Large format lenses from VEB Carl Zeiss Jena 1945 - 1991

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Introduction

Many large format photographers own a few lenses they bought used, either to save money or because specific features are no longer available in new production lenses. Until 1989, most lenses came from Western Europe, Japan, or previously the USA. However, there were view cameras and large format (LF) lenses in the Eastern Bloc countries during the Cold War, but not much was known about them. This changed since the Berlin wall came down, and many of these lenses have now found their way into the global used market. The largest manufacturer behind the iron curtain was Carl Zeiss Jena in the German Democratic Republic (GDR, the equivalent German acronym is DDR for "Deutsche Demokratische Republik") as the direct successor of the well-known prewar company of the same name. Other Eastern Bloc LF lens manufacturers included Meyer-Optik (formerly Hugo Meyer Görlitz, also in the GDR), Meopta in the Czech Republic, PZO in Poland, and several companies such as LOMO, KOMZ, and KMZ in the Soviet Union. The LF lenses from those manufacturers are described in a separate article [1].

VEB Carl Zeiss Jena

At the end of World War II the German state of Thuringia, where Jena is located, was under the control of British and American troops. However, the Yalta Conference agreement placed it under Soviet control shortly thereafter. Just before the US command handed the administration of Thuringia over to the Soviet Army, American troops moved a considerable part of the leading management and research staff of Carl Zeiss Jena and of the Schott glass company to Heidenheim near Stuttgart, 126 people in all [2]. This led to the foundation of "Opton Optische Werke" in Oberkochen, West Germany, initially as subsidiary of Carl Zeiss Jena. The latter, however, was nationalized in 1948 by the communist rulers of the GDR as "VEB[1] Carl Zeiss Jena" and later became one of the big industrial "combines" of the GDR. The nationalization and the Cold War subsequently led to the separation of Zeiss into a new independent establishment in Oberkochen (changing its name from Opton to Zeiss-Opton back to Carl Zeiss over a few years), and the traditional company location in Jena in the GDR.

Operations at Carl Zeiss Jena were initially hampered by war damage, the removal of key personnel to the American sector, and later also to Russia, as well as the subsequent dismantling of equipment by the Soviet army, leaving only 6% of the production equipment [2]. Nevertheless, Carl Zeiss Jena resumed production shortly after the war and became the major supplier of optical equipment in the Eastern Bloc countries during the cold war. Over the years, the GDR concentrated their optical, precision machining, and electronic industry under the roof of the VEB Carl Zeiss Jena. This also included the assimilation of the other well-known GDR manufacturer of photographic lenses, Meyer-Optik, through the integration of the camera manufacturer VEB Pentacon into VEB Carl Zeiss

[1] "VEB" is a GDR acronym for a nationalized company, standing for "Volkseigener Betrieb – People-owned enterprise".

Jena in 1985. In 1989, VEB Carl Zeiss Jena was one of the biggest GDR companies with about 69,000 employees. A vast range of products in the fields of optics and precision machinery was produced, from binoculars to planetariums to microelectronics.

The postwar separation of Zeiss lead to two distinctively different large format lens lines. The West-German Zeiss Oberkochen developed a completely new line of Biogon, Planar, Sonnar, and Tessar lenses for Linhof press and technical cameras, to be used at wide apertures for the 6x9cm and 4x5" formats, described in another article [3]. These were discontinued around 1972, and subsequently Zeiss Oberkochen left the large format field except for a few special orders. Carl Zeiss Jena initially continued some of the pre-war lens lines for large format and process cameras, and later phased in replacements and new developments.

Over the years, a long and convoluted legal struggle on the use of the Zeiss name ensued between Zeiss in Oberkochen and Carl Zeiss Jena, which was finally resolved in 1971 with the "London agreement" between the two Zeiss companies [2]. As a result, Carl Zeiss Jena (CZJ) could not use the Carl Zeiss name in most Western countries - with some exceptions, e.g. the British Commonwealth - but had to use the name "Jenoptik" or "ausJena" instead. Conversely, Carl Zeiss Oberkochen had to use the name "Opton" or "Oberkochen Opton" for exports to the Eastern Bloc countries. Similar rules governed the use of the established prewar lens names such as Biogon, Planar, Sonnar, Tessar, etc., as well as other product lines.

Most or all of the Carl Zeiss Jena lenses were not manufactured in Jena proper, but at another Zeiss plant in Saalfeld, Thuringia, about 30 miles from Jena. The Saalfeld plant has its own history. It was originally founded in 1910/1911 as Optische Anstalt Saalfeld (OAS) by Carl Zeiss Jena, the microscope company Winkel from Göttingen, and Alfred Gruchot, a former manager of Hugo Meyer Görlitz. Initially, OAS produced optical parts and low- to medium-priced objectives for camera manufacturers such as Contessa-Nettel and Franke & Heidecke (i.e. Rollei). After the famous merger of Contessa-Nettel, Ernemann, Goerz, and ICA in 1926 to form Zeiss-Ikon, that company became OAS' main customer. After WWII, OAS was integrated into the VEB Carl Zeiss Jena, where they made most photographic, movie, video, projection, and process lenses for Zeiss, as well as other components. In 1985, there were plans to move the GDR production of photographic lenses from Saalfeld to the Görlitz plant of VEB Pentacon/Meyer-Optik [2], but this was never realized.

Four years later, in 1989, the Berlin wall came down and on October 3, 1990, Germany was reunited. Following the reunification, the nationalized companies of the GDR, about 8000, were taken over by a government trust agency called "Treuhand", to be turned over to new management through privatization or to be closed down. This included Carl Zeiss Jena and its Saalfeld plant. Carl Zeiss Oberkochen took back only core parts of CZJ, including microscopy, astronomical, and geodetic instruments, but not photographic optics. Another part of Zeiss Jena formed the new company Jenoptik, now successfully working in clean room technology, photonics, and other fields. The Saalfeld plant continued operations under the Treuhand trustee management until they were sold to the West-German company Docter Optic in August 1991. The last large format lenses produced before Docter Optic took over were a batch of 300mm f/4.5 Tessars made in June 1991. The short-lived Docter Optic era of the Saalfeld plant is the topic of a separate article [4].

LF lenses from Carl Zeiss Jena

Before WWII, CZJ was a major supplier of photographic optics in Germany and around the world. The main LF lens lines were the convertible Protar VII series, the wide-angle Protar V series, and five different Tessar series with maximum openings of f/2.7, f/3.5, f/4.5, f/5, and f/6.3, respectively. Less common lenses were the Biotessar, the Double Amatar, the Dagor, the Hypergon and the Tele-Tessar. The main process lens line was the Apo-Tessar, but Apo-Planars also existed. The production of Protars already stopped in the early 1930's, although they were offered for sale up to the start of WWII. Their production was not resumed after the war, they only continued with the Tessars and the Apo-Tessars , and introduced two new process lens lines in the 1960's and 1980's, the Apo-Germinar and Apo-Germinar W. They never added a replacement for the convertible Protar, i.e. a lens with large coverage at a medium aperture comparable to the Schneider Symmar or Rodenstock Sironar, or – except for aerial and photogrammetry lenses, and a few prototypes – a real LF wide angle.

An important difference compared to Western production was that the majority of the Carl Zeiss Jena LF lenses came in barrel mounts. The GDR produced leaf shutters, but mostly in the 00 size for 35mm or medium format folders. Shutter names were "Tempor" (VEB Zeiss Ikon Dresden), "Junior" (Werner/Fotoverschlüsse Tharandt), "Priomat", and "Prestor" (VEB KKWD/VEB Pentacon Dresden [5]), but not many were made for LF lenses. Prestors 1, 3, and 5 were the only ones usable for LF and were only produced from 1964-1966; note that these Prestors were a different construction than the better known high-speed Prestor Rapid 00 made by VEB Zeiss Ikon since 1958. CZJ also used West-German Compound and Compur shutters for Tessars in the 1950's and occasionally later, probably for selling them on Western markets. It is important to note that the Prestor shutters have different threads and spacing than their Western counterparts as listed in table 1, so lens cells are not easily transferred between shutters.

