Image-forming and Illuminating Systems of the Microscope

Objectives, eyepieces, condensers

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Optical path in the ORTHOPLAN largefield microscope

S   = light source
S'   = image of the light source in the aperture diaphragm of the condenser
S'' = 2nd image of the light source in the exit pupil of the objective
S''' = 3rd image of the light source in the exit pupil of the eyepiece
L   = field diaphragm
L'   = image of the field diaphragm in the object
L'' = second image of the field diaphragm in the field-of-view plane of the eyepiece
The 3rd image of the field diaphragm is produced on the retina of the eye together with the microscopic image.

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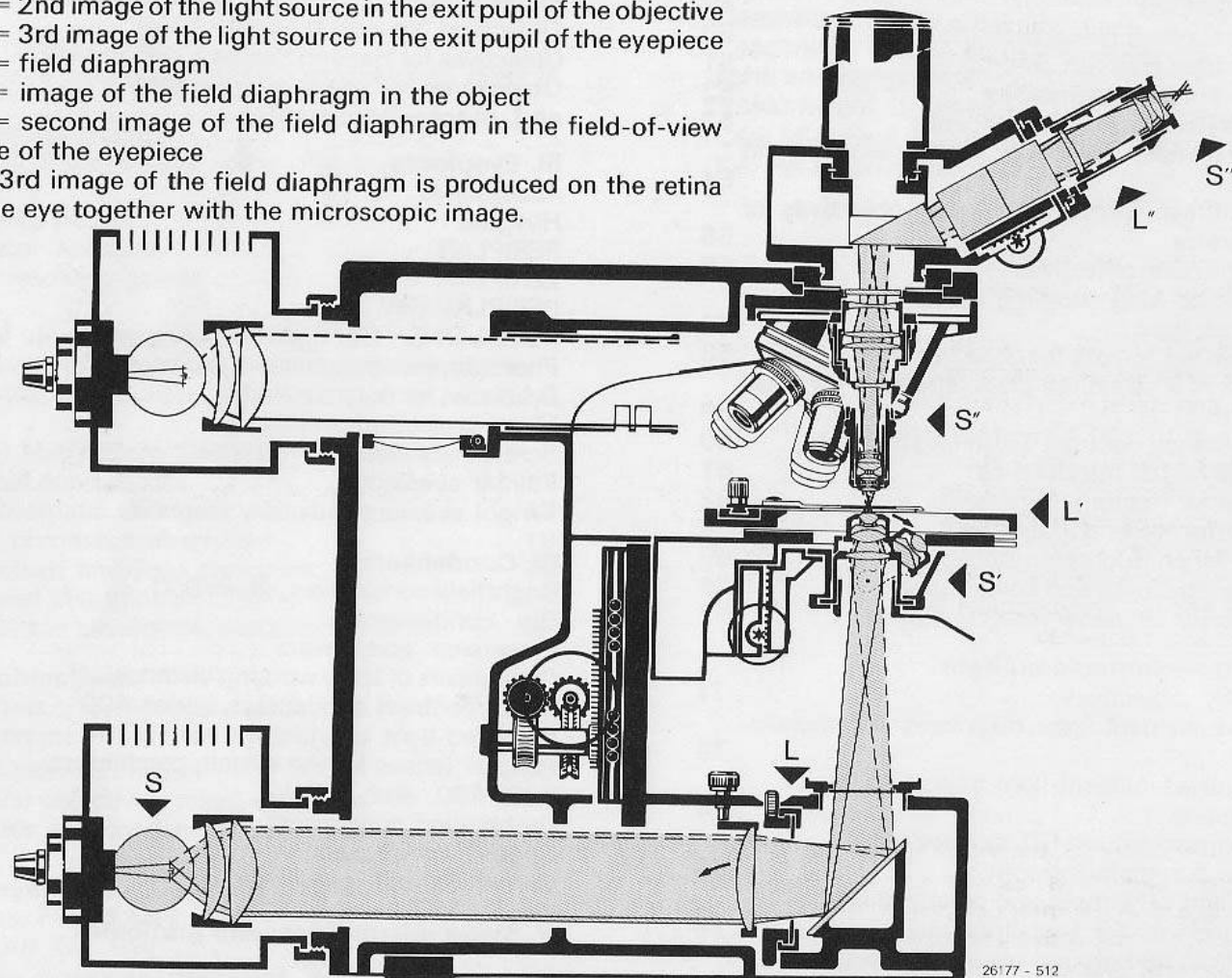
Image-forming system of the microscope

Unaided vision

When we sight an object with our eyes an image of this object will be formed on the retina of the eyes according to the laws of geometrical optics. Dimensions and distance of the object determine the size of the retinal image and thus the visual angle* within which the eye perceives the object. If this is very small or at a great distance, the visual angle becomes very small. However, below a certain physiological limiting angle, which in good illumination is about 1', the eye can no longer distinguish details in the object, or even the object itself. This physiological limiting value is determined by the arrangement and the distance between the visual elements on the retina. The only method of making structures below this limiting angle clearly visible or recognizable therefore involves the extension of the visual angle.

Unfortunately the limited accommodation of the eye rules out the possibility of approaching a small object as closely as we like and still see it in sharp focus. For the normal eye focuses, with the aid of its facilities for accommodation, objects from infinity to only about 200mm. This minimum distance, at which the lens of the eye forms its strongest curvature, is called the near point. In ophthalmic optics the average near-point distance of 250mm is defined as the „reference visual distance". It is the standard distance for the calculation of the magnification and the focal length of magnifiers and eyepieces.

* In the strictest sense, the visual angle is the angle individually perceived. It is not necessarily always identical with the objective geometrical „angle of vision", because this depends on the retina and can therefore be affected by physiological changes in it. Generally, however, both expressions are identical.
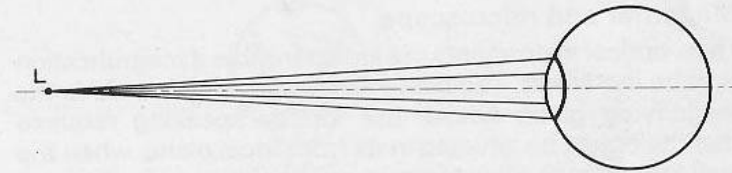
Fig. 2
Direct vision
We see an object, in the simplest case a luminous point L, directly if the rays it emits enter our eye without changing their direction. The sensory impression is based on the incidence of divergent rays in our eye.
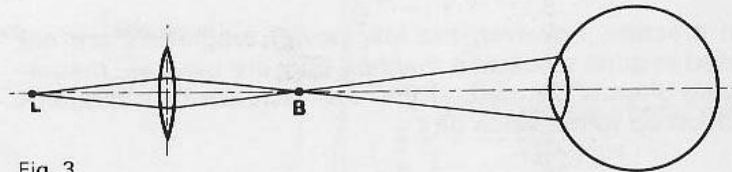
Fig. 3
Real image
In this case, too, only the progress of the rays towards our eye is decisive. We therefore see the object where the rays appear to diverge from. The point B in space is called a real image. A real image can be intercepted on a screen.
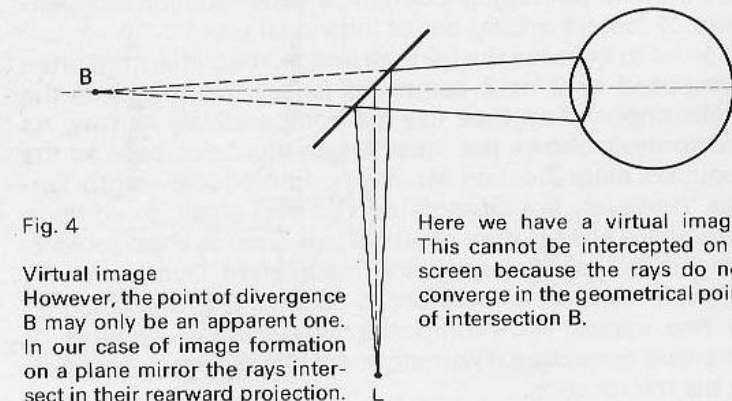
Fig. 4

Virtual image
However, the point of divergence B may only be an apparent one. In our case of image formation on a plane mirror the rays intersect in their rearward projection.

Here we have a virtual image. This cannot be intercepted on a screen because the rays do not converge in the geometrical point of intersection B.

Magnifier and microscope

Thus, optical instruments are indispensable if magnification is to be increased. The best-known and simplest aid is the magnifying glass, whose use strictly speaking requires that the object be situated in its front focal plane, when the well known magnifier formula will apply:

$$M = \frac{250}{f} \text{ mm or } f = \frac{250}{M} \text{ mm}$$

where M = magnification
f = focal length

In practice, however, the low power magnifiers are not used in quite so exact a manner; they are used as „magnifying glasses", a method that can increase their magnification up to the value of

$$M = \frac{250}{f} + 1$$

The magnification values engraved on the magnifier always refer to the first-named method of use, because this is the one method permitting a definitive determination independent of factors arising out of individual use.
In order to improve the (virtual) image, magnifiers are often composed of 2 or 3 cemented lenses. Nevertheless the limits imposed on their use are comparatively narrow. As the formula shows the focal length must decrease as the required magnification increases. Short-focal-length lenses, however, are strongly curved and small, in addition difficulties arise in their practical use, such as short „object-magnifier-eye" distances and insufficient illumination. A sensible solution is therefore to achieve the magnification in two stages with composite lens systems capable of effective correction. The instrument born of this conception is the microscope.

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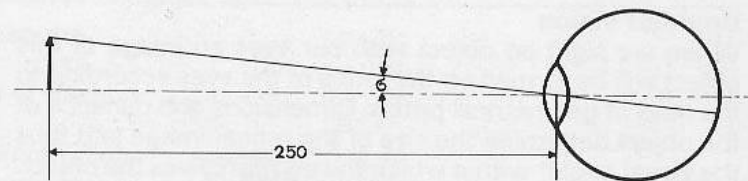
Fig. 5
Direct vision
The object is at the reference visual distance. The eye sees it within the visual angle δ.

26540 - 519 R
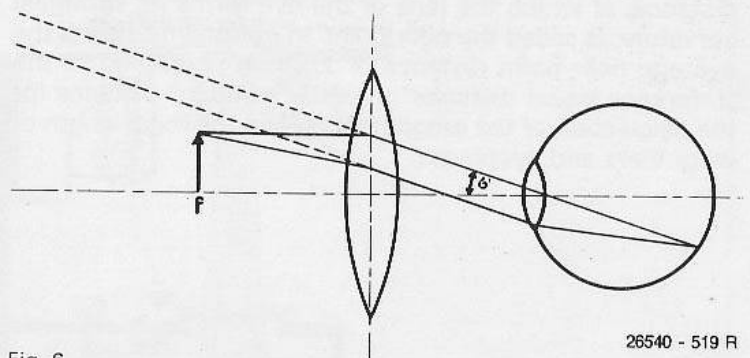
Fig. 6
Eyepiece
The object is situated in the front focal point of the eyepiece. A virtual image is formed at infinity from where the rays seem also to come within the visual angle δ' widened for the eye. Only the resultant enlargement of the retinal image is of importance to the eye. The image situated at infinity of linear „infinite" magnification is of no consequence to the determination of the magnification.

The microscope, too, has the task of offering to the eye a very small object under a strongly extended visual angle. The optical nucleus to achieve this is the objective. At the first stage of image formation it produces a magnified, real image of the object, whose quality decisively affects the general performance of the instrument. Details not present in the image formed at a certain distance from the object plane can never be rendered visible by any means at a later stage. The inverted, real aerial image formed by the objective is also called „intermediate image" since it is, so to speak, an intermediate result. It can be seen even without eyepiece on a small groundglass screen in the tube or by viewing it from a distance of 250mm.

At the second stage of image formation the intermediate image is viewed through the eyepiece, with the latter functioning exactly like a magnifier. The eye, situated in the exit pupil of the eyepiece, therefore sees a further magnified image of the object, which is now virtual and, like the intermediate image, inverted.

Let us now deal, one by one, with magnifying power, resolving power, field of view and image quality of a microscope. These are the factors concerning the image-forming system of a microscope-consisting of the objectives, eyepieces, and tube lens systems – of the greatest interest to the user of a microscope.
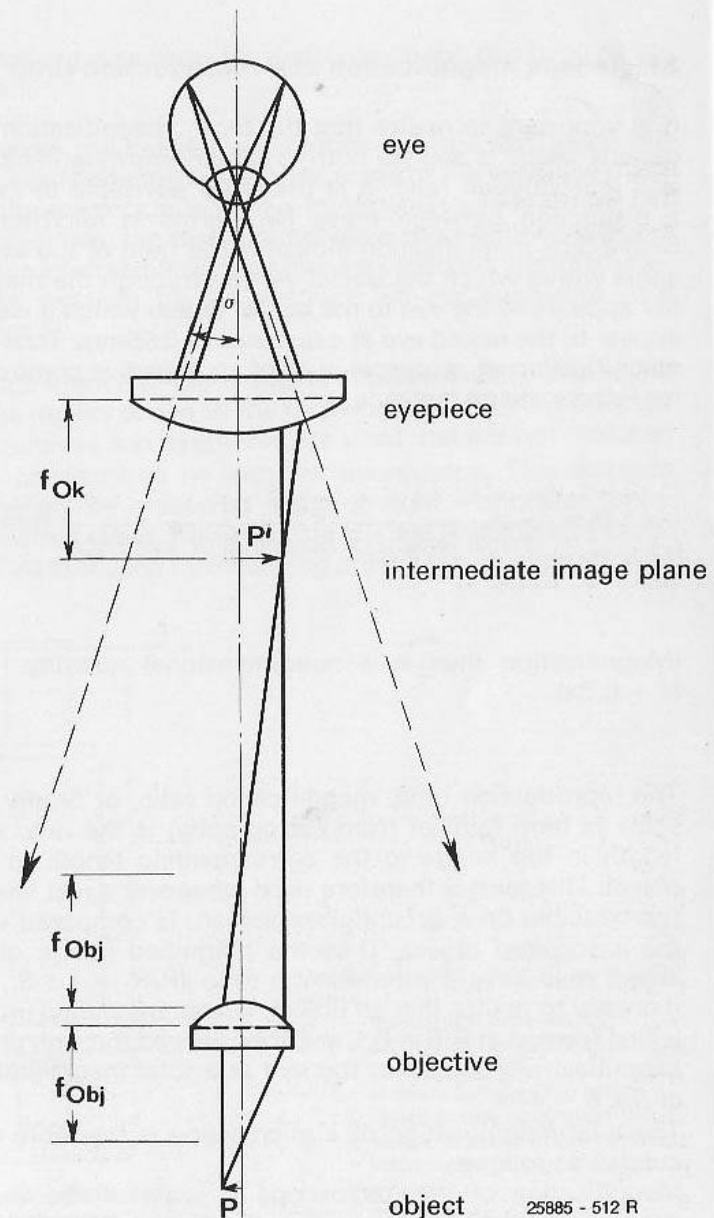
Fig. 7
Optical path in the microscope (diagrammatic)
The objective forms a magnified, real, inverted and side-reversed image of object P at the reproduction scale 5:1. The subsequent 8x eyepiece magnifies this intermediate image another 8x. The observer thus sees the image as if he viewed the 5x8 = 40x magnified object from a distance of 250mm without an instrument. The magnification in the diagram is not to scale.

eye

eyepiece

f_{Ok}

P'

intermediate image plane

f_{Obj}

f_{Obj}

objective

f_{Obj}

P   object   25885 - 512 R

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Magnifying power

Single-lens magnification and reproduction ratio

It is important to realize that the term „magnification" of general usage is applied both to single-lens magnification and reproduction ratio. It is therefore advisable to make a distinction between these two terms in microscopy. Single-lens magnification indicates the ratio of the visual angle within which the object viewed through the magnifier appears to the eye to the angle* within which it would appear to the naked eye at a distance of 250mm. Thus the magnifiaction of an eyepiece or of an objective computed for infinite image distance is

$$M = \frac{250}{\text{Focal length of objective or eyepiece}} \text{ mm}$$

(Magnification thus is a nondimensional quantity, e.g. $M = 6.3x$).

The reproduction ratio, magnification ratio, or briefly the scale (a term familiar from cartography) is the ratio of a length in the image to the corresponding length in the object. This term is therefore used whenever a real image, reproducible on a groundglass screen, is compared with the associated object. Thus the magnified image of an object may have a reproduction ratio (R/R) = 1 : 3.
It is easy to realize that an object, whose magnified image is first formed at R/R = 5:1, and then viewed through an 8x magnifier, will appear to the eye at a total magnification of 5 x 8 = 40x.
The total magnification of a microscope is therefore calculated as follows:
Magnification of the microscope = scale of the image produced by the objective x magnification by the eyepiece.

If a tube lens system is built into the microscope, the factor of this system, too, must be allowed for. Here the total magnification of the microscope is

$$M_{microscope} = M_{objective} \times M_{eyepiece} \times \text{tube factor}$$

These values are engraved on the objective, eyepieces and tube lens mounts respectively.

Since the ratio of the visual angles with and without instrument equals the ratio of the retinal images, we speak here also of visual magnification. Further details, particularly concerning the special cases of photomicrography and microprojection are contained in our publication „Structure and Function of the Microscope".

* strictly the tangents of these angles

Connecting lengths

Mechanical and optical connecting lengths

Depending on the fineness of the object detail we use various magnifications even with simple magnifiers, i.e. we use magnifiers of various focal lengths. When we progress to the compound microscope, in which the total magnification is the product of objective and of eyepiece magnification, we want to expand the magnification even more. However, changes in magnification through a change of eyepieces are subject to relatively narrow tolerances. This reason alone makes it necessary to develop a set of objectives for the total magnification range of the microscope, quite apart from the fact that the demands of resolution and image quality within the various ranges of magnification can be met only by a suitably graduated series of objectives. In a modern microscope these objectives are used on a revolving nosepiece, which permits a rapid changeover between the various objectives. In practical microscopy it is essential that the focus of the image should be preserved after the change of objectives or eyepieces. Objectives and eyepieces must therefore be matched on the microscope.

To meet this demand, the "object – intermediate image" distance must be constant for every reproduction ratio; in addition the intermediate image must always be located in the same plane in the tube. These conditions can be realized by a choice of objectives of suitable focal lengths. The tube length, the distance between the shoulder of the objective and the top rim of the tube, measures 170mm in LEITZ transmitted-light stands and is determined by practical reasons; a constant „objective shoulder – object" distance is the obvious consequence, and is called the adjustment length – 37mm with our earlier transmitted-light objectives.

Because of the large number of lenses required for flattening the image field, plano objectives cannot be designed for this length, and are standardized at 45mm. This longer adjustment length also permits the design of very low magnifying objectives for matching on the revolving nosepiece.

Obviously the image must remain in focus also when the eyepiece is changed. The focal plane of the eyepiece must therefore coincide with the intermediate-image plane of the objective, the distance between the eyepiece support and the intermediate image plane is called the intermediate-image distance of the eyepiece. In our eyepieces it is 18mm.

The adherence to these data is important, since beside the image quality above all the focusing adjustment is affected if objectives and eyepieces are used that are not matched with one another or with the microscope. This distance can easily be measured along straight monocular tubes. With other tubes, however, the change in the length of the light-path caused by deflecting prisms etc. must be allowed for.

Object without coverglass
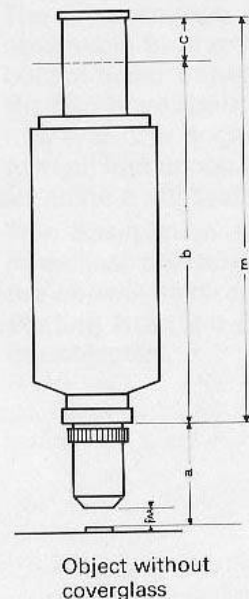
fig. 8
Mechanical and optical connecting length
m = mechanical tube length
a   = adjustment length. With covered objects, the adjustment length extends as far as the image raised by the coverglass.
b   = image distance of the objective
c   = intermediate image distance of the eyepiece
fAA = free working distance

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Within recent years objective series for tube length „infinity" have been developed. These systems on their own do not form a real intermediate image in the tube, but an image at infinity. Only in combination with a tube lens system permanently built into the stand do they produce the real intermediate image, also 18mm below the rim of the tube. The magnification value of these objectives is always referred to an associated tube lens of 250mm focal length. If reasons of design call for a tube lens of different focal length, e.g. 320 or 200mm, the magnification value of the objective is not changed; instead, the tube is given the factor 1:25 or 0.8 respectively. For further information about tube lenses see p. 16.

Infinity objectives differ from those of a real reproduction ratio in that their magnification is called 'single-lens magnification' in accordance with the magnifier formula, which in this case applies precisely. This is expressed by the symbol x engraved on the objective mount, e.g. 50x instead of 50:1.

Standard series

Whereas in the past objective and eyepiece magnifications were chosen rather haphazardly, for some considerable time the magnifications have now been standardized; the range between two decimal powers, i.e. for instance between 1 and 10 or 10 and 100, but also between 0.1 and 1 in the case of tube lenses, is divided into 10 equal steps in the form of a geometrical progression. This results in the round factor 1.25 from one step to the next and the following standard series.

								0.63	0.8	1
1	1.25	1.6	2	2.5	3.2	4	5	6.3	8	10
10	12.5	16	20	25	32	40	50	63	80	100
100	125	160	200	250	320	400	500	630	800	1000

Each standard magnification of an objective, multiplied by the standard magnification of the eyepiece and where applicable by the factor of tube lens system, results in a standard value of the total magnification. Small differences, such as 8 x 80 ≈ 630 instead of 640, are a result of rounding off.

Resolving power
of the microscope

Numerical aperture

The performance of a microscope rests primarily on that of the objective. The ability of the microscope to form a discrete image of finest detail, i.e. to resolve it, does, however, not depend on the reproduction ratio of the objective, but only on its numerical aperture. Because of the importance of the concept, often simply called „aperture", it is dealt with in somewhat greater detail here.

Numerical aperture A is the product of n and sin α:

$$A = n \times \sin \alpha$$

where α = the angle included between the most marginal ray accepted by the objective or its imagined extension and the optical axis, and n = the refractive index of the optical medium (e.g. air, immersion oil, coverglass) traversed by the ray between the object and the front lens of the objective.

The following three diagrams show the maximum aperture values that can be achieved.

Light radiates in all directions from an object point on the underside of the coverglass. If, as assumed in Fig. 9, the space between the coverglass and the front lens of the objective is filled with air (refractive index n = 1), according to the refraction law only those rays on the top surface of the coverglass that are not totally reflected inside the glass i.e. within the limiting angle of total reflection, here 41.5°, can enter the intervening air space.

In air, a so-called „glancing exit", i.e. 90° would correspond to this limiting angle. According to the formula given above, this would produce the value 1 as the theoretical maximum value of the numerical aperture for dry systems. The impossibility of utilizing this angle fully can easily be appreciated, because this would mean that the front lens and the coverglass surface would have to coincide.

