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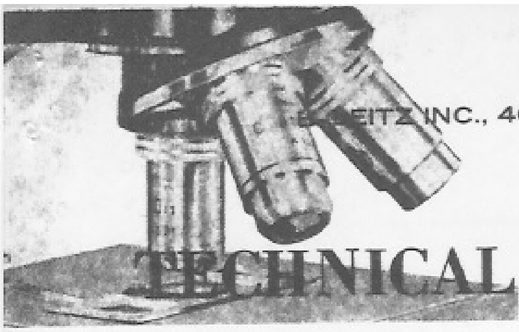

TECHNICAL INFORMATION BULLETIN

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HOW IMPORTANT IS A LENS SYSTEM BETWEEN EYEPIECE AND CAMERA?

Abstract:

Attachments for 35 mm Photomicrography should always include a lens system which focuses the image onto the film plane. Without such a lens the image clarity decreases, especially when high dry objectives are used. Only if the camera length of the bellows extension is at least 250 mm the lens system may be omitted; the spherical aberration is then negligible.

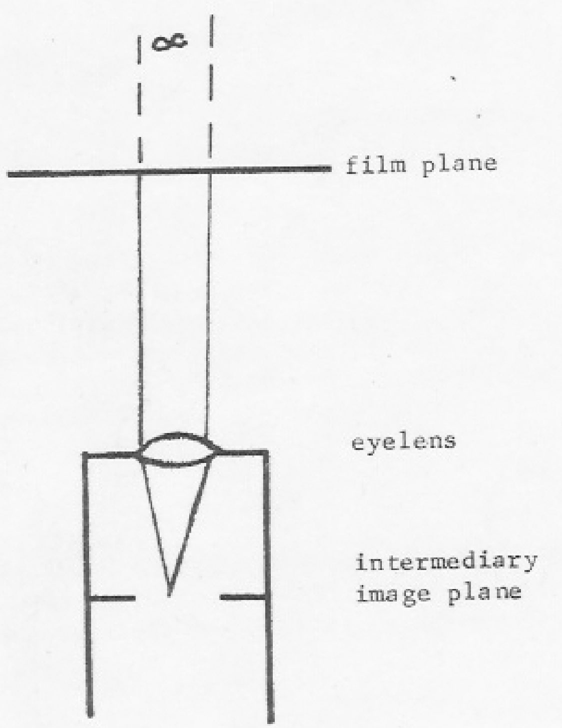

Figure 1

The intermediary image plane of a compound microscope is located at the front focal plane of the eyelens of the ocular. This means that all rays emerging from any point of the intermediary image leave the eyepiece parallel to each another. They come to a focus at infinity. (See figure 1.) The image is not focused onto the film plane.

In order to obtain a sharp image in the film plane, the objective has to be refocused. This shifts the location of the intermediary image, so that its distance from the eyelens is larger than f, that is greater than the focal length of the eyelens. (See figure 2.) The image is now in focus at the film plane, however, the working - and intermediary image - distance of the objective have been changed. Since the objective is spherically corrected only for one specific working distance, the image may look hazy and lack crispness because of spherical aberration. In order to avoid a change in working distance and the resulting spherical aberration, a lens has to be placed between eyepiece and film plane. This lens focuses the parallel pencil of rays onto the film emulsion and the correct working distance of the objective is maintained. (See figure 3) It acts in the same way as the lens of the human eye which focuses the image onto the retina.