Table 1: Dimensions and data for the Prestor 1, 3, and 5 shutters, with comparison data for Copal 1, 3, and Compound 5. Note that the Prestors 3 and 5 usually come with additional spacer tubes holding the lens cells, depending on the lens focal length. The cell spacing listed for the Prestors is the value without *additional tubes, and the tube threads are often, but not always, smaller than the threads of the shutter itself.*

Shutter	Exposure Times	Front Thread	Rear Thread	Cell Spacing [mm]	Diameter [mm]	Mount Thread
Prestor 1	T, B, 1/250, 1/125, 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, 1	M40 x 0.75	M40 x 0.75	23.5	77	M45 x 0.75
Prestor 3	T, B, 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, 1	M58 x 0.75	M58 x 0.75	28	94	M63 x 0.75
Prestor 5	T, B, 1/30, 1/15, 1/8, 1/4, 1/2, 1	M85 x 0.75	M85 x 0.75	30	130	M90 x 1.0
Copal 1	T, B, 1/400, 1/250, 1/125, 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, 1	M40 x 0.75	M36 x 0.75	20	73	M39 x 0.75
Copal 3 (not 3s)	T, B, 1/125, 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, 1	M58 x 0.75	M 58 x 0.75	32	102	M62 x 0.75
Compound 5	T, B, 1/50, 1/25, 1/10, 1/5, 1/2, 1	82.77 x 40tpi	82.77 x 40tpi	33.2 (tube I) 25.2 (tube II)	125.5	M90 x 1.0

The production numbers of the shuttered Tessars are listed in table 3a. Many Zeiss LF lenses were originally used with a shutter behind the lens in the cameras of the Pentacon "Mentor" lines, or in the "Globica", a traditional tailboard camera on a stand. For instance, between 1946 and 1991 Carl Zeiss Jena produced over 21,000 units of the f/4.5 210mm Tessar (their LF lens with the highest production number) in various barrel mounts, but only 1,737 lenses of the same type in a shutter [6]. The most common barrel mounts show an "N" on the mount followed by a number, examples are shown in figs. 3-5. The N stands for "Normalfassung", "standard mount" in German, and the number denotes the nominal outside cylinder diameter of the lens mount, not counting the aperture ring. Note that the barrel lenses can usually not be put into a shutter without some machining. Some of them, like the Apo-Germinar W, actually have the individual lenses mounted directly into the barrel, not with assembled front and back lens cells that screw into a separate barrel mount with aperture. In others, like some of the Apo-Tessars, the lens cells unscrew easily from the mount. Nevertheless, lenses from Carl Zeiss Jena are usually of very high quality and therefore the cost for having them mounted in a shutter or in front of one can sometimes be justified. In addition, they can be used without major modifications on cameras with a shutter behind the lens, such as a Sinar or Packard shutter. Most barrel mounts have the classic nonlinear aperture scale with a nearly round diaphragm opening using many blades. Apo-Germinar and Apo-Germinar W models have a linearized scale and only six aperture blades.



Fig. 1: Different labels on CZJ lenses. From left to right: the older regular "Carl Zeiss Jena" label, the older "Ernst Abbe Jena" label for export to Western countries, the later "ausJENA" label for export to Western countries, and the late "Carl Zeiss Jena DDR" version for regular sale in Eastern Block countries. Note that the red "T" on the left lens stands for the coating, whereas the "white "T"'s of the two center lenses designate them as Tessars – the old lens names from before WWII fell under the same rules as the Zeiss name after the "London agreement" between the companies, so just their first letter was used in the export versions. The first three lenses are all 210mm f/6.3 Tessars, the right one is a 135mm f/4.5 Tessar.

The manufacturers name engraved on the lens might be "Carl Zeiss Jena", "Carl Zeiss Jena DDR", "CZJ", "Jenoptik", "ausJENA" (meaning "from Jena"), "Ernst Abbe Jena", or simply "Jena", depending on when and where the lens was sold (fig. 1). These differences result from the legal struggles on the use of the Zeiss name between Zeiss Oberkochen and Zeiss Jena during the Cold War that

were finally resolved in the London agreement as mentioned above. Since the same rules applied to the traditional Zeiss lens names like Tessar, Sonnar, Planar, etc., they could not be used in Western countries; usually just the first letter of the lens name was used for these, such as the white "T" in the two center lenses in fig. 1. New names like Apo-Germinar or Lamegon could be used everywhere, though. There was also a small series of lenses labeled "Meyer-Optik" that were Tessars made by CZJ for Meyer in 1991 for a mahogany version of the "Globica" studio camera – it has the serial number of the last lot under the Carl Zeiss Jena era and the mount is the same [1]. There is no lens name (neither "Tessar" nor "Trioplan" - Meyers old triplet name) engraved. Whether this was an exception because of the turbulent economic situation after the German reunification, or if there was previous production by Zeiss Jena for other companies as an OEM supplier is unknown.

Carl Zeiss Jena serial numbers followed the prewar numbering scheme until 1980, when they changed to a new system [6]. The old system, with up to 8 digits (highest numbers are between 11,000,000 and 12,000,000), was only approximately chronological, and semi-continuous across lens types. Once an internal order for a lot of lenses was issued, a continuous block of numbers was assigned to this order, even though the production might have taken considerable time, sometimes years. Occasionally not all numbers assigned were used, in which case these numbers were reused and assigned to a different lot or some prototype production [6]. Unless one has the numbers from the original production files [6], the number range given in table 2 allows only a rough estimate of production time, with an error of ±2 years, occasionally more. In 1980, the system changed completely. Each specific lens type had its own number series with 4 - 5 digits, usually starting at 1001[2]. Thus different lenses will have the same serial no. and will also duplicate very early Zeiss production numbers. Errors occurred occasionally with the new system and sometimes the same serial no. block was issued to the same lens type twice. Without the production files, no easy dating of lenses is possible within the new system, but it was only in effect for 12 years (1980-1991).

Table 2: Approximate VEB Carl Zeiss Jena serial number range for the old number system through 1980, after [6]. See text for details.

Year	Serial Number
1947	3,000,000
1951	3,500,000
1954	4,000,000
1957	5,000,000
1960	6,000,000
1965	7,000,000
1968	8,000,000
1972	9,000,000
1976	10,000,000
1980	11,000,000

All post-war Carl Zeiss Jena LF lenses were coated, with the possible exception of early post-war lenses. Initially the red "T" designation for "Transparency" was used for coated lenses, but dropped later when coating became standard procedure. Zeiss Jena introduced multicoating in 1976, 4 years after Zeiss Oberkochen, but mostly for 35mm and medium format lenses. To my knowledge, the only Zeiss Jena LF lenses with multicoating are the Apo-Germinar W lenses [7]. The combined "1" and "Q" symbol " ⏀ " on many mounts, e.g. on the left three lenses in fig. 1, means "1st Quality".

A note on tables 3-8 in the following chapters: The Zeiss production files indicate that lens design parameters were changed occasionally for a lens of a given name, as listed in tables 3b, 4b, and 6b, to adjust for different glasses available, or to improve the performance. The mounts

[2] Lower numbers, such as 0907, have been seen occasionally. These could be engraving errors, or if there was another purpose, it is not known.

and mount materials (e.g. brass vs. aluminum) also changed over 45 years, so weights and filter dimensions can vary. The mounts of the most recent lenses will most likely be identical to the Docter Optic counterparts described in the Docter article [4]. Image circles were calculated from the coverage angle; for the Tessars (table 3a) and the specialty lenses (table 9), the image circle is given for infinity. For the process lenses (tables 4a, 6a, 7) it is given for 1:1. At infinity, the image circle is about half that value.

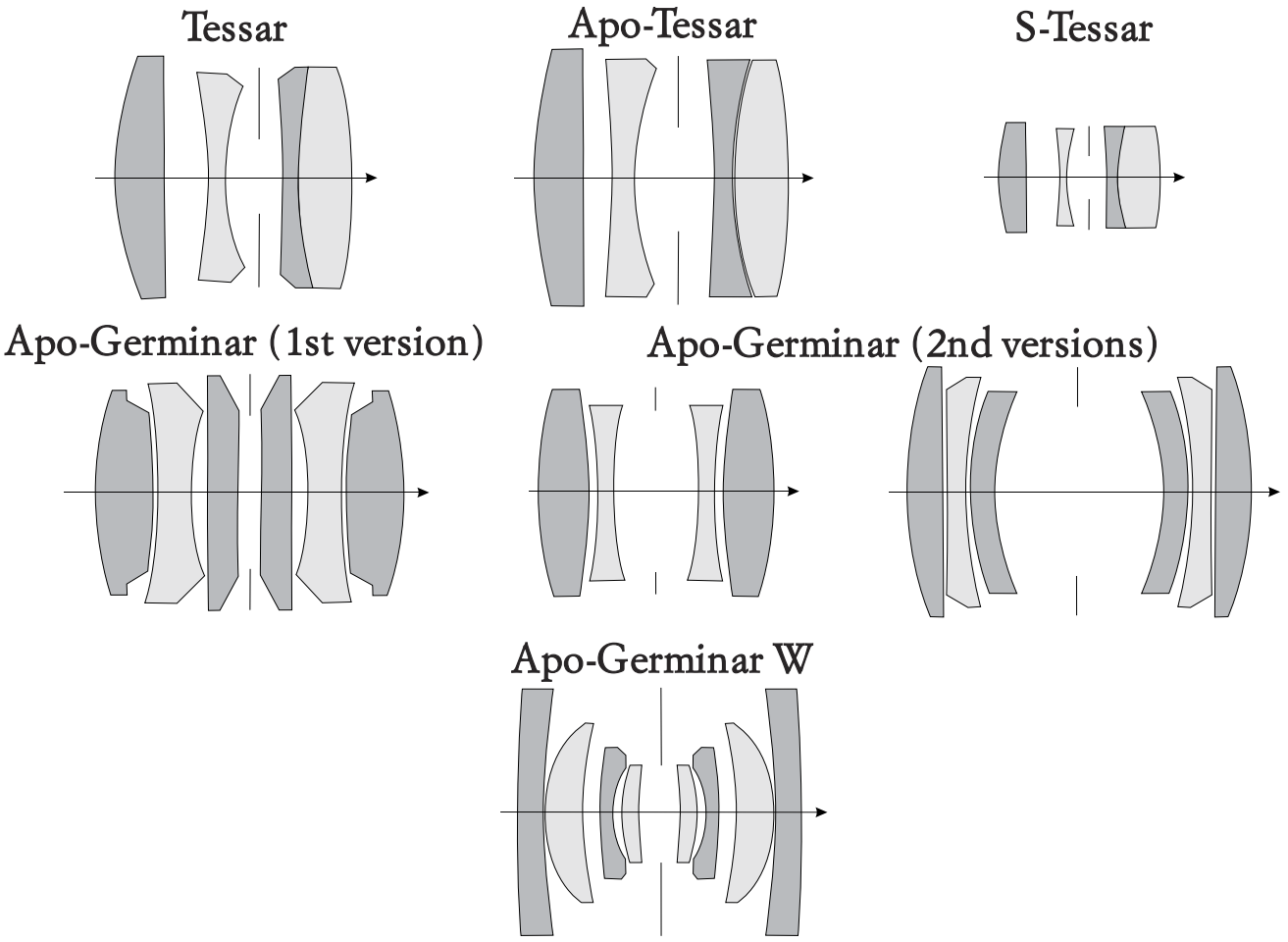


Fig. 2: Schematic lens diagrams of CZJ lenses suitable for LF, based on ref. [7]. For the Apo-Tessar, the later version with a very small air gap between the last two lens elements, instead of a cemented group, is shown. See text for details.