As a result of the need for separating coverglass and objective and because of the limited diameter of the front lens of the objective a maximum angle of only 72° is accepted; the maximum aperture obtainable in practice for this type of objectives is therefore 0.95.

Fig. 10 shows a water immersion objective. Here the limiting angle of total reflection is as high as 61.5°, which raises the theoretical limit of the numerical aperture to 1.33. However, the technical conditions described in the previous paragraph also apply here, but reduce the utilizable angle in water to 64.5°, and the practical numerical aperture to 1.20 (1.33 x 0.905).

Lastly, Fig. 11 shows the ray path of an oil immersion objective. Because coverglass (n_e = 1.525) and immersion oil (n_e = 1.518) have almost the same refractive index, almost all the light inclined up to 90° to the optical axis would reach the front lens if only it were possible to make the latter large enough. The short focal lengths of the high-power immersion objectives have however the effect of reducing the front lens diameter to about 1mm; in spite of a short working distance they can accept, at the very extreme, an angle of only 67.5°, which corresponds to an upper limit of 1.40 numerical aperture (1.518 x 0.92).

The three limiting cases described here of the apertures obtainable in practice are represented in the diagrams in bolder lines. Between the coverglass and the objective the rays have about the same inclination. In the coverglass, however, the angle of these rays is considerably longer with oil immersion (67°) than with water immersion (53°), let alone a dry system (39°).

This observation shows with particular clarity how the numerical aperture and therefore the resolving power of the objectives directly increases with the ray cone which, starting from the object, has the chance of passing into the objective.

Every group contains objectives which do not have the maximum possible numerical aperture. However, this does not make them inferior to the top-class objectives; they are useful and necessary for observations with comparatively low microscope magnifications. In such cases, too large a numerical aperture would not be fully utilized.

Figs. 9—11

Diagrammatic representation of the aperture values

9 of a dry system
10 of a water immersion objective
11 of an oil immersion objective

Front lens

Air
n = 1

glancing
emergence

total reflection

coverglass
n = 1.515

α

α = max. 72°

Water
n = 1.333

glancing
emergence

total reflection

α

α = max. 85°

Oel n = 1.515

α

α = max. 67°

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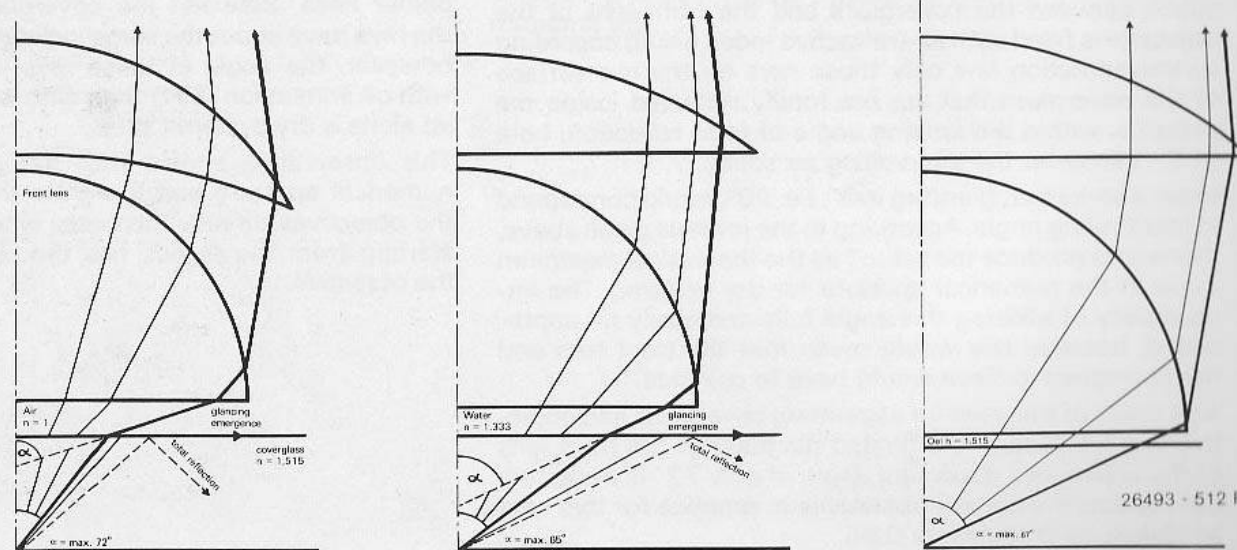
Lateral resolving power

A given total magnification can be achieved either with an objective of low primary magnification and a high-power eyepiece, or, conversely, with an objective of high primary magnification and a low-power eyepiece. However, the appearances of the two images will basically differ from each other, in that the latter combination produces considerably finer detail than the first.

The reason for this is that the high-power objectives generally have larger apertures than the low-power ones, and that the magnitude of the numerical aperture determines which fine structures can be revealed.

The power of an objective to render two closely-spaced object points visible as distinct features is called its resolving power; it is called lateral resolving power when the two points are situated side by side in the object plane. The limit of the resolving power is defined as the shortest distance at which two points are reproduced as separate features. A resolving power of 1μm therefore means that two point-shaped particles 1μm apart can still be recognized as two distinct points, whereas at a distance of e.g. 0.8μm they would appear as one point only.

This will immediately become clear if the following facts are considered:

Even an objective of perfect spherical and colour correction reproduces an object point not as a point; each object point in the focusing plane of the microscope has a correlated image of a tiny light disc, called a diffraction disc.
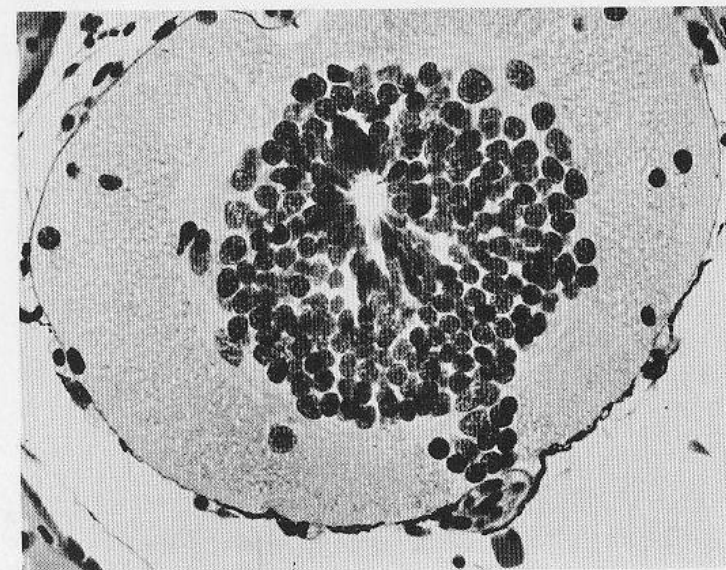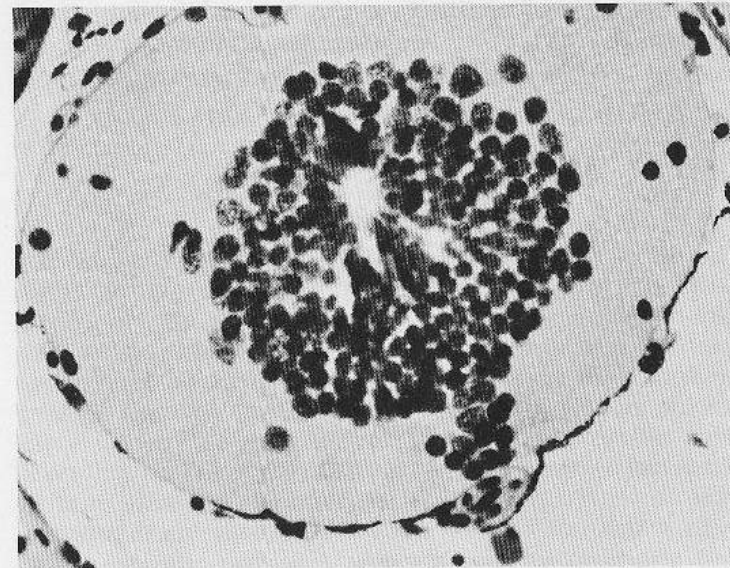
Fig. 12
Two photographs with different objective/eyepiece combinations, but at the same final magnification; top: 10/0.25 objective, 25x eyepiece, bottom: 25/0.50 objective, 10x eyepiece.
It can be seen that the larger-aperture objective resolves considerably finer details (bottom picture).

This fact is based on the wave character of the light. If we imagine the diffraction disc projected on to the object, i.e. think of its dimensions in terms of object detail dimensions, its diameter at full condenser aperture will be $d = 1.22 \frac{\lambda}{A}$,

where λ = wave length of the light
A = numerical aperture of the objective
1.22 = a theoretical factor.

The diffraction disc is, in addition, surrounded by darker diffraction rings which, however, will be visible in darkground illumination only because of their very low light intensity. The magnitude of this apparent diffraction disc measured on the object is obviously decisive for the resolving power. If two object points are situated so that their diffraction discs just touch, they can certainly be observed as clearly separate features. It will be still possible to regard the two object points as separate entities even if their diffraction discs are partially superimposed and interfere with each other. However, the power of distinction also depends on the ability of the human eye to recognize differences in shape and brightness.

If we consider all this, we can write the following formula for the resolving power:

$$\delta = \varkappa \frac{\lambda}{A}$$

where $\varkappa$ = a factor representing all these conditions, which usually can be assumed to be considerably smaller than 1. This shows that when a certain type of light (λ) is used the only method of increasing the resolving power is increasing the aperture.

Fig. 13 gives the approximate values of the resolving power in μm (for λ = 550nm) as a function of the aperture.

It can be seen that the resolving power obtainable with the microscope and a high-power oil immersion objective can at best be about half a light wave length. By the use of short wave light, e.g. by the insertion of a blue filter in the beam path, it would be possible to increase the resolving power even within the visible range of the spectrum. However, optimum performance of the objective can be fully achieved only if the state of correction is perfect.

In a particular limiting condition, which Abbe preferred specially in the development of his theory, the question of the limits of performance of the microscope is answered somewhat differently. If the object has a periodic structure (e.g. a grating) and light beams of very small aperture (almost parallel light) are used for the illumination, it can be shown that a periodically recurring structural characteristic of an object is just visible in the image if the length of its period is d = $\frac{\lambda}{A}$ in perpendicular, d $\frac{\lambda}{2A}$ in extremely oblique illumination.

Returning to the question at the beginning of this paragraph we now appreciate that the reproduction of microscopic detail depends not only on the realization, somehow or other, of a certain magnification, but first and foremost on the choice of an objective aperture which guarantees a certain resolving power. This must be followed by the choice of the additional eyepiece magnification to ensure that all the detail resolved by the objective aperture is comfortably seen by the eye, i.e. offered to it within a sufficiently wide angle of view. This condition applies when the total magnification lies between 500 x and 1000x the aperture of the objective used. This is the range of the so-called „useful magnification". Total magnifications appreciably in excess of the upper limit produce no gain in visible detail, whereas those below the lower limit do not fully utilize the power of the objective.
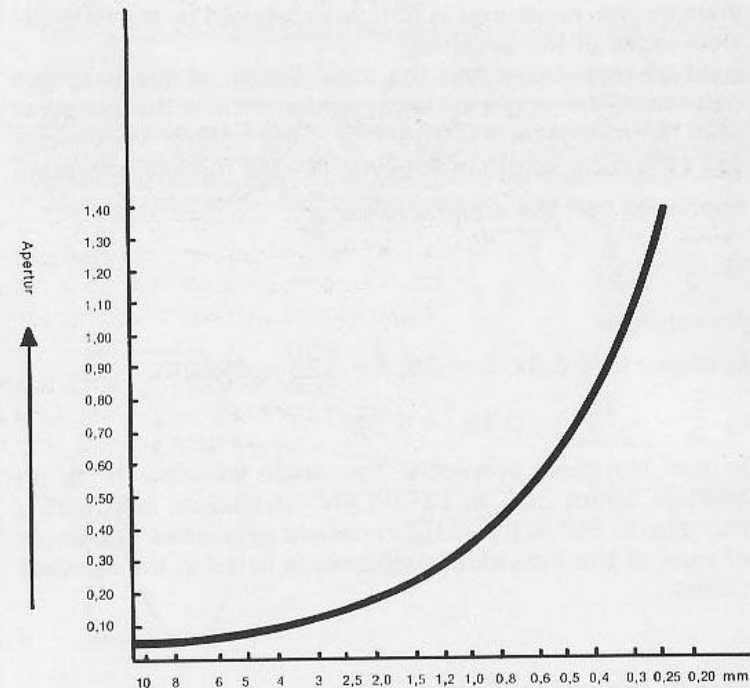

Fig. 13
Relationship between resolving power in μm for green light (λ = 550nm) and aperture.

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Field of view and object field

Size of the field of view

Whereas the resolving power is determined wholly by the quality of the objective, the size of the field of view depends on the characteristics of the eyepiece. Let us remenber: the objective forms an inverted, real intermediate image at the scale of its reproduction ratio. This image is situated 18mm below the rim of the tube. It will be obvious that with the standard tubes of 23.2mm internal diameter the size of the intermediate image is limited.

It depends on the design, state of correction, and focal length of the eyepiece how much of the intermediate image is in fact covered. At best the diameter is 18, maximally 19mm. This effectively accepted diameter of the intermediate image, measured in mm, is expressed by the field-of-view index of the eyepiece.

Field-of-view index and the focal length of the eyepiece determine the angle of view, within which the observer sees the microscope image. If S is the field-of-view index and f the focal length of the eyepiece the following formula applies to half the angle of view $\frac{\sigma}{2}$

$$tg \ \frac{\sigma}{2} = \frac{S}{2f}$$

An example:

Eyepiece GW 6.3x, S = 28, f = $\frac{250}{6.3} \approx 40mm$

$$tg \ \frac{\sigma}{2} = \frac{28}{2 \times 40} = 0.35 \quad \sigma \approx 38°$$

In our Huygens eyepieces the angle of view σ is on average about 30°, in PERIPLAN® eyepieces about 35°, rising up to 50° in the LEITZ widefield eyepieces. The angle of view of the individual eyepieces is listed in the relevant tables.

Size of the object field

If the field-of-view index is divided by the magnification of the objective and the tube factor, the diameter of the field of the specimen that can be surveyed, the object field

diameter, is obtained. The diameter of the object field observable with an eyepiece of field-of-view index 28, a 10:1 objective, and tube factor 1 can therefore be calculated:

Observable object field = $\frac{28}{10 \times 1}$ = 2.8mm.

Tube lens systems

Binocular tubes and other design requirements often force the designer to deviate from the prescribed mechanical tube length. In order to maintain the adjustment length with the low-power objectives and not to reduce the image quality of the high-power ones, here the intermediate image is displaced by means of a tube lens system. The objective is thus used in the way necessary to ensure its optimum performance, and the image displaced only subsequently by means of an also highly corrected optical system. Depending on the structural advantages and those of optical performance aimed at, tube lens systems of the factors 0.8x, 1x or 1.25x are used. The tube factor 1.25x increases the reproduction ratio by 25%. Systems of the 0.8x factor are often used in order to enlarge the surveyable object field; however, this will be at the expense of the reproduction ratio.
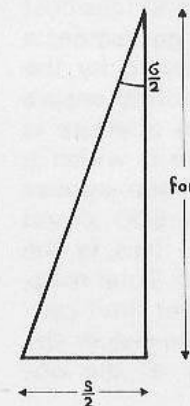

Fig. 14
Example for a GW 6.3x eyepiece
f = focal length of the eyepiece (40mm)
S = field-of-view index (28)
σ = picture angle (38°)

Optical aberrations and their correction

The optimum performance of an optical system will be realized only if the state of correction is high. This condition must be met the more strictly the more widely the illuminating cone of rays is open, i.e. the larger the condenser aperture. Unfortunately it is impossible even in theory to build optical systems that are absolutely perfect. The very complicated interconnection between the existing optical aberrations simply rules out this ideal case. Almost invariably measures to correct a given aberration adversely affect measures against other aberrations. However, modern correction methods make the reduction of the disturbing aberrations below the level of perception possible, which is, after all, the decisive point. But such objectives are complicated and correspondingly expensive. Therefore, residual aberrations are sometimes tolerated, and certain types of correction established.

Fig. 15
Spherical aberration at three different levels of intersection in monocromatic light.
O is the point of intersection of a paraxial ray (ray close to the axis) with the optical axis. If the intercept lengths associated with several levels of intersection are determined and entered on graph paper with the vertical axis passing through O, a number of points are obtained on a paraboloid curve, which reveals immediately the magnitude of the spherical aberration for any level of intersection.

Spherical aberration

If monochromatic (i.e. single-coloured) light is passed through a single collecting lens, it will be seen that the rays coming from an object point do not intersect in a point. The various rays of a bundle therefore have different intercept lengths depending on their level of passage through the lens. As Fig. 15 shows the light is refracted more strongly across the marginal portions than near the optical axis. This aberration caused by the spherical shape of the lens surfaces is called spherical aberration. It increases with the aperture of the lens referred to its focal length. One therefore also calls it the aperture error of the objective. It cannot be completely eliminated from spherical surfaces; on the other hand it can be largely corrected by means of combinations consisting of collecting and dispersing lenses, Fig. 16.

Fig. 16
Correction of spherical aberration by means of a lens combination consisting of a collecting and a dispersing lens.
The shape of the curve is radically altered compared with that in Fig. 15. The differences in intercept lengths have become smaller at the same levels of intersection.

Axial chromatic aberration

However, for visual observation the microscopist uses not monochromatic, but white light, which is composed of all wave lengths from 400 to 800nm. On its passage through the lens it is dispersed into various colours. Red light is least, violet light most refracted during this passage. To correct this error, lenses are combined which consist of glasses of different refractive index and dispersion.

If the differences in intercept length for a few levels of lens passage for four colours are determined and plotted on a graph paper, the four curves obtained reflect the colour correction of an optical system (Fig. 17). In practice the wave lengths λ = 656nm red, 546nm green, 486nm blue and 405nm violet are used for this purpose, because for these or very closely neighbouring spectral lines the optical data of the glasses can be easily and reliably determined with spectral lamps. The object of optical computation is the equalization of the intercept lengths for two or three colours by suitable lens combinations with glasses of different light refraction (Fig. 18).
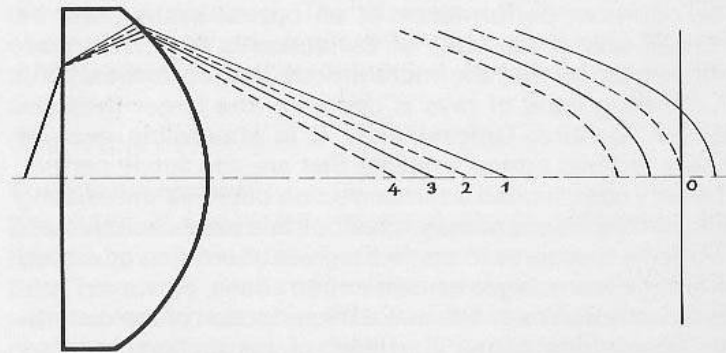
Fig. 17
Diagram of the chromatic aberration for four different spectral colours. Because of dispersion the white light ray is fanned out into rays of various wave lengths. Accordingly a separate curve is obtained for each spectral colour. The method of plotting the curves was similar to that used in Fig. 15.

Line 1	= red light
dashed line 2	= green light
line 3	= blue light
dashed line 4	= violet light
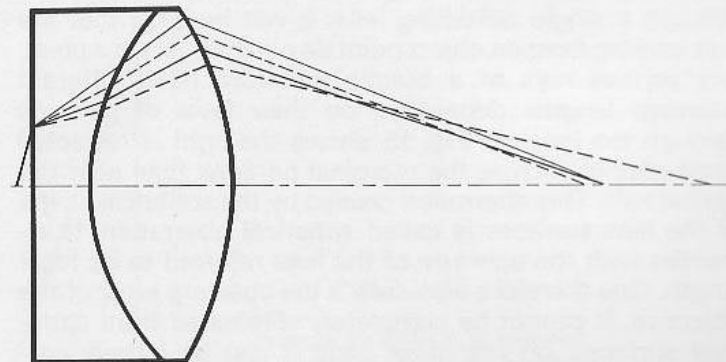
Fig. 18
Correction of chromatic aberration by means of a lens combination.

18

Lateral chromatic aberration

Besides the axial (longitudinal) chromatic aberration dealt with in the preceding paragraph, we have to cope with chromatic aberration transversely to the optical axis, which increases with the distance of the object point from the optical axis. Fig. 19 illustrates this „chromatic difference of magnification", also called lateral or transverse chromatic aberration. It can be seen that although the intermediate images are situated in the same plane, the blue is larger than the red image. Inspite of the complete elimination of the axial chromatic aberration the eye would not receive an image in pure colours but one surrounded by weak colour fringes. Lateral chromatic aberration is best eliminated by means of cemented lenses in the eyepieces. As a matter of routine, all modern LEITZ objectives are computed for the same chromatic difference of magnification, so that optimum performance is obtained whenever a PERIPLAN-type LEITZ eyepiece is used.
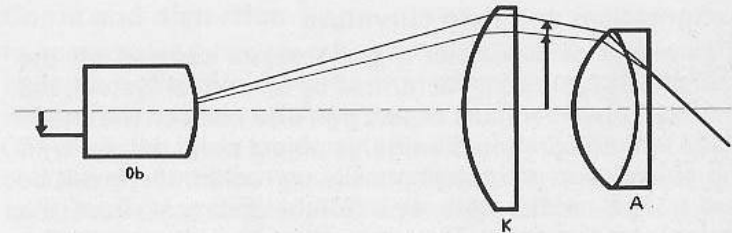
Fig. 19
Correction of lateral chromatic aberration by means of a PERIPLAN eyepiece. The objective forms coloured intermediate images at the same distance, but at different magnifications. PERIPLAN eyepieces magnify the red image more strongly, thereby compensating lateral chromatic aberration. The microscope objective on the left is only diagramatically represented.

Ob = objective	Long arrow within the eyepiece	= blue image
K = field lens	short arrow within the eyepiece	= red image
A = eyelens		

Astigmatism and field curvature

If an image of a point of a plane object situated off the optical axis (paraxially) is formed by an optical system, the unbiased observer must expect that **one** point on the image plane will be correlated with this object point. In reality, if the objective is not astigmatically corrected, there will be two image points, both at different distances from the image plane proper. This aberration increases with the distance of the object point from the optical axis. Hence two image fields of different curvature are produced by a plane object. It is not possible with such a system to produce an image that is definitely sharp in the marginal regions. This aberration is called astigmatism (= non-punctiform image formation). Suitable measures of correction will result in an identical curvature of the two image fields — which does away with astigmatism, but the image remains curved. This field curvature cannot be eliminated with microscope objectives of conventional design. The radius of curvature of the image field is roughly the same as the focal length of the objective. It is therefore understandable that this aberration is particularly disturbing with high-power objectives.

