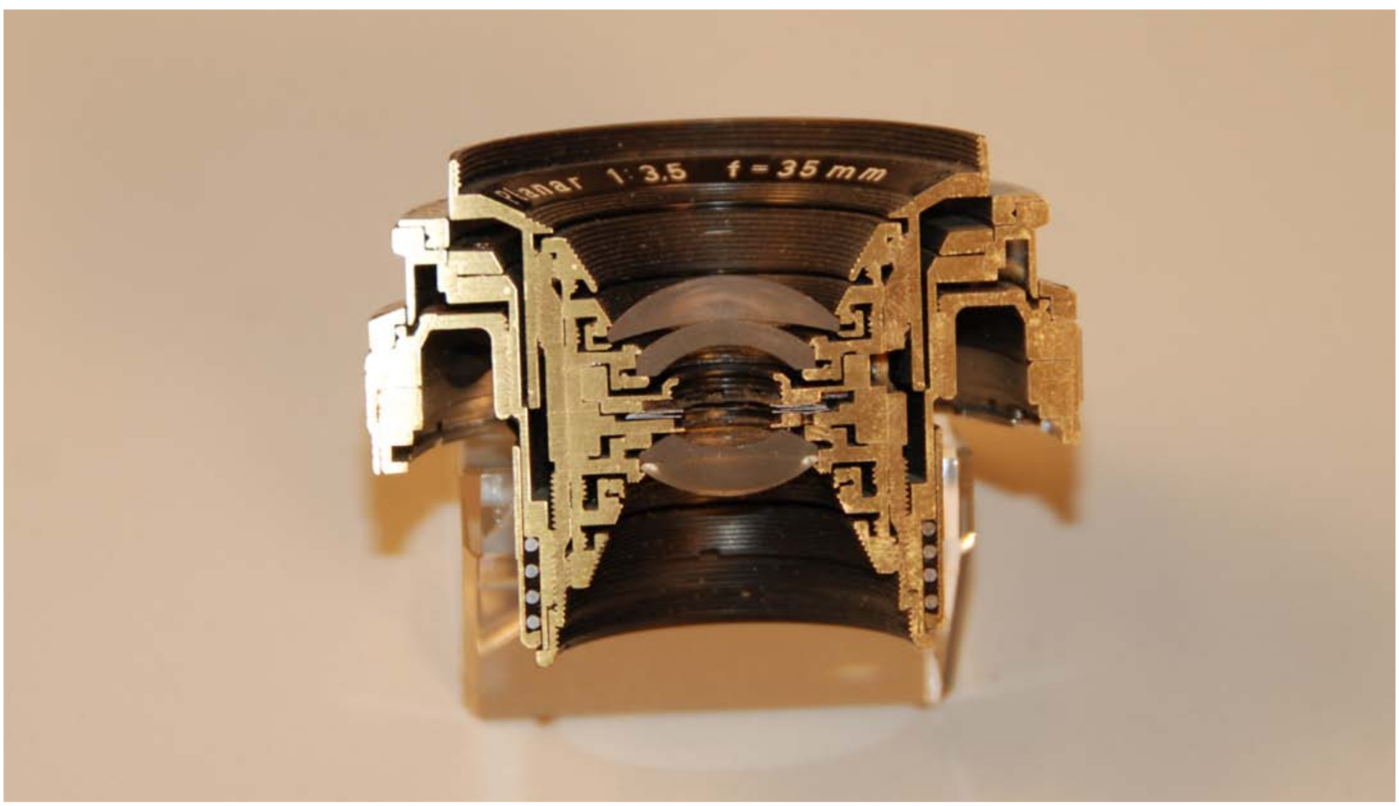
A worldwide banking crisis followed the "panic of 1873" (history repeats itself: bank failures, stock market crashes, businesses closing, economic depression). Ernst Abbe, astute businessman as well as brilliant scientist, saw the need to diversify the ZEISS product line, which had, up until then, focused almost exclusively on microscopes. The first steps of a Camera Lens Division were taken in 1888 and completed by 1890. Carl Zeiss scientist Paul Rudolf designed the Anastigmat in 1890, and the four-element Planar in 1896.

Abbe was an extremely successful entrepreneur. In 1862, 25 people worked at Carl Zeiss, generating revenues of 12,618 marks. In the year of Ernst Abbe' death, the enterprise had grown to just under 1,400 employees, with revenues totaling over 5 million marks.

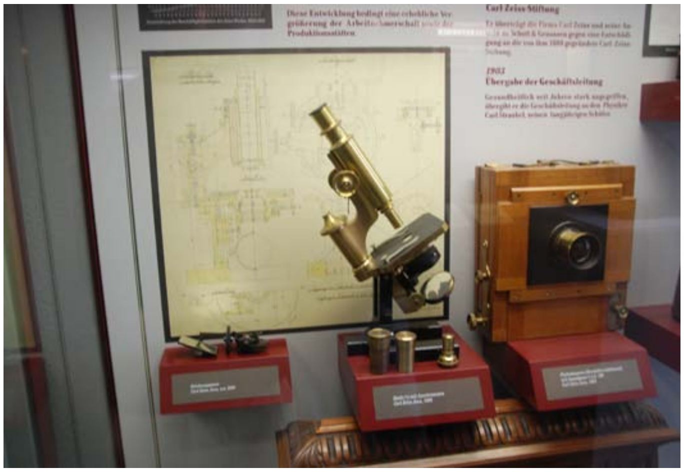
Abbe was a courageous reformer who was far ahead of his times with his socio-political ideas. In order to safeguard the existence of the companies Carl Zeiss and SCHOTT irrespective of personal ownership interests, Abbe founded the Carl Zeiss Foundation in 1889 and made it the sole owner of the ZEISS works and part owner of the SCHOTT works in 1891 (in 1919, Otto Schott also transferred his shares in the glassworks to the Foundation).

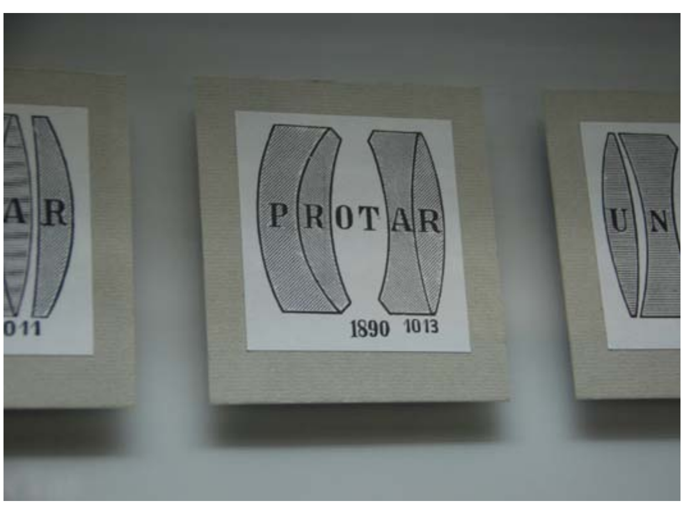
With his foundation statutes of 1896, Abbe gave the enterprise a unique corporate constitution. In addition to revolutionary stipulations on corporate management and legally enshrined labor relations, the constitution reflected Abbe's high degree of social commitment. Some examples include co-determination rights for the employees, paid vacation, profit-sharing, a documented right to retirement pensions, continued payment of wages in the event of illness and, from 1900, the eight-hour working day. This made the foundation companies Carl Zeiss and SCHOTT forerunners of modern social legislation. Abbe's amazing creative power is impressively underscored in his numerous inventions and in his many publications on scientific, entrepreneurial and social issues.

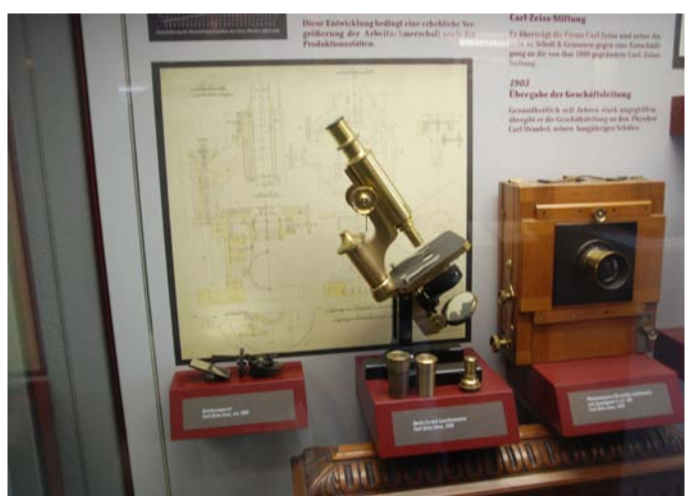



Planar 1:3,5 f = 35 mm

Jena Optical Museum







Oberkochen Optical Museum

Oberkochen also has a fine optical museum in the lobby of the headquarters tower.

A Tale of Two Cities


50

Carl Zeiss Jena

Jena is about 4 or 5 hours north of Munich, in central Germany, on the river Saale. With a population of 102,494, it is the second largest city in the state of Thüringen.

This is where Carl Zeiss set up his optical company in 1848.

The metropolitan area of Jena is among Germany's 50 fastest growing regions, with many internationally renowned research institutes and companies, a comparatively low unemployment, and a very young population structure. Jena was awarded with the title "Stadt der Wissenschaft" (city of science) by the Stifterverband für die Deutsche Wirtschaft, the German business association, in 2008.

Jena is headquarters for microscopy and planetariums, optical and mechanical manufacturing, component assembly, lens polishing and grinding, receiving of optical elements, and finishing. It has a research center.

About 1500 employees work in Jena; 4000 in Oberkochen

One third of all cine lenses come from here, all under 300mm. Grinding, polishing and most of the big machining is done here, in Jena. Tthe plant in Jena is a few blocks from the famous University and next to the Carl Zeiss Planetarium.

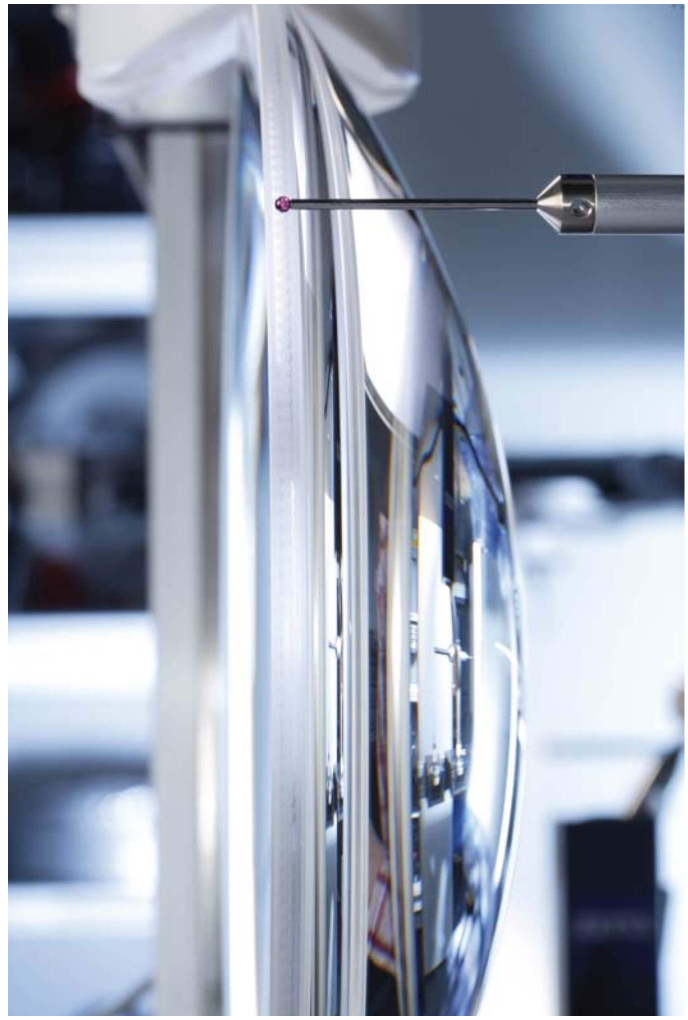
Carl Zeiss Oberkochen

Oberkochen is about 2.5 hours northwest of Munich. It is a company town in the Ostalbkreis, in Baden-Württemberg, Germany. About 2,000 people live in this picturesque village, which is the headquarters of Carl Zeiss AG.