Tessar lenses

Tessars were the standard LF lenses made by Carl Zeiss Jena after WWII. These are direct descendants of Paul Rudolph's original Tessar from 1902 [8], with 4 lens elements in 3 groups (see fig. 2 upper left). Tables 3a and 3b list only Tessars from 135mm up, since anything shorter won't cover 4x5", but there were of course shorter focal lengths available, like the 75mm one shown in fig. 5. Tessars were also used and sold for use as enlarging lenses. Initially, of the five pre-WWII Tessar series, three series were continued after WWII, with maximum openings of f/3.5, f/4.5, and f/6.3, respectively. The number of focal lengths available was considerably reduced compared to the prewar offerings, in the f/6.3 range only three focal lengths remained in production.



Fig. 3: f/3.5 Tessars from Carl Zeiss Jena. Bottom row from left to right: 210mm and 150mm, both in barrel. Top row from left to right: 250mm in barrel and 250mm in Compound V. Scale is in cm.

The f/3.5 Tessars (fig. 3) were - except for later prototypes - based on a 2nd generation design by Willy Merté and Ernst Wandersleb from the 1920's and 1930's; their production was discontinued in the mid 1950's. The final remaining f/6.3 Tessars (fig. 4) were discontinued in the late 1960's; both were new designs from 1947 and differed from Wandersleb's 1911 versions with the same specifica-

tions. Only the f/4.5 series (figs. 5 and 6) was continued to the very end in 1991. A variety of designs existed for the f/4.5 series; the shorter focal lengths used mostly postwar designs, but the longer ones used the late 1920's designs - probably also by Merté - to the very end (table 3b).



Fig. 4: f/6.3 Tessars. Bottom row from left to right: 120mm S-Tessar macro lens (see section on Apo-Tessars and fig. 2 top right), Tessar 135mm in barrel, and 135mm in Compur 0. The top row shows 210mm models with different designations, from left to right: regular version in barrel, regular version in Synchro-Compur 1, early export version ("Ernst Abbe Jena") in barrel, late export version ("aus JENA") in Synchro-Compur 1. Scale is in cm.

The optimum aperture for the Tessars is generally f/22. The f/3.5 and f/4.5 versions can do double duty, as portrait lenses wide open, and stopped down to the optimum aperture for technical subjects, architecture etc. Note that the f/3.5 versions do show some visible focus shift when stopped down from the full aperture, so for best results it is advisable to focus at the taking aperture from wide open down to about f/5.6. From f/8 on down, f/8 can be used for focusing. If this is taken into account, even those older f/3.5 Tessars can deliver high quality results.

The f/6.3 versions with their larger coverage of 70° (table 3a) and small size are quite interesting alternatives for the landscape photographer, especially the shuttered versions. Similar to the last Xenars built by Schneider (f/5.6 150mm and f/6.1 210mm), the reduced maximum opening allows for a better correction than the regular f/4.5 version, with a much reduced size and weight.

The f/4.5 Tessars are the general workhorse of the Tessar series with good center performance wide open and excellent overall performance within their specified coverage when stopped down. There is no discernible focus shift. MTF curves of the last f/4.5 Tessar versions can be found in the appendix of the accompanying article on Docter lenses [4].

Table 3a. VEB Carl Zeiss Jena Tessars. Different weights for the same lens are from different sources and are caused by the change in mount materials over time. The 60° angle and the image circle numbers in {} for the f/4.5 Tessars are from a 1969 Zeiss brochure, the other values from later sources.

Focal Length [mm]	Max. Aperture	Angle of Coverage [°]	Image Circle (calculated) [mm]	Mount/ Shutter	Filter Size	Weight [g/oz.]	Remarks
150	3.5	57	163	Compur 2			50 produced
				barrel	M49x0.75	270/9.5	155 produced
165	3.5	57	179	Compound III			50 produced
				barrel			1375 produced
210	3.5	57	228	Compound IV			75 produced
				barrel	M67x0.75	660/23.3	2200 produced
250	3.5	57	271	Compound V	M84x1	1252/44.2	45 produced
				barrel	M84x1	920/32.5	665 produced
300	3.5	57	326	barrel			305 produced
135	4.5	57/60	147 {160}	Compur 1	M40.5x0.5	257/9.1	300 produced
				barrel	M40.5x0.5	105/3.7	11016 produced
150	4.5	55/60	156 {180}	Compur 1	M40.5x0.5	210/7.4	1750 produced
				barrel	M49x0.75	220/7.8	972 produced
165	4.5	55/60	172 {200}	barrel	M58x0.75	280/9.9	690 produced
180	4.5	55/60	187 {220}	Compur 2	M49x0.75	343/12.1	330 produced
				Compound III			25 produced
				barrel	M58x0.75	390/13.8 215/7.6	18512 produced
210	4.5	55/60	219 {250}	Compound III			1637 produced
				Prestor 3	M58x0.75	521/18.4	100 produced (in 1968)
				barrel	M67x0.75	490/17.3 335/11.8	21664 produced
250	4.5	55/60	260 {300}	Compound IV			325 produced
				barrel	M77x0.75	690/24.3 500/17.6	15696 produced
300	4.5	55/60	312 {360}	Compound V	M84?	1176/41.5	488 produced
				Prestor 5		1188/41.9	
				barrel	M95x1	1270/44.8 1005/35.5	11270 produced
360	4.5	55/60	375 {430}	barrel	M105x1	1870/66 1550/54.7	3525 produced
135	6.3	70	189	Compur 0			250 produced
				barrel	M35.5x0.5	110/3.9	811 produced
165	6.3	?	?	barrel			800 produced
210	6.3	70	294	Compur 1	M40.5x0.5	195/6.9	125 produced
				Prestor 1			25 produced (in 1965)
				barrel	M40.5x0.5	110/3.9	3272 produced

Table 3b. VEB Carl Zeiss Jena Tessar design dates and serial numbers, after ref. [6].

Focal Length [mm]	Max. Aperture	Design Year	Serial Numbers
150	3.5	1926	3,605,301-3,605,400 4,009,801-4,009,900
		1952	3,746,023-3,746024 3,746029 – 3,746,030
165	3.5	1926	3,075,001 and higher
210	3.5	1929	3,072,101 and higher
250	3.5	1935	2,731,551 and higher
300	3.5	1937	2,770,035 and higher except
		1953	3,746,102-3,746,103
135	4.5	1927	2,850,601-2,850,700 2,868,901-2,869,900
		1948	Between 3,072,001 and 4,869,260 except
		1952	3,746,058-3,746,059
		1957	4,870,946 and higher 1001-1637 (1980-1986)
150	4.5	1947	Between 3,179,494 and 3,669,701 except
		1911	3,406,151 – 3,406,600 and
		1951	3,623,051-3,623,550
		1928	3,873,201 and higher except
		1926	3,893,951 – 3,894,000
165	4.5	1911	2,732,001-2,732100 2,743,501-2,743,600
		1959	1,001-1,145 (1980-1984) and 5,909,201 and higher except
		1926	8,272,129 - 8,272,228
180	4.5	1929	2,814,301-2,814,500 3,778,601-11,022,432 1,001-11,650 (1980-1991)
		1948	3,017,685-3,624,900
210	4.5	1929	2,814,501-10,833,987 1,001-7,417; 7,818-8,063 (1981-1991)
		1975	7,418-7,817 (1990)
250	4.5	1928	2,789,151 and higher
300	4.5	1928	2,773,566 - 3,181,297 3,791,601-10,832,987 1001-4100 (1981-1991)
		1948	3,408,501-3,606,700
360	4.5	1928	2,798,001 and higher; 1001-1800 (1981-1985)[3]
135	6.3	1911	2,920,899
		1947	3,087,701 and higher
165	6.3	1911	2,731,601 - 2,938,550
210	6.3	1911	2,919,628-2,920,350
		1947	3,071,701 and higher

[3] At least one lens with a serial number below 1001 (0907) has been seen.



Fig. 5: f/4.5 Tessars in barrel. Bottom row from left to right: 75mm (only usable for medium format), 135mm, and 210mm. Top row from left to right: 250mm, 300mm, and 360mm. Scale is in cm.



Fig. 6: f/4.5 Tessars in shutter. Bottom row left to right: 135mm in Press-Compur 1, 150mm in Press-Compur 1, 180mm in Compur 2, 180mm in Prestor 3 (made by VEB Pentacon in Dresden). Top row left to right: , 210mm in Prestor 3, 300mm in Compound V, and 300mm in Prestor 5. Scale is in cm.