To a certain extent curvature of field can be compensated by the eyepiece. This method is practised above all in photomicrography. Negative eyepieces are used for this purpose, which compensate field curvature of medium-to-high-power objectives. Since this method has other advantages and negative eyepieces are, in addition, unsuitable for visual observation, elimination of the field curvature is preferable at its source, i.e. in the objective. Further details: our chapter on plano objectives.
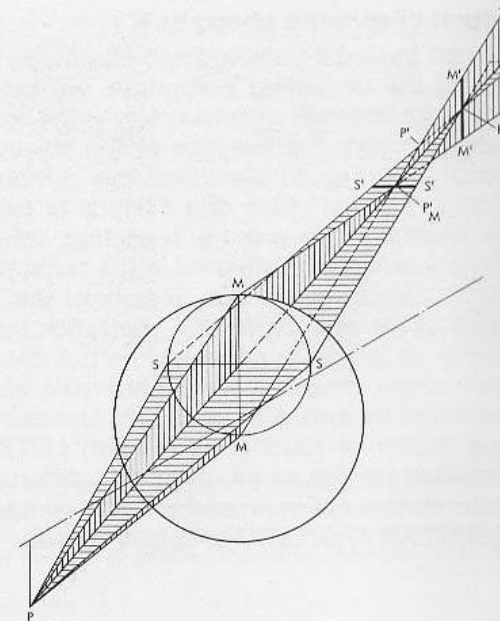
Fig. 20
Astigmatism
Up to now we have considered rays proceeding only in the two-dimensional drawing plane. These beam paths are always symmetrical. In a three-dimensional, spatial bundle as shown in Fig. 20, however, the rays are differentially refracted in two sections which are perpendicular to each other (hatched in the drawing), because the effective radii of curvature are different in both directions (a circular bundle is degraded after passage through such a lens into an elliptical bundle). Thus two clearly defined image points are formed in different planes for the two components of the bundle, however, owing to the incomplete union of the other rays of the entire spatial bundle they may be broadened into slightly unsharp lines.
The refraction of the principal ray is not represented.

SS   = sagittal section (corresponds to the circle of latitude of a sphere)
MM = meridional section (corresponds to the circle of longitude [meridian] of a sphere).
S–S', M–M'   = image points degraded into image lines
P'M, P'S   = conjugated image points

Fig. 21

Fig. 22

Coma and distortion

In uncorrected lenses two further aberrations occur, which become noticeable towards the marginal regions of the image field; coma and distortion.

Coma is the asymmetrical spherical aberration of the oblique ray bundles. It takes the form of image dots with tails resembling comets . This aberration has been eliminated from Leitz objectives.

In distortion the reproduction ratio is not constant over the entire image, it either increases or decreases towards the margin. As a result, the image, e.g. of a square, is reproduced in the shape of a cushion or a barrel. We therefore also speak of pincushion- or barrel distortion. Its complete elimination is economical only with measuring objectives.

Fig. 21
Image of a system of concentric circles and radii formed by an astigmatic lens. Increasing unsharpness of the circles is seen towards the periphery. The lens was focused on M′−M′ in Fig. 20.
If the lens is focused on S′−S′ in Fig. 20, the circles will be sharp, but the radii unsharp.

Fig. 22
The same object, but the image is formed by an optical system corrected for astigmatism and field curvature.

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Fig. 24
Diagram of pincushion- and barrel distortion of a square object.

Fig. 23
If astigmatism only is corrected, the aberration of field curvature persists. Fig. 23 shows the remaining curvature of field; only the meridional section has been drawn in order to simplify the diagrammatic representation.

Effect of the coverglass, correction mount

The influence of the coverglass becomes noticeable with objectives of apertures above 0.4. Since it has the effect of spherical over-correction – it must be compensated by under-correction of the objective. However, this is based on the assumption that the thickness of the coverglass is always constant. A thickness of 0.17mm has therefore been adopted as standard. At the thickness of 0.17mm the coverglass is therefore a component of the image-forming system. The required accuracy of the coverglass thickness increases with dry systems as their aperture increases.

These considerations apply to the case that the object directly touches the underside of the coverglass. However, as a rule a layer of embedding medium will be present between the object and the coverglass, which has the effect of increasing the thickness of the coverglass. For this reason, and because often the coverglass thickness is not known, dry systems of large apertures are fitted with correction mounts which permit compensation of variations from the standard thickness within the range of 0.12 to 0.22mm. The correction mount has a knurled ring with graduations, corresponding to the coverglass thickness, at 1/100mm intervals. Immersion objectives, especially those using oil, are not so sensitive to coverglass deviations, since thickness variations in the glass are largely compensated by a corresponding variation in the thickness of the oil film, so that image quality is less affected. However, excessively thick coverglasses can make focusing impossible because of the short working distances.

The only remedy here is the replacement of the coverglass by one of correct thickness. In our plano immersion objective the working distance is always long enough.

Low-power objectives can be used either with or without coverglass, and are designated DO in our tables.

Objectives for use in incident light are as a rule computed for use without coverglass. Coverglasses here have similarly adverse effects as their omission with objectives which are corrected for them.
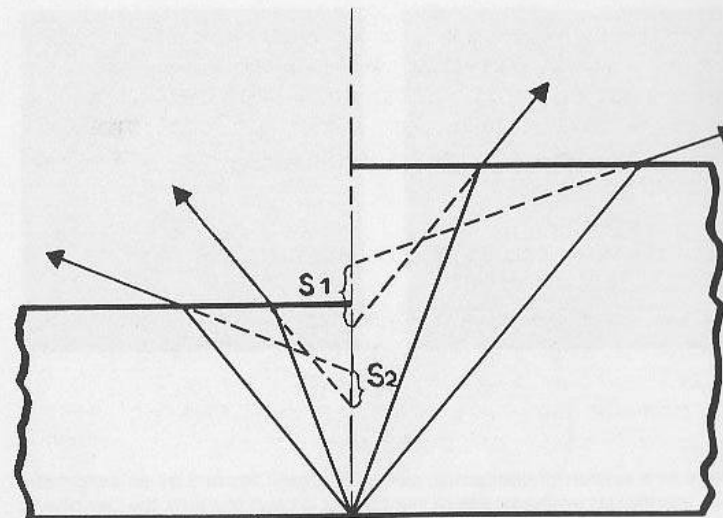
Fig. 25
Change in the optical path caused by the wrong coverglass thickness. Optically the coverglass is equivalent to a plane-parallel plate which, as is well known, deflects the rays the more strongly the more they diverge from the perpendicular. In the angle-true, but not true-to-scale, illustration on the left the rays originating in the same object point appear, after leaving the coverglass, to originate in two different points at a distance S2. In the excessively thick coverglass (on the right), however, this distance is S1, Since S2 ≠ S1, the thicker coverglass causes an intercept distance error and therefore influences the image quality.

LEITZ objectives

Generally, microscope objectives are classified according to their state of correction, with the correction of chromatic aberration playing the most prominent part. Naturally, as colour correction is improved, the means to achieve this become more complicated, so that the classification in

Achromats,
Fluorite systems or semi apochromats,
Apochromats,

also coincides with a price classification. Special objectives have been developed for investigations in phase contrast, in polarized light and in incident light. However, basically this classification also applies to these objectives. Further details will be found in the description of the relevant objectives.

Achromats
Achromats are objectives in which the intercept length of two colours has been equalized. The colours red and blue are used for this purpose. Therefore, achromats are well corrected within the region of the maximum colour sensitivity of the human eye, and therefore eminently suitable for visual observation. For photomicrography on black-and-white film a green filter is indicated, which filters out particularly the photographically effective violet which is not completely included in the correction. Obviously achromats are also suitable for colour photography, especially where demands of resolution and contrast are normal. The inherent colour displacement can often be neglected.

Fluorite systems or semi-apochromats
Obviously, the chromatic aberration of an optical system is not completely eliminated if it has been removed only for two colours. A slight residual aberration remains for the rest of the colours whose intercept lengths have not been equalized. This residual aberration is called secondary spectrum. It has the effect, for instance, of reducing colour contrast during visual observation. However, the elimination of the secondary spectrum is not possible simply by means of the flint and crown glasses used in the achromats. This elimination will be successful only if the crownglass is wholly or partly replaced by fluorspar-like materials.

Our fluorite systems represent a step in this direction. These objectives have approximately the same number of elements as the achromats, however, some of them consist of fluorspar. Although the secondary spectrum is not completely eliminated here, it is far less noticeable than in achromats. As a result of the improved possibility of correction, considerably larger apertures can be obtained; thus the microscopic image is appreciably brighter and shows improved resolution.

Thus, fluorite systems are particularly suitable for photomicrography. For colour photography they are recommended if the demands of contrast and resolution in the centre of the picture are more stringent.

Apochromats

In these objectives a complete combination has been obtained for three spectral colours. This completely eliminates the secondary spectrum, and the remaining tertiary spectrum is practically insignificant.

Figs. 26 und 27 illustrate the extent to which modern means of correction succed in the elimination of residual chromatic aberration. These illustrations represent the correction curves of an achromat and an apochromat respectively. As can be seen clearly the correction curves for red, green and blue have approximately the same pattern in the achromat. However, violet is not yet completely incorporated in the correction. In addition, all curves still show a slight curvature. In the representation of the apochromat the larger aperture and the almost straight line pattern of all the correction curves are evident. The correction curves are curved only at approximately full aperture. However, it must be borne in mind that the curves are drawn at about 5000 to 10000x magnification in order to make the residual aberration at all evident.

The general image definition of an apochromat is therefore fascinatingly crisp; sharpness, contrast and resolution are the best that can be obtained. Apochromats are therefore the favourite objectives for research problems in which the recognition of the most delicate structural elements is essential. Naturally, apochromats are also eminently suitable for colour photomicrography at large condenser apertures. Naturally the high material and manufacturing costs result in a higher price of these apochromats. However, if you compare critically the performance of both systems you will never want to be without apochromats in the optical outfit of your microscope.

Highly corrected objectives, if possible, should not be used during investigations to be carried out in connection with corrosive solvents or fixatives such as acetic acid etc.
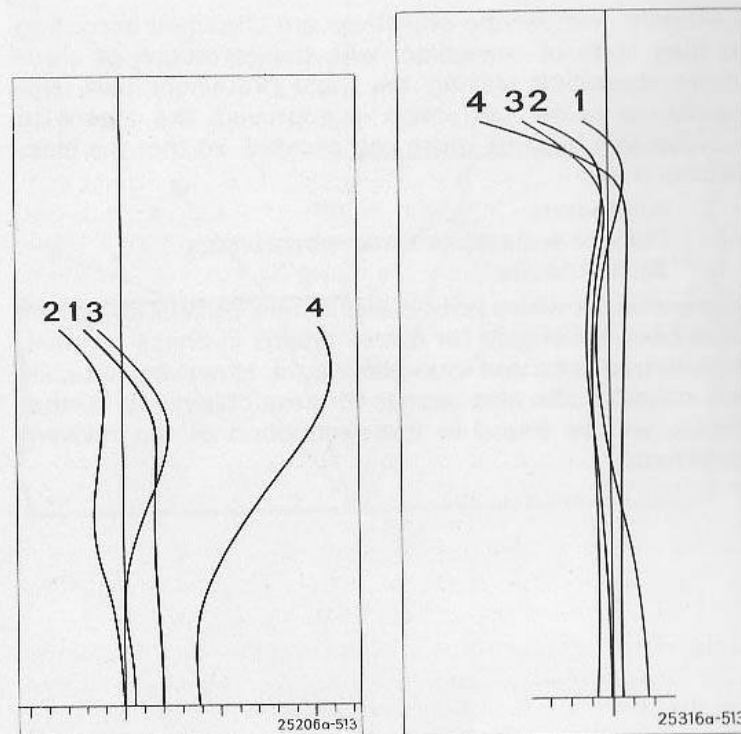
Figs. 26, 27
Correction curves of an achromat and an apochromat for the spectral
colours   656 nm   (red) 1
           546 nm   (green) 2
           486 nm   (blue) 3
           405 nm   (violet) 4.
Horizontal axis: differences in intercept length.
Vertical axis: levels of intersection from the optical axis to the full aperture.

PI Apo plan-apochromats

As long as the microscopist uses his instruments for visual purposes only, he will be prepared to accept the curvature of field occurring in conventional systems. After all, he is always at liberty to focus any point of the field of view critically simply by re-focusing with the fine adjustment. The situation is different in photomicrography, where sharpness extending over the entire field of view is demanded of the individual picture. As the importance of photomicrographic recording increased, so did the demand to eliminate curvature of field.

The introduction of suitably shaped negative lenses such as, for instance, thick menisci of converging effect has made this possible. Thus fields of view of even high-power systems can be flattened. Obviously many more means of correction must be used for a large field than in the conventional systems of the past. Nevertheless LEITZ classified only these objectives as plano objectives, which form a flat intermediate image of a field of 28mm diameter. All LEITZ-PI plano objectives meet this demand.

Naturally, a high degree of colour correction must be aimed at even with plano objectives. Unfortunately almost all the means suitable for flattening the field counteract the apochromatic correction of the objective. It is therefore necessary to use the fluorspar, familiar means of apochromatic correction of objectives, for the largest possible number of elements. If it is borne in mind that with high-power, non-flattened objectives astigmatism and asymmetrical aberrations are submerged in the curvature of field and need therefore to be corrected only within limits, it will be easily seen that for flattened images a high additional number of elements is necessary.

LEITZ plan-apochromats can be used on all our stands. Their main preserve is photomicrography; here they are superior to all other objectives. The excellent quality of our plano objectives both visually and photomicrographically is, however, fully utilized only in our ORTHOPLAN large-field microscope whose illuminating as well as image-forming systems have been fundamentally designed for largefield microscopy.

28004-519 R   28005-519 R   28006-519 R

28007-519 R   28010-519 R
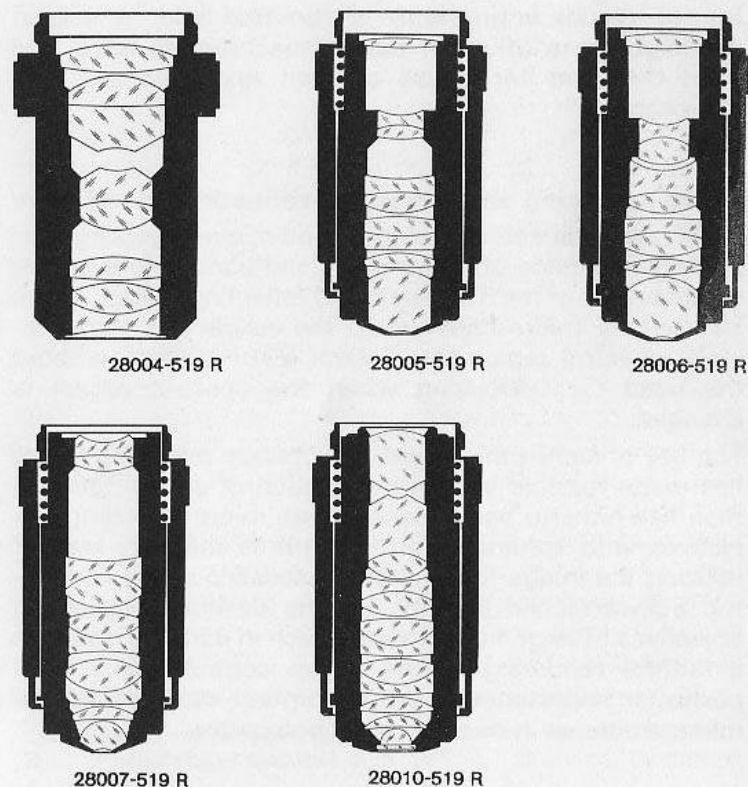
Fig. 28
LEITZ plano objectives with cross sections
The PI Apo Oel 100/1.32 has 12 lenses

25

NPI plano objectives

For stands with standard tubes (23.2mm) such a radical flattening as that of our PI plano objectives is not always required. This is why we have developed our NPI plano objectives. These are planachromats with less ambitious correction. They are correspondingly less expensive and therefore the favourite objectives for routine investigations or photomicrographic recording mainly on black-and-white films.

However, LEITZ NPI plano objectives are available not only for observation in brightfield transmitted light. In view of the importance of a flat field planachromats have also been designed for phase contrast and polarized-light microscopy.

Micro reflecting objectives and reflecting condensers

LEITZ micro-reflecting objectives and micro-reflecting condensers are made of quartz glass and constitute a further development of the Schwarzschild reflecting system. It can be used for microscopy within the visible and the ultra-violet spectral region from about 220–700nm, without the need for refocusing when the spectral region is changed.

The use of semi-transparent and opaque reflecting layers has made feasible a further reduction of central shading than has hitherto been possible with micro-reflecting objectives with spherical mirrors. This is the only way of utilizing the image-forming characteristics of the concentric Schwarzschild systems for the design of reflecting objectives of large field of view which in addition also give a faithful rendering of the object contrast. This is of particular importance in the absorption measurement of microstructures in microspectrophotometry.
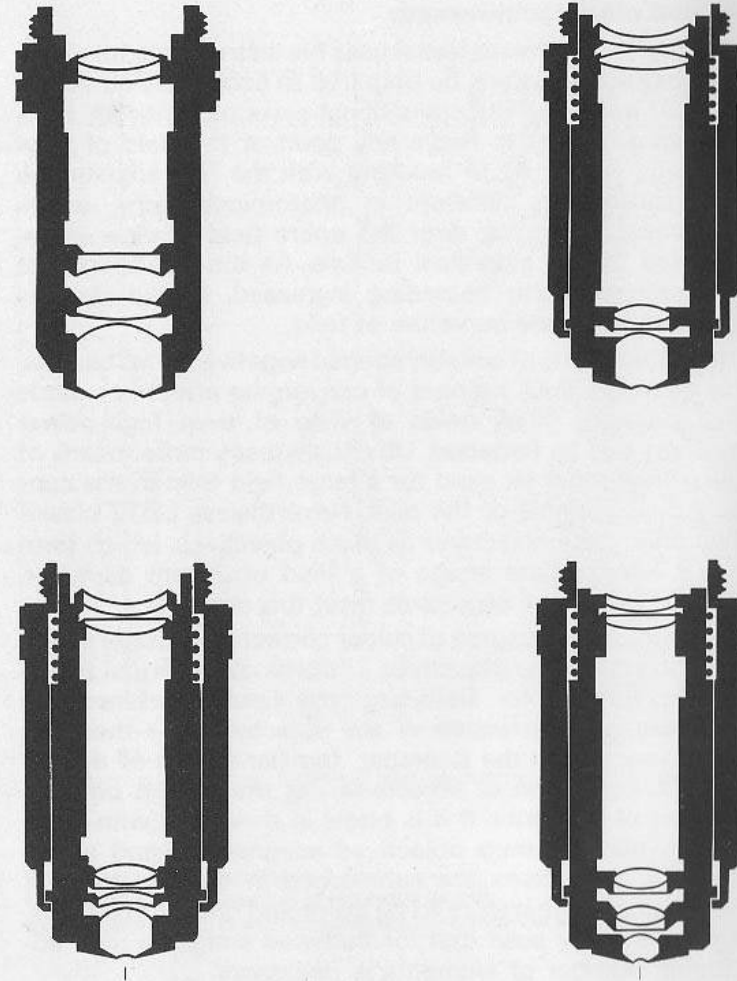
Figs. 29–32
Cross sections of 4 NPI Plano objectives

LEITZ eyepieces

The objective produces an inverted, real intermediate image at the reproduction ratio of its magnification. Since the intermediate-image plane of the object coincides with the focal plane of the eyepiece, the eyepiece projects the image into infinity. It can therefore be observed with an eye which is accommodated to infinity in the exit pupil of the eyepiece. A narrow, parallel bundle of light corresponds to each individual object point, and the eye focuses this bundle on the retina to form an image of this object point.

In theory a single collecting lens could be used as an eyepiece. However, it can be easily seen that if such a type of eyepiece were used the lens diameter and the distance of the exit pupil would become excessively large. It is therefore better to divide the eyepiece into two lenses. In such a type of eyepiece the oblique bundles diverging towards the margin of the image are collected by the first lens, the field lens, and directed towards the eyelens. This makes it possible to keep the lens diameters within practically acceptable dimensions and the distance between the exit pupil and the eyepiece assumes a value favourable for observation.

Fig. 33 shows the optical path in such an eyepiece. The oblique bundles arriving from the objective before they reach the plane BB (dashed lines) are deflected by the field lens K (also called collecting lens) and focused in a slightly reduced image B' in the plane B'B'. Thus the intermediate image B is displaced by the field lens to the plane B'B'. The magnifying power of the following eyelens A, which has the function of the magnifier proper, has been rated so that together with the weak reduction through the field lens it represents the nominal magnification of the eyepiece.
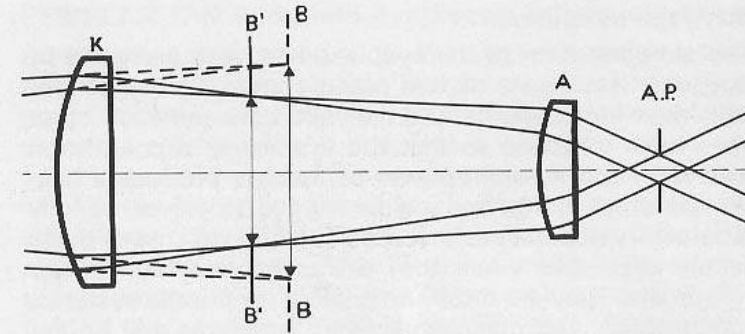
Fig. 33
Optical path in the Huygens eyepiece
K   = collecting or field lens
A   = eyelens
AP   = exit pupil
B'B' = intermediate image plane affected by the field lens
BB   = intermediate image plane unaffected by the field lens

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Huygens eyepieces

This simplest form of the eyepiece has been designed by Huygens. It consists of two plano-convex lenses, whose individual focal lengths and distance between each other have been matched so that the eyepieces in connection with low- and medium-power achromats produce a field of view which is free from colour fringes. However, no fully satisfactory general performance can be expected of these simple eyepieces when they are used with high-power achromats. They are totally unsuitable for fluorite systems, apochromats and plano objectives, which, as will be explained in the chapter on PERIPLAN eyepieces, require eyepieces of special correction.

Externally Huygens eyepieces can be recognized by the absence of any further indication besides the name of the manufacturers and the magnification.

