

What is a Variogon?

„**Variogon**“ is the ► **brand name** for a vario-lens made by "Jos. Schneider Optische Werke GmbH". But what is a vario-lens? It is a lens that has no fixed focal length and can be changed by the user with certain limitations. This is accomplished without having to bring the image of the subject into focus again and again each time the focal length is changed. A lens of this kind is also known as a **zoom lens**.

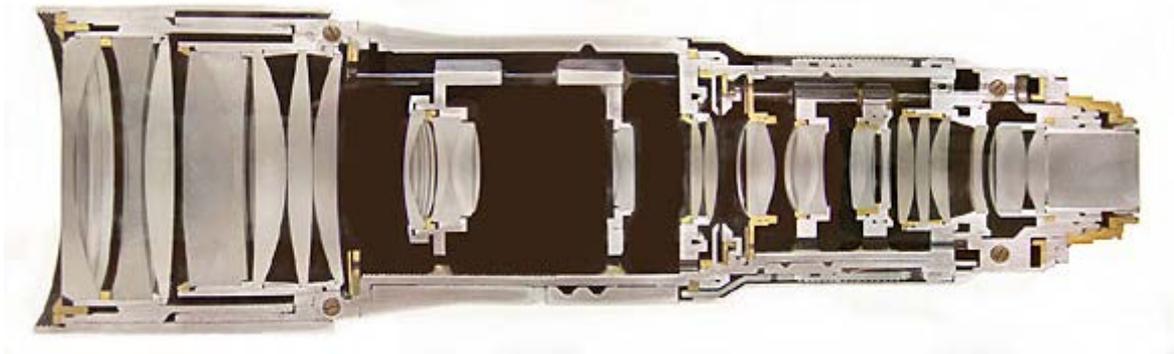


Fig. 1: Optical and mechanical competence in construction and production:
Cross section of the 30-fold zoom-lens **Variogon 1.8 / 6 - 180 mm** for Super-8mm narrow-gauge film

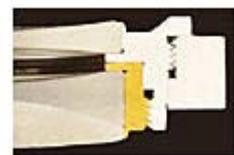
Vario-lenses were already under development at Schneider-Kreuznach by the mid-50s. Because of our extensive experience in optical calculation, construction, and full-scale serial production, the vario-lenses were found in a wide range of applications:

- For **television** (TV-Variogon) and **surveillance cameras**
- in the still photography (single-lens reflex cameras) - here again in the **35 mm and medium-format sector**
- for **enlargers** in the darkroom (Betavaron)
- for variable **still projection** (Vario-Cine-Xenon)
- in various **OEM applications for designed specifically for certain customers**, e.g., in **printing, scanning and reproduction technology** (Variomorphot).

In the most recent technical innovation in photography, **digital photography**, the Variogon has also assumed a position of importance. As an integrated lens with variable focal length, it finds use in the series of various **Kodak EasyShare zoom digital cameras**.

The following list offers a short historical retrospective, together with background information about the "**Variogon**"-lens in its extremely widely varied areas of use:

- Different areas of application of a zoom-lens
- Variogon lenses for narrow-gauge film
- Variogons in television technology
- 35 mm- / medium-format vario-lenses
- Enlarging technology with Betavaron



The way a zoom lens works

The secret of a ► **Variogon**, i.e. of a vario- or zoom lens, is that it cleverly takes advantage of a number of basic optical laws, and by appropriately correcting the aberrations which arise in connection with them, makes it possible to achieve good ► **imaging quality**. To this end, there are three essential preconditions: adequate computer programs, high-performance computers, and above all, the optical-physical know how.



The zoom lenses of today are very complex, both in their construction and their mode of operation. For that reason, to better understand how the traditional Variogon lens, **its main principle of operation is described below**. All zoom lenses, however, have the property of projecting the image to be depicted exactly onto a fixed local imaging plane, be it the surface of the film or the plane of an image sensor, while the focal length is being changed.