Process lenses: Apo-Tessar

The other main group of lenses usable for large format are the process lenses made by Carl Zeiss Jena. They first produced Apo-Tessars (tables 4a and b), similar to what they had prior to WWII. As process lenses, they are optimized for a 1:1 reproduction ratio, but can be used at infinity. Apo-Tessars were originally built like regular Tessars (4 elements/3 groups), but used a special glass (a short flint, "KF" in the Schott nomenclature) with abnormal dispersion. They are optimized for high definition over a smaller field than regular Tessars. Thus they have less coverage (43°), and a maximum opening of f/9 or less. The coverage may be higher for less stringent requirements in pictorial use. Optimum aperture is again f/22. Initially, these were based on designs from the late 1920's, although the 140mm and 180mm versions got redesigned in 1939. All those lenses are still marked in cm instead of mm, despite post-war production dates and coating. In 1955, CZJ redesigned them again, introducing a small air gap in the back cell instead of the cemented interface as indicated in fig. 2 top center [8], so the latest design is actually a 4/4 construction and not strictly a Tessar. Those versions carry the focal length in mm. Fig. 7 shows some of the Apo-Tessars, and tables 4a and 4b list the data and design dates. The last version with the air gap can be identified by three strip-like reflecting structures visible at 120° intervals at the perimeter of the back lens cell, as shown in fig. 8, or by looking at the reflections of a light source in the back cell: an older Apo-Tessar, coated or uncoated, will show two strong reflections from the surfaces and a very weak one from the cemented interface, whereas the last version will show three equally strong reflections (not four reflections, the air gap is very small with only 15-20μm), colored by the coating.

Table 4a. VEB Carl Zeiss Jena Apo-Tessars and the related S-Tessar. Note that Apo-Tessar mounts often have no filter threads, or uncommon ones.

Focal Length [mm]	Max. Aperture	Angle of Coverage [°]	Image Circle @ 1:1 and f/22 (calculated)	Mount/ Shutter	Weight [g/oz]	Remarks
140	9	43	221	barrel		1031 produced
180	9	43	284			1010 produced
180	15	30-35	193-227			560 produced
240	9	43	378			1073 produced
300	9	43	473		385/13.6	2395 produced
375	9	43	591			469 produced
450	9	43	709		460/16.2	2407 produced
600	9	43	945		1000/35.3	2296 produced
750	9	43	1182		1790/63.1	1261 produced
900	9	43	1418			Only 1 listed in manufacturing files, more exist
1200	11	43	1890			70 produced
1800	15	30-35	1929-2270			Not listed in post-WWII Zeiss Jena manufacturing files
120 "S-Tessar"	6.3	30	128			for color separations



Fig. 7: Apo-Tessar lenses, all are f/9. Bottom row from left to right: 140mm (1955 design), 240mm (1929 design), 300mm (1927 design), 300mm (1955 design), and 600mm (1955 design). Top row from left to right: 750mm (1955 design) and 900mm (1928 design). Scale is in cm.

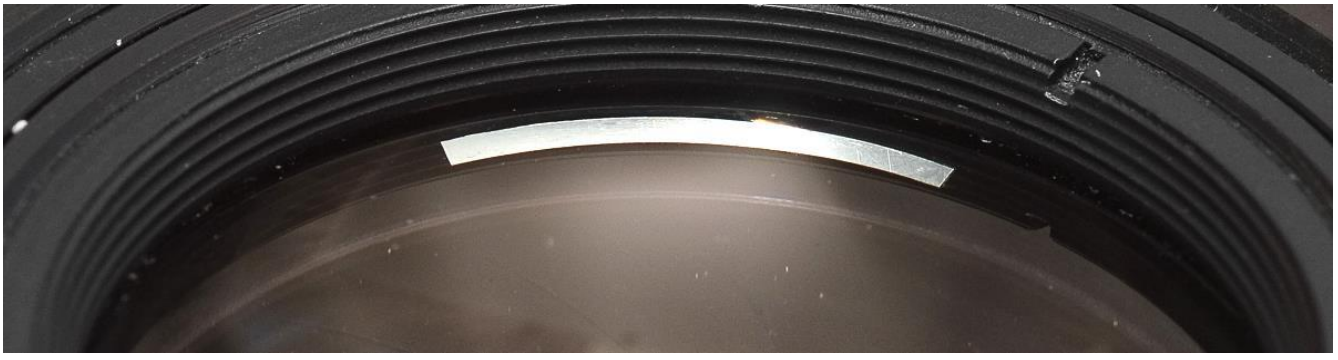


Fig. 8: Reflective aluminum strip between the last two lens elements inside the back cell of newer Apo-Tessars, producing a small air gap between the lenses of the back cell. The structure shows up three times at 120° intervals. The example shown is from a 300mm lens, but other focal lengths look similar.

Note that the outer front ring of all Apo-Tessar mounts unscrews to mount the lens in reverse for magnifications larger than 1:1. This is also marked in the lens mount inscription. Instead of the "N"

designation of the standard mounts, the Apo-Tessars have an "R" for "reverse mount", followed by the number for the barrel diameter in mm.

A lens closely related to the Apo-Tessars is the 120mm f/6.3 S-Tessar (fig. 4 lower left, and fig. 2 upper right), officially specified as a lens for color separations. It was also used successfully for macrophotography. The design is from 1931. After WWII, 1052 S-Tessars were built by CZJ from 1945 to 1962.

Table 4b. VEB Carl Zeiss Jena Apo-Tessar design dates and serial numbers, after ref. [6]. The 1955 designs used a small air gap in the back cell (figs. 2 and 8) instead of the cemented interface.

Focal Length [mm]	Max. Aperture	Design Year	Serial Numbers
140	9	1939	Between 2,907,501 and 3,622,200
		1955	3,622,201 and higher
180	9	1939	Between 2,799,101 and 4,435,700
		1955	4,676,016 and higher
180	15	1955	7,289,976 – 7,290,000
		1968	7,326,281 and higher
240	9	1929	Between 2,913,801 and 3,410,770; 6,360,551-600; 7,047,601 - 650; 7,258,826 - 850
		1955	6,223,701 and higher except the above range
300	9	1927	Between 3,008,101 and 3,411,040
		1955	3,411,041 and higher
375	9	1937	Between 3,181,693 and 4,498,834
		1955	4,678,126 and higher
450	9	1928	Between 3,016,691 and 4,870,945
		1955	4,951,631 and higher
600	9	1928	Between 2,801,161 and 3,608,350; also 4,498,951 - 4,499,050; 4,543,204
		1955	4,467,396 and higher except the above range
750	9	1927	Between 2,915,126 and 3,875,870
		1955	4,467,431 and higher
900	9	1928	3,608,571; 3,746,098;
1200	11	?	3,016,941 and higher

Process lenses: Apo-Planar

The second line of process lenses made by CZJ before the war was the Apo-Planar line. The Apo-Planars were based on the Planar lens, invented by Paul Rudolph six years before the Tessar, in 1896. It is a variant of the "double Gauss" lens type. The standard double Gauss lens consists of a positive and a negative meniscus lens on each side of the aperture, 4 elements in 4 groups. Rudolph improved this design by thickening the inner negative menisci considerably and splitting them into cemented doublets (6 elements in 4 groups). The two glasses of the doublet had about the same index of refraction, but different dispersion; by adjusting the curvature of the interface between the two elements, Rudolph could change the chromatic aberration correction in a wide range to improve the lens correc-

tion considerably. The "Planar" name is due to the low field curvature, giving a "plane" image, which makes them well suited for copying flat originals. The Apo-Planar had a coverage of 40°, close to the 43° of the Apo-Tessar. It was better corrected than the Apo-Tessar, but more prone to flare and ghosting due to the 8 air-glass interfaces. The latter problem was of course remedied by the introduction of coating. The Apo-Planars were only made in longer focal lengths, from 410mm to 1700mm (table 5). They are therefore not as common and much more expensive than the Apo-Tessars. Just a few batches were made after WWII, in late 1945 and in 1946. These are essentially the only coated versions of this lens type. Table 5 lists the few lenses that were made after the war.

Table 5: Apo-Planar lenses made in 1945 and 1946, after Thiele [6].

Focal length [mm]	Max. Aperture	Design date	Lenses manufactured	Serial nos.
410	7.5	1919	35	2,770,891-895; 2,789,271-280; 2,868,851-870
590	9	1920	45	2,747,921-930; 2,788,166-180; 2,889,481-500
800	10	1911	45	2,788,151-165; 2,799,581-590; 2,912,351-370
1050	10	1919	5	2,814,986-990
1300	12.5	1919	17	2,814,981-985; 2,912,915-926
1700	12.5	1919	35	2,747,901-910; 2,788,745-749; 2,789,251-265; 2,912,927-931

Process lenses: Apo-Germinar

The Apo-Tessars were replaced as the main process lens line by the newly developed Apo-Germinars (figs. 9 and 10, tables 6a and b). They were originally designed by Harry Zöllner, the head of the Zeiss Jena lens design office from 1946 to 1977. There was some overlap in production as the last Apo-Tessars where produced up to the early 1970's, and Apo-Germinars were introduced in the early 1960's.

Table 6a. VEB Carl Zeiss Jena Apo-Germinars. All lenses came in barrel mounts.