PERIPLAN eyepieces

It will be easily appreciated that it is hardly possible to correct residual aberration of an objective by means of an eyepiece consisting of only two lenses. Eyepieces with members consisting of several elements are therefore used where higher quality is essential. With such eyepieces, which we call PERIPLAN eyepieces, the lateral chromatic aberration, which occurs particularly in the marginal regions of the image, is corrected and the eye presented with an image free from colour fringes throughout the entire field. This applies both to all apochromats and fluorite systems and to the high-power achromats. Their use is based on these properties:

PERIPLAN eyepieces **should** be used with higher-power achromats, and **must** be used with fluorite objectives, apochromats, and plano objectives.

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Fig. 34
Cross section through a Huygens eyepiece

PERIPLAN GF widefield eyepieces

Our PERIPLAN widefield eyepieces represent a further development in the direction of larger fields. Whereas the 10x PERIPLAN eyepiece covers a field of 15.2mm diameter, the corresponding PERIPLAN widefield eyepiece takes in a diameter of 18mm. This increase of about 20% in the diameter represents more than 40% in area and therefore a corresponding increase of pictorial content. To the eye the diameter of the microscope image will appear 10x15.2 = 152mm and 10x18 = 180mm respectively. At this size the image can also be observed on a groundglass screen at a distance of 250mm. With the 16x and 25x GF eyepieces the image diameter increases to as much as 240 and 250mm respectively. As their designation indicates, they are corrected as PERIPLAN types, so that they can be combined with the same objectives.
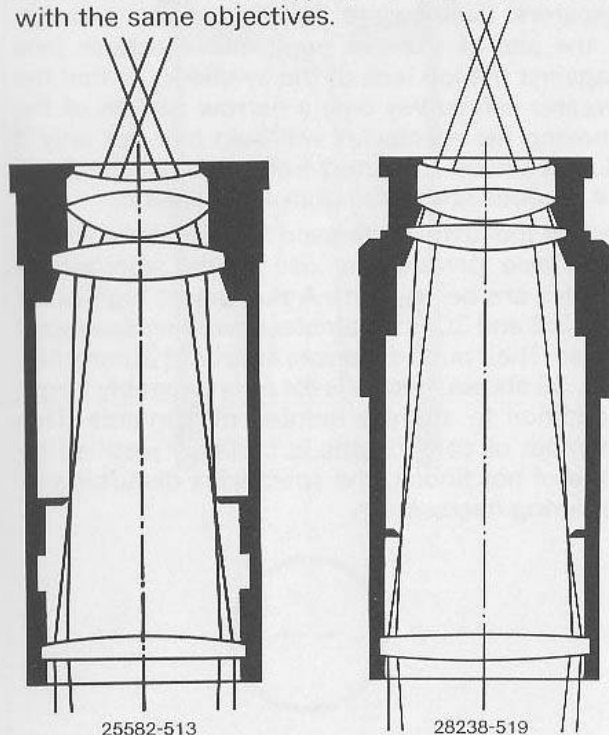
PERIPLAN GW widefield eyepieces, 30mm diameter

As already explained on p. 16, the largest possible useful diameter of the intermediate image in a standard tube is about 18mm. Eyepieces of higher field-of-view indices therefore call for wider tubes. This is why we have developed large-field tubes of 30mm diameter for GW eyepieces of field-of-view indices of up to 28. This is the upper limit still observable without eyestrain. With the 6.3x GW eyepiece, field-of-view index 28, the diameter of the microscopic image is 6.3x28 = 176mm, with the GW 8x, field-of-view index 28, it is 8x 28 = 224mm. With higher-power eyepieces the field-of-view index must be further reduced in order to limit the angle of view to a value acceptable to the eye.

According to their correction the GW eyepieces belong to the PERIPLAN type. However, they can be used only with plano objectives, because the field correction of the conventional objectives is insufficient for these very high field-of-view indices.

Purchase of a microscope with a wide tube (ORTHOPLAN) does not preclude the use of GF eyepieces of conventional diameter, because an adapter is available for these.

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Figs. 35, 36
Cross sections and optical paths: on the left of the GF eyepiece, on the right of the GW eyepiece. It can be clearly seen that a considerably larger intermediate image can be accommodated in the GW type.

Eyepieces with focusing eyelenses

For photomicrography with cameras without focusing telescope eyepieces with focusing eyelens and graticule are indespensable. On the graticule, which is situated in the focal plane of the eyepiece, small concentric double circles are engraved in addition to the outline of the picture area. The user adjusts the eyelens until the double circles appear in sharp focus. He accommodates, as it is called, his eye to the double circles and therefore to the focal plane of the eyepiece. When the microscopic image is focused the intermediate image will then be placed exactly in the focal plane of the eyepiece. It is then also sharp in the film plane of the 35mm camera if a photo tube with an automatic visual compensation is used.

Eyepieces with focusing eyelenses are either of the PERI-PLAN or of Huygens design. Designation: M for focusing eyelens and graticule mount.

High-point eyepieces

It is a well-known fact that all the bundles of rays coming from the microscope intersect in the exit pupil of the eyepiece. This is where the pupil of the observer's eye must be situated if he is to survey the entire field of view. The further the eye pupil is removed from the site of the exit pupil, the more of the oblique bundles of the marginal portions of the microscopic image are lost. Fig. 37 illustrates this wasteful cutting-off of rays and its effect on the field to be surveyed.

Without special constructional measures the exit pupil approaches the eyelens more and more closely as the eyepiece magnification increases. But even with low-power eyepieces the distance between the exit pupil and the last lens surface at about 10mm is still too small for spectacle wearers. Even before they can move their eye pupils into the site of the exit pupil, the spectacle lens will knock against the top lens of the eyepiece, so that the spectacle wearer can survey only a narrow section of the image. Removing his spectacles will help him but only if his visual defect can be corrected with spherical spectacle lenses, i.e. if he does not suffer from astigmatism.

This has created the justified demand for eyepieces whose pupil position also permits the use of the microscope when spectacles are being worn. A number of high-point eyepieces of 23.2 and 30mm diameter have been developed for this purpose. Their pupil distances are about 20mm. Naturally, as Fig. 38 shows, this calls for a considerably larger eyelens in addition to a larger number of elements. This increased number of components is certainly justified by the advantage of not finding the spectacles disturbing or a hindrance during microscopy.

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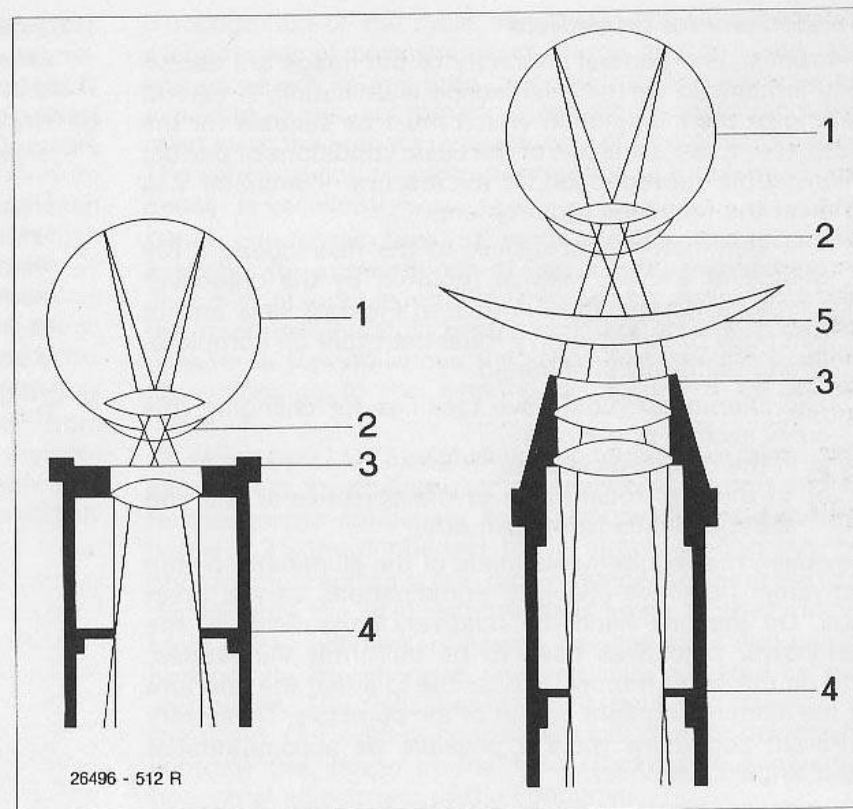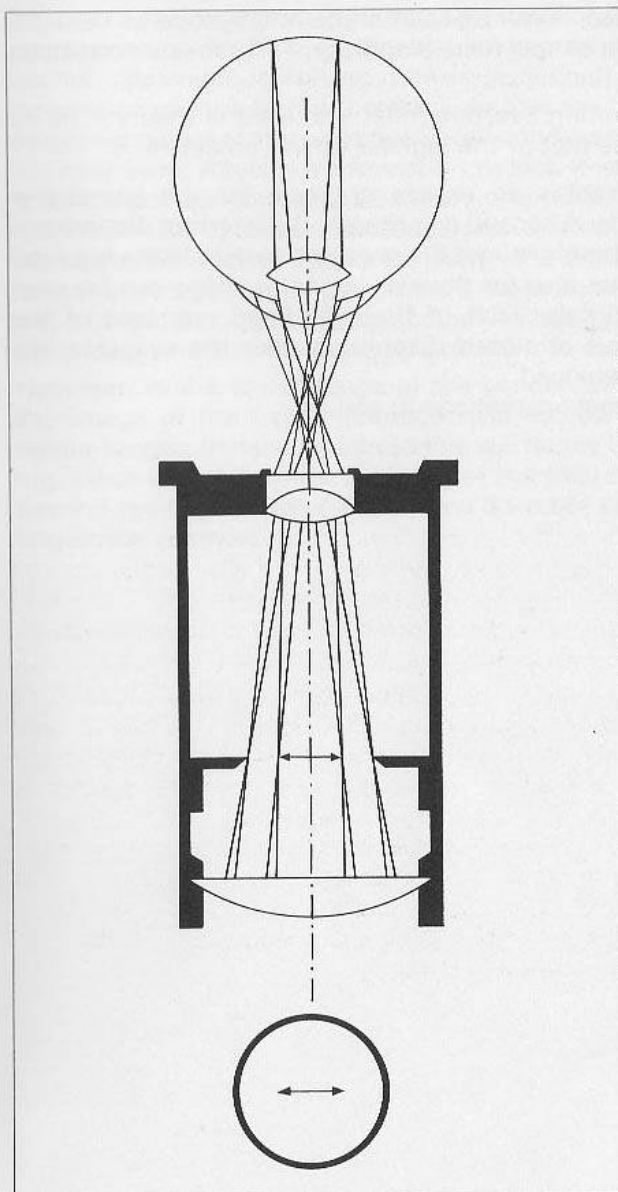
Fig. 38
Comparison of the position of the pupils in the 10x PERIPLAN eyepiece and the 10x
PERIPLAN high-point eyepiece 𝟞𝟘𝟘 (strongly diagrammatic):

Left
1 eye
2 exit pupil
2 vertex of lens
4 eyepiece diaphragm

Right
1 eye
2 exit pupil
3 vertex of lens
4 eyepiece diaphragm
5 spectacle

Fig. 37
Because of too great a distance between the eye and the eyepiece only a part of the
bundles (solid lines) can enter the eye. The reduced field is indicated by an arrow.

Illuminating systems

Condensers for brightfield

Sharpness and general character of the image are decisively influenced by the microscope illumination. A careful setting of the illumination which must be suitable for the microscope section is one of the basic conditions of perfect microscopic reproduction. A microscope illuminator has to meet the following requirements:

I. The illuminator must deliver to the microscope a ray bundle of a cross section required by the objective/eyepiece combination in use. a) Field of view and b) exit pupil of the objective must therefore be completely and uniformly illuminated.

II. The illuminator must have facilities for changing this cross section of the rays
   a) in the object, as well as
   b) in the rear focal plane of the objective at will and independently from each other.

However, the requirements made of the illuminator by the individual objective-eyepiece combinations vary a great deal. On the one hand the relatively large fields of the low-power objectives have to be uniformly illuminated, and on the other it must be possible to adapt the aperture of the illuminating light to that of the objective. These very different conditions must if possible be accommodated by a single condenser.

A condenser therefore has to meet the following conditions:
a) it must be able to deliver the full ray cross section for the lowest-power objectives.

   However, this creates a surplus for high-power objectives which cannot be fully utilized, which may even adversely affect the image quality through reduced contrast, reflections, and needless exposure of the specimen to heat. As a result it must be possible to reduce the cross section of the ray bundle to the dimension that can be utilized and is „useful" in any individual case. This is achieved by means of a field diaphragm introduced into the illuminating beam. The image of this diaphragm limits the rays in the object. If the diaphragm is closed, it will be seen in the microscope as field-of-view, or simply field, diaphragm. This meets conditions Ia and IIa.

b) The limiting aperture must – at least in theory – be as large as that of the highest-power objective.

This creates an excess aperture for the low-power systems. A second diaphragm, the aperture diaphragm, must therefore limit the ray cross section to the required diameter also for the exit pupil. Its image can be seen as a circular limit of the light-filled rear lens of the objective at closed diaphragm after the eyepiece has been removed.
This meets conditions Ib and IIb.

However, for most investigations the condenser aperture corresponding to that of the objective used is not required. Maximum resolving power is almost invariably accompanied by a lack of contrast, so that the theoretical resolving power of the objective at full condenser aperture is rarely used. It has been found in practice that therefore a condenser aperture of 0.90 is very often adequate even for immersion systems. Condensers of this aperture can be corrected without much difficulty at a comparatively longer intercept length. In addition, these condensers do not require the often cumbersome immersion between their front lens and the underside of the microscope slide.

However, in the upper range of the condenser apertures the image of the field diaphragm will not be free from colour fringes. In most instances this will hardly be disturbing, since a slightly wider opening of the field diaphragm beyond the edge of the field of view does not appreciably impair the contrast.

If recognition of the most minute structures is essential, a condenser of correspondingly large aperture and high correction will be required. Here illuminating systems are available in our achromatic-aplanatic condensers which meet even the highest requirements of photomicrography. The spherical and chromatic correction of this type of condenser is excellent.

Other condenser tops of long working distances are available for examinations in tissue culture chambers, of very thick objects, in intravital microscopy, or for work with the micromanipulator. Here the image of the field diaphragm is formed above the stage surface at a distance corresponding to the working distance. For details see tables.

All series 600 LEITZ brightfield condensers are convertible condensers, consisting of a standard bottom part and interchangeable condenser tops. For condenser apertures below 0.25 the condenser top is simply swung out. For photomicrography it is also recommended to lower the condenser until the field diaphragm is again in sharp focus.

Most of our condensers have a dovetail slide and can be horizontally interchanged and vertically adjusted by rack and pinion. The field diaphragm is built into the foot of the stand. Our system condensers incorporate devices for centring the image of the field diaphragm, allowing a horizontal adjustment of the condenser.

In the simplest versions of our classroom microscopes the condenser is pushed into a cylindrical sleeve permanently mounted below the microscope stage.

Function of the field- and aperture diaphragms
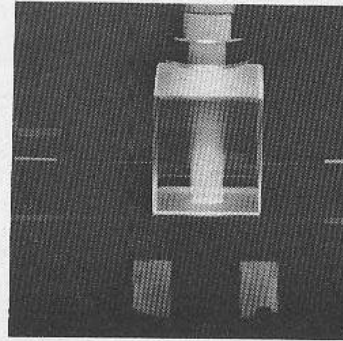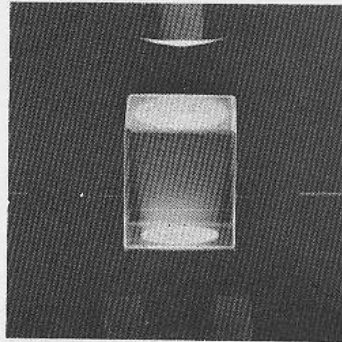
Fig. 39, 40
These illustrations show how to change the diameter of the beam in the object plane by means of opening and closing the field diaphragm.
Left: Maximum diameter of the beam for the lowest-power objectives (large illuminated area in the object plane).
Right: Reduced beam diameter for a high-power objective (small illuminated area in the object plane).

Figs. 43, 44
By means of opening and closing the aperture diaphragm the beam diameter in the rear focal plane (exit pupil of the objective) can be changed.
Left: Small condenser aperture for an objective of small aperture (narrow ray cone).
Right: Large condenser aperture for an objective of large aperture (wide open ray cone).

Figs. 41, 42
The field diaphragm in the field of view of the microscope.
Left: Centred and closed.
Right: Opened beyond the edge of the field of view.
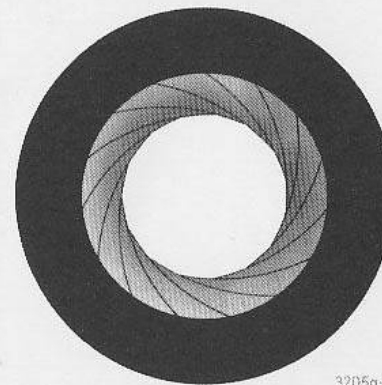
Fig. 45
The aperture diaphragm can be observed on the rear focal plane of the objective through an auxiliary magnifier.

Condensers for darkground

In darkground microscopy only the light diffracted on the object contributes to the formation of the image. The undiffracted direct light does not enter the objective; blank areas of the microscope slide therefore appear dark in the field of view in the microscope. Hence the objects appear bright against a dark background. In practice the object is illuminated with a hollow cone of light with a darkground condenser, whose internal aperture (limiting aperture) is larger than that of the objective used. The internal limiting aperture is always stated with the darkground condenser, e.g. D 0.80 or D 1.20. If objectives of larger apertures are used, funnel stops or built-in iris diaphragms are necessary. Darkground observation is preferable for very small and thin objects, which will then be clearly visible against the dark background. Of extensive objects, on the other hand, usually only the periphery is reproduced, but not the internal structure. With thick objects, details situated outside the plane of focus produce bright blurred areas in the image, which strongly reduce the contrast.
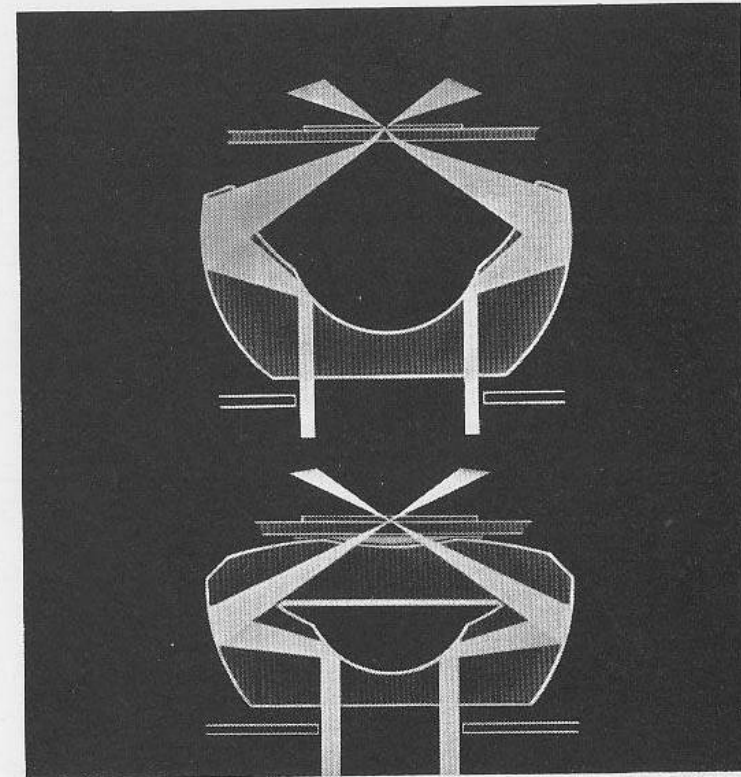
Fig. 46
Optical path in darkground
a) dry darkground condenser
b) immersion darkground condenser

Condensers for phase contrast, polarized light, and fluorescence

These condensers are described on p. 104 where their technical data will also be found.

Incident-light illuminators

During work in incident light the light coming from the light source must mostly be deflected and directed towards the specimen. The optical components producing this effect are called vertical illuminators. Depending on their design the illuminating light is directed to the object e.g. through concentric annular mirrors and condensers surrounding the objective (ULTROPAK-darkground-illuminator) or directly through the objective. Here objective and condenser are identical (e.g. fluorescence incident-light illuminator according to Ploem).

Our programme includes the following:
ULTROPAK darkground illuminator objectives   page 71

Vertical illuminators for metallo-
graphic work with:
Achromats or Fluorites   page 73
Plano objectives

                                                page 76

Brightfield-darkground special
objectives   page 75, 77, 79
Phase contrast objectives   page 74, 78
Polarized-light vertical illuminators   page 80, 81, 83, 85
Fluorescence-incident-light illuminator page   53-55
according to Ploem, objectives

The individual vertical illuminators vary with the stand and the method of investigation and are described in the prospectuses of the relevant microscope stands.

2960 - 513 R
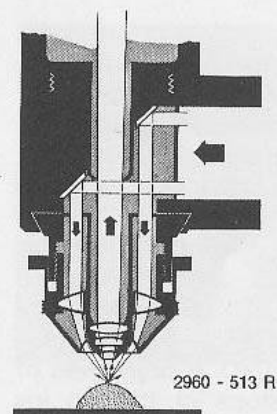
Fig. 47
Optical path in the darkground ULTROPAK incident-light illuminator.

26412 - 560 R

a

26413 - 560 R

b
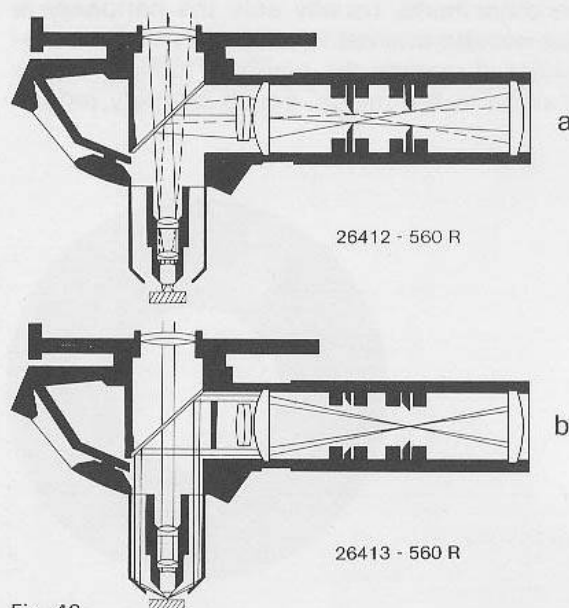
Fig. 48
Optical path in the vertical illuminator for metallographic microscopy.
a) in brightfield
b) in darkground.

Care of optical systems

The optical parts of the microscope must be kept meticulously clean. The external surfaces of microscopic optical equipment are coated with layers about as hard as glass, but very thin. Cleaning must therefore be carried out with the appropriate care.