Cine lenses are completed here, along with assembly, calibrating and testing. Oberkochen is also home to R&D as well as environmental testing.

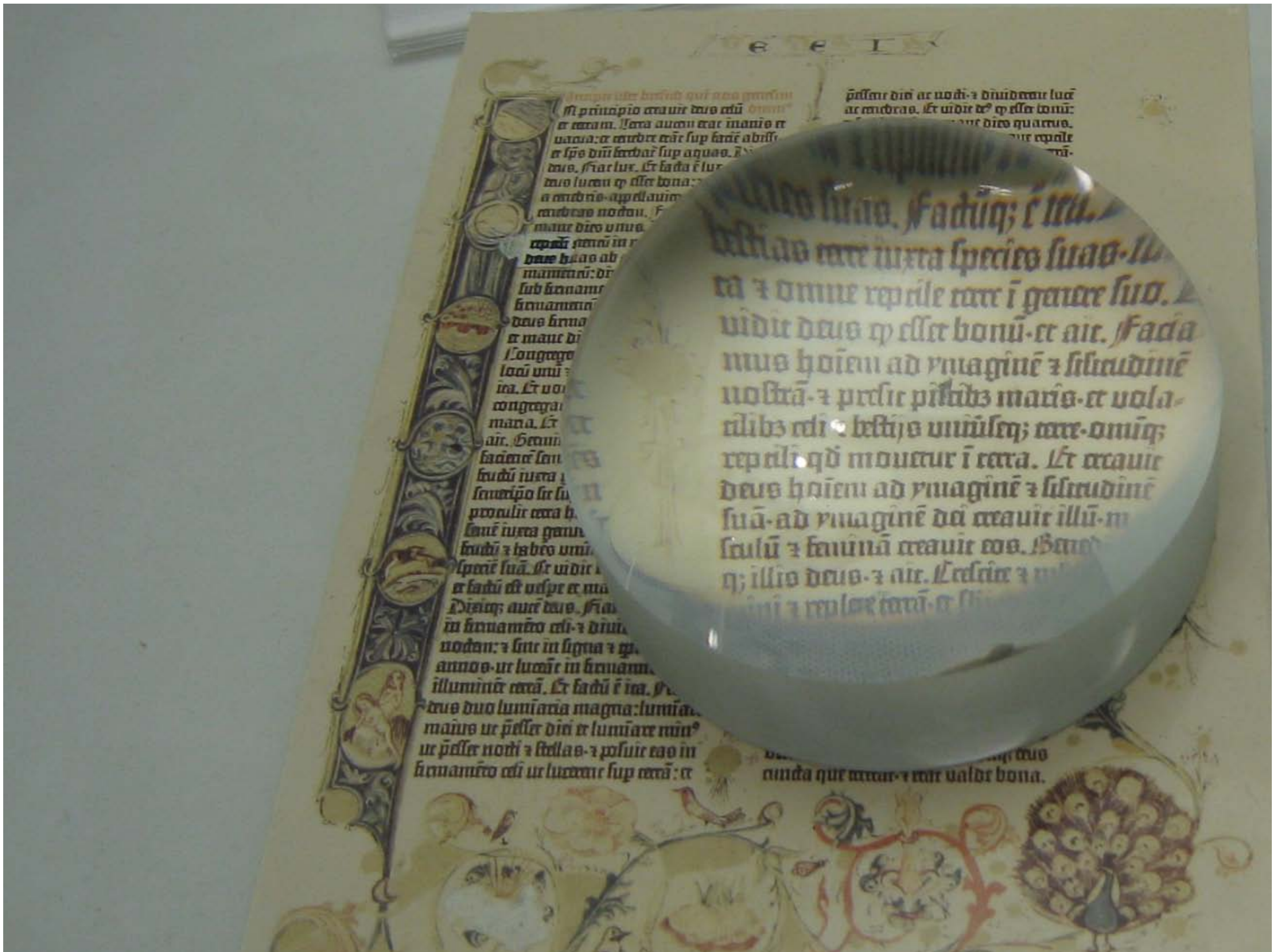
It is also the location of the new microchip fabrication plant.


ZEISS
ASML Lithography



Carl Zeiss Semiconductor lens. 870 kg. at left

Building a ZEISS Cine Lens



13th century Reading Stone

Let's learn how to build a ZEISS Cine Lens.

Actually, we'll let ZEISS do the building, because the more we find out about lens design and manufacture, the more we appreciate the elegant art and optical, mathematical and physical science at work in the two cities of Jena and Oberkochen.

A cine lens is a collection of glass elements, painstakingly cut, precisely ground, polished and coated, held in a complex mechanical (and sometimes electronic) aggregation of movable groups to maintain focus, aperture and frame size.

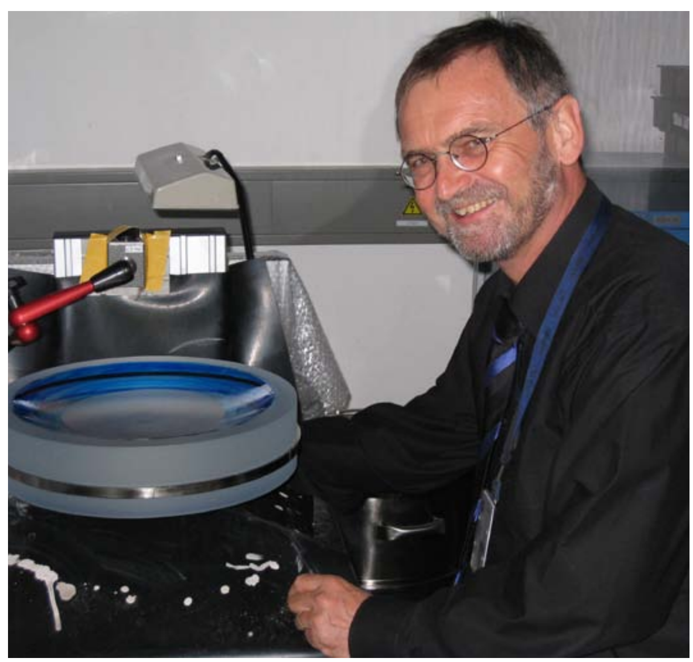
The "Reading Stone, " a 13th century Magnifying Glass in the ZEISS Optical Museum at Oberkochen, shows what happens when one surface of a glass block is ground and polished into a curve. The art of lens design is the math and physics of calculating flat, concave or convex combinations, distances, coatings, and countless variables conspiring to make your image either sharp, brilliant, flared or flawed—and then being able to turn those calculations into practical precision assemblies of glass, brass, steel, or composite.

It's common for lens designers to say that every lens is a compromise—the result of discussions, dialog and debate between cinematographers and rental houses, product managers and designers, scientists, accounting and finance analysts and marketing departments. An optical design may look good on paper or as a computer-generated model. However, the finished production lens will be the result of carefully considered compromises on speed, size, weight, performance and cost. If you want your lens to be faster, it's going to be bigger. But if you want to use it for handheld or Steadicam, it has to be lighter. What happens when lighter costs more?

Of course, if cost is no object, you don't have to compromise. Few compromises were made building the world's largest and possibly most expensive consumer lens, the one-off ZEISS Apo Sonnar Apo Sonnar 4/1700 (f/4 1700mm, opposite, top) with 15 optical elements in 13 groups, electronic temperature compensation, and a special vehicle to move it. Or, if you are someone like Stanley Kubrick, you might be able to call up and have an f/ 0.7 prime made for "Barry Lyndon.".

Holger Sehr, Product Manager Cine

That's a Hasselblad hanging off the end. The Apo Sonnar 4/1700mm lens covers 2¼x2¼ medium format. With 15 optical elements in 13 groups, it is being built as a one-off, special order for a client who wants to photograph a rare animal on the verge of extinction. A South African colleague speculates this lens could be used to photograph the elusive Oryx Antelope, also known as Gemsbok.