Focal Length [mm]	Max. Aperture	Lens Elements/ Groups	Angle of Coverage [°]	Image Circle @ 1:1 and f/22 (calculated)	Filter Size	Weight [g/oz]	Production numbers
140	9	6/6	46	232	-	192/6.8	ca. 140
180		6/6		298	-	452/15.9	ca. 1140
240		6/6 and 4/4		398	M49x0.75	300/10.6	1943
300		6/6 and 4/4		497	M49x0.75	330/11.6	454
360		4/4		596	M67x0.75	780/27.5	1295
375		6/6 and 4/4		621			1354
450		6/6 and 4/4		746	M67x0.75	900/31.7	2108
600		6/6		994	M86x1	1890/66.7	1709
750		6/6		1243	M105x1	3480/122.8	633
900		6/6		1491			96
1000	12	6/6		1657	M105x1	3800/134	230
1200	11	6/6		1988			65



Fig. 9: Apo-Germinar process lenses, all are f/9. Bottom row from left to right: 140mm in barrel (6/6 version), 180mm in barrel (6/6 version), and 240mm in barrel (4/4 version). Top row from left to right: 300mm in barrel (4/4 version), 360mm in barrel for motorized aperture change (4/4 version), and 450mm in barrel for motorized aperture change (4/4 version). Scale is in cm.

Apo-Germinars went through one or two redesigns, depending on the type. The original design from 1957 used 6 lenses in 6 groups for *all* focal lengths, shown in fig. 2 center left, but the redesign from 1962 switched to a classic process lens design of the Dialyte type, 4 elements in 4 groups, for focal lengths up to 450mm (fig. 2 center), and a different 6/6 design for the longer focal lengths (fig. 2 center right). Only a few hundred lenses of each of the original 6-element designs have been produced. Of the longer focal lengths, the 900 and 1200mm versions only came in the older 6/6 design, and the 600, 750, and 1000mm ones only in the newer one.

The Apo-Germinars have 46° coverage, with a maximum opening of f/9, except for the 1000mm and 1200mm lenses, which are restricted to f/12 and f/11, respectively. They are all optimized for a 1:1 reproduction ratio, but it is well known that this lens type holds



Fig. 10: 750mm Apo Germinar process lens. Scale is in cm.

up quite well when used at infinity. Since they are symmetrically built, there is no need to reverse the lens when going from reduction to enlarging as was the case for the Apo-Tessars.

Table 6b: VEB Carl Zeiss Jena Apo-Germinar design dates and serial numbers, after Thiele [6].

Focal Length [mm]	Max. Aperture	Design Year	Serial Numbers
140	9.0	1957	4,897,126 - 6,259,280
		1962	7,208,266 and higher
180	9.0	1957	5,634,668 - 6,259,310; 7,290,101 - 7,290,150
		1962	7,208,316 - 7,208,365; 7,333,689 - 7,334,688
240	9.0	1957	Between 4,897,128 and 6,389,424
		1962	Between 6,795,606 and 9,000,684
		1970	9,228,009 and higher 1;001-2;775 (1981-1989)
300	9.0	1957	Between 4,897,129 and 6,361,320
		1962	7,290,226 – 7,290,275
		1970	9,228,089 and higher 1,001-1,100 (1982)
360	9.0	1970	9,228,129 and higher 1,001-1,990 (1982-1988)
375	9.0	1957	Between 4,897,130 and 6,798,004
		1962	6,798,057 and higher
450	9.0	1955	8,787,771 - 8,787,790
		1957	Between 4,897,131 and 7,028,675
		1962	Between 8,826,425 and 9,000,764
		1964	Between 7,028,676 and 7,355,318
		1970	9,228,209 and higher 1,001 – 1,880 (1981-1988)
600	9.0	1956	Between 5,634,741 and 6,389,770
		1962	Between 6,504,841 and 9,000,780
		1970	9,228,249 and higher 1,001-1,600 (1982-1989)
750	9.0	1957	Between 4,897,132 and 6,621,130
		1962	Between 7,131,989 and 8,973,851
		1970	9,228,359 and higher (1,001-1,175) 1985-1988
900	9.0	1957	Between 4,897,133 and 10,405,585
1000	12.0	1970	9,469,721 and higher
1200	11.0	1957	Between 5,634,781 and 7,290,650

The optimum aperture of the Apo-Germinars is f/22. For the later 6/6 version, a patent was granted in 1964 in West-Germany and 1965 in Britain [23]. Apo-Germinars are very high quality lenses and offer exceptional performance. They are at least as good as their Apo-Ronar, Apo-Artar, or Apo-Nikkor counterparts and were sold on Western markets at a premium price. For comparison, in the long focal lengths Rodenstock offered similar 6- or 8-element Apo-Ronars as their ultimate process

lenses for the most demanding applications, in addition to their regular 4-element ones of the same focal lengths. MTF curves of the last Apo-Germinar versions can be found in the appendix of the accompanying article on Docter lenses [4].

The barrel mounts of the Apo-Germinars are difficult to remount into a shutter; extraction of lens cells is not a straightforward operation, although it has been done [12]. The best possibility is front mounting them to a shutter behind the lens such as a Copal-Sinar shutter, a Packard shutter, or a large Compound or Ilex shutter.

Process lenses: Apo-Germinar W



Fig. 11: Apo-Germinar W lenses with their custom center filters, all are f/8. Front left: 150mm, front right: 210mm, back: 240mm. Scale is in cm.

The latest development was the introduction of the Apo-Germinar W series (fig. 11, table 7) in 1981, symmetric wide-angle process lenses with 63-73° coverage and a maximum opening of f/8. The design is rather unique and expensive to manufacture with 8 elements in 8 groups (- + - + I + - + -), as shown in fig. 2 bottom row. Other process lenses with similar coverage either use a 6/4 Plasmat con-

struction (Rodenstock Apo-Gerogon, Schneider G-Claron, Fujinon-A, Eskofot Ultragon) or a 4/4 double Gauss meniscus construction of the Topogon type (Process Nikkors, Schneider G-Claron WA). The optimum aperture for the Apo-Germinar W is f/16, one stop faster than the lenses of most competitors. These lenses are multicoated, probably because of the 16 glass-air surfaces involved, but are not marked MC or otherwise. Zeiss Jena claimed a superior performance of the Apo-Germinar W compared to standard wide angle process lenses, and they indeed have a remarkably high and even modulation transfer function (MTF) over the field. MTF curves of the Apo-Germinar W's can be found in the appendix of the accompanying article on Docter lenses [4]. The price for the high performance is a rather large size and weight in relation to their focal length and coverage. Apo-Germinar W lenses were sold with individual center filters to counter any remaining illumination falloff (fig. 11). The 210mm and 240mm versions make great enlarging lenses for 8x10", and the 150mm for 4x5".

Table 7: VEB Carl Zeiss Jena Apo-Germinar W lenses. The design year was 1981 for all lenses, and the production dates were between 1982 and 1988. Production numbers were taken from Thiele [6].

Focal Length [mm]	Max. Aperture	Lens Elements/ Groups	Angle of Coverage	Image Circle @ 1:1 and f/16 (calculated)	Mount/ Shutter	Filter Size	Weight [g/oz]	Remarks
150	8.0	8/8	63	368	barrel	M67x0.75	1030/36.3	850 produced
210			68	567		M86x1	1490/52.5	850 produced
240			73	710		M110x1	3180/112.2	810 produced

Photomacrography lenses: Mikrotar

The Mikrotar lenses were originally introduced by Carl Zeiss Jena before WW II, and were sold for use on microscopes like the prewar Ultraphot (I) microscope, or for use directly on a camera such as the Contax, Exakta, or LF cameras. There was even a complete setup for using them on a Contax II [19]. VEB Carl Zeiss Jena continued this line of lenses after WWII, although it is not clear if they continued the whole line. Certainly the 15, 20, 30, 45, 60, and 90mm versions were produced after WWII (fig. 12) and offered for use on microscopes, e.g. with the Miflex microscope camera attachment [14] for 6.5x9cm plates, and other applications. Whether they were changed optically compared to their pre-WWII predecessors, in addition to the introduction of optical coatings, is not clear. There is a research report from 1962 by Dr. Harry Zöllner, the head of lens development at CZJ, on a Mikrotar 10mm f/1.5 (instead of the previous f/1.6) [16]. Whether this development or other design improvements made it into production is not known. The nominal design parameters of the Mikrotars available on the used market, such as focal length and maximum opening, are the same as the pre-WWII ones. The focal lengths of the Mikrotars made until the end of WWII are inscribed in cm on the barrel, whereas the more modern ones show it in mm, either with or without the "mm" designation, and they are coated. The barrels show the maximum aperture both as the f-stop number k and as the numerical aperture NA, standard in microscopy. NA is defined as:

$$NA = n \cdot sin(\vartheta/2)$$

where n is the refractive index of the surrounding medium (approximately 1 for air), and ϑ is the maximum angle of the full cone of light that can enter the lens. Assuming $n=1$ and infinity focus, NA can be calculated from k (and vice versa) by:

$$NA = \frac{1}{2k}$$

Table 8a: Zeiss Jena Mikrotars, after ref. [15]. The "maximum aperture" column shows the aperture first as the familiar f-stop number and then the numerical aperture NA. The 165mm lens is often just labeled as a "Tessar" in the literature [15,17]. Whether postwar versions of the 10, 120, and 165mm Mikrotars existed at some point in time remains an open question, they were not listed in a 1962 brochure [25]. Some more data can be found in refs. [21, 25]. Schematic lens diagrams are shown in fig. 13.