For cleaning, objectives must not be dismantled. Optical components with internal damage should be returned to the factory for repair.

Optical components	Cleaning
External surfaces of objectives, eyepieces, condensers	**Dust:** remove with a soft dry sable brush **Fingermarks:** immediately remove with a moistened piece of linen or chamois leather: if necessary use petrol **Resistant dirt:** With a moist, fine piece of linen or chamois leather; if water fails to remove the dirt, xylene or petrol can be used. Alcohol should never be used.
External surface of the front lens of plano objectives	The external surface of the front lenses of some plano objectives is concave. Preferably clean them with a piece of cotton wool wrapped round a matchstick. Here, too, water, xylene, or petrol can be used if the lens is very dirty.
Oil immersion objectives	**Clean immediately after use;** Dab off oil with blotting paper or a piece of linen. Remove the residual oil film with a piece of linen moistened in xylene. Finish cleaning, if necessary, with a petrol-soaked rag. Never use methylated spirits or other alcohol.

Special cases

a) Corrosive substances such as acetic acid etc.

If possible corrosive materials should not be used on the object stage of the microscope. Even if the objects are under coverglass, the objective will be exposed to a continuous stream of vapour from the corrosive substance. If this is allowed to act for prolonged periods, the front lens may be attacked and its optical quality considerably reduced. It is therefore preferable to use another fixative etc.

b) Hydrofluoric acid

This etching medium frequently used in metallography represents a considerable danger to optical components, since particularly in porous materials minute but very harmful concentrations of hydrofluoric acid will collect; however, they can be removed rapidly and reliably with the following method:

Introduce the etched preparation into a solution saturated with ammonium pentaborate for one hour. Rinse well and dry. The specimen is now ready for metallographic examination.

Ammonium pentaborate has been found compatible with numerous metallic, ceramic, metalloid, and semiconductor preparations which have to be etched with hydrofluoric acid.

The solution is prepared by the dissolution of 9.8 g ammonium pentaborate in 100 ml distilled water. This solution is 0.36 – molar and saturated.

Key to technical symbols

Engraving or designation	Significance
A	Aperture
AP	Exit pupil
Apo	Apochromat
D	Use objective with coverglass
DO	Use objective with or without coverglass
fAA	Free working distance
FI	Fluorite system, semi-apochromat, lately usually without fluorite components
GF	23.2mm widefield eyepiece
Glyz.	Glycerine immersion
GW	30mm diameter widefield eyepiece
H	Heating-stage objective
HD	Incident-light objective brightfield/darkground
Iris	Objective with iris diaphragm
L	Objective of relatively long working distance
M (with eyepieces)	Eyepiece with focusing eyelens
M	Reproduction ratio
N	Negative eyepiece
NPI	Plano objective for normal field
n	Refractive index
O	Use objective without coverglass
Oel and black ring	Oil immersion objective

Engraving or designation	Significance
P	Strainfree objective or eyepiece
(P)	Strainfree within limits
PERiPLAN	PERIPLAN® eyepiece
Phaco	Phase contrast Zernike
Pl	Plano objective for 28mm field
Pv	Phase contrast Heine
Q	Quartz glass
R	Radiation-resistant objective
S	Field-of-view index
UM (UMK)	Objective for universal rotating stages
UO	Ultropak objective
V	Magnification (single-lens magnification)
W	Water immersion

I. LEITZ-objectives for transmitted light

Standard objectives, achromats fluorite systems, and apochromats

170/0.17/45mm **

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Achromatic dry system	4	0.12	24	32	DO	P	519292
	10	0.25	6.8	17	DO	P	519293
	25	0.50	0.44	7.2	D	P	519301
	40	0.65	0.42	4,6	D	P	519419
Apo	40	0.95 korr.			D 2	P	519306
Fl	63	0.85	0.14	3.0	D !	P	519342
Oil immersion objective	Oel 100	1.30	0.10	1.9	D	P	519295

20385–519 R

[1] D: to be used with coverglass D = 0.17mm (adhere to coverglass thickness within + − 0.05mm)
O: to be used without, DO: with or without coverglass
Dl: adhere to 0.17mm coverglass thickness to within ± 0.01mm, or, where the objective has a correction mount, set this exactly at the actual coverglass thickness.

[2] These objectives have an adjustable correction mount. Image sharpness is almost completely preserved when this correction is operated. Ideal possibility for optimum setting when the coverglass thickness is not known.

[3] H = Huygens eyepieces, P = PERIPLAN or widefield eyepieces must be used.

Unless stated otherwise these figures apply to all the tables.

* Free working distance is the distance between the bottom edge of the objective mount and the top surface of the coverglass (0.17mm) or the top of an uncovered object.

** Tube length/coverglass thickness/adjustment length mm
Objectives of 45 and 37mm adjustment length can be combined on the revolving nosepiece, if the latter are screwed together with an 8mm long adapter, Code No. 519 164.

Fluorite systems

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Fluorite dry systems	Fl 40	0.85	0.28	4.3	D!	P	519 025
	Fl 40	0.85	0.28	4.3	O	P	519 238
Fluorite oil immersion objectives	Fl Oel 54	0.95	0.17	3.4	DO	P	519 027
	Fl Oel 95	1.32	0.12	2.0	D	P	519 026
	Iris Fl Oel 95	1.32 u. 1.10	0.12	2.0	D	P	519 046

Apochromats

170/0.17/37mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1])	Type of eyepiece[3])	Code No.
Apochromatic dry systems	Apo 12.5	0.30	2.3	13	DO	P	519009
	Apo 25	0.65	0.76	7.4	D	P	519007
	Apo 40	0.95	0.09	4.6	D!^{2}	P	519038*
	Apo 63	0.95	0.09	3.0	D!^{2}	P	519039*
Apochromatic oil immersion objectives	Apo Oel 90	1.32	0.09	2.0	D	P	519008
	Apo Oel 90	1.40	0.03	2.0	D	P	519010

* in correction mount
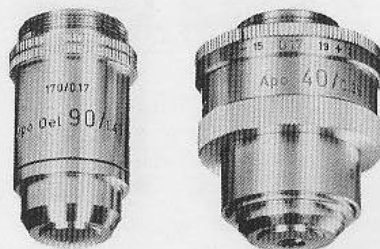
NPI Planachromats

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
NPI planachromats	NPI 6.3	0.20	2.0	24	DO	P	519 245
	NPI 10	0.25	0.53	16	DO	P	519 263
	NPI 16	0.40	0.50	11	D	P	519 246
	NPI 25	0.50	0.38	7.0	D	P	519 247
	NPI 40	0.65	0.15	4.5	D	P	519 248
	NPI Oel 100	1.30	0.26	1.7	D	P	519 249
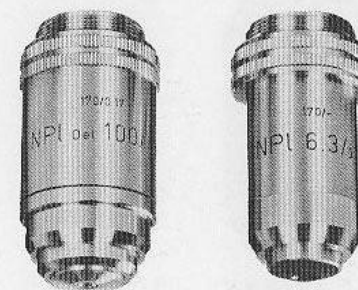
PI Plano objectives
achromats and fluorite systems

170/0.17/45mm
Exception PI 1:65.6mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Plano objective PI	PI 1 with Iris	0.04	30	33	DO	P	519050*
	PI 2.5	0.08	11	56	DO	P	519049
	PI FI 4	0.14	14	40	DO	P	519176
	PI FI 10	0.30	6.9	18	DO	P	519175
	PI 16	0.40	1.26	10.9	DO	P	519243
	PI 25	0.50	0.65	7.2	D	P	519163
	PI 40	0.65	0.28	4.3	D	P	519161

* including associated condenser

20386–519 R

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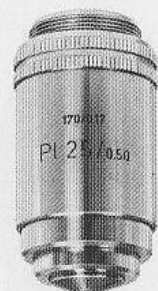
These objectives produce a flattened field for eyepieces of up to field-of-view index 28. Their full optical performance is utilized only in microscopes with a wide tube (diameter 30mm) and with GW eyepieces.

170/0,17/45 mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm*	Focal length mm	Coverglass correction[1]	Type of eyepiece[1]	Code No.
Plan-apochromats	Pl Apo 6.3	0.20	9.2	27.8	DO	P	519 386
	Pl Apo 16	0.40	1.2	10.5	DO	P	519 299
	Pl Apo 25	0.65	0.65	7.2	D	P	519 387
	Pl Apo 40	0.75	0.44	4.0	D!	P	519 244
	Pl Apo Oel 100	1.32	0.24	2.4	D	P	519 160
	Pl Apo Oel 100	1.32	0.25	1.8	D	P	519 383

Plan-apochromats produce the flattest field and have optimum colour correction. They are the most suitable objectives for the ORTHOPLAN largefield microscope.

20793–519 R

20387–519 R

Special objectives with built-in iris diaphragm for brightfield and darkground

170/0.17/37mm

Type of objective	Engraved: reproduction ratio/aperture	Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Fluorite oil immersion objective for condenser D 1.20	Iris Fl Oel 95 1.32 and 1.10 0.12	2.0		D	P	519 046

20787–519 R

17014 - 513 R

Funnel stops for medium- and high-power objectives for the reduction of the objective aperture

1, For objectives of 32mm adjustment length
For use with
a) dry darkground condenser D 0.80
 for objective

63/0.85	513 210
Fl 40/0.85	513 211
Fl Oel 54/0.95	513 212
Apo 40/0.95	513 213
Apo 63/0.95	513 214

b) immersion darkground condenser D 1.20 for objective

Oel 100/1.30	513 069
Apo Oel 90/1.32	513 215
Fl Oel 95/1.32	513 069
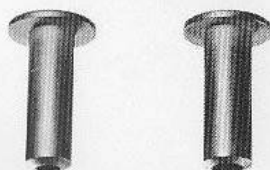
2, For objectives of 45mm adjustment length
For use with
immersion darkground condenser D 1.20-1.40
for objective Oel 100/1.30   513 362

Phaco phase contrast objectives for the Zernike condenser

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Dry systems	Phaco 1 10	0.25	6.8	17	D O	P	519 165
	Phaco 2 25	0.50	0.44	7.1	D	P	519 236
	Phaco 2 40	0.65	0.42	4.6	D	P	519 420
Oil immersion objectives	Phaco 3 Fl Oel 70	1.15	0.16	2.6	D O	P	519 278*)
	Phaco 3 Oel 100	1.30	0.11	1.9	D	P	519 167

*) for microspectrography;
with the objective adapter 519 164 can also be used
with phaco objectives 170/0.17/45mm.

The number after Phaco indicates the position of the annular diaphragm turret on the condenser with which the objective must be used.
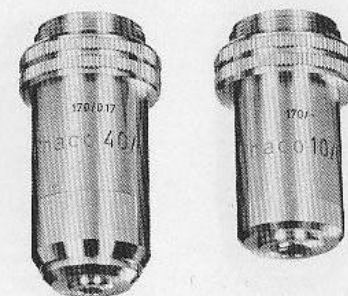
Phaco NPI phase contrast planachromats for the Zernike condenser

170/0.17/45mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
NPI phase contrast planachromats	Phaco 1 NPI 10	0.25	0.53	16	DO	P	519 250
	Phaco 1 NPI 16	0.40	0.50	11	D	P	519 251
	Phaco 2 NPI 25	0.50	0.38	7.0	D	P	519 252
	Phaco 2 NPI 40	0.65	0.15	4.5	D	P	519 253
	Phaco 3 NPI Oel 100	1.30	0.26	1.7	D	P	519 385

Phaco Pl Apo
Phase contrast plan-apochromats

Type of objective	Engraving Reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece	Code No.
Phase contrast plan-apochromats	Phaco 1 Pl Apo 16	0.40	1.2	10.5	DO	P	519 300
	Phaco 2 Pl Apo 25	0.65	0.65	7.2	D	P	519 389
	Phaco 2 Pl Apo 40	0.75	0.51	4.0	D!	P	519 390
	Phaco 3 Pl Apo Oel 100	1.32	0.25	1.8	D	P	519 349

20389–519 R

Pv Phase contrast objectives for the Heine condenser

Type of objective	Engraved: reproduction ratio/aperture		Free work- ing distance mm	Focal length mm	Coverglass correc- tion[1]	Type of eye- piece[3]	Code No.	Version of absorption		
								75 ± 5%	88 ± 2% See note	88 ± 2%
Dry systems	Pv 10	0.25	5.4	16	DO	P	519149	n	h	—
	Pv 25	0.50	0.72	7.1	D	P (H)	519150	n	h	—h
Immersion attachment for	Pv 10	0.25	0.3				519153*			
Dry systems of long working distance	Pv Apo L 40	0.70	0.33	4.5	D! 2	P	519151**	n	h	—h
	Pv Apo L 63	0.70	0.25	2.9	D! 2	P	519155**	n	h	—h
Glycerine immer- sion objective	Pv Glyc 50	1.00	0.13	3.6	Quartz 0,18	P	519276 for microspectrograph only			
Oil immersion objectives	Pv Fl Oel 70	1.15	0.17	2.6	DO	P	519154*	n	h	—h
	Pv Apo Oel 90	1.15	0.09	2.0	DO	P	519152	n	h	—
	Pv Apo Oel 90	1.32	0.09	2.0	DO	P	519158*	n	h	—
Water immersion objective	Pv WE 80	1.00	0.03	2.3	O	P	519215	n	h	—

** In correction mount

170/0.17
Pv 25/0.50

20789–519 R

Note:
unless otherwise required we supply objectives for positive phase contrast (designa-
tion „n"). However, on request the objectives 10/0.25 to Pv Fl Oel 70/1.15 can be
supplied for increased positive phase contrast (designation „h") and the objectives
Pv 25 to Pv Fl Oel 70 for increased negative phase contrast (designation „–h").
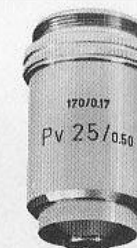
Special objectives for fluorescence microscopy

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1])	Type of eyepiece[3])	Code No.
Apochromat	FI 25 fluorescence	0.65	0.76	7.4	O	P	519040
Fluorite systems	FI 40 fluorescence	0.85	0.33	4.3	O	P	519011
	FI Oel 95 fluorescence	1.32	0.12	2.0	O	P	519012

These objectives have been developed for smear pre-parations without coverglass. They have a VG 5 front coverglass.

17008 - 519 R

53

Large-aperture special immersion objectives for fluorescence and brightfield

170/0.17/45 mm

Type of objective	Engraving: reproduction ratio / aperture		Free working distance	Focal length mm	Cover glass correction[1]	Type of eyepiece[3]	Code No.
Achromatic	W 25	0.60	1.57	7.1	D	P	519 380
immersion	W 50	1.00	0.68	3.7	D	P	519 376
objectives	W 100	1.20	0.18	1.7	D!	P	519 392
	Öl 10	0.45	0.39	16	D	P	519 433
	Öl 25	0.75	0.39	7.1	D	P	519 430

W = water

20390–519 R

These achromatic immersion objectives have particularly large apertures. They are therefore eminently suitable for work with the fluorescence vertical illuminator and in brightfield.

Phase contrast special immersion objectives of large aperture (also for fluorescence)

170/0.17/45 mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Achromatic immersion objectives for phase contrast fluorescence	Phaco 3 W 100	1.20	0.18	1.75	D!	P	519 427
	Phaco 2 Oel 10	0.45	0.39	16	D	P	519 431
	Phaco 2 Oel 25	0.75	0.37	7.1	D	P	519 432

W ; water

Phaco 3: Use with position 3 of the annular diaphragm turret on the condenser

These large-aperture special immersion objectives are designed for phase contrast fluorescence especially in combination with the fluorescence vertical illuminator. They can be used with water or oil.
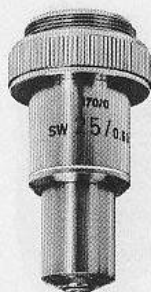
20391–519 R

55

Water immersion objectives

170/0/45 mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Achromatic water	SW 25	0.60	1.67	7.1	O	P	519 381
immersion	SW 50	1.00	0.75	3.7	O	P	519 426
objectives	SW 100	1.20	0.22	1.7	O	P	519 429
Achromatic water immersion objectives for phase contrast	Phaco 3 SW 100	1.20	0.22	1.7	O	P	519 428

20392–519 R

These objectives can be used on all transmitted light microscopes. They are designed for in vivo investigations etc. in water of up to 6 % NaCl content. The mounts of these objectives are particularly slender. Diameter of objective head 12mm.

Objectives of long working distances
Transmitted light

170/-/45 mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correc- tion[1]	Type of eyepiece[3]	Code No.
Achromatic dry systems	L 10 Iris	0.22	16		DO**)	P	519 438
	L 25 Iris	0.22	15		DO**)	P	519 439
	L 20 Iris	0.32	6.7		DO	P	519 434
	L 32 Iris	0.40	6.5		DO	P	519 435
Achromatic dry systems L for phase contrast	Phaco 1 L 20	0.32	6.7		DO	P	519 436
	Phaco 1 L 32	0.40	6.4		DO	P	519 437

*) not exact
**) These objectives can also be used for investigation of objects
   in laboratory vessels.

20396–519 R

57

Strainfree achromats and fluorite systems for polarizing microscopes

170/0.17/45mm
Exception Pl 1 65.6mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1])	Type of eyepiece[3])	Code No.
Planachromats	Pl (P) 1*	0.04	30	33	DO	P	559 065
	Pl P 2.5	0.08	11	56	DO	P	559 071
Achromatic dry systems	P 4	0.12	24	32	DO	P	559 079
	P 10	0.25	6.8	17	DO	P	559 054
	P 25	0.50	0.44	7.2	D	P	559 055
	P 40	0.65	0.42	4.6	D	P	559 110
Fluorite dry systems	Fl P 63 ✔	0.85	0.15	2.9	D!	P	559 097
Achromatic oil immersion objectives	P Öl 100	1.30	0.11	1.9	D	P	559 057

„(P)" strainfree within limits.   * with iris diaphragm; including largefield condenser

170/0.17
25/0.50 P

170/0.17
Oel 100/130

20395-519 R

The objectives for polarized light microscopy in strainfree mounts are distinguished by an additional letter P engraved on the mount. To preserve their freedom from strain permanently they must be protected against strong impact and temperature variations.

Strainfree achromats of conventional design, 45mm adjustment length and strainfree NPI planachromats are available. The latter are free from curvature of field over the entire field of view, so that they are eminently suitable for photomicrography or measuring.

The objectives are used either on a revolving nosepiece with individual centration for each objective or with a centring clutch.

NPI P and PI P strainfree planachromats for polarizing microscopes

170/0.17/45mm
Exception PI 1:65.6mm

Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
PI P strainfree	PI (P) 1	0.04	30	33	DO	P	559065*
plano objectives	PI P 2.5 ✓	0.08	11	56	DO	P	559071
NPI P strainfree	NPI P 6.3 ✓	0.20	2.0	24	DO	P	559058
planachromats	NPI P 16 ✓	0.40	0.50	11	D	P	559059
	NPI P 25 ✓	0.50	0.38	7.0	D	P	559060
	NPI P 40	0.65	0.15	4.5	D	P	559061
	NPI P Oel 100	1.30	0.26	1.7	D	P	559062

* Objective with irisdiaphragm, including widefield condenser

(P) strainfree within limits

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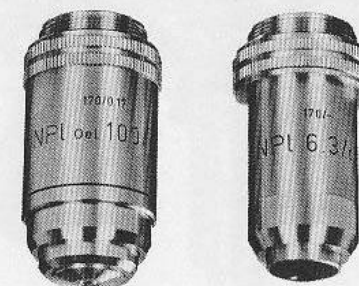
NPI Interference contrast T planachromats
(transmitted light)

170/0.17/45 mm

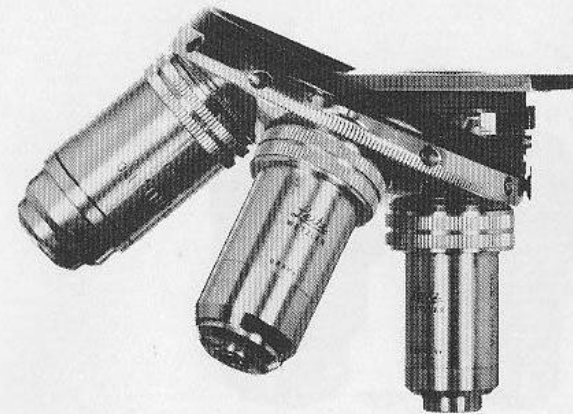| Type of objective	Engraved: reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
NPI planachromats interference contrast T	Interf.-Contrast T NPI P 25	0.50	0.38	6.9	D	P	Supplied only with condenser and permanently mounted on the nosepiece. Code No. for complete outfit:
	Interf.-Contrast T NPI P 40	0.65	0.15	4.5	D	P	
	Interf.-Contrast T NPI P Oel 100	1.30	0.25	1.7	D	P	
for polarizing microscopes	DIALUX-POL, LABORLUX-POL ORTHOLUX-POL, PANPHOT-POL ORTHOLUX-POL – MK and BK ORTHOPLAN-POL						553 206 553 207 553 271 553 208
for biological microscopes	LABORLUX® DIALUX® DIAVERT ORTHOLUX® 1 and PANPHOT® ORTHOLUX ORTHOPLAN®						553 209 553 266 553 306 553 210 553 265 553 211
for polarizing and biological microscopes with condenser-prepolarizer	ORTHOPLAN-POL ORTHOPLAN ORTHOLUX 2 POL – MK and BK ORTHOLUX 2 DIALUX						553 272 553 273 553 274 553 275 553 276

The interference contrast device consists of the special condenser, the revolving nosepiece for the microscope with which it is used, and the special objectives matched on and permanently screwed into the revolving nosepiece. In the outfits of the last paragraph (Code No. 553 272 to 553 276) a prepolarizer in the beam makes the condenser suitable also for powerful light sources (gas discharge lamps).

Pol-interference achromats

Type of objective	Engraved reproduction ratio/aperture		Free working distance mm	Focal length mm	Separation between sample beam and reference beam in the object field mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Pol-interference achromats	Pol-Interf. 16	0.35	5.3	11	0.25	DO	P	complete with revolving nosepiece:
	Pol-Interf. 40	0.65	0.70	4.7	0.1	D	P	
	Pol-Interf. Oel 100	1.20	0.16	1.7	0.04	D	P	for DIALUX-POL and LABORLUX-POL 553 154
								ORTHOLUX-POL 553 155
								PANPHOT-POL 553 164
								ORTHOLUX-POL MK and BK 553 268
								ORTHOPLAN-POL 553 156

Combined with the polarized-light interference device any large polarizing stand becomes a high quality interference microscope for transmitted light. The objectives used are achromats permanently mounted in a centring revolving nosepiece. The front lenses of the objectives are covered by crystal plates which recombine the sample and the reference beam. The interference condenser is situated below the rotating stage with slide and beam-splitting plate.