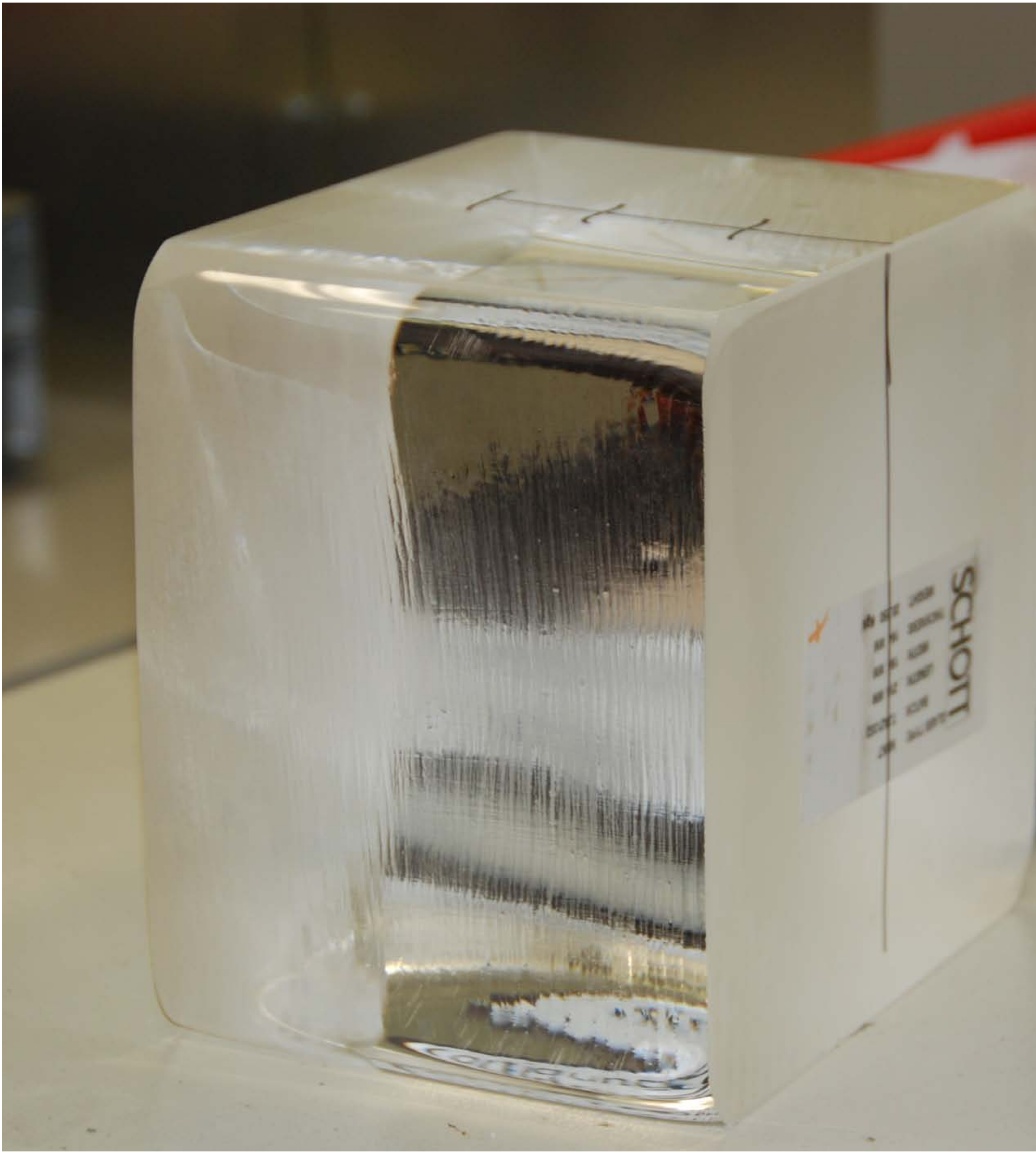


Dr. Winfried Scherle *(above)* with one of the 55 pound (25 kg) internal optical elements of the 4/1700 ZEISS Apo Sonnar.


Filmebene
22,8
Kleinstmaß
1,5
Planar 1:0,7 f=50 mm
715
Maße ohne Toleranzangabe
mittel
DIN 7168
1967
Tag
Bearb.
3. 8.
Gepr.
Norm.
Name
Zn.
Planar 0,7 / 50
10 21 08 (Ang 1)
Ersatz für
Ersetzt durch
CARL ZEISS

Kubrick f/ 0.7

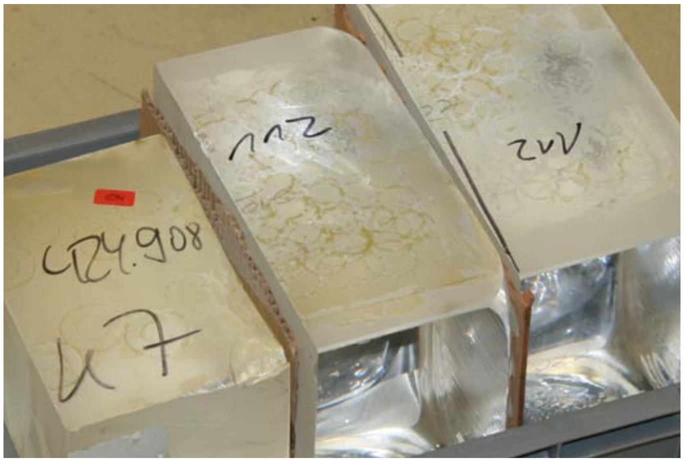
It starts with a block of glass



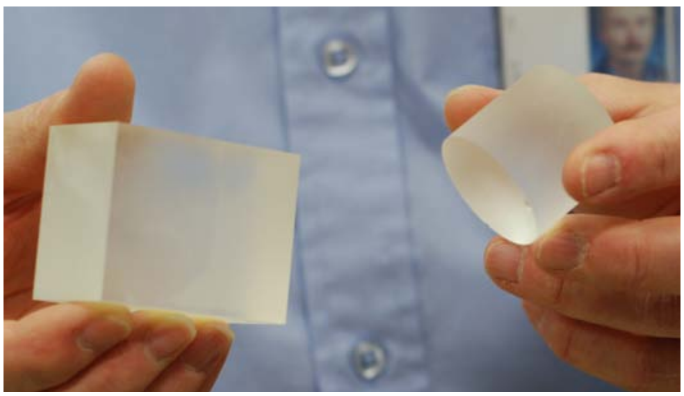

Carl Zeiss Jena

Computer-Controlled machines cut the big glass blocks down to size—about 10mm larger than the finished element. The glass is first cut into smaller rectangles. Next, the rectangles are rounded into cylinders.

Once the blanks are shaped to approximate diameter and thickness, the fine task of grinding and polishing begins, in two different processes: spherical grinding—where the curve of the lens is constant, and aspherical grinding, where the curvature is nonlinear. Both processes will be accurate to 1 micron. Some elements, especially smaller ones for eyepieces, are pre-ordered and pre-cut to approximate dimensions (bottom, right). Master Prime and DigiPrime lenses may contain up to 21 of these optical elements.



Glass comes from Schott and Ohara



The big blocks of glass are cut down to roughly the sizes needed for the optical elements.

Once the blanks are shaped for approximate diameter and thickness, the fine process of grinding and polishing begins, in two different processes:

spherical grinding--where the curve of the lens is constant, and asperical grinding, where the curvature is carefully shaped, accurate to 1 micron.

Spherical Grinding and Polishing

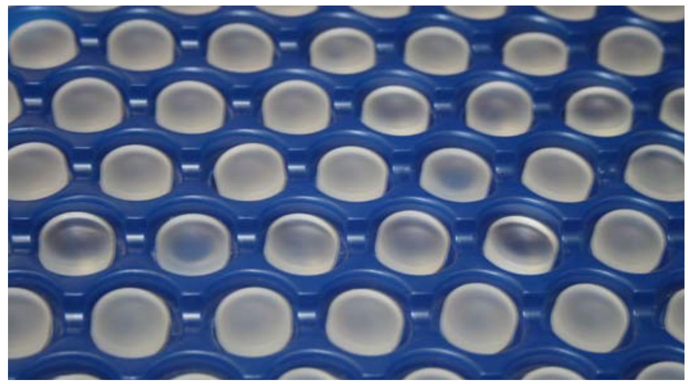
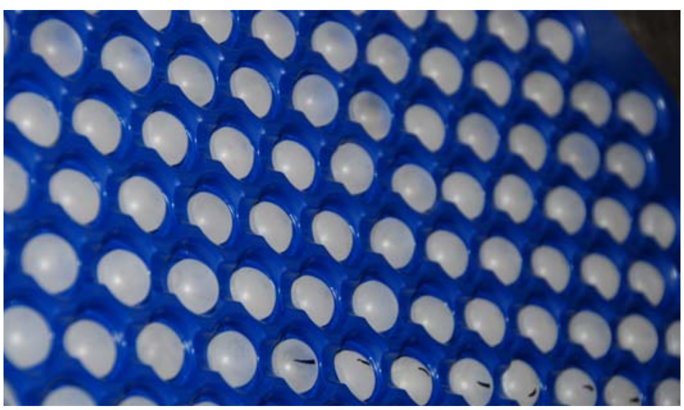
The first polishing cycle begins, using a coarse slurry of abrasive minerals in a chemical suspension. CNC (Computerized Numerical Control) machines are used. The next second step is done with a much finer polish. The "workflow" is: grind, measure, polish, measure, fine polish, assemble, test, finish and pack. After the polishing process every element is measured with interferometry lenses from Carl Zeiss to check image quality, tolerance, and uniformity as well as to reveal any lingering spherical and aspherical aberrations.
To see how polishing with an abrasive makes glass clear, scratch a piece of plexi with something rough. Then rub the scratches with a whitening toothpaste, and watch the scratches disappear.

High tech CNC machines

and still a lot of precision, highly skilled work by hand.