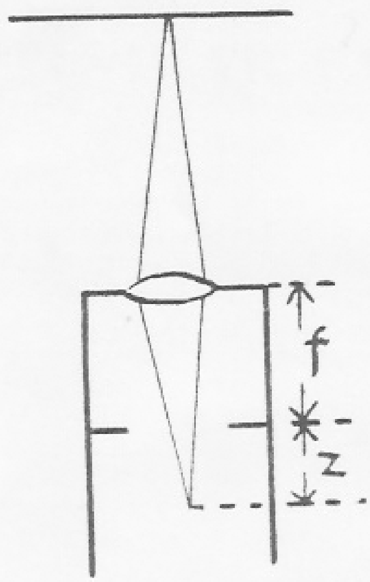

Figure 2

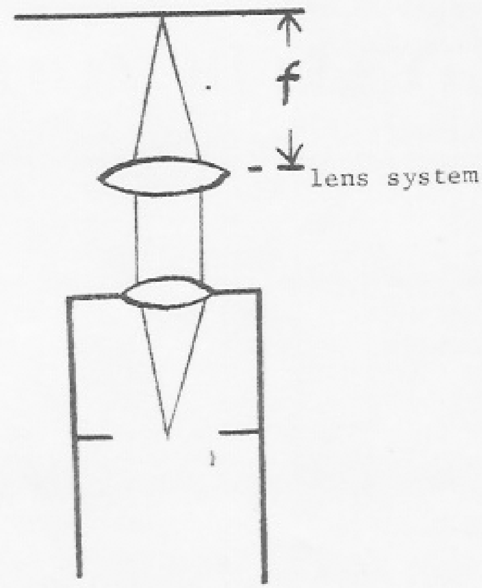

Figure 3

How serious is the image deterioration if no intermediate lens system is used? The amount of spherical aberration depends upon how far the intermediary image is displaced. This displacement or better the distance between the focal plane of the eyelens and the intermediary image is called: z. (See figure 2.)If the distance z is large, considerable aberration is introduced. "z" is calculated as

$$z = \frac{f^2}{C}$$

in which f is the focal length of the eyepiece and C the camera length or the distance between eyepiece and film plane. The table below shows how z changes if the camera length is changed and a 10x or a 6x eyepiece is used.

	10x eyepiece	6x eyepiece
C	z	z
500 mm	1, 25 mm	3, 53 mm
250 mm	2, 5 mm	7, 05 mm
125 mm	5 mm	14, 1 mm
100 mm	6, 25 mm	17, 64 mm
75 mm	8, 33 mm	23, 5 mm

It demonstrates that z and accordingly the image deterioration increase if the camera length is shortened. They also increase if eyepieces of lower magnification are used.

A simple 35 mm photomicrographic attachment usually has a camera length of approximately 100 mm. Using a 10x eyepiece the intermediary image will be displaced by 6.25 mm as may be seen in the above table.

This displacement z is nothing else but a change in tube length: by changing the tube length one can correct for spherical aberration which is introduced by a wrong cover-glass thickness. The relation between the change in tube length Δt and the deviation from the correct cover-glass thickness Δd is given by

$$\Delta d = \frac{\Delta t}{0,4 \, . \, M^2}$$

in which M is the magnification of the objective. If we assume a change in tube length by 6.25 mm (see table) and a 40x objective, Δd follows from

$$\Delta d = \frac{6,25}{0,4 \, . \, 1600} \approx 10 \, \mu$$

This means that a change in tube length by 6.25 mm has the same effect upon the image quality as a cover-glass which is off in its thickness by 10 μ. Such a deviation is, however, far beyond the limit of acceptable spherical aberration. It should be recalled that a deviation of only 3 μ will already introduce a visually noticeable image deterioration when a 40x objective with a numerical aperture of 0.95 is employed. (Compare Technical Information Bulletin, Vol. 1, # 4, The Influence of Cover-Glass Upon Microscopic Image Clarity.)

When such a lens system between eyepiece and camera is used, it is, of course, imperative that the film plane is mounted exactly into the back focal plane of the system. This may not be possible if a camera attachment of one manufacturer is used together with a camera back of another manufacturer. The distance toward the eyepiece is not critical.

Leitz 35 mm camera attachments (Micro-Ibso, Micro-Reflexhousing on Aristophot, Orthomat) are usually equipped with a 1/3 reducing lens system, the focal length of which is 83.3 mm. This is the distance between the principal plane of this intermediate lens and the film plane. It must critically be maintained. The reducing factor of 1/3 is chosen because a 35 mm negative is normally enlarged three times. This means that the magnification on the print will equal the visual microscopic magnification. If a higher magnification on the negative is required, the 1/3 reducing lens may be exchanged for a 1/2 reducing lens.