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Objectives for Heating Stage 350 – transmitted and incident light

	Transmitted light	Incident light
6/0.18	170/Q 1.80/37mm	215/Q 1.80/ca. 37mm
10/0.25		
UM	170/Q 1.80/45.5mm	215/Q 1.80/ca. 45mm

Type of objective	Engraved: aperture		repro-duction ratio/ aperture	Free object distance* mm	repro-duction ratio/ aperture	Free working distance mm	Focal length mm	Coverglass correction	Type of eyepiece[3])	Code No. for work in ordinary light	Code No. for polarized light
			in transmitted light		in incident light						
Heating	6	0.18	6/0.18	18	7.9/0.14	17	23	Q 1.80/0	H	519001	549044**
stage	10	0.25	10/0.25	6.0	13 /0.19	5.6	16	Q 1.80/0	H	519293	559045
objectives	UM 20	0.33	13/0.29	15	17 /0.22	15	12	Q 1.80/0	P	559004	
	UM 32	0.30	19/0.26	16	25 /0.20	16	8.2	Q 1.80/0	P	559005	

* see page 64
** use with objective adapter 519 164

According to the microscope stand used two series of objectives are offered for our Heating Stage 350. Both series consist of achromats of long working distances. The objectives on the table on p. 62 are designed for stands of 170mm and 250mm mechanical tube length respectively, those of p. 63 for infinity tube lens systems. As can be seen in column "Coverglass correction" a quartz glass plate of 1.8mm thickness can be used with all heating stage objectives. The „Free working distance" is measured from the bottom edge of the objective mount to the surface of the object including the quartz glass plate. If the objectives are used without this quartz glass plate the working distance will be decreased by 0.57mm. All objectives are suitable for transmitted light and, when a vertical illuminator is used, for incident light.

The "L" objectives of long working distance are also suitable for transmitted light, see page 69.

Objectives for Heating Stage 350 –
transmitted and incident light

		Transmitted light	**Incident light**
5x/0.09			
10x/0.18		∞/Q 1,80/45mm	∞/Q 180/45mm
H 20x and 32x		∞/Q 1,80/45mm	∞/Q 180/45mm

Type of objective	Engraved single-lens magnification/aperture		Free object distance mm*	Focal length mm	Coverglass correction	Type of eyepiece[3]	Code No.
Heating stage	5x	0.09	13	50	Q 1.80/0	P	569049
objectives	10x	0.18	14	25	Q 1.80/0	P	569050
	H 20x	0.40	8.3	12	Q 1.80	P	569001
	H 32x	0.60	5.7	8.0	Q 1.80	P	569002

* see page 64

17003 - 519 R

Objectives for Heating Stage 1350 – transmitted light and incident light

5x
10x ∞/Q 1.80/45mm L 20x ∞/0/45mm
H L 32x

	Engraved single-lens magnification/aperture		Free object distance mm*	Focal length mm	Coverglass correction	Type of eyepiece[3]	Code No.
Heating stage objectives	5x	0.09	13	50	Q 1.80/0	P	569 049
	10x	0.18	14	25	Q 1.80/0	P	569 050
	H 20x	0.40	8.3	12	Q 1.80	P	569 001
	H 32x	0.60	5.7	8.0	Q 1.80	P	569 002
	L 20x	0.40	6.6	12	DO[1]	P	569 003
	L 32x	0.60	4.0	8.0	O[1]	P	569 004

* with the L-objective from botton rim of the objective mount to the object, with the other objectives a thickness of 1.8mm of a quartz glass coverplate must be included.
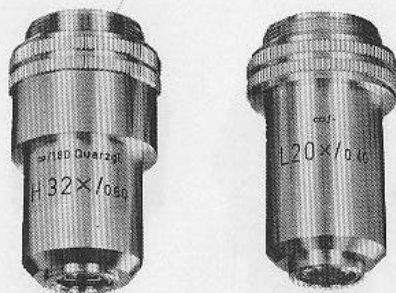
17005 - 519 R

For low-power work with the Heating Stage 1350 achromats are available which are also used with our metallographic microscope. The high-power systems are special heating stage objectives of the series H or L. In the series H a quartz glass plate of 1.8mm thickness has been allowed for in the computation. All objectives are suitable for transmitted- and for incident light. Objectives for phase contrast incident light see p. 74.

Objective for photographic emulsions

170/0/37mm
** Exception: use KS 45/0.65 with coverglass 0.17

Type of objective	Engraved reproduction ratio/aperture		suitable for emulsion thickness	Maximum fAA in oil or air	Focal length mm	Type of eyepiece[3])	Code No.
Achromat	KS 45**	0.65	0–750 μm	500 μm	4.1	P(H)	519042

fAA = free working distance.

The objective described here is suitable for the special requirements of the measurement of photographic emulsions and specially computed for this purpose. One of the main objects was the development of a system of large aperture and long working distance at suitable magnification.

For measurements of thick layers with objectives of large aperture, oil immersion is essential because the state of correction of a dry system changes too much with the depth focused on in the object.

20791–519 R

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Reflecting objectives and condensers

Type of objective	Engraved reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Shading factor	Area shading in %	Code No.
Dry objective	Q 170	0.50	2.1	2.5	Q 0.18	0.1/0.5	5	520108
Immersion objectives	Q Glyc. 300	0.85	0.4	1.35	Q 0.18	0.18/0.85	5	520109
	Q Glyc. 300 S	0.85	0.4	1.35	Q 0.18	0.18/0.85	5	520110
Immersion condenser*	Q Glyc.	0.60	[1]	1.45		0.2/0.6	12	520112
Immersion condenser	Q Glyc.	0.40	[1]	1.45		0.2/0.4	25	520111

* can also be used as dry condenser
[1] quartz glass object slide 0.5mm

8976 - 52 R

LEITZ reflecting objectives can be used within the entire ultra-violet and visible region from 220 to 700nm. They must be used with quartz glass object slides of 0.5mm thickness and quartz glass coverglasses of 0.18mm thickness. Glycerin of refractive index nD = 1.4400, corresponding to a water content of about 10%, is recommended as immersion medium.

Objectives for universal rotating stages

170/−/45.4mm for UM
170/−/37mm for UMK

Designation and aperture	Code No.	with pair of segments n_D	Radius	Code No. (segment)	Reproduction ratio	aperture	Focal length mm	Coverglass correction[1]	Type of eye-piece[3]	Working distance mm
UM 5/0.10	559002	without		−	3.2	0.07	34	DO	H	14
		1.554	13.5	553051	5	0.10				1.40
		1.516	13.5	553010	4.9	0.10				
		1.649	13.5	553011	5.3	0.11				
UM 10/0.22	559003	without		−	6.4	0.15	23	DO	H	14
		1.554	13.5	553051	10	0.22				1.40
		1.516	13.5	553010	9.8	0.21				
		1.649	13.5	553011	11	0.23				
UM 20/0.33	559004	without		−	13	0.22	12	DO	P	14
		1.554	13.5	553051	20	0.33				1.40
		1.516	13.5	553010	19.5	0.32				
		1.649	13.5	553011	21	0.35				
UM 32/0.30	559005	without		−	20	0.20	8.2	DO	P	15
		1.554	13.5	553051	32	0.30				1.40
		1.516	13.5	553010	31	0.29				
		1.649	13.5	553011	34	0.32				
UMK 32/0.60	559016	without		−	20	0.40	8.5	DO	P	6.3
		1.554	5.73	553056	32	0.60				0.56
		1.516	5.73	553057	31	0.59				
		1.649	5.73	553058	34	0.64				
UMK 50/0.60	559040	without		−	32	0.40	5.1	DO	P	6.1
		1.554	5.73	553056	50	0.60				0.41
		1.516	5.73	553057	49	0.59				
		1.649	5.73	553058	53	0.64				

Focusing objective   559 041

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The UM special objectives have been designed for use on the universal rotating stage in connection with a polarizing microscope. All UM objectives have an iris diaphragm. The UM 20 and 30 objectives require an additional condenser, and can be used to advantage for the measurement of crystallographic reference directions.

When a segment is used the working distance is calculated from the front lens of the objective to the segment.

UMK objectives are required if a U- stage is to be extended into a U- stage conoscope. The values reproduction ratio/aperture engraved on the objectives apply to segments 1.554. If UM objectives are used without segments advantage can be taken of their long working distances.

Note : This was a blank page.

II. LEITZ objectives for incident light

ULTROPAK-objectives for incident-light-darkground

Type of objective	Engraved reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
ULTROPAK-dry objectives with annular condenser	UO 4	0.10	13	34	DO	P	513182
	UO 6.5	0.18	16	25	DO	H	513004
	UO 11	0.25	5.6	16	DO	H	513005
	UO 22	0.45	2.0	9.3	DO	H	513006
	UO 32	0.55	0.92	6.0	O	P	513119
	UO 42	0.60	0.65	4.6	O	P	513241
ULTROPAK-immersion objectives with annular condenser	UO W 55	0.85	0.59	3.6	O	P	513008
	UO Fl Oel 60	0.85	0.30	3.5	DO	P	513010

Accessories for the ULTROPAK see p. 72   W = water immersion

The UO objectives have been computed for a tube length of 185mm. They are used on the ULTROPAK illuminator with their own tube lens system. All objectives have been corrected for use without coverglass, however, most of them can also be used with coverglass.

17027 - 519 R
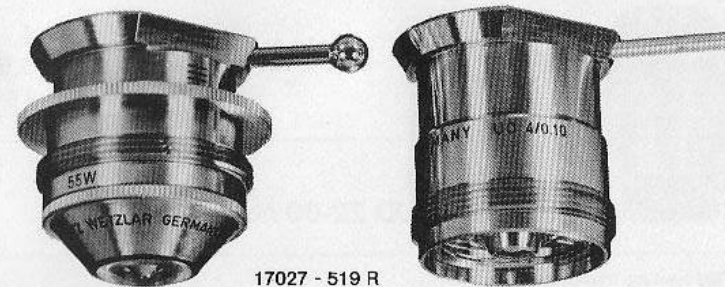
Special ULTROPAK objectives of long working distance

Type of objective	Engraved reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Achromats with annular condenser	Sp UO 1.5/L 110	0.02	108	69	DO	H	500973
	Sp UO 2/L 90	0.03	88	61	DO	H	500972
	Sp UO 3/L 60	0.04	62	47	DO	H	500971
Achromat without annular condenser	UO 1.5/L 110	0.04	108	69	DO	H	580550*

Accessories for the ULTROPAK

		Code No.
Relief condenser for the UO 4, 6.5, 11–50 objectives		513147
Extension pieces with tubular stop for objectives	UO 4	513306
	UO 6.5	513148
	UO 11–50	513149
Immersion attachment for objective	UO 4	513294
	UO 6.5	513015
	UO 11	513016
Dipping cones EZ 23-100		513017
Reflecting condenser for UO 22-60 objectives		513013

* for heating microscope

Incident-light brightfield objectives for metallographic microscopes

∞/0/45mm

Type of objectives	Engraved single-lens magnification/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Achromatic dry systems	5x	0.09	12	50	DO	P	569049
	10x	0.18	13	25	DO	P	569050
	20x	0.35	1.0	12	DO	P	569051
Fluorite systems	Fl 50x	0.85	0.26	5.0	O	P	569052
	Fl 50x	0.85	0.28	5.0	D	P	569085*
	Fl 100x	0.95	0.09	2.5	O	P	569053
Fluorite oil immersion objective	Fl Oel 100x	1.36	0.26	2.5	O	P	569046

* use with coverglass, e.g. for LEITZ-transmitted light interference microscope.

The standard magnifications 50x, 100x, 200x, 500x, and 1000x adopted for metallography can be obtained with the LEITZ incident-light objectives for metallographic microscopy. They are achromats and fluorite systems corrected for use without coverglass. For visual purposes PERIPLAN eyepieces, for photomicrography negative eyepieces are used.

Incident-light phase contrast objectives for metallographic microscopes

∞/0/45mm

Type of objective	Engraved single-lens magnification/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Phaco achromatic dry systems	Phaco 5x	0.09	12	50	DO	P	569019
	Phaco 10x	0.18	13	25	DO	P	569020
	Phaco 20x	0.35	1.0	12	DO	P	569021
Phaco fluorite system	Phaco FI 50x	0.85	0.26	5.0	O	P	569022
	Phaco FI 100x	0.95	0.09	2.5	O	P	569047

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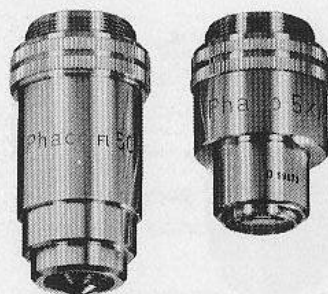
Incident-light brightfield/darkground HD objectives for metallographic microscopes

∞/0/42mm, special thread M 30x0.75

Type of objective	Engraved single-lens magnification/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Achromats	HD 10x	0.18	7.0	25	DO	P	569074
	HD 20x	0.35	1.1	13	DO	P	569075
	HD Fl 50x	0.75	0.26	5.0	O	P	569076

These objectives do not have a standard thread but a M 30x0.75 thread. They can be used for investigations in incident-light brightfield and incident-light darkground in connection with the HD vertical illuminator. An annular mirror system has been built in for darkground illumination. The 2 10x and 20x objectives have the same aperture as the brightfield objectives of the same power, whereas in the 50x objective the aperture has been limited to 0.75 in order to obtain space for the darkground illumination. The incident-light brightfield objectives listed on p. 73, the Plano objectives on p. 76, and DPL objectives on p. 77 can also be used on the HD vertical illuminator. Adapter rings 563 115 are required for the objectives listed on p. 73 and 76.

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Plano objectives for metallographic microscopes
Incident-light brightfield and polarized light
(orientating)

∞/0/45mm

Type of objective	Engraved single-lens magnification/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Without centring ring Code No.	With centring ring Code No.
Achromats	PI R 2x	0.04	18	125	DO	P	569094*	
	PI 3.2x	0.06	12	78	DO	P	569007	569025
	PI 8x	0.18	13	32	DO	P	569008	569026
	PI Oel 8x	0.18	0.14	32	DO	P	569014	569040
	PI 16x	0.30	7.0	16	DO	P	569068	569069
	PI Oel 16x	0.30	0.21	16	DO	P	569015	569041
	PI 32x	0.50	0.43	7.9	O	P	569090	569093
	PI 80x	0.95	0.08	3.1	O	P	569073	569029
	PI 160x	0.95	0.08	1.6	O	P	569012	569030
Apochromat	PI Apo Oel 160x	1.40	0.27	1.6	O	P	569013	569031

* only in conjunction with the Pol-vertical illuminator

Centring ring extra, code No. 562028

The field of these plano objectives has been flattened fully for eyepieces of up to field-of-view index 28. They are therefore preferred for metallographic microscopes with wide tubes and in connection with GW eyepieces, e.g. MM6, METALLOPLAN. They are suitable for investigations in brightfield, and orientating observations in polarized light.

Plano objectives for metallographic microscopes
Incident-light darkground (brightfield)

Type of objective	Engraved single-lens magnification/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Without centring ring without diaphragm Code No.	Without centring ring with diaphragm Code No.	With centring ring Code No.
Achromats	PI 16xD	0.30	6.9*	16	DO	P	569115	569082	569054
	PI 32xD	0.50	2.0*	7.8	DO	P	569116	569083	569038
	PI 80xD	0.75	0.16	3.2	O	P	569117	569084	569070

* from top edge of reflecting condenser to object

Centring ring extra, Code No. 562029

These objectives can be used on the MM6 without centring ring in the version without diaphragm, on the METALLO-PLAN without centring ring in the version with diaphragm, and on the MM5 with centring ring. They have fully flattened fields for eyepieces of up to field-of-view index 28. They can be used also on the METALLUX®, but do not produce standard magnifications.

The two low-power darkground objectives are equally suitable for investigations in brightfield. The high-power darkground objective has a smaller aperture than the brightfield objective, however, it can also be used in brightfield. If demands of quality are high the incident-light brightfield objective PI 80x/0.95 is preferable.

Plano objectives for metallographic microscopes
Incident-light phase contrast

∞/0/45mm

Type of objective	Engraved single-lens magnification/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Without centring ring Code No.	With centring ring Code No.
Achromats	Phaco Pl 8x	0.18	14	31	DO	P	569077	569032
	Phaco Pl 32x	0.50	2.4	7.8	DO	P	569078	569033
	Phaco Pl 80x	0.95	0.08	3.1	O	P	569091	569034
	Phaco Pl 160x	0.95	0.08	1.6	O	P	569092	569035
Apochromat	Phaco Pl Apo Oel 160x	1.40	0.27	1.6	O	P	569081	569036

Phase contrast objectives can be used within limits also in brightfield. For high demands of quality the use of our plano brightfield objectives is recommended.
These objectives can be used only on the MM5 px and MM6 metallographic microscopes.

Radiation-resistant objectives R for metallographic microscopes

					HDR ∞/0/42mm Special thread M 30 x 0.75			**Pl R and R** ∞/0/45mm Exception: Pl R 2x = 63mm

Type of objective	Engraved single-lens magnification/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Achromats	Pl R 2x	0.04	18	125	D O	P	569 094
for brightfield	R 5x	0.09	11.5	49	D O	P	569 103
	R 10x	0.18	14	25	D O	P	569 086
	R 20x	0.35	1.4	12.5	D O	P	569 087
	R 50x	0.75	0.41	5.0	O	P	569 088
Achromats for	HDR 10x	0.18	14	25	D O	P	569 106
brightfield and	HDR 20x	0.35	1.4	12.5	D O	P	569 105
darkground	HDR 50x	0.75	0.4	5.0	O	P	569 104

Our R 10x, 20, 50x, radiation-resistant objectives have been developed for use in hot boxes and consist of special types of glass. They are achromats of standardized mechanical length for use on the revolving nosepiece of the vertical illuminator. They should be used with GF eyepieces and reducing collar. The Pl R 2x objective is an achromatic radiation-resistant plano objective with a crystal plate mounted in front. It is used between two crossed polarizers on the pol-vertical illuminator. This produces an image free from reflections. The objective is short enough for use with the other objectives on the same revolving nosepiece.

The HDR objectives can be used for incident-light brightfield and darkground with the HD incident-light illuminator. An annular mirror system is built in for darkground illumination.

17034 - 519 R

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Strainfree objectives for polarizing microscopes incident light

Achromats: 215/0/not parfocal
Fluorite systems: 215/0/14mm

Type of objective	Engraved reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Code No.
Achromats	P 6.3	0.20	21	30	DO	P	559051
	P 8	0.18	16	23	DO	H	559015
	P 16	0.40	3.3	13	DO	H	559008
	P 44	0.65	0.53	4.5	O	P	559033
	P Oel+W 12.5	0.25	0.26	16	DO	H	559010
	P Oel+W 25	0.65	0.38	8.1	DO	P	559011
Fluorite systems	(P) Fl 45	0.85	0.33	4.4	O	P	559009
	(P) Fl Oel 60	0.95	0.33	3.4	DO	P	559012
	(P) Fl Oel 80	1.30	0.33	2.5	DO	P	559013
	(P) Fl Oel 105	1.32	0.27	2.0	DO	P	559014

The objectives designated (P) have been specially selected, but they are not completely strainfree.

Strainfree objectives for incident light are used on the polarized-light vertical illuminator in connection with the objective centring clutch. Compared with dry objectives, the immersion systems produce an image which is free from reflections and therefore richer in contrast. See also page 81.

Immersion contrast objectives incident light

Type of objective	Engraved reproduction ratio	/ aperture	Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece[3]	Adjustment length mm	Code No.
Immersion systems with crystal plates	P Oel 8	0.18	0.25	23	D O	H	37	559 075
	P Oel 16	0.40	0.25	13.2	D O	H	26	559 076
Immersion systems for methylene iodide with crystal plate	P Meth.-iodide 8	0.18	0.10	23	D O	H	37	559 077
	P Meth.-iodide 16	0.40	0.10	13.2	D O	H	26	559 078

These immersion systems, computed for oil or methylene iodide have a crystal plate mounted in front to cut down reflections. The contrast is therefore particularly high.
Use on the polarizing vertical illuminator, preferably for the investigation of mineralogical specimens.

20397–519 R

Pol-interference contrast objectives according to Françon

215/0/44.9 to 45.5mm

Type of objective	Engraved reproduction ratio/aperture		Free working distance mm	Focal length mm	Coverglass correction[1])	Type of eyepiece[3])	Code No.
	Pol. Interf. contrast						
Achromats for							
ORTHOLUX®-POL	8	0.15	2.6	23	DO	H	559066
LABORLUX-POL	16	0.22	3	12	DO	P	559067
DIALUX-POL	25	0.20	3.2	8.2	DO	P	559068
PANPHOT-POL							
for	8	0.15	2.6	23	DO	H	559072
ORTHOPLAN-POL*	16	0.22	3	12.3	DO	P	559073
	25	0.20	3.2	8.2	DO	P	559074

* supplied for existing Pol-vertical illuminator

25/0.20 16/0.22 8/0.15
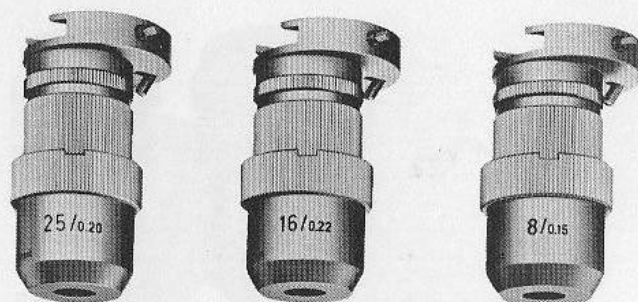
For incident-light observation in interference contrast three achromats have been developed which are permanently connected with a centring ring. The interference contrast is produced by means of two cemented quartz plates, which can be tilted with a knurled ring on the objective. A second knurled ring actuates the aperture diaphragm. The objectives are suitable only for observations in interference contrast, not for measurement.

NPI P strainfree planachromats and immersion systems for incident-light polarizing microscopy

∞/0/30 mm
Except NPI P 5x: 40 mm

Type of objective	Engraved: Single lens magnification	aperture	Free working distance mm*)	Focal length mm	Coverglass correction[1])	Type of eyepiece	Code No.	
Planachromats	NPI P 5x	0.09	12	50	D O	P	559 080	559 115
NPI P	NPI P 10x	0.20	14	25	D O	P	559 109	559 116
incident light	NPI P 20x	0.40	0.90	12.7	D O	P	559 111	559 117
	NPI P 50x	0.85	0.38	5.0	O	P	559 085	559 118
	NPI P 100x	0.90	0.10	2.5	O	P	559 112	559 119
Immersion systems	Oel P 20x	0.40	0.46	12.5	D O	P	559 083	559 126
Incident light	Oel P 32x	0.65	0.30	7.8	D O	P	559 084	559 127
	Oel P 50x	0.85	0.35	5.0	D O	P	559 086	559 128
	Oel P 125x	1.30	0.28	2.0	O	P	559 087	559 120

for stationary metallographic microscopes of the MM series. For MM6 with centring ring 562 028.

for polarizing microscopes of the new series.