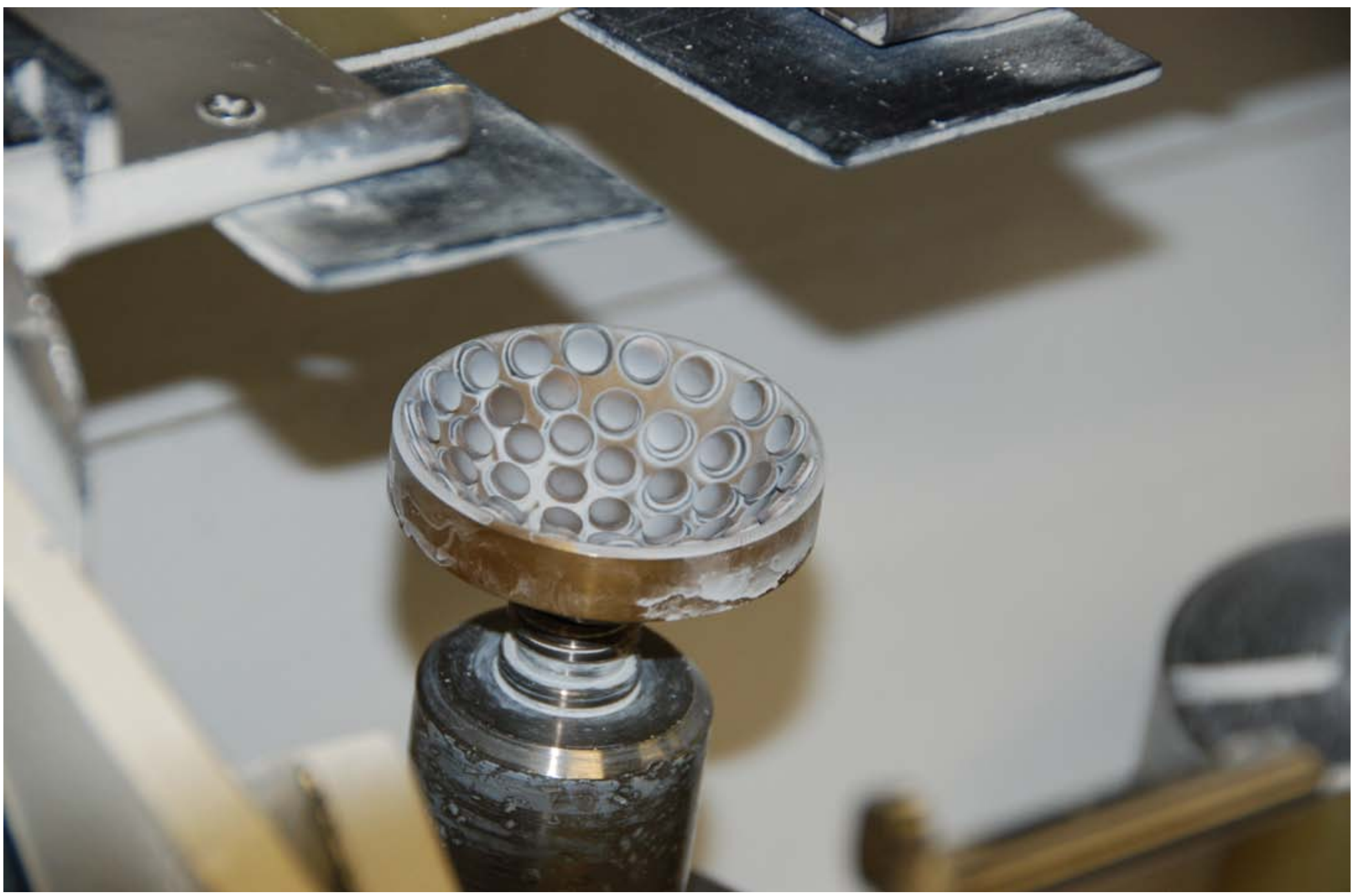
checking and re-checking

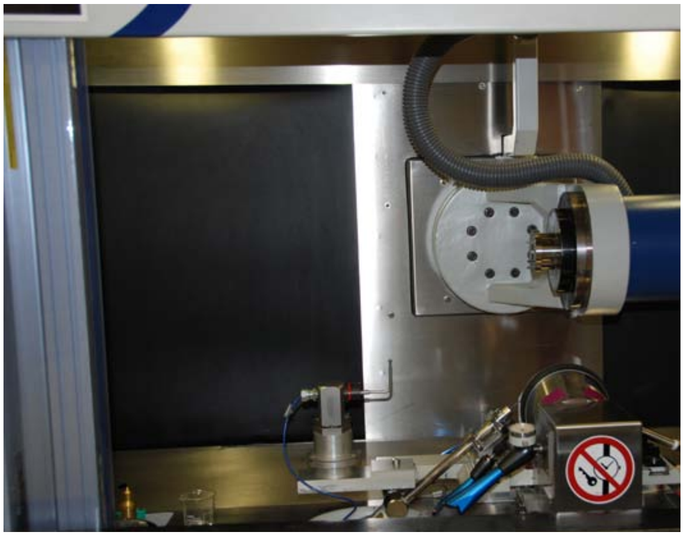


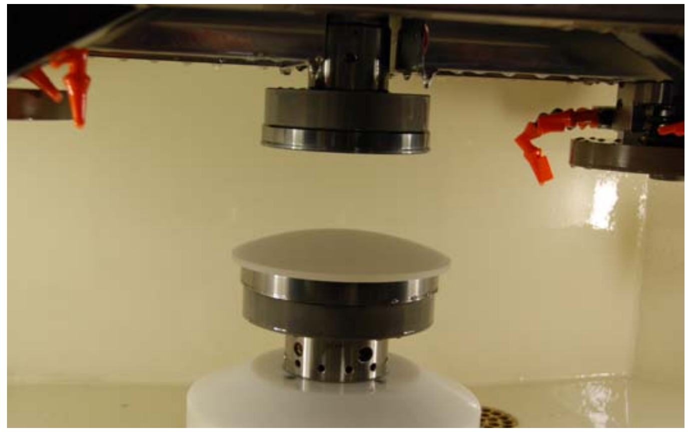




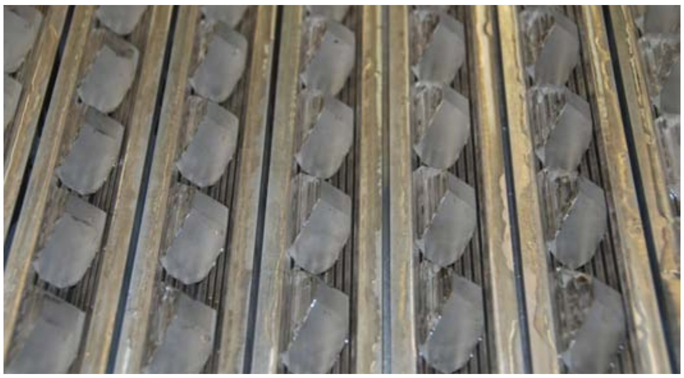


CM-2 SL

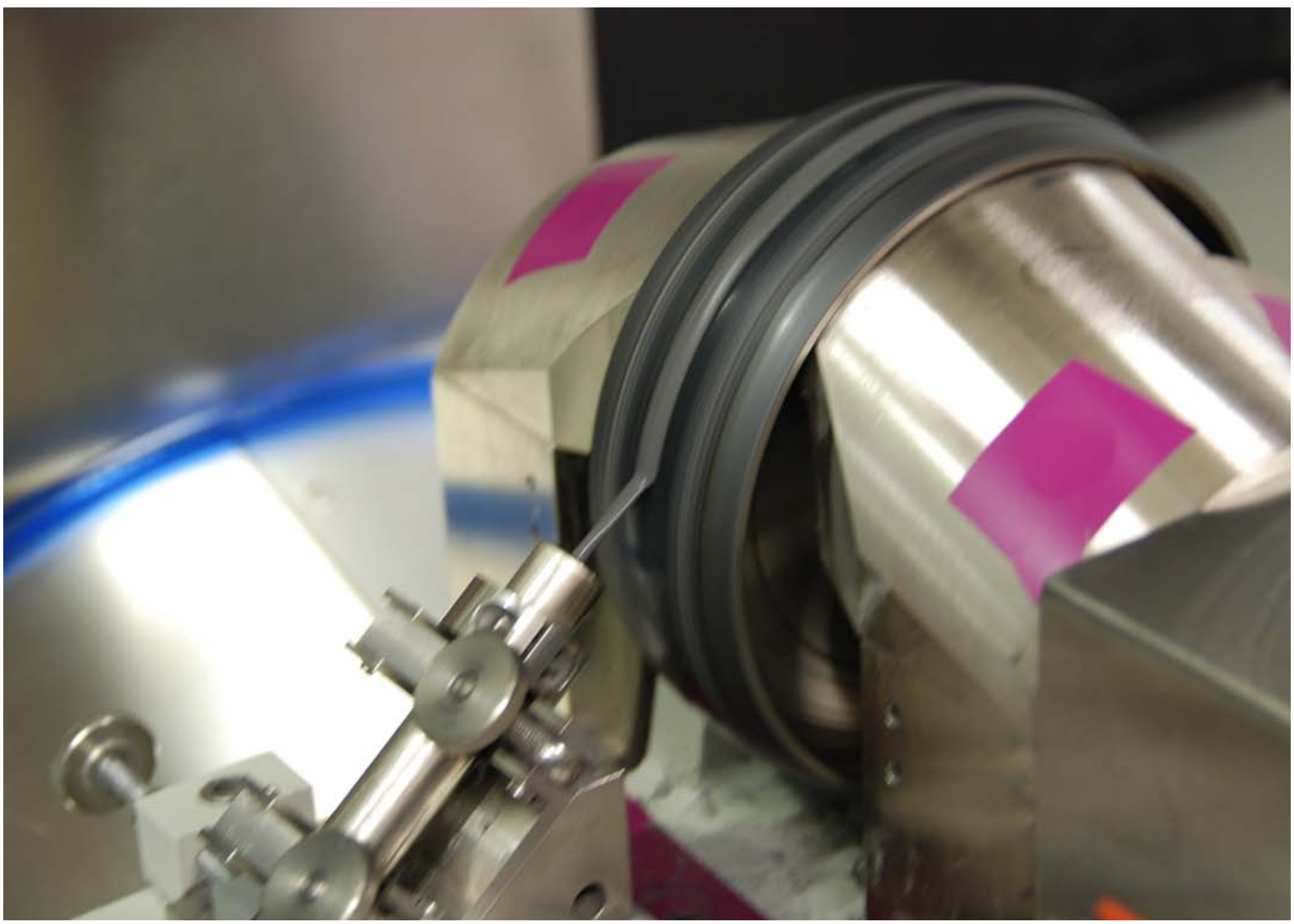




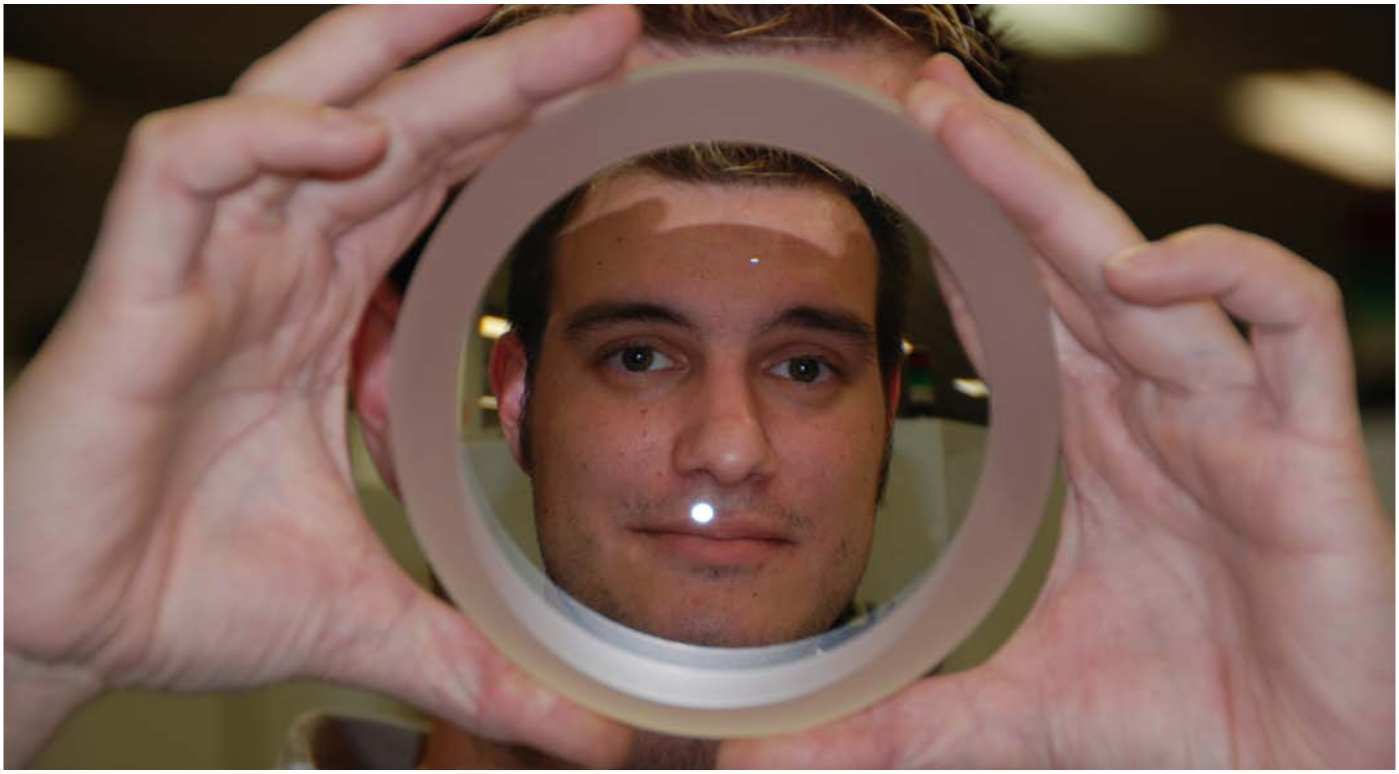


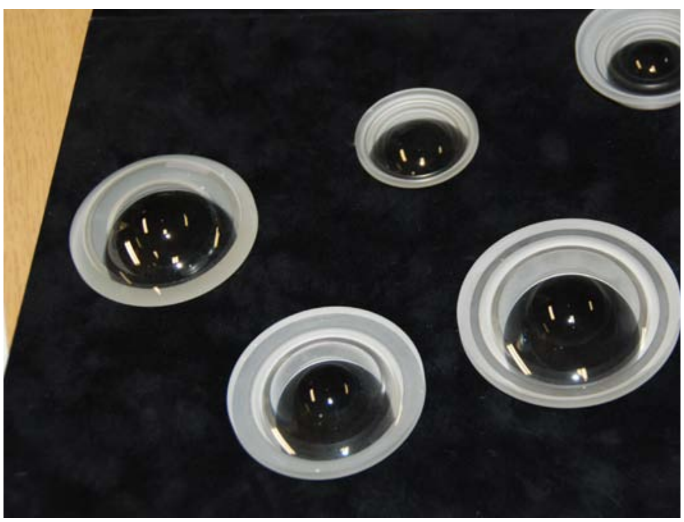


Magneto-Rheological Polishing

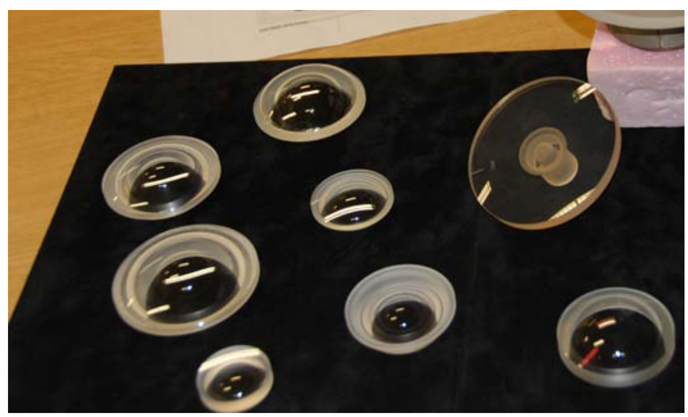


Aspherical Grinding and Polishing

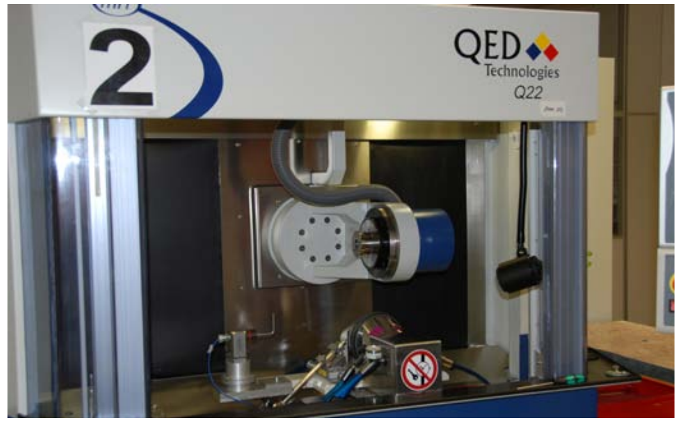




Aspherical grinding takes 1 to 20 hours per element, getting it to an accuracy of 1 to 3 microns.

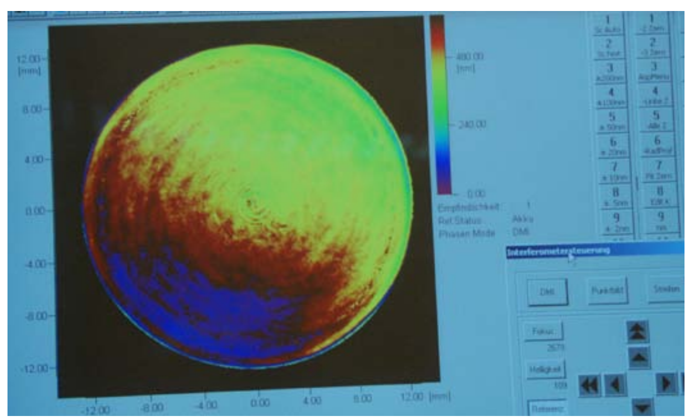


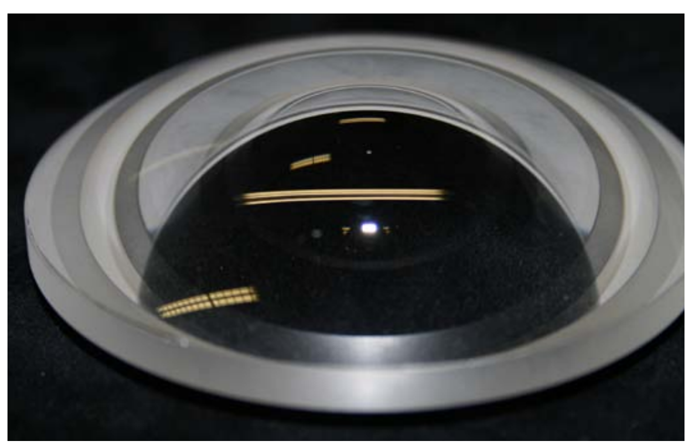
Aspherical Grinding and Polishing



Aspheric elements are crafted by a specialized team in Jena. Aspheric cine lenses include Ultra Prime lenses from 8 to 300mm, Master Prime lenses 14 to 150mm, Ultra 16 from 6 to 50mm, Master Zoom, Lightweight Zoom, DigiPrime 3.9 to 135mm and DigiZoom 6-24 and 17-112mm lenses. Aspherical grinding takes 1 to 20 hours per element, to an accuracy of 1 to 3 microns. *Above:* QED Magneto Realogical Finishing.

Over 400 aspheric lenses are made each month on 20 machines, in three 8 hour shifts. A computer generated hologram is used for precise interferometer testing; each optical surface is checked for any deviations beyond 1 micron. This technology is a benefit of experience with SMT lenses for computer chip fabrication. *Below*: the computer screen image when testing the optical element's surface with an interferometry lens from Carl Zeiss.





On to Oberkochen

Oberkochen is about three and a half hours southwest of Jena.

The better part of the trip has been devoted to entering our destination into our rented car's GPS.

After stops for paper maps and pretzels, we pull into a scenic overlook to get our bearings. In the beautiful valley below is ZEISS and Oberkochen. There's a sign "Limes Thermes," and suddenly it's high school Latin and Roman history. "*Gallia est omnis divisa in partes tres,*" all Gaul is divided in three parts.

We're a few miles away from Aalen, the largest cavalry outpost of the Roman Empire along the *Limes Romanus* of the province of Raetia.

By the second century A.D., Roman protective walls stretched 5,000 kilometers from Britain (Hadrian's Wall), through Europe, around the Mediterranean and across North Africa.

The Upper Germanic-Rhaetian Limes border stretches about 550 km between the Rhine and Danube Rivers. It consisted of Roman defensive fortifications with ditches, ramparts, palisades, walls, towers and forts, and is one of the largest archaeological monuments in Central Europe.