The principle of design of a Variogon of the traditional type of construction is easy to understand. The essential factor is that the image is not projected directly onto the film, but arrives there only after several intermediate virtual images have been created.

The first lens group creates an image of the subject like any other lens. Only this part of the optical system is adjusted for the distance from the subject, not the entire lens, as is often customary. From this first image, a second group of lens elements creates a second image; it is only the third group of lens elements that creates the final image.

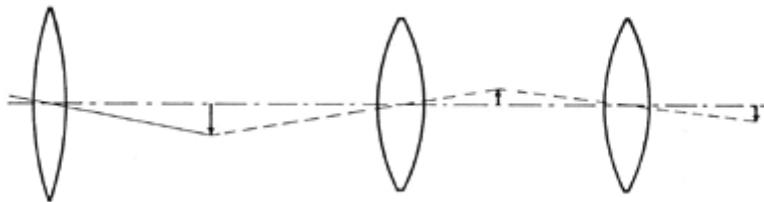


Fig. 1:
Schematic representation of the basic structure of a Variogon lens

Because the second group is shifted, the image ratio from the first to the second intermediate image is changed, and with it the size, too, of the subject as it finally appears on the sensitive medium (Fig. 1). But at the same time, this means that the focal length of the entire system has been changed. With the axial shift, however, the position of the second and third realized image has changed. So that the user does not have to re-focus after every change in the focal length, another lens group is brought into play. Its function is to restore the sharpness simultaneously with the change in the focal length.

The variation in focal length can be realized basically in two ways. In one case, the two lens groups are controlled mechanically in such a way that both carry out specific, but different, movements (**mechanical compensation**), in the other case, both lens groups are moved together; then, by a clever choice of the optical values of both components, one can keep the position of the image constant; to be sure, in this second case, in theory not entirely strictly, but in practice with sufficient precision (**optical compensation**).

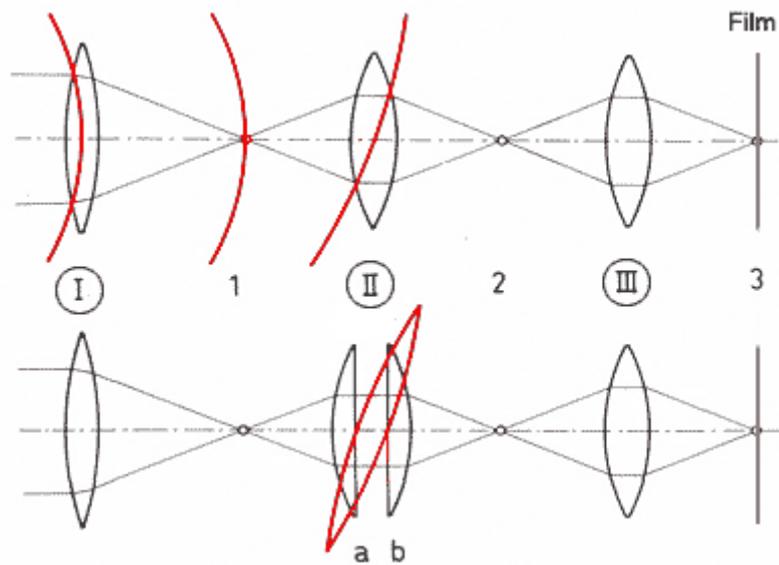


Fig. 2 : 2: Mechanical compensation for the change in the focal distance.

above: The motion of the second lens changes the focal length, that of the first keeps the sharpness constant.

below: The second lens element consists of two parts; by means of their relative movement, the sharpness is kept constant.

Fig. 2 shows schematically the principle of mechanical compensation which is used in all traditional Variogon lenses. In it, the lens groups - here represented by one or two lenses - are indicated by Roman numerals I, II and III, the images by Arabic numbers 1, 2 and 3. The curves which are drawn in the diagram give the position of the lenses with different focal lengths, above with the shortest ones, below with the longest ones.