Focal Length [mm]	Max. Aperture	Lenses/ Groups	Mount	Weight [g/oz]	Remarks
10	1.6/0.31	6/4	N20, RMS		Planar type
15	2.3/0.21	6/4	N20, RMS		
20	3.2/0.15	5/3	N20, RMS	39/1.38	Dynar (2nd Heliar) type
30	4.5/0.11	3/3	N20, RMS	38/1.34	Triplet
45	4.5/0.11	3/3	N20, RMS	50/1.67	
60	4.5/0.11	3/3	N20, RMS		
90	6.3/0.08	4/3	N24, M26x0.5	68/2.4	Reverse Tessar type, also existed in a version without variable aperture
120	6.3/0.08	4/3	N00W, M26x0.5		Reverse Tessar type
165	6.3/0.08	4/3	N??, M45x?		

The numerical aperture number on the barrel is preceded by "Ap". Most Mikrotars have a mount with an adjustable aperture, but barrel versions without aperture were also available. The aperture scale on the Mikrotar mount gives the physical aperture diameter in mm (not the entrance or exit pupil diameter), so it is the same for all Mikrotars using the same mount, and the smallest number refers to the closed aperture position. This is opposite to the Zeiss Oberkochen Luminars [3] where the largest number designates the smallest aperture opening. For the 10, 15, 20, and 30mm Mikrotars, the aperture is behind the lens assembly, for the 60mm it is behind the first lens, and for the 45, 90, 120, and 165mm version it is in front of the last lens (Fig. 13). Note that the whole diameter range of the aperture might not be used for a given lens, e.g. for the 30mm Mikrotar the "open" position is any setting between 11 and 4mm aperture diameter. The mounts are small versions of Zeiss' standard mounts with the "N" designation for "Normalfassung", as explained in the section on LF lenses above, and the lens cell(s) screw into this mount. The "N20" mount has a maximum aperture opening of 11mm, the "N24" mount of 13mm, and the related "N00w" mount of 16mm. The N20 mount for the shorter

focal lengths Mikrotars has the common microscope RMS thread[4], so it can be directly screwed into a microscope lens turret. The three longer Mikrotars have larger metric threads as listed in table 8a, since they cannot be used on a standard microscope with 160mm or 170mm optical path length anyway. The use of the "N" type mount is different from similar lenses, such as the Luminars made by Zeiss Oberkochen at their Winkel factory in Göttingen, or Reicherts Neupolar lenses. All of these came as microscope objectives with an integrated aperture, not using lens cells.



Fig. 12: Mikrotar lenses from VEB Carl Zeiss Jena in CZJ's standard barrel ("N") mounts. From left to right: 20mm f/3.2, 30mm f/4.5, 45mm f/4.5, 90mm f/6.3. Note the different inscriptions: the 20 and 45mm say "Mikrotar", the 30 and 90mm just "M" (bottom row), the 20, 45, and 90mm use the Carl Zeiss Jena logo, the 30mm the "ausJENA" one (top row). Scale is in cm.

When Mikrotars are used in a microscope for transmitted light photomacrography, a special "condenser" lens should be used, positioned as close as possible to the object stage. It differs from a regular condenser lens in that it has a much longer focal length. It projects the field stop of the lighting stage into the entrance pupil of the Mikrotar lens, whereas regular condenser lenses, with much shorter

[4] RMS stands for Royal Microscopical Society and refers to their standard microscope thread, defined in 1896, which is still in widespread use today. It is a Whitworth thread (55° angle) with male thread dimensions of 0.7952-0.7982" x 36tpi. Microscopists sometimes affectionately refer to it as the "Royal Screw".

focal lengths, project the field stop into the object plane [22]. Usually these are just single lenses mounted at the top of a cylindrical housing that fits onto the condenser stage. For this reason they are often called "spectacle condenser" ("Brillenglaskondensor" in German). Zeiss Jena made such "condenser lenses" for the Mikrotars, they carry an inscription on the front ring designating the lens(es) they are meant for.

*Table 8b: Magnification ranges given by Michel [15] for the Mikrotars; calculated magnification for an extension of 250mm, such as the combination of a microscope stand with a photo attachment; maximum object area diameter according to Michel [15]; calculated image circle at 250mm extension; magnification for 150mm image circle; extension for 150mm image circle. *Magnification is not an option on a regular microscope stand due to the resulting large object distance.*

Focal Length [mm]	Magnification Range [15]	Magnification @ 250mm extension	Object Diameter [mm] [15]	Image circle @ 250mm extension [mm]	Magnification for 150mm image circle	Extension for 150mm image circle [mm]
10	30x - 85x	24x	3.5	84	43x	439
15	18x - 60x	15.7x	5	78	30x	465
20	12x - 40x	11.5x	7	81	21.5x	449
30	7x - 25x	7.3x	15	110	10x	330
45	5x - 20x	4.6x	20	91	7.5x	383
60	3x - 15x	3.2x	30	95	5x	360
90	1.5x - 10x	1.8x*	60	107	2.5x	315
120	1x - 7x	1.1x*	80	87	1.9x	345
165	1x - 5x	0.5x*	150	77	1x	330

The Mikrotars made for sale in the Eastern Bloc usually have the traditional Carl Zeiss Jena logo plus the "Mikrotar" name engraved (fig. 12). Mikrotars made for export to Western countries are not marked "Mikrotar" on the barrel, but just "M", in addition to either a "Jena" or an "aus JENA" designation instead of the Carl Zeiss logo. However, other combinations are not uncommon, such as the "M" together with the full Carl Zeiss Jena label (fig. 12). Early versions made shortly after the war have the red "T" symbol to indicate they are coated [19], but, similar to regular CZJ lenses, this was omitted in later years when coating became commonplace. Note that the serial numbers engraved on the barrel do *not* follow the serial numbers of the photographic lenses given in table 2, they used a different numbering system, always with six digits. A reasonable assumption would be that they are part of Zeiss Jena's numbering system for microscope objectives. Early Mikrotars with "T" designation have numbers around 490,000 whereas late ones with "ausJENA" designation start with a 0 like the 30mm one in fig. 12 or are in the low 100,000 range. The "ausJENA" designation started after the 1971 "London agreement" between Zeiss Oberkochen and Carl Zeiss Jena on the use of names. CZJ's regular microscope objectives show similar number ranges, so it can be assumed that once they reached 999,999, they started over with 000,001. Microscope objectives that are clearly postwar constructions with numbers such as 000,381 can be found, and for microscope objectives from the 1980's, Zeiss Jena

numbers were back in the 400,000 range. From these three data points it might be possible to roughly interpolate a production year range for a given Mikrotar.

Table 8a lists the Mikrotars and their data, fig. 13 shows the basic construction type. It is based on a list from a 1943 article by Kurt Michel on microphotography, published in an addendum volume to the "Handbook of Scientific and Applied Photography" [15]. Michel worked for Zeiss Jena at the time and later became the Science team lead of the West-German microscope division of Zeiss Oberkochen. Table 8b lists his data for suggested magnification ranges and object diameters in columns 2 and 4, respectively. The other columns in table 8b show calculated values for the magnification and coverage for two cases, one is for a bellows or tube extension of 250mm, similar to a regular microscope stand with photo attachment, and the other for an image circle of 150mm, i.e. covering 4x5. The numbers are based on Michel's suggested object field diameters in column 4 and the focal lengths. The object field diameter values are only approximate numbers and depend on the aperture used and the magnification, as noted by Michel. Michel apparently based his suggested magnification ranges, which seem rather large, on two hypothetical setups. One setup would have a maximum bellows extension of 50cm, and the other one 100cm, i.e. 1000mm. The latter results in the high value of his ranges; for the low value he apparently assumed a minimum bellows extension of 250-300mm. Comparing these values to the ones for a microscope setup shows that the latter are at the lower end or even below his magnification range, but they are probably closer to a realistic value for good performance.

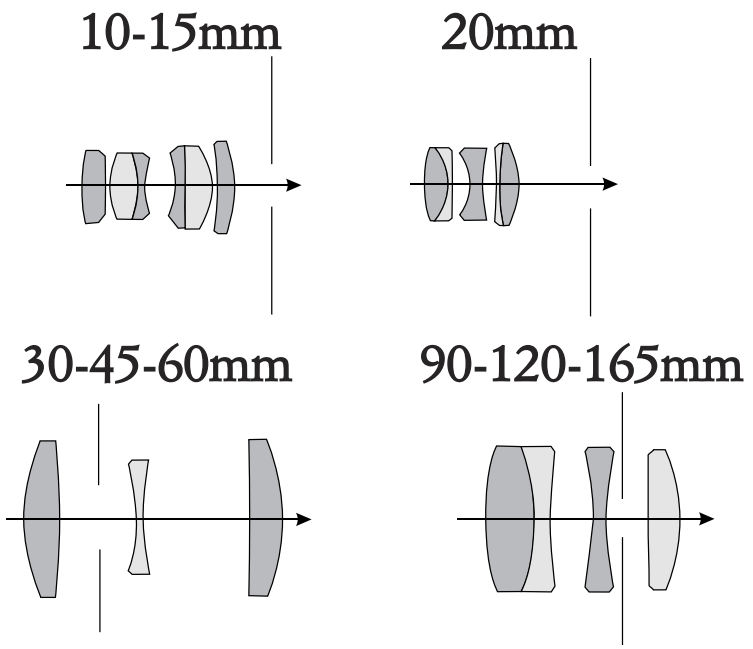


Fig. 13: Schematic lens diagrams for the Mikrotar line, based on refs. [15, 17].