It was a major part of the Roman defensive strategy, and analogies can certainly be made with current United States policy on its southern border.

The Roman army headquarters at Aalen has been excavated and restored in a museum. Hot springs in the area provided floor heating. Hot air was blown through the space between the little columns that supported the floor.

The ruins, towns and museums are on the world cultural heritage list of UNESCO. You can rent a bike and ride the 900 km long bike trails, visiting Roman sites, or you can soak your jetlagged body in the spa at the Ramada Hotel Limes Thermes, in the same baths used by Roman generals almost 2,000 years ago.

Assembly in Oberkochen

160 years after Carl Zeiss opened his workshop the company is now the largest optical manufacturing company in the world, making eyeglasses, lenses for the semiconductor industry, coordinate measuring machines, telescopes, planetariums, mapping, and health care products. In addition to lenses for Hasselblad, Nikon, Canon, Sony, and about 20 million cell phones, including Nokia, ZEISS still finds time to make high end lenses for analog and digital cinematography.

Although most products are marketed directly by ZEISS in their 150 locations worldwide, camera lenses are sometimes sold by their strategic partners. Therefore, some ZEISS PL mounted motion picture lenses are marketed by ARRI, while others are handled by ZEISS.

B4 mounted lenses for ⅔ inch digital cameras were developed with Band Pro, who partnered with ZEISS in the design, development and worldwide marketing. Over 1000 DigiPrime and DigiZoom lenses have been sold since their introduction in 2002.

Coordinating lenses with companies and cameras is Dr. Winfried Scherle, along with Christian Bannert, Holger Sehr, and Helmut Lenhof. At ARRI, Marc Shipman-Mueller is Product Manager Cameras & Lenses . Marc travels the world talking with cinematographers and crews about their needs and wishes.

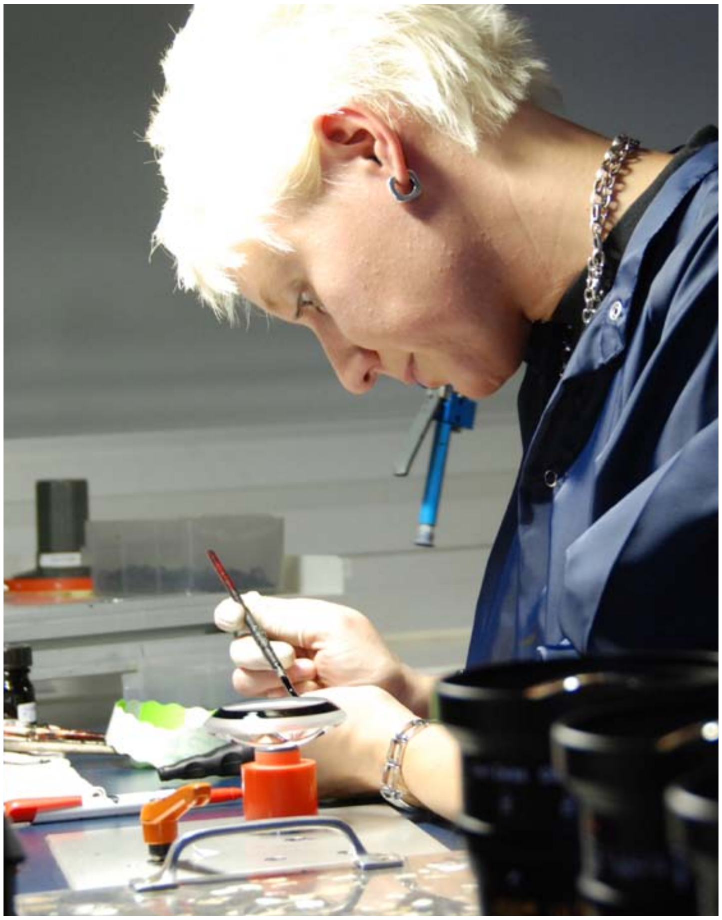
Oberkochen is home to the design department. A concept took shape in Munich, Burbank, Shepperton Studios or wherever else user feedback and technical input to provided the designers at ZEISS the parameters and wish lists for a new lens. When Marc Shipman-Mueller *(above, right)* calls you up and asks what Master Prime you cannot live without—those comments go to Helmut Lenhof, Project Manager Cine, *(above, left)*, Christian Bannert, Senior Director Product Development *(above, center),* Holger Sehr, Prduct Manager Cine, and many others who will guide the lens design.