In the upper part of Fig. 2, the movement of Lens II changes the focal length, that of Lens I keeps the positions of images 2 and 3 constant. In the lower portion of Fig. 2, Lens Group II is split (IIa and IIb); here the change in the distance of the two lenses serves to retain the image.

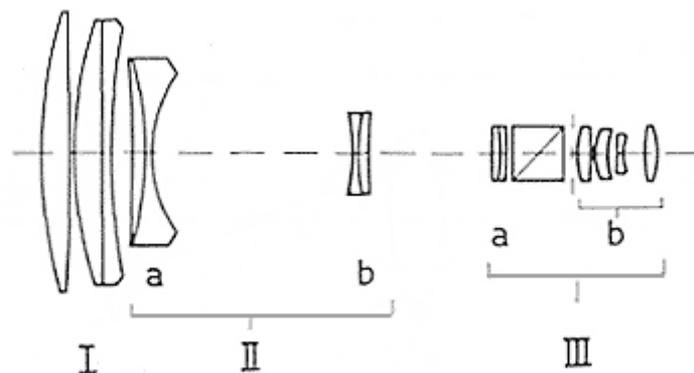


Fig. 3:
Practical demonstration using the Variogon 2.8/10-40 mm. In the practical demonstration in Fig. 2, one part of the lens group has negative refractive power and the intermediate images are virtual images.

As a **practical example** of the principle illustrated in Fig. 2, the Variogon 1:2.8/10-40 is shown in cross-section. The individual elements are indicated with Roman numerals.

In some cases, the third group of lens elements is divided in such a way (IIIa and IIIb in Fig. 3) that the rays between them are parallel. Then one can imagine the entire lens in this position as separated into a supplementary lens without focal length and the main lens. Lenses without focal length function to a certain extent like **Galileo's telescope**, which, depending on which end one looks into, makes the image larger or smaller. When the supplementary lens enlarges, the focal length of the combination is lengthened, and vice versa. The supplementary part of

the Variogon is such that one can change its enlarging property constantly, and hence the focal length of the lens can be adjusted as desired.

As early as the thirties in Germany, lenses of this kind appeared on the market and attracted a great deal of attention; after the war, the "Optical Works Jos. Schneider & Co." was the first German firm to create such a lens for 8-mm narrow-gauge cine cameras. This was the ► Variogon 2,8/10-40 mm, which is shown in Fig. 4.



Fig. 4:
Variogon 2,8/10-40 mm

Zoom lenses for narrow-gauge cine cameras



Fig. 1:
Variogon 1.8 / 8 - 48 mm
for normal-8-narrow-gauge
film with reflex viewfinder

The history of the Variogon zoom-lens is closely tied to that of the narrow-gauge cine film era. An impeccable sharpness of focus right into the corners of the image, even with varying focal lengths, was a basic precondition of its success.

The first lenses with variable focal length for narrow-gauge cine cameras appear as early as the year 1937; they were used on a **16-mm** Siemens camera. Wider use, however, only became possible beginning in the fifties, through the use of [computers](#).

This development ran parallel to technical progress in the anti-reflection coating of optical lenses. Because of the relatively large number of lens elements, the high degree of transparency of the glass became especially important.

Even at the time of the **normal-8-format** (3.6 x 4.9 mm²), almost all manufacturers of narrow-gauge cine cameras in Europe made use of the Schneider-Variogon.

The first types that time:

- ▶ Variogon 2,8 / 10-40 mm,
- Variogon 1,8 / 9-30 mm,
- Variogon 1,8 / 7,5-37,5 mm,
- ▶ Variogon 1,8 / 8-48 mm.

With the introduction of the Super-8-format on the market, a larger picture format (4.22 x 5.69 mm²) was possible, and with it a picture area about 40% larger, which in all areas, and even at full aperture, was distinguished by its sharpness.