These objectives are suitable for incident-light investigations in polarized light and brightfield. They can all be used for interference contrast R (incident light) with the accessories listed on p. 84.

20398–519 R

83

Accessories with Wollaston prisms for Interference Contrast R

(suitable for the objectives listed on p. 83)

For objective	15 mm adapter with Wollaston-prism for revolving nosepiece Code No.	15 mm adapter with Wollaston-prism for centring clutch Code No.	15 mm objective carrier with Wollaston-prism for brightfield vertical illuminator Code No.
NPl P 5x	553 238	553 243	553 251
NPl P 10x	553 296	553 292	553 294
NPl P 20x	553 240	553 245	553 253
NPl P 50x	553 241	553 246	553 254
NPl P 100x	553 295	553 291	553 293
Öl P 125x	553 242	553 247	553 255

10 mm adapters for incident-light devices for the HM-POL
and SM-LUX-POL. Code No. 553 303

20792–519 R

19979–519 R

Immersion contrast planachromats for incident light

Pos. 1 + 2 ∞/0/40 mm
from Pos. 3 ∞/0/30 mm

Type of objective	Engraved single-lens magnification / aperture		Free working distance mm	Focal length mm	Coverglass correction[1]	Type of eyepiece	Code No.
NPI Planachromats	Immers.-Contr. NPI Öl 5x	0.09	0.35	50	O	P	559 088
	Immers.-Contr. NPI Meth.-iodide 5x	0.09	0.37	50	O	P	559 092
NPI Planachromats	Immers.-Contr. NPI Öl 10x	0.20	0.20	25	O	P	559 089
	Immers.-Contr. NPI Meth.-iodide 10x	0.20	0.22	25	O	P	559 093
	Immers.-Contr. NPI Öl 20x	0.40	0.23	12.5	O	P	559 090
	Immers.-Contr. NPI Meth. iodide 20x	0.40	0.37	12.5	O	P	559 094
	Immers.-Contr. NPI Öl 50x	0.65	0.22	5.0	O	P	559 091
	Immers.-Contr. NPI Meth.-iodide 50x	0.65	0.25	5.0	O	P	559 095

10 mm adapter for adjustment   Code No. 559 081

These immersion objectives include a rotatable crystal plate. Hereby optimum contrast can be obtained. They are eminentely suitable for transparent mineralogical objects and are designed for use on the pol-incident-light illuminator; They can, however, also be used with crossed polarizers on the metallographic incident-light illuminator.

20794–519 R   20795–519 R

85

Objectives for Heating Stage 1750 – incident light

5x		L 20x	
10x	∞/Q 1.80/45mm	L 32x	∞/0/45mm
H 20 and 32x			

Type of objective	Engraved single-lens magnification/aperture		Free working distance mm*	Focal length mm	Coverglass correction	Type of eyepiece[3])	Code No.
Achromats	5x	0.09	13	50	Q 1.80/0	P	569 049
	10x	0.18	14	25	Q 1.80/0	P	569 050
	H 20x	0.40	8.3	12	Q 1.80	P	569 001
	H 32x	0.60	5.7	8.0	Q 1.80	P	569 002
	L 20x	0.40	6.5	12	DO	P	569 003
	L 32x	0.60	3.9	8.0	O	P	569 004

* from bottom edge of objective mount to object including a quartz glass cover plate of 1.8mm thickness. L-objectives without quartz plate.

17024 - 519 R

These objectives are the same as those described on p. 64. They are used on the Heating Stage 1750 in incident light with the vertical illuminator.

∞/Q 1.80/45mm

Type of objective	Engraved single-lens magnification/aperture		Free working distance mm*	Focal length mm	Coverglass correc- tion	Type of eyepiece[1])	Code No.
Achromats	Phaco 5x	0.09	13	50	Q 1.80/0	P	569019
	Phaco 10x	0.18	14	25	Q 1.80/0	P	569020
	Phaco H 20x	0.40	8.3	12	Q 1.80	P	569005
	Phaco H 32x	0.60	5.7	8.0	Q 1.80	P	569006
	Phaco L 20x	0.40	7.7	12.5	DO	P	569 112
	Phaco L 32x	0.60	4.3	7.8	O	P	569 114

* See p. 86

These objectives for the Heating Stage 1750 and 1350 are used with the phase contrast vertical illuminator. Mechanical tube length, coverglass correction, and adjustment length correspond to table p. 86. Objectives for the Heating Stage 1350, incident light brightfield see
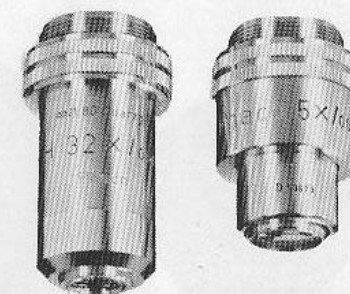
Objectives for photomicrography and macrophotography

Engraved:		Focal length mm	For infinity image distance aperture	relative aperture	Reproduction ratios obtainable with 9x12cm camera and macro-dia-aparatus from	to	Code No.
SUMMARON® 28 mm with ring		28	0.09	1:5.6	10 :1	22 :1	549 001
PHOTAR	120/5.6*	120	0.09	1:5.6	1.2:1	3 :1	549 022
PHOTAR	80/4.5*	80	0.11	1:4.5	2.5:1	6.5:1	549 021
PHOTAR	50/2.8*	50	0.18	1:2.8	4.5:1	12 :1	549 020
PHOTAR	50/4**	50	0.12	1:4	4.5:1	12 :1	549 019
PHOTAR	25/2.5**	25	0.20	1:2.5	10 :1	25 :1	549 018
PHOTAR	12.5/1.9*	12.5	0.27	1:1.9	22 :1	55 :1	549 017

* Thread 40 mm dia.

** Thread: micro-objective

18560–519 R

III. LEITZ-eyepieces

Reductions collars for 23.2 mm eyepieces in 30 mm tubes;
for pol stands of earlier design
Code No. single 552 053
Reduction collars for 23.2 mm eyepieces in 30 mm tubes;
for MM6, MM5, ORTHOPLAN, and METALLOPLAN.
Code No. single 513 122. Pair 513 256

Huygens eyepieces
diameter 23.2mm

Designation	Single-lens magnification	Focal length mm	Field-of-view index	Angle of view	Code No. Single	2nd eyepiece for pair	Pair
H 6.3x	6.3x	40	18.0	26°	519180	519 180	519181
10x	10x	25	14.0	31˘	519221	519 221	519222

In addition: Pr. of eyecups, soft rubber   Code No. 511 054
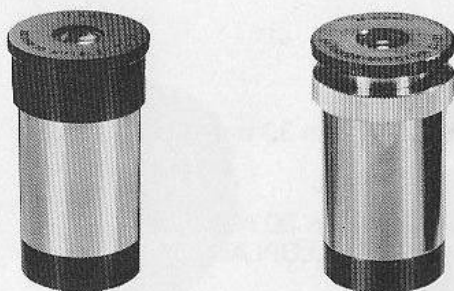
M = eyepiece with focusing eyelens and graticule mount
Z = pointer, movable

Designation	Single-lens magnification	Focal length mm	Field-of-view index	Angle of view	Code No. Single	2nd eyepiece for the pair	Pair
6.3x	6.3x	40	18	26°	519 185	519 185	519 186
6.3xM	6.3x	40	18	26°	519 188	519 188	519 187
10xM	10x	25	15	33°	519 170	519 170	519 035
10x°	10x	25	16	35°	519 335	519 335	519 336
10x°Z	10x	25	16	35°	519 341	–	–
NF 10x	10x	25	18	40°	519 319	519 319	519 318
NF 10xM	10x	25	18	40°	519 320	519 319	519 327
NF 10xM	10x	25	18	40°	519 320	519 320	519 328
NF 10xZ	10x	25	18	40°	519 321	–	–
12.5x	12.5x	20	14	39°	519 367	519 367	519 368
25xB	25x	10	8	43°	519 198	519 198	519 218

In addition: Pr. of eyecups, soft rubber   Code No. 511 054

M = eyepiece with focusing eyelens and graticule mount

Z = pointer, fixed

GF PERIPLAN widefield eyepieces
diameter 23.2mm

Designation	Single-lens magnification	Focal length mm	Field-of-view index	Angle of view	Code No. Single	2nd eyepiece for the pair	Pair
GF 10x	10x	25	18	40°	519 137	519 137	519 142
GF 10x M	10x	25	18	40°	519 126	519 137	519 127
GF 10x M	10x	25	18	40°	519 126	519 126	519 281
GF 10x M 20 points	10x	25	18	40°	519 312		
GF 10x M 10 points	10x	25	18	40°	519 313		
GF 12.5x	12.5x	20	18	48°	519 051	519 051	519 053
GF 12.5x M	12.5x	20	18	48°	519 055	519 051	519 056 Have
GF 16x	16x	16	15	52°	519 369	519 369	519 370
GF 25x	25x	10	10	53°	519 140	519 140	519 144
GF 25x M	25x	10	10	53°	519 141	519 140	519 130

M = eyepiece with focusing eyelens and graticule mount

17704

20402–519 R

Designation	Single-lens magnification	Focal length mm	Field-of-view index	Angle of view	Code No. Single	2nd eyepiece for the pair	Pair
GW 6.3x	6.3x	40	28	39°	519 398	519 398	519 397
GW 8x M	8x	31	28	48°	519 400	519 400	519 399
GW 8x M (20 points)	8x	31	28	48°	519 393		
GW 8x M (10 points)					519 394		
GW 10x	10x	25	24	51°	519 133	519 133	519 174
GW 10x M	10x	25	24	51°	519 234	519 234	519 235
GW 10x MF (for ORTHOMAT® W)	10x	25	24	51°	519 344	519 234	519 345

M = eyepiece with focusing eyelens and graticule mount
MF = with focusing eyelens and focusing graticule for photomicrography
Graticules see p. 112
In addition: Pair of eyecups 511 251
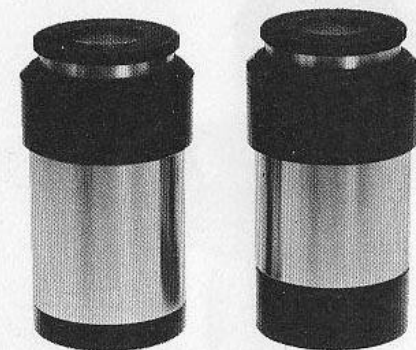
20370–519 R

Highpoint eyepieces
PERIPLAN GF, diameter 23.2 mm, and PERIPLAN-GW, diameter 30mm

Designation		Single-lens magnification	Focal length mm	Field-of-view index	Angle of view	Code No. Single	2nd eyepiece for the pair	Pair
PERIPLAN								
8x	🕶	8x	31	18	33°	519 377	519 377	519 378
10x	🕶	10x	25	15	34°	519 135	519 135	519 136
10x M	🕶	10x	25	15	34°	519 134	519 135	519 125
GF 12.5x	🕶	12.5x	20			519 411	519 411	519 412
GW 6.3x	🕶	6.3x	40	28	38°	519 291	519 291	519 290
GW 8x	🕶	8x	31	24	42°	519 441	519 441	519 443
GW 8x M	🕶	8x	31	24	42°	519 442	519 442	519 445
GW 8x M 🕶 for photomicrography		8x	31	24	42°	519 442	519 441	519 444
GW 10x	🕶	10x	25	22	47°	519 261	519 261	519 262

20413–519 R

M = eyepiece with focusing eyelens and graticule mount

Photographic eyepieces (negative eyepieces)

Designation	Single-lens magnification	Focal length mm	Field-of-view index	Angle of view	Code No. Single
N 6.3x m	6.3x	−40	20	28°	569 023
N 6.3x h	6.3x	−40	20	28°	569 024
N 8x h	8x				MNIID

m = for objectives of up to medium primary magnification
h = for objectives of high primary magnification

95
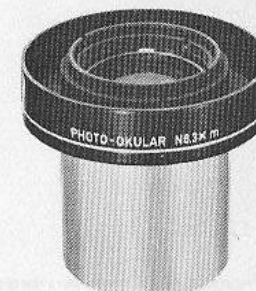
Eyepieces for polarizing microscopes 30mm and 23.2mm diameter

Designation	Type	Diameter	Graticule	Focal length mm	Field-of-view index	Angle of view	Code No. Single	2nd eyepiece for the pair	Pair
P 6,3x M	H	30	for the insertion of graticules	41	21	29°	559 001		
P 8x ⊕	H	30	crosslines	31	19	35°	559 006		
P 10x M	P	23,2	for 20 points graticule	25	14	31°	519 170	519 170	519 035
H 6,3x ⊕	H	23,2	crosslines	40	18	26°	559 049	519 180	559 050
GF 10x ⊕	P	23,2	crosslines	25	18	40°	559 034	519 137*	559 035
GF 10x ⊕	P	23,2	crosslines	25	18	40°	559 034	519 126	559 070
GF 10x M	P	23,2	accepting the following graticules:	25	18	40°	519 126	519 126	519 281
GF 10x M	P	23,2	10 mm = 100 intervals 20 points graticule	25	18 519 905 519 921 519 904	40°	519 126	519 137	519 127

for eyepiece P 10x M

These eyepieces are all equipped with focusing eyelens

* without graticule

17277 - 519 R

Designation	Single-lens magnification	Focal length mm	Field-of-view index	Code No. Single
Proj. 1x	1x	249	22	592 026
Proj. 1.25x	1.25x	200	22	592 025
Proj. 1.6x	1.6x	155	22	592 024
Proj. 2x	2x	125	22	592 028
Proj. 2.5 sbj	2.5x	100	22	592 023
Proj. 3.2x sbj	3.2x	79	22	592 022
Proj. 4x sbj	4x	63	22	592 021
Proj. 5x sbj	5x	50	22	592 020
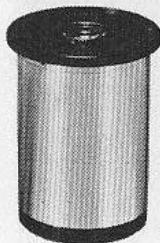
Microprojection eyepieces have a long focal length for the projection of the microscope image. They have a standard field-of-view index, and are graduated so that the most favourable image diameter is obtained for the projection distances used.

Unless they bear the designation sbj in the table above, they are unsuitable for visual observation.
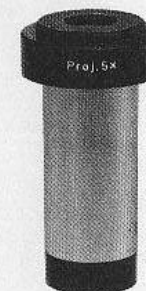
20400–519 R

Screw micrometer eyepiece

For all microscope tubes:	Code No.	Not for binocular tubes of the new series:	Code No.
16x metric	500 932	12.5x metric	519061
16x English system	500 933	12.5x English system	810212
16x for monochromatic light	500 938		
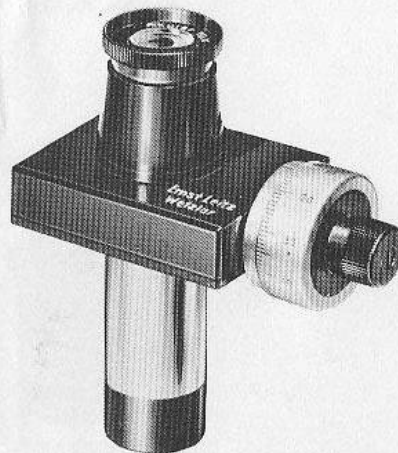
With the 12.5x or 16x screw micrometer eyepiece a much higher measuring accuracy can be obtained than with the conventional eyepieces. It is inserted in the tube instead of the ordinary eyepiece. It includes a precision scale of 12 intervals of 0.5mm length each on which the user can focus. A measuring line sweeps the entire length of the scale when the micrometer screw on the right is turned. The drum of the micrometer screw is graduated in 100 intervals. One drum rotation corresponds to one interval of the eyepiece scale, hence a drum division represents 1/100 interval.

Designation	Single-lens magnification	Focal length mm	Field-of-view index	Angle of view	Code No. Single
PERIPLAN 10x° eyepiece with fixed pointer	10x	25	16	35°	519 341
H 6x double pointer eyepiece	6x	42	14	26°	519 048
PERIPLAN GF 10x with fixed pointer	10x	25	18	40°	519 329
PERIPLAN NF 10x with fixed pointer	10x	25	18	40°	519 321

In the eyepiece 519 054 a pointer has been built into the image plane, which can be brought to any part of the microscopic field of view. The pointer double-eyepiece has two eyelenses- one of them a telescope in an oblique observation tube- so that it is suitable as a simultaneous-viewing eyepiece for two observers.
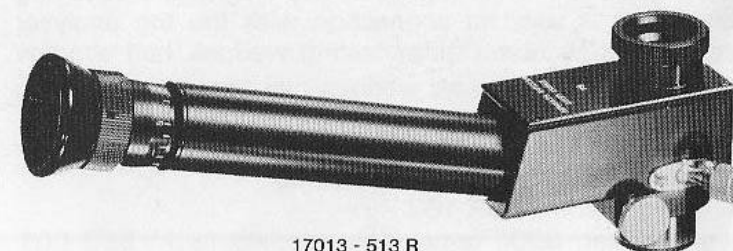
17013 - 513 R

Wright eyepiece

Auxiliary magnifier
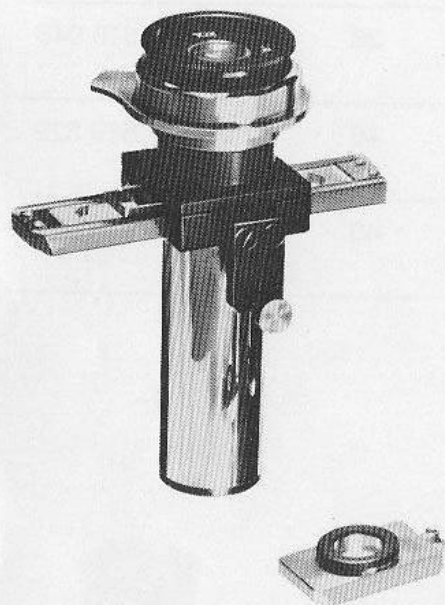
This eyepiece has a field iris diaphragm and focusing eyelens. It is used in connection with the top analyser and a straight tube. Compensating wedges, half shadow plates, and half shadow wedges can be introduced into the intermediate image plane.
Code No. 553015
Required for the new series of stands:
Tube attachment 552 157
Top analyser, 360° graduation, reading to 1° 553 001
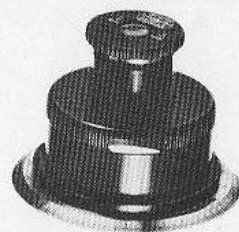
The auxiliary magnifier is inserted in the tube in place of the eyepiece. It permits observation of the enlarged exit pupil of the objective and the image of the aperture diaphragm. It is required for the adjustment of the annular stops of the phase contrast condenser, in the absence of a swing-in Bertrand lens. Code No. 513123
It is offered as a focusing telescope for the ORTHOMAT W under the same Code No.

Brightfield condenser system 600

Condenser No.	Designation	Aperture	Intercept distance above object stage	Focal length mm	Illumination of the objectives in the field and in aperture	Code No.
Dry condensers						
600	Condenser bottom part	0.25	25mm	35	from 2.5 to 0.25 aperture for low-power objectives	512081
001	Top 0.90 As					512420
601	Aspherical Condenser	0.90	1.2mm glass	10	from 2.5 to 1.30 aperture for achromats with stopped-down condenser aperture	512085
002	Top Achr.	0.90				512083
602	Achromatic condenser	0.90	1.2mm glass	10	from 2.5 to 1.32 aperture for highly corrected objectives especially for photo micrography	512086
Immersion condensers						
602	Top Oil	1.25				512352
010	simple immersion condenser	1.25	1.2mm glass*	7.9	from 2.5 to 1.30 aperture for immersion achromats at large condencer apertures	512351
003	Top Apl. Oil	1.25				512084
603	Aplanatic immersion condenser	1.25	1.2mm glass*	8.1	from 2.5 to 1.32 aperture for highly corrected immersion objectives at large condenser apertures	512087
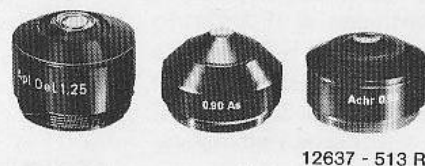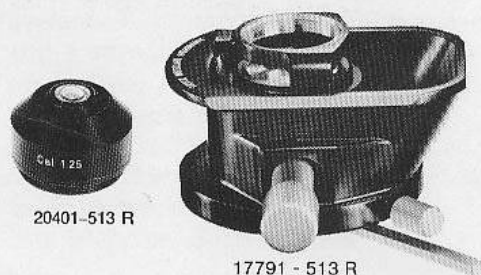
20401–513 R

17791 - 513 R

12637 - 513 R

Condenser No.	Designation	Aperture	Intercept distance above object stage	Focal length mm	Illumination of the objectives in the field and in aperture	Code No.
009	Top Achr.Oil 1.40					513305
609	Achromatic 1.40 Immersion condenser 1.40		1.2mm glass*	8.0	from 2.5 to 1.40 aperture for most highly corrected immersion objectives, for highest resolution	

Condensers for long working distance

Condenser No.	Designation	Aperture	Intercept distance above object stage	Focal length mm	Illumination of the objectives in the field and in aperture	Code No.
005	Top Achr. 0.70/L4					513183
605	Condenser 0.70		4mm glass	13	from 10:1 to 1.1 aperture for all objectives, with special cells and microscope slides	512311
006	Top 0.60/L11					513184
606	Condenser 0.60		11mm of which 6mm glass	17	from 6.3:1 to 0.90 aperture for all dry systems, with special cells	512312
007	Top 0.45/L20					513185
607	Condenser 0.45		20mm of which 6mm glass	20	from 6.3:1 to 0.70 aperture for up to medium-power objectives, with special cells	512313

Adapter lenses for the various stands see IV.

Various condenser tops

Condenser top No.	Engraved	Code No.
001	0.90 As	512082
002	Achr. 0.90	512083
003	Apl. Oel 1.25	512084
005	Achr. 0.70/L4	513183
006	0.60/L11	513184
007	0.45/L20	513185
009	Achr. Oel 1.40	513305
010	Oel 1.25	512352*

Our centring convertible condensers, series 600, consist of a standard bottom part No. 600 with condenser lens, the condenser for low powers, an aperture diaphragm for the whole condenser, as well as interchangeable condenser tops of various corrections, intercept lengths and apertures. The condenser top can be swung out of the beam path. The condensers can be horizontally exchanged in a dovetail slide and vertically adjusted by rack and pinion. They are computed for a field diaphragm built into the stand of the microscope.

* Not parfocal.
If the condenser is raised beyond the focusing position of the field diaphragm, the condenser top will lift the object slide off the stage.