For film and digital motion picture lenses, ARRI and Band Pro partner in the development, marketing and sales; ZEISS does the design, implementation and manufacturing.

With concepts developed for the SMT semiconductor division, cine lenses are now built faster than ever. A new assembly paradigm means that some lenses can be put together in a day.

Many procedures require the attention of highly skilled technicians. *On the facing page,* optical surfaces are covered with a blue protective layer while the edges are polished and painted with a special black lacquer that prevents internal reflections. The blue coating is then removed, and the elements are assembled in a clean room.

After grinding, polishing, and treating with special anti-reflective coatings, the optical elements and mechanical housings are delivered by truck from the ZEISS plant in Jena to headquarters in Oberkochen for assembling, finishing, testing and packing.

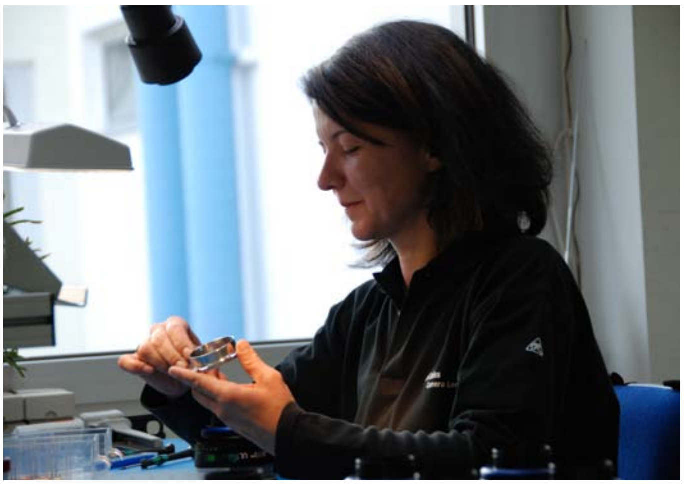


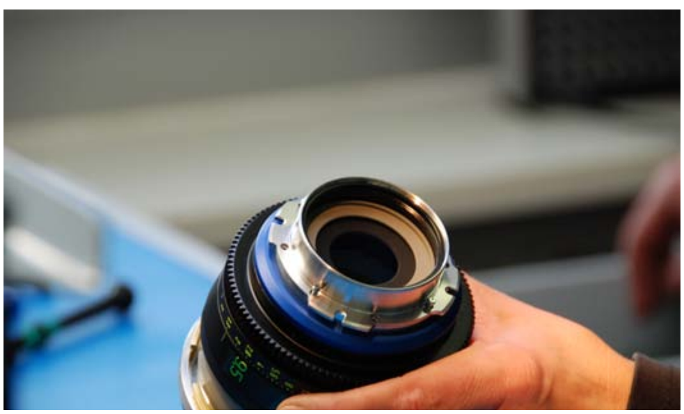
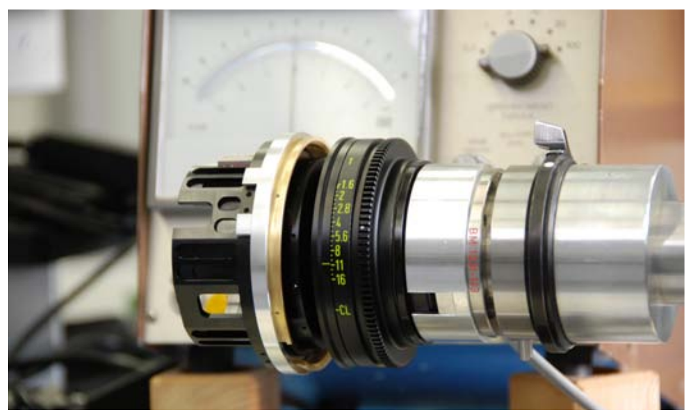
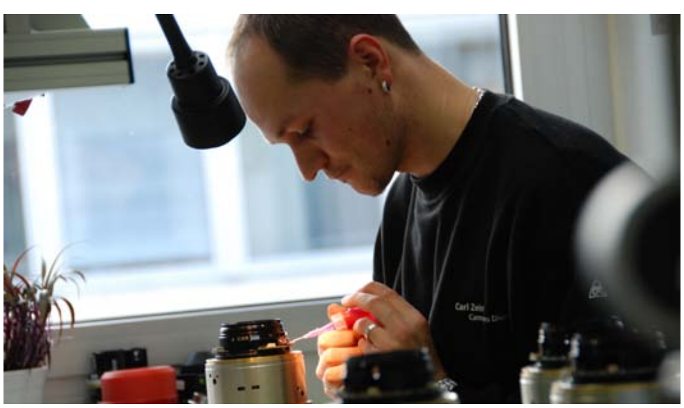
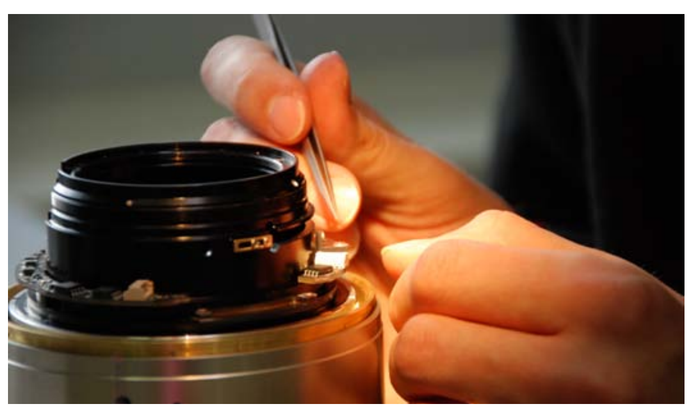






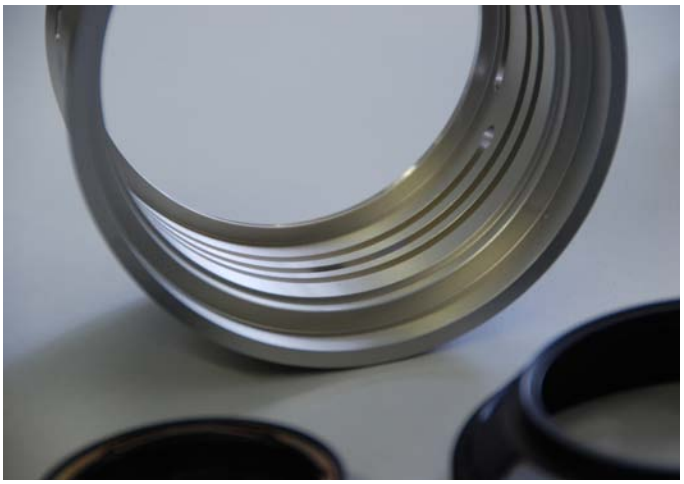


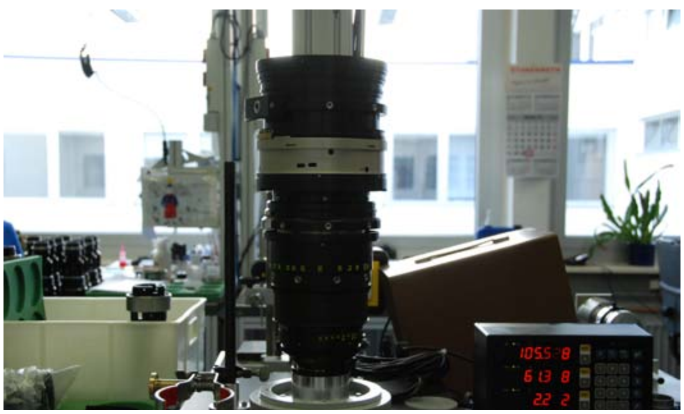




15.5 - 45
ARRI

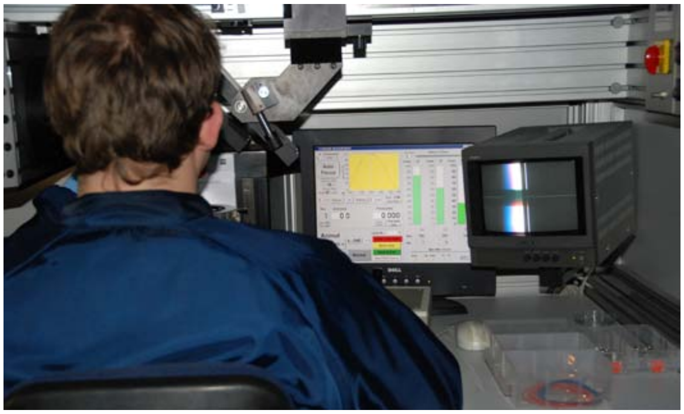

65
ARRI
ULTRA PRIME

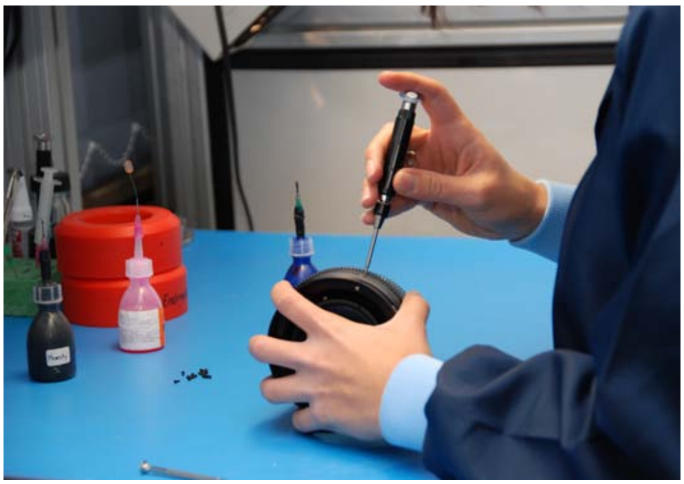





5.5-45
Lightweight Zoom


Carl Zeiss
Camera Len

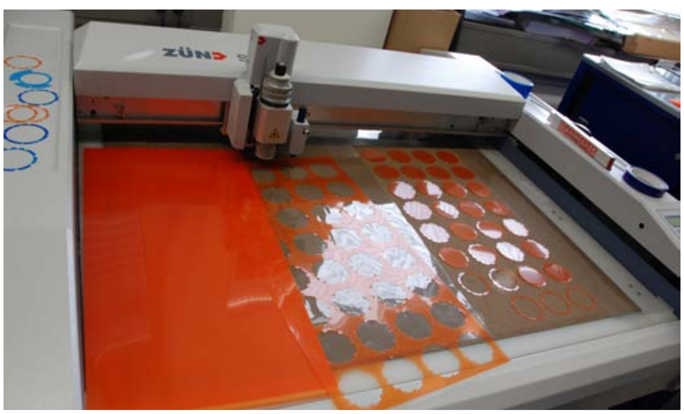








28
Carl Zeiss

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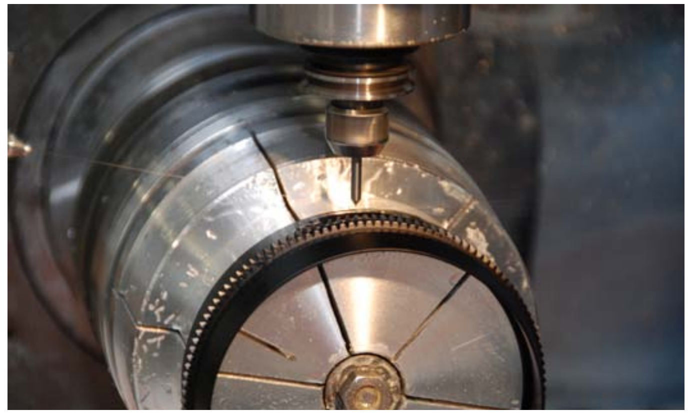
Calibrating Focus Marks