The underlying principle of this type of Variogon was based on the **mechanically compensated focal distance adjustment**. In this system, mechanical radial cams move two lens groups according to mathematical-physical guidelines I and II relative to one another - in Fig. 3 represented by blue lines - in order to continuously change the focal length of the lens. As a result, the locus of the picture always remains in the same position, the film plane. The camera-to-subject distance is set with the front group of lens elements.

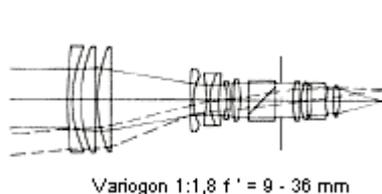


Fig. 2:
Because of the construction and the optical-mechanical action, the locus of the picture remains **constant**, and the **picture quality is largely maintained**.

see Fig. 1, - a beam splitter is situated in front of the iris diaphragm.

An overall view of the Variogon and Optivaron lenses from our earlier product line for Super-8-narrow-gauge cine cameras is presented in a [brochure](#).

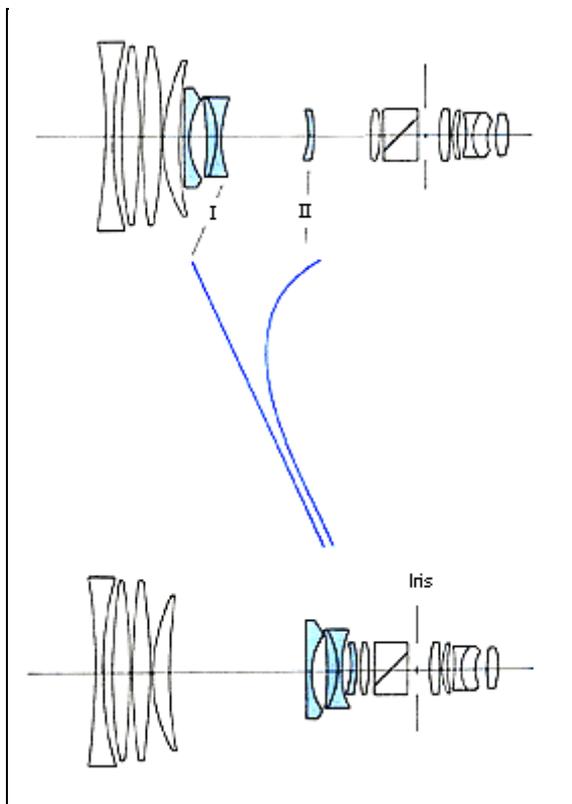
What is remarkable is the **30-fold zoom lens** that was made at the end of the seventies for Beaulieu Cameras:

Variogon 1,8 / 6 - 180 mm



Enlargement by mouse click!

Fig. 3 right:
Principle of function of the mechanical focal distance adjustment



Zoom lenses for television

The development of lenses of adjustable focal lengths, the so-called zoom- or Vario-lenses, was already under way at Schneider-Kreuznach in 1957. Two years later, production of the first prototype began, the ► [Variogon 2,8/10-40 mm](#), for the 8mm film size. At the same time as the development of zoom lenses for other formats, such as the Super-8-, 16 mm- and 35 mm-/medium-format, development was under way for **color television cameras** with all current formats from 1/2" to 1 1/4".

The following configurations provide a brief look into the history of the **TV-Variogons**. In studio or ENG/EFP¹⁾ configurations, they were in use world-wide on the television cameras of [leading manufacturers](#)²⁾. Numerous ► [patents](#) document the innovative development phase in the seventies through the nineties.

► [C-Mount zoom lenses](#) of the 2/3" standard construction series, on the other hand, are still today among the range of lens products for industrial applications.



Fig. 1:
ENG television lens
APO-Varon HM 14X,
Type TV59.02, for 1/2"



Fig. 2
Studio

television lens 30X
Variogon 2.1/16 - 480 mm,
Type TV 31, for 1 1/4"

► [A typical data sheet for a television lens](#) (pdf: 620kB)

At that time, the first 30-fold zoom TV lens with **two optical zoom groups** for adjustment of the focal length , each consisting of a **zoom component** and a **compensator** was regarded as a technological advance. Unlike the [customary method of construction](#), the patented TV-Variogon operated on the following principle.