II Phase contrast condenser system 400 according to Zernike

Condenser No.	Designation	Aperture	Intercept distance above object stage	Focal length mm	Use	Code No.
402a	Achromatic phase contrast condenser bottom part 400a and top 002	0.90	1.2mm glass	10	Brightfield with objectives 2.5:1–100:1 Phase contrast with the objectives for annular stops 1, 2, 3 darkground with annular stop 4 for objectives 10:1–40/0.65	513140
403c	Aplanatic immersion condenser bottom part 400c and top 003	1.25	1.2mm glass*	8.1	Phase contrast with objectives for annular stops 2 and 3	513194
405e	Achromatic condenser, bottom part 400e and top 005	0.70	4mm glass	13	Phase contrast with all Phaco objectives for annular stops 1, 2, and 3	513186
406f	Condenser, bottom part 400f and top 006	0.60	11mm of which 6mm glass	17	Phase contrast with objectives for annular stops 1 and 2	513196
407g	Condenser, bottom part 400g and top 007	0.45	20mm of which 6mm glass	20	Phase contrast with objectives for annular stops 1 and 2	513198

Adapter lenses for the various stands see IV.

These condensers, too, consist of a bottom part with aperture diaphragm for brightfield observation and the swing-out condenser top, which is interchangeable. The bottom part contains an annular stop turret with a number of annular stops. The arrangement of these is specific to the purpose for which they are used. All annular stops can be individually centred with a small box spanner. For the centration of the image of the field diaphragm the condenser has two centring screws.

The condensers have been computed for a field diaphragm built into the stand.

Condenser No.	Designation	Aperture	Focal length mm	Illumination	Code No.
700f	Condenser bottom part with filter polarizer	0.25	35	All tungsten filament lamps	552078
702f	Achromatic condenser bottom part 700f and top 002P	0.90	10	All tungsten filament lamps	552076
700fv	Condenser bottom part with filter and pre-polarizer	0.25	35	All lamps	552177
702fv	Achromatic condenser bottom part 700fv and top 002P	0.90	10	All lamps	552178
700p	Condenser bottom part with prism polarizer	0.25	35	All lamps, especially for projection, since condenser is brighter than 700fv	552169
702p	Achromatic condenser bottom part 700p and top 002P	0.90	10	All lamps, especially for projection, since condenser is brighter than 700fv	552170
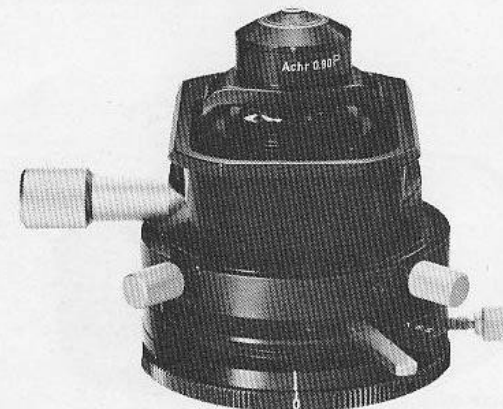
Separate condenser tops

Condenser No.	Designation	Aperture	Focal length mm	Illumination of the objectives, in field and aperture	Code No.
011 P	0.90 P	0.90	7.3	For achromats of up to 0.85 aperture	in pre-paration
002 P	Achr. 0.90 P	0.90	10	For highly corrected objectives	552079
004 P	Oil 1.33 P	1.33	7.3	For all immersion objectives above 1.0 aperture	552128
	Condenser top attach-ment UT 0.35	0.35	40	For U-stage orthoscopy (large segment)	553139
	Condenser top attach-ment UT K 0.60	0.60	30	For U-stage conoscopy (small segment) on DIALUX-POL, ORTHOLUX 2-POL and ORTHOPLAN-POL	553140

Adapter lenses for the various stands see IV.

Our polarizing condensers, series 700 consist of the bottom part and the achromatic condenser top 002P, which can be interchanged with the top 004P Oel, A 1.33. All bottom parts have in common the condenser lens for low-power objectives, aperture diaphragm for the complete condenser, centring device, and dovetail changer. However, they differ in their swing-out polarizers.

Depending on the purpose for which they are used filter-polarizers with pre-polarizers or prism-polarizers are built in. All these lenses are in strain-free mounts.

The condensers have been computed for a field diaphragm built into the stand. After a special $\lambda/4$ plate has been inserted in the slot provided for it in the condenser, the condenser can also be used for measurements in circularly polarized light.

No.	Code No.	Use		Condensers with adapter lens, Code No.						
K1	512 140	SM-LUX, LABORLUX	601 K1 512 137	602 K1 512 138	603 K1 512 165	605 K1 512 314	606 K1 512 315	607 K1 512 316	610 K1 512 399
				402a K1 513 156	403c K1 513 195	405e K1 513 187	406f K1 513 197	407g K1 513 199		
K2	552 080	LABORLUX-POL DIALUX-POL		702f K2 552 077						
K3	512 413	LABORLUX 2	601 K3 512 414							
K4	512 400	required for ORTHOPLAN recommended for ORTHOLUX 2 and DIALUX		602 K4 512 401						
K5	553 141	U-stage with DIALUX-POL and LABORLUX-POL								

The system condensers are computed for a certain distance between field diaphragm and object stage. An adapter lens must therefore be inserted in some microscopes in which this distance is shorter. With the lens K4 for the ORTHOPLAN it is not the distance that is adjusted; the illuminated field is enlarged for improved illumination.
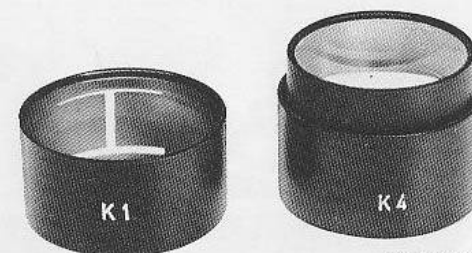
20383–513 R

V Darkground condensers

Condenser No.	Designation	Aperture range	Focal length	Use	Code No.
88	D 0.80 Dovetail change	0.80-0.95	11	For objectives below 0.70 aperture or objectives for stopping down, magnification 10:1 upwards	513 350
85	D 0.80 Sleeve change	0.80-0.95	11	As above	513 145
86	D 1.20-1.40	1.20-1.40		For objectives below 1.10 aperture or objectives for stopping down, magnification from 40:1 upwards	513 355

Immersion darkground condenser D 1.20

This condenser is designed mainly for work with oil immersion at high magnification. Its internal limiting aperture is 1.20. Immersion systems of aperture larger than 1.10 must therefore be fitted with funnel stops (p. 48) unless they are fitted with an iris diaphragm. The condenser has a centring device.

Dry darkground condenser D 0.80

This condenser is suitable for dry objectives of medium power. The internal limiting aperture is 0.80. With objectives of apertures larger than 0.70 funnel stops must be used unless the objectives have a built-in iris diaphragm. The dry darkground condenser can be supplied with a centring device and either with dovetail – or with sleeve change.
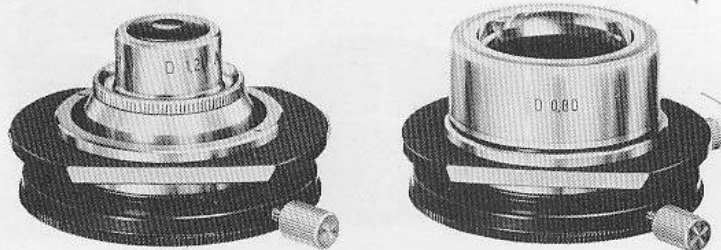
Condenser No.	Designation	Aperture	Focal length mm	Use	Code No.
65	Single-lens condenser, sleeve change	0.65	18	For low- and medium-power-achromats	512020
66	Two-lens condenser, sleeve change	1.20	10	For all achromats including immersion achromats	512021
69	Three-lens condenser, long sleeve change	1.20		HM-LUX only	512423
72r	Three-lens condenser, dovetail change	1.40	7.2	Mainly for fluorescence	512024
none	Large-field condenser, sleeve- and dovetail change	0.30	53	For low-power objectives, especially for Pl 1/0.04	512234
	Low-power condenser for the DIAVERT				520379

b) Phase contrast

Condenser No.	Designation	Aperture	Use	Code No.
64	Phase contrast condenser according to Heine, dovetail change; with immersion cap	0.25– 0.75 0.50– 1.40	For very thin objects, only with Pv objectives, p. 52, continuous transition between phase contrast, brightfield, and darkground	513 125

c) Polarized light

Condenser No.	Designation	Aperture	Use	Code No.
500p	Five-lens condenser with field- and aperture diaphragm	0.85	DIALUX-POL, DIALUX-POL SB, prism polarizer	552 017
500pz	As above	0.85	DIALUX-POL, DIALUX-POL SB, prism polarizer with emergent ray	552 019
580f	As above	0.85	ORTHOLUX-POL, filter polarizer	552 020
580p	As above	0.85	ORTHOLUX-POL, prism polarizer	552 021
580pz	As above	0.85	ORTHOLUX-POL, prism polarizer with emergent ray	552 022
	Condenser top	1.32	Suitable for all condensers 500 and 580	552 025
	Additional condenser top	0.35	For condenser 500 or 580, for orthoscopic observation on the U-stage	553 006
	Additional condenser	0.60	For U-stage conoscopy with large segment, special condenser with polarizer of condensers 500 or 580	553 059

Correction Pol-condenser

With this condenser the brightening of the field-of-view at crossed Nicols, caused by the image-forming objective, can be considerably reduced. The condenser consists of the correction polarizer and a series 500 condenser. Objectives of 45mm adjustment length are required for this.
Code No. 553 171
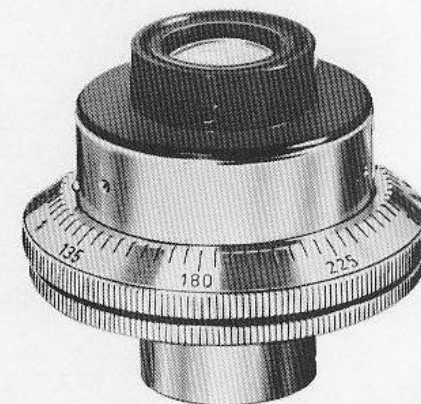
V. Stage micrometers and graticules
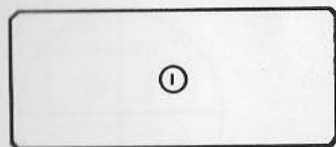
Stage micrometer with graduation 1mm = 100 intervals Code No. 513107

Stage micrometer with graduation and numbering on both sides
2mm = 200 intervals
Code No. 513106

0,0 — 0,0
0,1 — 0,1
0,2 — 0,2

Mikrometer
2 mm lang
geteilt in
200 Teile

E.LEITZ
GMBH
WETZLAR
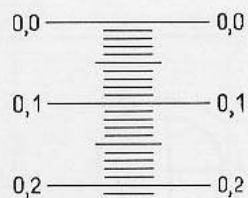
Graticule with graduation 10mm = 200 intervals,
diameter 17.5mm
Code No. 519907
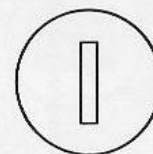
Graticule with graduation and numbering
10mm = 100 intervals
diameter 17.5mm
Code No. 519905
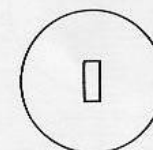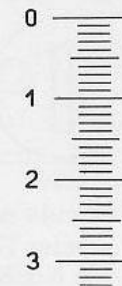
Graticule with graduation and numbering
10mm = 100 intervals
diameter 24mm
Code No. 519920
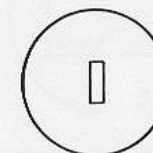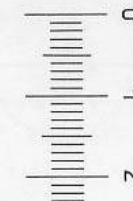
Graticule with graduation 5mm = 100 intervals,
diameter 17.5mm
Code No. 519906
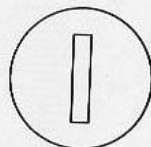
LEITZ 519932

26392-519

Graticule with graduation 0.4" = 40 intervals,
diameter 17.5 mm
Code No. 519 932
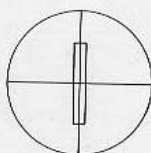
Graticule with crosslines and graduation
10mm = 10 intervals
diameter 17.5mm
Code No. 519 910
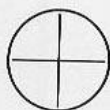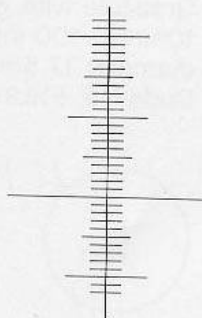
26388-519

Graticule with crosslines,
diameter 17.5mm, Code No. 519 904
diameter 24mm, Code No. 511 139
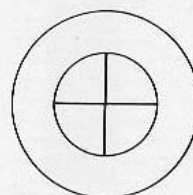
26383-519

Graticule for Snyder-Graff-method,
diameter 24mm, to be used with GW 8xM
eyepiece
Code No. 569 901
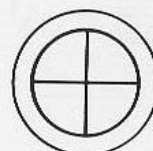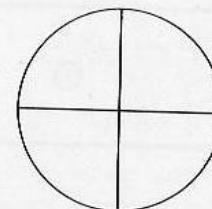
26407-519

Graticule
for Snyder-Graff-method, diameter 17.5mm
for 10xM PERIPLAN eyepiece only
Code No. 569 902
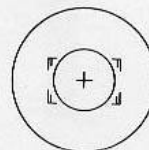
26384-519

Graticule with photographic field outline,
diameter 17.5mm
Code No. 569 900
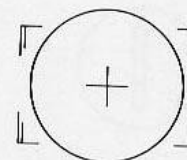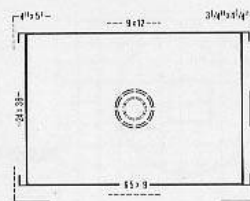
27936-519R

Graticule SY 1
(for photomicrography) with format outline
with PERIPLAN GW 8x MF eyepiece
Code No. 519 316
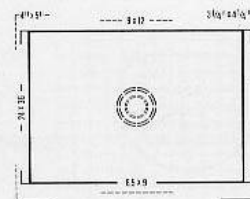
27937-519R

Graticule SY 2
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with PERIPLAN widefield GF 12.5x MF eyepiece
Code No. 519 465
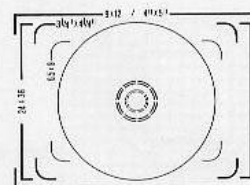
27938-519R

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(for photomicrography) with format outline
with PERIPLAN widefield GF 12.5x MF eyepiece
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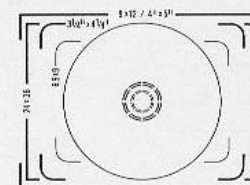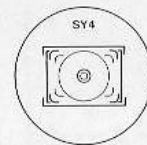
27939-519R

Graticule SY 4
(for photomicrography) with format outline
with PERIPLAN widefield GF 12.5x MF eyepiece
Code No. 519 469
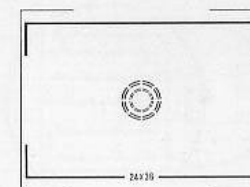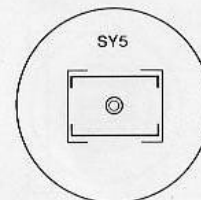
27940-519R

Graticule SY 5
(for photomicrography) with format outline
with W 16x MF eyepiece, Code No. 511 347
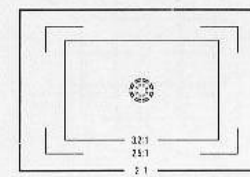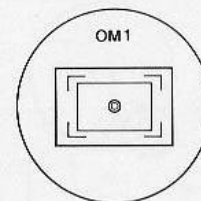
27941-519R

Graticule OM 1
(for ORTHOMAT W) with format outline
with PERIPLAN GW 10x MF eyepiece,
Code No. 519 344

Graticule OM 2
(for ORTHOMAT W) with format outline
with PERIPLAN widefield GF 12.5x MF eyepiece
Code No. 519 467
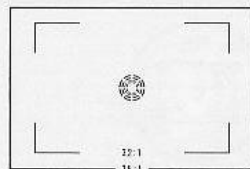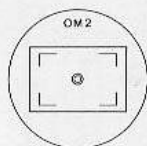
27942-519R

Graticule (for photomicrography) with format
outline with PERIPLAN widefield GF 12.5x MF
eyepiece. Code No. 519 466
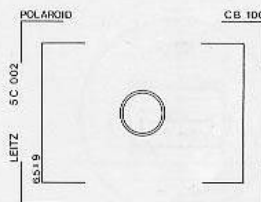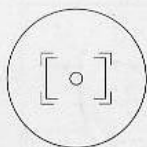
27944-519R

Graticule K 1
(for cinemicrography) with format outline
with PERIPLAN widefield GF 12.5x MF eyepiece
Code No. 519 470
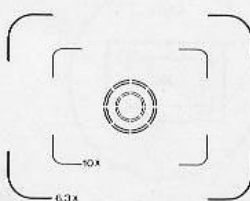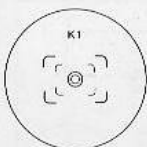
27943-519R
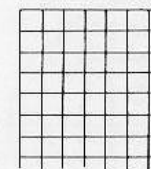
Graticule with grid division 5x5mm;
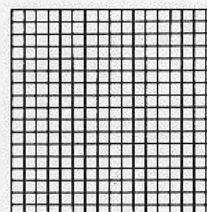graduation: 5mm = 10 intervals, diameter 17.5mm
Code No. 519 903

26382-519
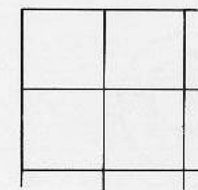
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graduation 10mm = 5 intervals, diameter 17.5mm
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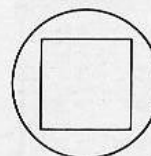
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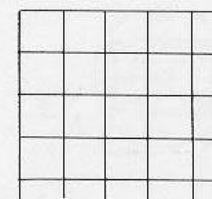
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graduation: 10mm = 10 intervals, diameter 17.5mm
Code No. 519 901

26381-519
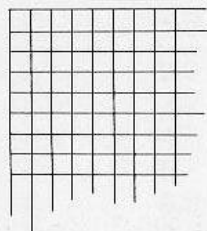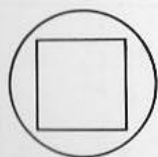
Graticule with grid division 10x10mm;
graduation: 10mm = 20 intervals,
diameter 17.5mm
Code No. 519 900
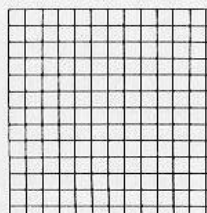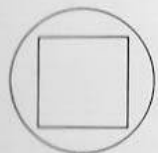
Graticule with grid division 10x10mm;
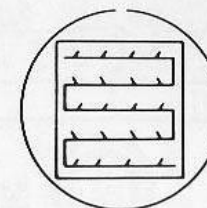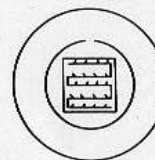graduation: 10mm = 50 intervals, diameter 17.5mm
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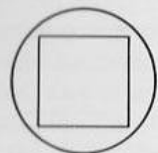
Graduation with grid division 10x10mm;
graduation 10mm = 133 intervals, diameter 17.5mm
Code No. 519 912
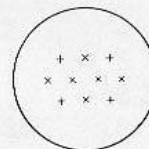
Graticule for ten-point eyepiece, diameter 17.5mm
to be used with GF 10xM PERIPLAN eyepiece
Code No. 519 922

Graticule for 20-point eyepiece according to
Blaschke, diameter 17.5mm
to be used with GF 10xM PERIPLAN eyepiece
Code No. 519 929
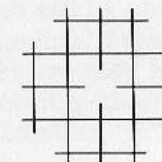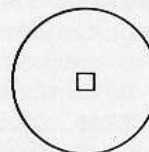
Graticule for the 20-point eyepiece.
To be used only with 10xM PERIPLAN eyepiece,
25/0.65 P objective, binocular tube 1.25x,
diameter 17.5mm
Code No. 519 921
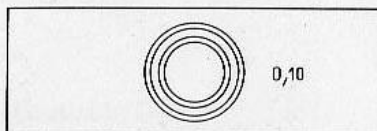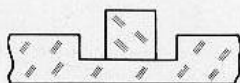
Culture chamber for phase contrast
depth of rings 0.1mm
Code No. 513128
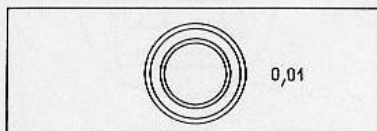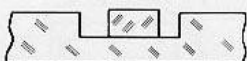
Culture chamber for phase contrast
depth of rings 0.01mm
Code No. 513129

	1	1.25	1.6	2	2.5	3.2	4	5	6.3	8	10
1	1	1.25	1.6	2	2.5	3.2	4	5	6.3	8	10
1.25	1.25	1.6	2	2.5	3.2	4	5	6.3	8	10	12.5
1.6	1.6	2	2.5	3.2	4	5	6.3	8	10	12.5	16
2	2	2.5	3.2	4	5	6.3	8	10	12.5	16	20
2.5	2.5	3.2	4	5	6.3	8	10	12.5	16	20	25
3.2	3.2	4	5	6.3	8	10	12.5	16	20	25	32
4	4	5	6.3	8	10	12.5	16	20	25	32	40
5	5	6.3	8	10	12.5	16	20	25	32	40	50
6.3	6.3	8	10	12.5	16	20	25	32	40	50	63
8	8	10	12.5	16	20	25	32	40	50	63	80
10	10	12.5	16	20	25	32	40	50	63	80	100

The reproduction ratios and magnifications of new products of microscopic optics (objectives, eyepieces, tube lenses) are based on the series of standard magnifications with the exception of special designs. This is a geometrical progression of factor $\sqrt[10]{10}$ = 1.258926...c≈ 1.25). It offers the advantage that standard magnification x standard magnification will again be a standard magnification and that the above table will be valid for all possible combinations of optical systems. Since the standard values continue equally towards the top and the bottom, all that has to be done is to shift the decimal point to the relevant digit. The change of final magnification by the tube lens, too, can be immediately read off the table: with tube factor 0.8x the product to the left or above, with tube factor 1.25x the product to the right or below will be applicable.

Apparent discrepancies (e.g. 80x8 = 630 or 4x32 = 125) are due to rounding off.
A series of objectives or eyepieces need not comprise all the values of the standard series.

If standardized optical systems are used reproduction ratios according to standardized values will be obtained in photomicrography and microprojection, too, if the bellows extensions or the projection distances are also based on standardized values, i.e. bellows extension 25cm, 40cm, 63cm, or projection distances 3.2meters, 6.3meters, 10meters.

Leitz
WETZLAR

Design subject to alteration without notice.

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Subsidiary: Ernst Leitz (Canada) Ltd., Midland, Ontario

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