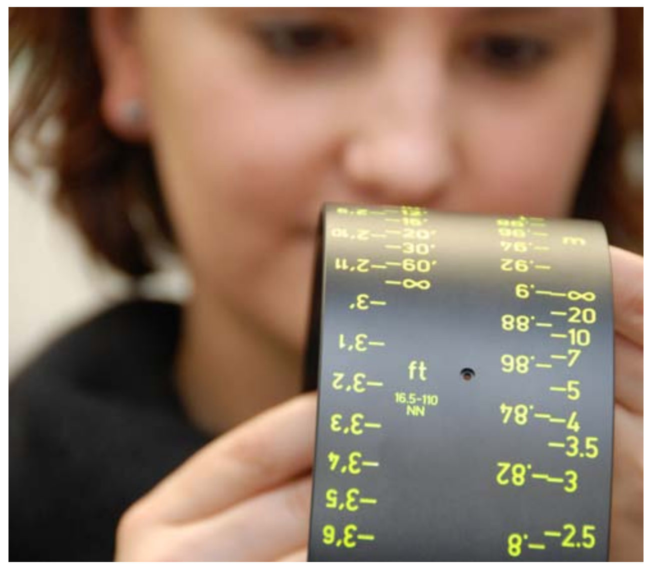


Cinematographers and camera assistants might be interested in the way ZEISS calibrates focus marks.

Once the lens is assembled, it is checked and double-checked for centering, tracking and focus with MTF test equipment.

Next, the precise focus scale is determined and matched.

The scales come in feet or meters, and are identified with a letter. If you're shooting 3D, it's helpful to get lenses with matching letters. After final testing, cleaning and inspection, the finished ZEISS Cine Lens is ready to be shipped to you.











UP 180
UP 8
UP 16
UP 24

Technical Specifications

Master Prime Lenses

Lens	Aperture	Type	Close focus (5)	Length (lens mount to front)	Front diameter	Weight	Horizontal angle of view	Horizontal angle of view	Horizontal angle of view
							ANSI Super 35 (1)	DIN Super 35 (2)	Normal 35 (3)
							l'=12.45mm (4)	l'=12.00mm (4)	l'=11.00mm (4)
12 mm	T1.3-T22	Distagon T*XP	0.40 m / 16"	249 mm / 9.8"	156 mm / 6.1"	2.9 kg / 6.4 lbs	90.98°	88.85°	83.87°
14 mm	T1.3-T22	Distagon T*XP	0.35 m / 14"	224 mm / 8.8"	114 mm / 4.5"	2.4 kg / 5.3 lbs	83.4°	81.3°	76.4°
16 mm	T1.3-T22	Distagon T*XP	0.35 m / 14"	205 mm / 8"	114 mm / 4.5"	2.2 kg / 4.8 lbs	77.0°	75.0°	70.2°
18 mm	T1.3-T22	Distagon T*XP	0.35 m / 14"	205 mm / 8"	114 mm / 4.5"	2.2 kg / 4.8 lbs	70.6°	68.6°	64.0°
21 mm	T1.3-T22	Distagon T*XP	0.35 m / 14"	205 mm / 8"	114 mm / 4.5"	2.4 kg / 5.3 lbs	62.1°	60.2°	56.0°
25 mm	T1.3-T22	Distagon T*XP	0.35 m / 14"	205 mm / 8"	114 mm / 4.5"	2.3 kg / 5.1 lbs	53.8°	52.0°	48.2°
27 mm	T1.3-T22	Distagon T*XP	0.35 m / 14"	205 mm / 8"	114 mm / 4.5"	2.2 kg / 4.8 lbs	49.2°	47.6°	44.0°
32 mm	T1.3-T22	Distagon T*XP	0.35 m / 14"	205 mm / 8"	114 mm / 4.5"	2.3 kg / 5.1 lbs	43.6°	42.0°	38.8°
35 mm	T1.3-T22	Distagon T*XP	0.35 m / 14"	205 mm / 8"	114 mm / 4.5"	2.2 kg / 4.8 lbs	39.4°	38.0°	35.0°
40 mm	T1.3-T22	Distagon T*XP	0.40 m / 16"	205 mm / 8"	114 mm / 4.5"	2.3 kg / 5.1 lbs	34.8°	33.6°	31.0°
50 mm	T1.3-T22	Planar T*XP	0.50 m / 20"	205 mm / 8"	114 mm / 4.5"	2.7 kg / 5.9 lbs	28.2°	27.2°	25.0°
65 mm	T1.3-T22	Planar T*XP	0.65 m / 2'3"	205 mm / 8"	114 mm / 4.5"	2.6 kg / 5.7 lbs	21.8°	21.0°	19.2°
75 mm	T1.3-T22	Sonnar T*XP	0.80 m / 2'9"	205 mm / 8"	114 mm / 4.5"	2.8 kg / 6.2 lbs	18.8°	18.2°	16.6°
100 mm	T1.3-T22	Sonnar T*XP	1.00 m / 3'6"	205 mm / 8"	114 mm / 4.5"	2.9 kg / 6.4 lbs	14.2°	13.8°	12.6°
150 mm	T1.3-T22	Sonnar T*XP	1.50 m / 4'11"	262 mm / 10.3"	134 mm / 5.3"	4.0 kg / 8.8 lbs	9.6°	9.3°	8.5°

All Master Prime lenses are T1.3 - T22 and have T*XP coatings

1) Horizontal angle of view for an ANSI Super 35 Silent camera aperture (aspect ratio 1:1.33, dimensions 24.9mm x 18.7mm / 0.980" x 0.7362"). Ground glasses available for ARRICAM, ARRIFLEX 235 and all 435 and 535 models.

(2) Horizontal angle of view for a DIN Super 35 Silent camera aperture (aspect ratio 1:1.33, dimensions 24mm x 18mm / 0.944" x 0.7087"). Ground glasses available for ARRIFLEX 235 and all 435 and 535 models.

(3) Horizontal angle of view for a Normal 35 Academy camera aperture (aspect ratio 1:1.37, dimensions 22mm x 16mm / 0.8661" x 0.6299"). Ground glasses available for ARRICAM, ARRIFLEX 235 and all 435 and 535 models.

(4) I' is the radius of the image circle needed for the respective format. It is the same as the distance from the image center to a corner.

(5) Close focus is measured from the film plane.

T* XP is the trademark for the improved ZEISS anti-reflection lens coating that reduces veiling glare and other reflections. XP stands for extended performance.

Ultra Prime Lenses

Lens	Aperture	Type	Close focus (5)	Length (lens mount to front)	Front diameter	Weight	Horizontal angle of view	Horizontal angle of view	Horizontal angle of view
							ANSI Super 35 (1)	DIN Super 35 (2)	Normal 35 (3)
							l'=12.45mm (4)	l'=12.00mm (4)	l'=11.00mm (4)
8 mm 8R	T2.8-T22	Distagon T* XP	0.35m / 1 1/4'	130mm / 5.1"	134mm / 5.3"	2kg / 4.4lbs	114.0°	112.0°	107.0°
10 mm	T2.1-T22	Distagon T*	0.35m / 1 1/4'	143mm / 5.6"	156mm / 6.1"	2.9kg / 6.4lbs	102.1°	100.2°	90.8°
12 mm	T2-T22	Distagon T*	0.3m / 1'	140mm / 5.5"	156mm / 6.1"	2.0kg / 4.4lbs	92.6°	90.2°	85.2°
14 mm	T1.9-T22	Distagon T*	0.22m / 3/4'	112mm / 4.4"	114mm / 4.5"	1.8kg / 4.0lbs	82.6°	80.6°	75.6°
16 mm	T1.9-T22	Distagon T*	0.25m / 1'	94mm / 3.7"	95mm / 3.7"	1.2kg / 2.6lbs	75.2°	73.0°	70.8°
20 mm	T1.9-T22	Distagon T*	0.28m / 1'	91mm / 3.6"	95mm / 3.7"	1.2kg / 2.6lbs	65.0°	62.8°	58.4°
24 mm	T1.9-T22	Distagon T*	0.3m / 1'	91mm / 3.6"	95mm / 3.7"	1.0kg / 2.2lbs	55.8°	54.2°	50.2°
28 mm	T1.9-T22	Distagon T*	0.28m / 1'	91mm / 3.6"	95mm / 3.7"	1.0kg / 2.2lbs	48.4°	46.8°	43.2°
32 mm	T1.9-T22	Distagon T*	0.35m / 1 1/4'	91mm / 3.6"	95mm / 3.7"	1.1kg / 2.4lbs	43.0°	41.6°	38.2°
40 mm	T1.9-T22	Distagon T*	0.38m / 1 1/4'	91mm / 3.6"	95mm / 3.7"	1.0kg / 2.2lbs	34.7°	33.2°	30.6°
50 mm	T1.9-T22	Planar T*	0.6m / 2'	91mm / 3.6"	95mm / 3.7"	1.0kg / 2.2lbs	27.2°	26.2°	24.0°
65 mm	T1.9-T22	Planar T*	0.65m / 2 1/4'	91mm / 3.6"	95mm / 3.7"	1.1kg / 2.4lbs	21.8°	21.0°	19.2°
85 mm	T1.9-T22	Planar T*	0.9m / 3'	91mm / 3.6"	95mm / 3.7"	1.2kg / 2.6lbs	17.1°	16.5°	15.2°
100 mm	T1.9-T22	Sonnar T*	1m / 3 1/4'	91mm / 3.6"	95mm / 3.7"	1.2kg / 2.6lbs	13.9°	13.7°	12.6°
135 mm	T1.9-T22	Sonnar T*	1.5m / 5'	119mm / 4.7"	95mm / 3.7"	1.6kg / 3.5lbs	10.5°	10.2°	9.3°
180 mm	T1.9-T22	Sonnar T*	2.6m / 8 1/2'	166mm / 6.5"	114mm / 4.5"	2.6kg / 5.7lbs	7.9°	7.6°	7.0°

(1) Horizontal angle of view for an ANSI Super 35 Silent camera aperture (aspect ratio 1:1.33, dimensions 24.9mm x 18.7mm / 0.980” x 0.7362”). Ground glasses available for ARRICAM, ARRIFLEX 235 and all 435 and 535 models.

(2) Horizontal angle of view for a DIN Super 35 Silent camera aperture (aspect ratio 1:1.33, dimensions 24mm x 18mm / 0.944” x 0.7087”). Ground glasses available for ARRIFLEX 235 and all 435 and 535 models.