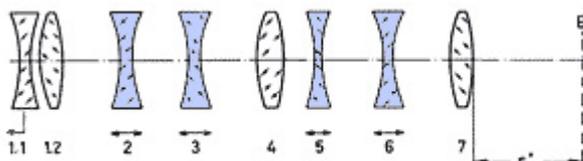


Fig. 3:
TV-Variogon with two optical zoom components

All in all, eight operational components were required. Three of them (1.2, 4 and 7) remain fixed, four (2, 3, 5 and 6) are axially movable to change the focal length, and 1.1 is to adjust the camera-to-subject distance. The value s' is the distance between the last lens surface and image plane B, the so-called back focal distance. Fig. 4 conveys an impression of the optical components

(31 lenses in 22 elements), which are required for this purpose.

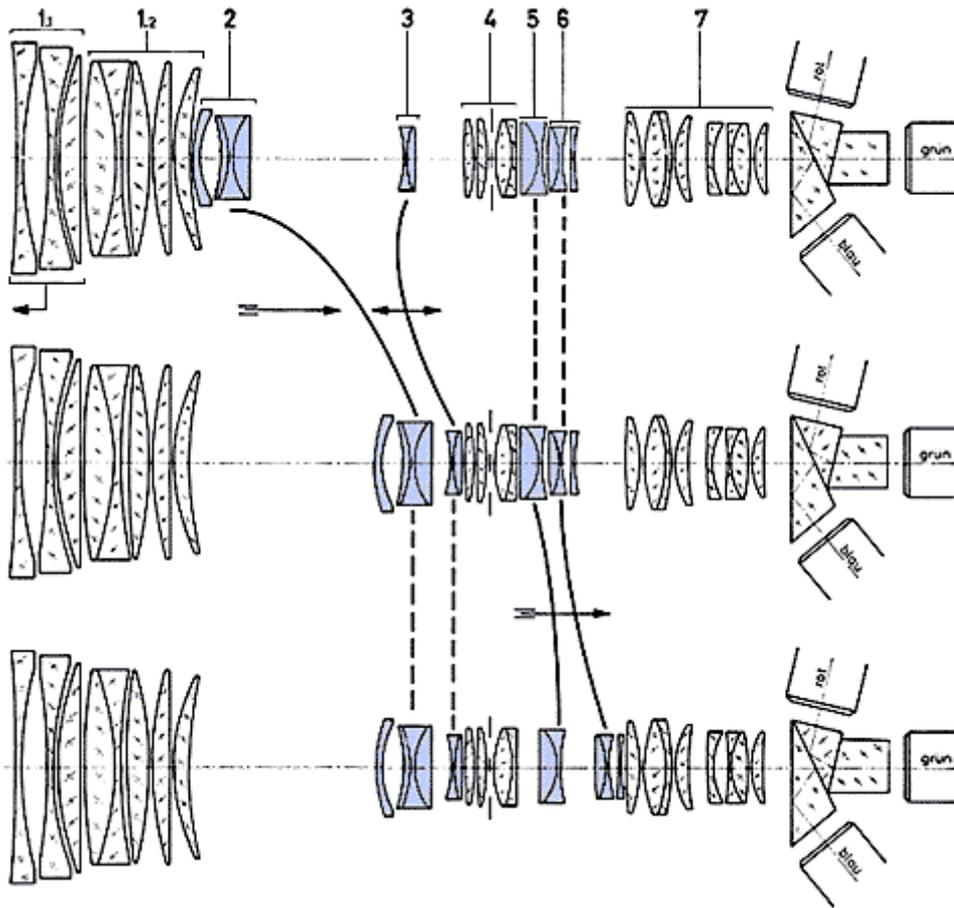


Fig. 4:
Optical structure of the 30-fold zoom television lens **TV-Variogon 2.1 - 6.6 / 20 - 600 mm** with the shortest focal length and focus on infinity