Note that similarly named lenses made by other companies, usually spelled with a "c" as "Microtar", can be found on the market. These include barrel lenses made by the (post-WWII) Goerz Am. Opt. company, e.g. an 8¼" f/9 "Microtar" (possibly a special version of their process lenses). Another example is an f/6.3 lens for a Whittaker spy camera from the 1950's. None of these lenses are related to the Zeiss Mikrotar lens line.

Aerial, photogrammetry, prototype, and other specialty lenses

In addition to the lenses described above, Carl Zeiss Jena produced small prototype batches of LF lenses that never found their way into full production. These include the 65mm f/4.5 Lamegon, 90mm f/4.5 Lamegon, 135mm f/3.5 Biometar, 210mm f/5.4 Biometar, and 270mm f/8 Tessar series for the "Grandina" view camera planned by the Czechoslovakian company Meopta as described in a separate article [13], as well as other longer focal lengths Biometars.



Fig. 14: Lamegon 55mm f/5.6 (left) from a SMK 5.5/0808 camera, and a Lamegon 100mm f/8 (right) from a UMK 10/1318 camera as examples for photogrammetry lenses from Carl Zeiss Jena [20]. Both lenses came in shutter, the 55mm one shown uses a mechanical shutter, the 100mm an electric one. Scale is in cm.

They also made a large range of lenses for aerial mapping and reconnaissance, as well as for aerial and terrestrial photogrammetry like the Lamegon (fig. 14), Superlamegon, Lametar, and Pinatar lenses. There were also lenses for other uses such as some Dagors that may be usable as large format optics. Most of these lenses are listed in table 9, and fig. 15 shows some schematic lens diagrams. Their aerial cameras were either named "LMK" (for "Luftbildmeßkammer", aerial measuring camera), or "MRB" (for "Meßreihenbildner", serial measuring camera). The "UMK" camera name stood for "Universalmeßkammer" (universal measuring camera) and was used for terrestrial photogrammetry applications, the "IMK" ("Industriemeßkammer) for industrial applications at closer distances, whereas the "SMK" ("Stereomeßkammer") was a setup for terrestrial stereo photos. The two numbers following the name indicate the focal length of the lens and the film format in *cm*, e.g. an MRB 30/2323 has a

300mm lens for an image size of 230x230mm. Just a four-digit number indicates the film format in cm without specifying the lens.

In addition to their aerial and photogrammetric cameras, Carl Zeiss Jena produced a range of equipment for printing, rectifying, and analyzing those photos. Their photogrammetric rectifier, essentially a vertical enlarger with tiltable base plate, was called "Rectimat", and came in several different versions: The first one was the Rectimat-A from 1968, replaced by the Rectimat-B in 1970 [25, 28]. The last, computerized, model was the Rectimat-C in 1983 [27]. These supplanted the SEG series of Zeiss rectifiers (SEG stands for "Standardentzerrungsgerät, Standard Rectifying Apparatus") that started in 1921 [26]. The West-German Zeiss Oberkochen company, however, kept the "SEG" name and their equivalent offerings for the Rectimat-B and -C were the SEG-V (5) and SEG-6 rectifiers, respectively.

The enlarging lenses of the Rectimat series were called "Transformar" and were corrected for minimal distortion ("orthoscopic"). The fact that several languages, including Russian, use the term "photo transformer" for photogrammetric rectifiers was probably the reason for this name. The lenses were optimized for ranges between 0.85x to 8x, or 3x to 18x, depending on the model, as listed in table 9. They were wide angle lenses similar to the Lamegon series, with negative menisci at both ends, but obviously corrected for close distances, with reported resolution of 100lp/mm in the center and 80lp/mm in the corners . The West-German equivalents used in the SEG-5 or -6 were 180mm f/6.3 and f/5.6 Topogons, respectively.

The aerial and photogrammetry cameras and lenses as well as the associated equipment were sold both to the Eastern Bloc countries and on Western markets. Their systems were strong competitors of the offerings from Wild-Heerbrugg in Switzerland as well as of the ones made by their West-German counterpart Zeiss Aerotopgraph (see ref. [3]). Sales to Western countries were probably the reason for the name change from "SEG" to "Rectimat".

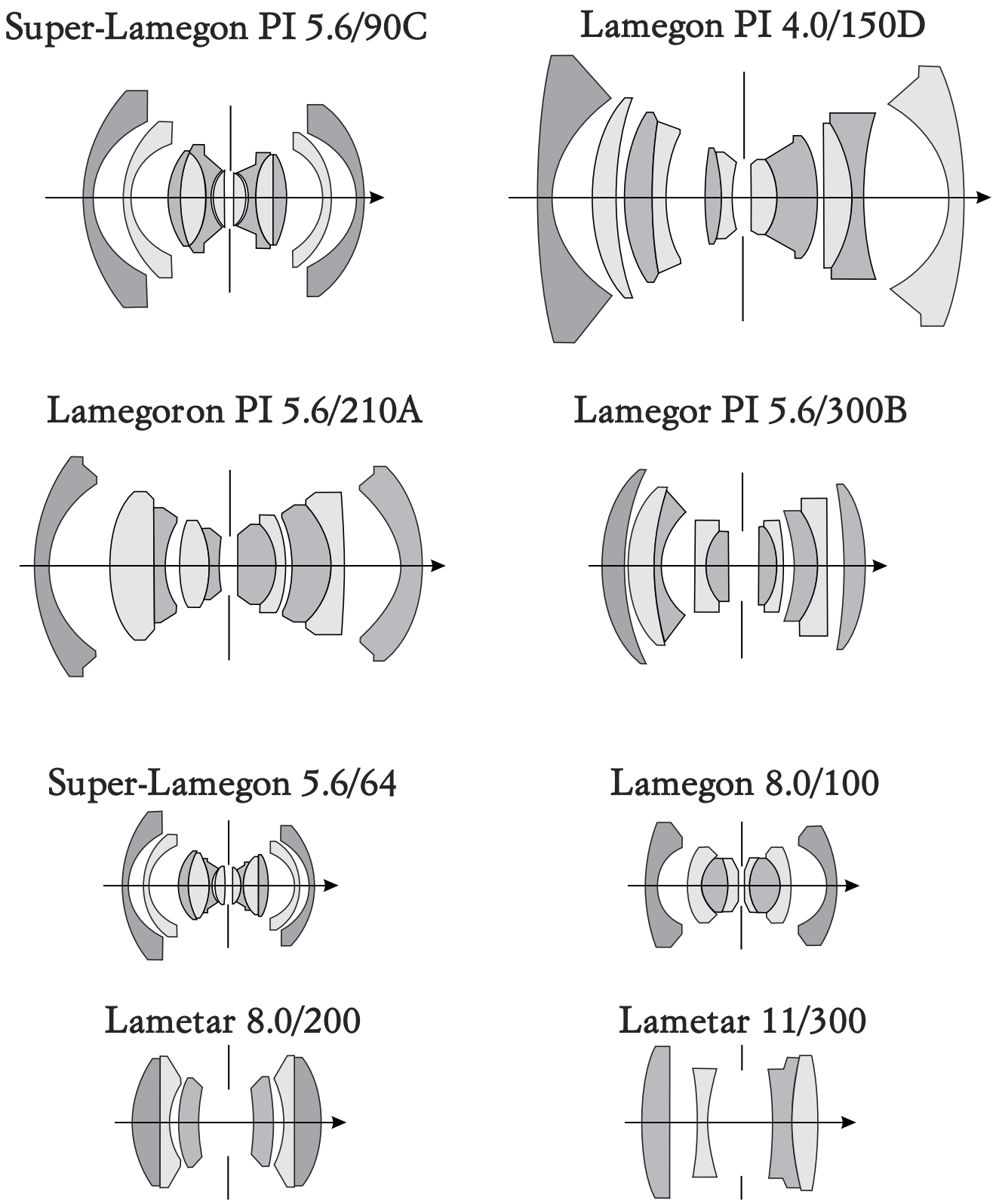


Fig. 15: Schematic lens diagrams for some of CZJ's aerial and photogrammetry lenses, after refs. [20, 24]. The top two rows show infrared-corrected ("PI") lenses for the LMK aerial cameras, the bottom two rows show lenses for the UMK photogrammetry cameras.