(3) Horizontal angle of view for a Normal 35 Academy camera aperture (aspect ratio 1:1.37, dimensions 22mm x 16mm / 0.8661” x 0.6299”). Ground glasses available for ARRICAM, ARRIFLEX 235 and all 435 and 535 models.

(4) I’ is the radius of the image circle needed for the respective format. It is the same as the distance from the image center to a corner.

(5) Close focus is measured from the film plane.

T* is the trademark for the special ZEISS anti-reflex lens coating that reduces veiling glare and other reflections

T* XP is the trademark for the improved ZEISS anti-reflex lens coating that reduces veiling glare and other reflections even furthr. XP stands for extended performance.

Lightweight Zoom LWZ.2 Lens

Focal Length	Aperture	Type	Close Focus (1)	Length (3)	Front Diameter	Weight	Horizontal Angle of View (2)
15.5 - 45 mm	T2.6 to T22	Vario Sonnar T* XP	0.45 m / 18"	209 mm / 8.2"	114mm / 4.5"	2.0 kg / 4.4 lbs	90.2° - 40°

1) Close focus is measured from the film plane.

(2) Horizontal angle of view for an ANSI Super 35 Silent camera aperture (aspect ratio 1:1.33, dimensions 24.9 mm x 18.7 mm / 0.980” x 0.7362”).

ZEISS Compact Prime CP.2 Lenses

Lens	Type	Aperture	Close focus	Horiz Angle Full Frame	Horiz Angle ANSI S35	Horiz Angle N35	Length	Front diam	Weight
18 mm	Distagon T*	T3.6 - 22	0.3 m / 12"	-	69°	62.5°	80 mm / 3.15"	114 mm / 4.5"	0.9 kg / 2.0 lbs
21 mm	Distagon T*	T 2.9 - 22	0.24 m / 10"	80.8°	60.9°	54.8°	80 mm / 3.15"	114 mm / 4.5"	1.0 kg / 2.2 lbs
25 mm	Distagon T*	T 2.9 - 22	0.17 m / 7"	71.3°	52.5°	47°	80 mm / 3.15"	114 mm / 4.5"	0.9 kg / 2.0 lbs
28 mm	Distagon T*	T 2.1 - 22	0.24 m / 10"	65.2°	47.4°	42.3°	80 mm / 3.15"	114 mm / 4.5"	1.0 kg / 2.2 lbs
35 mm	Distagon T*	T 2.1 - 22	0.3 m / 12"	54.0°	38.5°	34.3°	80 mm / 3.15"	114 mm / 4.5"	1.0 kg / 2.2 lbs
50 mm	Planar T*	T 2.1 - 22	0.45 m / 18"	39.0°	27.3°	24.2°	80 mm / 3.15"	114 mm / 4.5"	0.9 kg /2.0 lbs
85 mm	Planar T*	T 2.1 - 22	1 m / 3'3"	23.9	16.7°	14.8°	80 mm / 3.15"	114 mm / 4.5"	0.9 kg / 2.0 lbs
100 mm	Planar T* Close-Focus	T 2.1 - 22	0.7 m / 2'6"	21.0°	14.7°	13.1°	132 mm / 5.19"	114 mm / 4.5"	1.49 kg / 3.3 lbs
50 mm Macro	Makro-Planar T*	T 2.1 - 22	0.24 m / 10"	39.0°	27.3°	24.2	132 mm / 5.19"	134 mm / 5.3"	1.35 kg / 3.0 lbs

Close focus distance is measured from the film / sensor plane. Horizontal angle of view for a full-frame camera aperture (aspect ratio 1:1.5, dimensions 24 mm x 36 mm). Horizontal angle of view for a Normal 35 Academy camera aperture (aspect ratio 1:1.37, dimensions 22 mm x 16 mm). Length is Front to PL mount flange.

Ultra 16 Prime Lenses

Focal Length	Aperture	Type (1)	Close Focus (2)	Length (3)	Front Diameter	Weight	Horizontal Angle of View (4)
6 mm	T1.3 to T16	Distagon T* XP	0.20 m / 8"	91.6 mm / 3.6"	95mm / 3.7"	1.0 kg / 2.2 lbs	90.22°
8 mm	T1.3 to T16	Distagon T* XP	0.30 m / 12"	91.6 mm / 3.6"	95mm / 3.7"	1.0 kg / 2.2 lbs	75.83°
9.5 mm	T1.3 to T16	Distagon T* XP	0.30 m / 12"	91.6 mm / 3.6"	95mm / 3.7"	1.0 kg / 2.2 lbs	66.34°
12 mm	T1.3 to T16	Distagon T* XP	0.30 m / 12"	91.6 mm / 3.6"	95mm / 3.7"	1.0 kg / 2.2 lbs	55.32°
14 mm	T1.3 to T16	Distagon T* XP	0.30 m / 12"	91.6 mm / 3.6"	95mm / 3.7"	1.0 kg / 2.2 lbs	48.17°
18 mm	T1.3 to T16	Distagon T* XP	0.30 m / 12"	91.6 mm / 3.6"	95mm / 3.7"	1.2 kg / 2.6 lbs	37.88°
25 mm	T1.3 to T16	Distagon T* XP	0.30 m / 12"	91.6 mm / 3.6"	95mm / 3.7"	1.2 kg / 2.6 lbs	27.82°
35 mm	T1.3 to T16	Planar T* XP	0.35 m / 14"	91.6 mm / 3.6"	95mm / 3.7"	1.1 kg / 2.4 lbs	20.46°
50 mm	T1.3 to T16	Planar T* XP	0.40 m / 16"	91.6 mm / 3.6"	95mm / 3.7"	1.2 kg / 2.6 lbs	14.76°

(1) T* XP is the trademark of the improved ZEISS anti-reflection lens coating that reduces flaring and other reflections. XP stands for extended performance.

(2) Close focus is measured from the film plane.

(3) Measured from lens mount to lens front. This measurement shows how far the lens will protrude beyond the camera body.

(4) Horizontal angle of view for a Super 16 camera aperture:
(DIN 15602 and ISO-5768-1998, aspect ratio 1:1.66, dimensions 12.35mm x 7.5mm / 0.486” x 0.295”).

DigiPrime Lenses

Lens	Aperture	Type	Close focus from film plane	Length (lens mount to front)	Front Diameter	Weight	Horizontal angle of view 4:3	Horizontal angle of view 16:9
3.9 mm	T1.9 - T16	Distagon	0.5 m / 20"	203 mm	117 mm	1.89 kg / 4 lbs. 3 oz	96.9°	101.8°
5 mm	T1.9 - T16	Distagon	0.5 m / 20"	164 mm	95	1.38 kg / 3 lbs	82.0°	87°
7 mm	T1.6 - T16	Distagon	0.5 m / 20"	164 mm	95	1.55 kg / 3 lbs. 6 oz	65.0°	69.6°
10 mm	T1.6 - T16	Distagon	0.5 m / 20"	164 mm	95	1.51 kg / 3 lbs. 5 oz	48.0°	52.0°
14 mm	T1.6 - T16	Distagon	0.5 m / 20"	164 mm	95	1.33 kg / 2 lbs. 15 oz	35.4°	38.4°
20 mm	T1.6 - T16	Distagon	0.5 m / 20"	164 mm	95	1.35 kg / 3 lbs.	24.8°	27.0°
28 mm	T1.6 - T16	Distagon	0.5 m / 20"	164 mm	95	1.42 kg / 3 lbs. 2 oz	17.8°	19.4°
40 mm	T1.6 - T16	Distagon	0.5 m / 20"	164 mm	95	1.44 kg / 3 lbs. 3 oz	12.6°	13.8°
52 mm	T1.6 - T16	Distagon	0.5 20"	164	95	1.56 kg / 3 lbs. 6oz	9.6°	10.5°
70 mm	T1.6 - T16	Distagon	0.32 m / 13"	194 mm	95	1.8 kg / 3 lbs. 15 oz	7.2°	7.8°
135 mm	T1.9 - T16	Sonnar	0.85 m / 33"	297 mm	117	3.15 kg / 7 lbs.	3.7°	4.1°

DigiPrime Lenses — Additonal Specs

Lens	Elements	Groups	Angle of view 4:3			Angle of view 16:9			focus angular rotation	Approx 16:9 equivalent Super 35 ZEISS Ultra Prime
			hor	vert	diag	hor	vert	diag		
3.9 mm	23	16	96.9°	80.5°	109.3°	101.8°	69.3°	69.3°	323°	10mm
5 mm	19	13	82.0°	66.0°	94.2°	87°	55.8°	94.2°	294°	12mm
7 mm	18	14	65.0°	51.0°	76.6°	69.6°	42.4°	76.6°	289°	16mm
10 mm	17	13	48.0°	37.0°	58.0°	52.0°	30.6°	58.0°	308°	24
14 mm	15	12	35.4°	26.8°	43.4°	38.4°	22.0°	43.4°	285°	32
20 mm	15	11	24.8°	18.8°	30.8°	27.0°	15.4°	30.8°	299°	50
28 mm	14	10	17.8°	13.4°	22.1°	19.4°	11.0°	22.1°	323°	70
40 mm	14	12	12.6°	9.6°	15.8°	13.8°	7.8°	15.8°	312°	100
52 mm	16	12	9.6°	7.2°	11.9°	10.5°	5.9°	11.9°	330°	130
70 mm	20	14	7.2°	5.4°	9.0°	7.8°	4.4°	9.0°	310°	180
135 mm	18	15	3.7°	2.8°	4.7°	4.1°	2.3°	4.7°	330°	340

All DigiPrimes and DigiZooms have MTF > 90% for 56 lp/mm for Infinity GN Channel.

All have irises that fully close, indicated by CL label and line below T16 mark.

DigiZoom Lenses

Lens	Aperture	Type	Close focus from film plane	Length (lens mount to front)	Front Diameter	Weight	Horizontal angle of view 4:3	Horizontal angle of view 16:9
6-24 mm	T1.9 - T16	Vario Sonnar	0.55 m / 22"	249 mm / 9.8"	95 mm	2.75 kg / 6 lbs.	73.9° - 20.7°	78.9° - 22.5°
17-112 mm	T1.9 - T16	Vario Sonnar	0.75 m / 30"	300 mm / 11.8"	95 mm	4 kg / 9 lbs	29.0° - 4.5°	31° - 4.9°

DigiZoom Lenses — Additonal Specs

Lens	Elements	Groups	Angle of view at wide end - 4:3			Angle of view at tight end - 4:3			Angle of view at wide end - 16:9			Angle of view at tight end - 16:9			focus angular rotation
			hor	**vert**	**diag**	**hor**	**vert**	**diag**	**hor**	**vert**	**diag**	**hor**	**vert**	**diag**	
6-24 mm	26	20	73.9°	58.4°	86.7	20.7°	15.6°	25.6°	78.9°	49.1°	86.7°	22.5°	12.8°	25.6°	330°
17-112 mm	28	21	82.0°	66.0°	94.2°	4.5°	3.4°	5.6°	31.0°	17.8°	35.4°	4.9°	2.8°	5.6°	310°

by Jon Fauer, ASC

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Photos by Jon Fauer, Marc Shipman-Mueller, ARRI, ZEISS

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