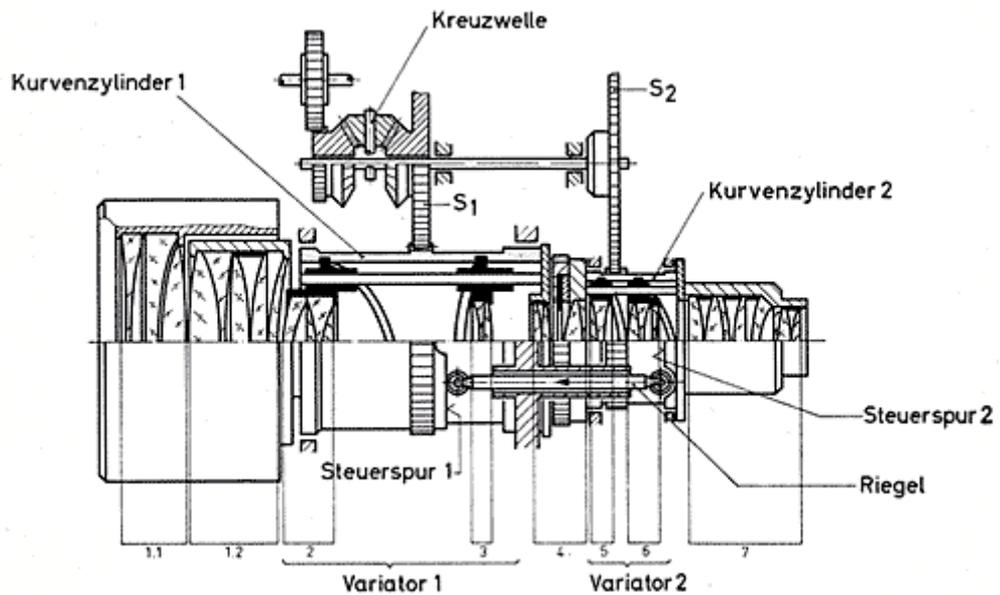


Fig. 5:
TV-Variogon with two optical zoom components

For the mechanical realization of a larger range of focal lengths according to the optical functional principle in Fig. 4, the two zoom components are driven reciprocally by means of a differential mechanism.

The culmination of many years of developmental activities in the area of television lenses was marked by the innovative change from mechanical to electronic control of the position of the movable optical zoom components.

On the occasion of the International Symposiums 1987 in Montreux, Schneider-Kreuznach introduced the first TV zoom lens for the 1"-picture size not controlled by cam gears. The 16-bit lens controlled by a micro-processor, **the TV 91**, attained a 35-fold variation in focal length.



Fig. 6:
High Resolution **Variogon 2/16 - 560 mm**

- 1) ENG - Electronic News Gathering, EFP - Electronic Field Production
- 2) Ampex, Bosch, EMI, Gates, Ikegami, IVC, Link, Marconi, RCA, Sony, Siemens, Thomson

Zoom lenses for still camera photography

Our experience in the construction of zoom lenses for film and television cameras also inspired the development and construction of the Variogon for the **35 mm** and **medium-format**.

The Variogons of still camera photography were placed in single-lens reflex cameras with a focal-plane and between-the-lens shutter (e.g., Rolleiflex), because only there could the variably dimensioned viewfinder image be observed and adjusted on a ground-glass focusing screen.

Fig. 1 shows by way of example the configuration of the **Tele-Variogon 4/80-240 mm** with the diaphragm and shutter controls on the hand grip. A high-speed **Variogon 2.8/45-100 mm** was an addition to the product series. With the appropriate adapter base, both lenses could also be used on **8-, 16- and 35-mm film** cameras.