*Table 9: VEB Carl Zeiss Jena prototype, aerial, and photogrammetry lenses. "PI" stands for Pan-Infra, i.e. the correction is for both the visible and the near IR part of the spectrum, from 400-900nm. The PI models also came in updated versions, labeled -B, -C, -D, etc. *A few additional units were produced in the 1970's in Copal/Copal electric shutters and offered in the USA under the "aus Jena" label, see ref. [13].*

Lens Name	Focal Length [mm]	Max. Aperture	Lens Elements/ Groups	Angle of Coverage [°]	Image Circle (calculated)	Mount/ Shutter	Remarks
Biometar	120	2.8	5/4	?	?	barrel	Prototype, around 1979/1980
Biometar	135	4.0	5/4	67	156@f/4 180@f/11	Prestor 1	For Meopta Grandina camera, 5 produced for test purposes*
Biometar	165	2.8	5/4	?	?	?	2 produced for test purposes (designed 1956)
Biometar	180	2.8	5/4	?	?	?	2 produced for test purposes (designed 1955)
Biometar	210	4.0	5/4	?	?	?	2 produced for test purposes (designed 1957)
Biometar	210	5.4	5/4	66	240@f/5.4 270@f/16	Prestor 1	For Meopta Grandina camera, 5 produced for test purposes*
Biometar	250	4.0	5/4	?	?	?	2 produced for test purposes (designed 1952)
Dagor	125	9.0	6/2	?	?	?	26 produced (some for planetarium use)
Dagor	180	6.8	6/2	?	?	?	88 produced in special mount, possibly for an aerial image rectifier
Lamegon	55	5.6	8/4	90	110	Electric shutter/ Compur	For SMK 5,5/0808, weight 1860g/65.6oz
Lamegon	65	4.5	8/4	105	156@f/4.5 170@f/22	Prestor 1	For Meopta Grandina camera, 5 each produced for test purposes*
Lamegon	90	4.5	8/4	105	200@f/4.5 224@f/11	Prestor 1	
Lamegon A/B	100/99	8	8/4	98	230	Electric shutter	For UMK 1318, weight 3870g/136.5oz
Lamegon	110	16	?	?	?	barrel	Fixed aperture
Lamegon	115	4	10/6	95	255	?	Aerial for MRB 1818 designed 1962
Lamegon PI	115	4	?	92.7			For MRB 1818
Lamegon	150	4.5	10/6	95	325	?	Aerial for LMK 2323, designed 1968/74
Lamegon PI	152	4.5	10/6	91.8	305	?	Aerial/Photogrammetry, designed 1984
Lamegon PI-D	150	4.0	11/7	91	305	?	Aerial/Photogrammetry, designed 1984

Lens Name	Focal Length [mm]	Max. Aperture	Lens Elements/ Groups	Angle of Coverage [°]	Image Circle (calculated)	Mount/ Shutter	Remarks
Lamegoron	210	5.6	10/6	76	328	?	Aerial/Photogrammetry
Lamegor PI	305	5.6	10/6	53-54		?	Aerial, for MRB 30/2323, designed 1973
Lamegot	300	5.6	?	53		?	Aerial/Photogrammetry
Pinatar	115	4	10/6	?	?	?	
Pinatar	125	4	10/?	?	?	Electric shutter, 1/20 – 1/200s [18]	MKF-6/6M multispectral camera (55x81mm images on 70mm film)
Pinatar	210	4	10/6	62.1		?	Photogrammetry
Pinatar PI	210	4	10/6	62.1		?	Photogrammetry
Super-Lamegon PI	64	5.6	12/7 or 12/8	112		Electric shutter	Photogrammetry/8m fixed focus, for UMK 1318
Super-Lamegon	70	5.6	10/6	?	?	?	Aerial, for MRB 1818
Super-Lamegon	90	5.6	11/?	122	318	Electric shutter	Aerial, for MRB 2323
Super-Lamegon PI	90	5.6	12/8	122 (-B) 119 (-C)	318		Aerial for MRB 2323 and LMK 2000
Lametar	200	8	6/4	60	230	?	Photogrammetry, designed 1972, Plasmat type, for UMK 1318
Lametar	300	11	4/3	42	230	?	Photogrammetry , designed 1972/79, Tessar type, for UMK 1318
Quarz-Steinsalz-Anastigmat	120	4.5	5/3	35	150@1:1	barrel	For UV macrophotography, covers 9x12cm at 1:1. Symmetric triplet derivative with 3 element center group made from fused quartz, and halite (NaCl) crystals for UV transmission down to 200nm.
Tessar	270	8	4/3	53	250@f/8 270@f/16	Prestor 1	For Meopta Grandina camera, 5 produced for test purposes*
Topogon	115	10	4/4	90?		barrel	Calculated 1958
Transformar	70	5.6	10/6	85	128 @ infinity	barrel	For Rectimat-C, for 3x to 18x enlargements
	125	8	?	?	?		For Rectimat-B
	150	5.6	11/6	85	275 @ infinity		For Rectimat-C, for 0.85x to 8x enlargements, Weight ca. 9kg

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References

I've drawn on printed sources as well as internet postings. A major help were the books by Hartmut Thiele based on the original Zeiss file cards, listing the manufacturing dates and numbers of nearly all Zeiss Jena lenses from 1927 to 1991. URL's last retrieved on October 4, 2019.

[1]Cröll, Arne: Large Format Lenses from the Eastern Bloc Countries 1945-1991, http://www.arnecroell.com/eastern-bloc-new.pdf

[2]Hermann, Armin: Und trotzdem Brüder- die deutsch-deutsche Geschichte der Firma Carl Zeiss. Piper, Munich 2002, (ISBN 3-492-23821-1)

[3]Cröll, Arne: Large format lenses from Carl Zeiss in Oberkochen. http://www.arnecroell.com/zeissoberkochen.pdf

[4]Cröll, Arne: Large Format Lenses from Docter Optic 1991-1996. View Camera Sept./Oct. 2003, Corrales, NM, USA, pp.48-53, also: http://www.arnecroell.com/docter.pdf

[5]Jehmlich, Gerhard: Der VEB Pentacon Dresden. Sandstein Verlag, Dresden 2009. ISBN 978-3-940319-75-3

[6]Thiele, Hartmut: Fabrikationsbuch Photooptik II – Carl Zeiss Jena. Private printing, 6th Ed., Munich 2011.

[7]German and English Carl Zeiss Jena brochures on the Apo-Germinars (1974, 1982, 1984) and the barrel Tessars (1969).

[8]Thiele, Hartmut: Carl Zeiss Jena – Entwicklung und Beschreibung der Photoobjektive und ihre Erfinder. Private printing, 2nd edition Munich 2007

[9]Thiele, Hartmut: Die deutsche Photoindustrie – wer war wer. Private printing, 2nd Ed., Munich 2002.

[10]Thiele, Hartmut: 150 Jahre Photooptik in Deutschland 1849-1999. Private printing, 4th Ed., Munich 2002.

[11]Wright, A.N. and Matthews, D.: A Lens Collectors Vade Mecum. 3rd Ed., Redruth, Cornwall 2001 (pdf files on CD)

[12]http://www.skgrimes.com/lens-mounting/table-of-lenses-fitted-to-shutters

[13]Cröll, Arne: The "Grandina" LF lenses from Carl Zeiss Jena – a tale of technical excellence and economic absurdity. View Camera Sept./Oct. 2005, Corrales, NM, USA, pp. 34-38, also: http://www.arnecroell.com/grandina.pdf

[14]VEB Carl Zeiss Jena: Zeiss Universal-Aufsetzkamera Miflex. Product catalog from 1953. http://www.mikroskop-online.de/Mikroskop%20BDA/30-605a-1.CZ%20%20MIFLEX.pdf

[15]Michel, Kurt: Mikrophotographie. In: Ergänzungsband, Handbuch der wissenschaftlichen und angewandten Photographie, pp. 464-683. Springer, Vienna 1943; Reprint, Verlag der H. Lindemanns Buchhandlung, Stuttgart 1991 (ISBN 3-928126-18-0)

[16]Zöllner, Harry: Abschlußbericht Mikrotare – Mikrotar 10/1,5 V234. Zeiss archive no. BACZ 21929
[17] Michel, Kurt: Die wissenschaftliche und angewandte Photographie, Vol. 10: Die Mikrophotographie. 3rd Ed., Springer, Vienna/New York 1967. (Library of Congress no. 66-22393).
[18] http://www.deutsches-museum.de/sammlungen/verkehr/raumfahrt/weltraumkameras/kamera-mkf-6/
[19] Barringer, Charles.: The Mikrotar macro lenses. Journal of the Zeiss Historica Society 29 (2007), 6-10
[20] UMK 1318/SMK 5,5/0808 brochure from Carl Zeiss Jena. Jena, GDR 1983
[21] Schmitt, Klaus: http://www.macrolenses.de/objektive.php?lang
[22] Göke, Gerhard: Moderne Methoden der Lichtmikroskopie. Frankh, Stuttgart 1988, pp. 76-77 (ISBN 3-440-05765-8)
[23] Zöllner, Harry and Disep, Fritz: Photo- und Reproduktionsobjektiv. German Patent no. 1171633 from December 23, 1964
[24] http://foto.hut.fi/opetus/300/luennot/8/8.html
[25] Schöler, Horst H.: Über die Aktivitäten auf dem Gebiet der Photogrammetrie und des Baues von Bildmessgeräten im Jenaer Zeisswerk in der zweiten Hälfte des 20. Jahrhunderts. In: Geschichte und Entwicklung der Geodäsie, Reihe E, Heft 27, C.H. Beck, München 2006
[26] Fritsch, Dieter: The Photogrammetric Week – A Centennial Success Story. In: Photogrammetric Week '05, Wichmann Publisher, Heidelberg 2005, pp. 3-12
[27] Rectimat C, brochure from Carl Zeiss Jena. Jena, GDR 1984
[28] Photogrammetrische Geräte, brochure from Carl Zeiss Jena. Jena, GDR 1972
[29] Mikroskope für Wissenschaft und Technik, brochure from Carl Zeiss Jena, GDR 1962

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