Fig. 1: Tele-Variogon 4 / 80 - 240 mm

Some technical details:

- mechanical focal distance adjustment of the highest accuracy,
- focusing by means of a knurled on the front side,
- a click-stop diaphragm for diaphragm presetting,
- diaphragm opener for viewing the picture image without changing the selected aperture adjustment for picture monitoring,
- a total of 19 interchangeable adapters for use with single-lens reflex-cameras with focal-plane shutter,
- the camera on which the lens is mounted can, if desired, be shifted by means of a notch and lever for vertical or horizontal format.

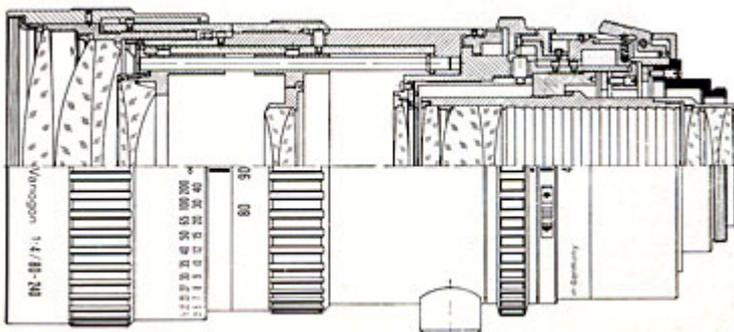


Fig. 2:
 Sectional drawing
 of the
 Tele-Variogon lens
 for 35 mm single-lens reflex-
 cameras

Zoom lenses for enlarger and printers

What the Variogon is for the photo and film technology, the **Betavaron** is for enlargers and printers: a lens with a continuously variable image ratio combined with constant high imaging quality. While up to now several fixed-focal-length lenses have been required for different enlargement sizes, these have now been replaced by a single lens - the Betavaron. It is world-wide **the first zoom lens for enlargers and printers**.

Intended at first for traditional enlargers and printers, the Betavaron also finds use today in **OEM-applications** modified for individual customers for their specific purposes.

The typical Betavaron for enlargers in Fig. 1 makes possible, in addition to completely new picture effects, a considerable simplification of enlarging procedures, thus significantly reducing the time and effort hitherto required for these tasks.

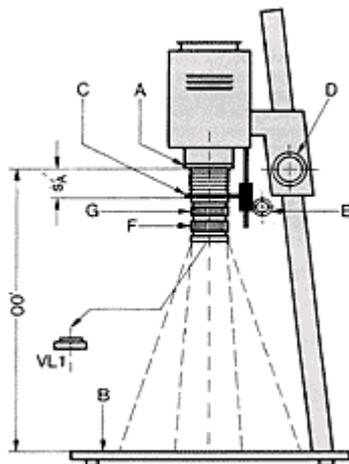
After the correct aperture setting and exposure time have been determined for a specific image ratio, when that image-ratio is changed, the required correction of aperture and exposure can then be ascertained by referring to a table.



Fig. 1: Betavaron 3,1 ... 10 / 0,08

With the exemplary Betavaron (Fig. 1), at a constant distance between negative and positive, changes in the scale of reproduction from 3.1- to 10-fold can be made continuously. The value 0.08 characterizes the numerical aperture on the negative side.

Especially coordinated **close-up lenses**, which with the help of a bayonet can be attached to the zoom lens, give the user a wide range of applications.



After a one-time setting on the enlarger, the positions of Negative (A), Positive (B), and Enlargement lens (G, F) relative to one another remain constant.

By simply moving the focusing ring (F) for the image ratio, the desired enlargement or that part of the negative which completely fills the frame can be easily and quickly focused for the desired positive format. In so doing, the sharpness and imaging quality is fully retained over the entire focusing range. The diaphragm is adjusted with the knurled ring (G).

Fig. 2 left: Enlarger with Betavaron

As an example of solutions for specific customers, the adjacent figure shows a complex industrial application with a fast motorized zoom lens. The optical construction is based on a modified **Variogon**.

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Fig 3 right: An electronic/mechanical/optical modular unit

