

Heavy Duty Camera Bellows for Digital Imaging

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My previous article on digital imaging in the April 1997 issue of *Microscopy Today* noted the use of an Olympus Auto Bellows with a Kodak MegaPlus 1.6i/AB CCD camera for digital photomicrographs equivalent to 4 x 5 Polaroid prints with magnifications between 10X and 50X. The purpose of this article is to document the high resolution obtainable with the bellows system and the design modifications needed to eliminate the plastic dovetail inserts of the Olympus Auto Bellows, which are susceptible to delayed stress cracking when used with a heavier camera like the MegaPlus. Total failure of the dovetail inserts could cause costly damage to the lens and the camera.

The readers may question the use of a bellows and macro lenses when a stereo microscope is commonly used for photomicrography in the 6X - 50X magnification range. Our high resolution Zeiss Stemi SV 11 stereo microscope is located in the SEM laboratory, where it is most needed. The MegaPlus camera is located in the metallography laboratory with a metallurgical microscope on one side of the PC and a copy stand on the other side. The copy stand is used to document large features with the MegaPlus camera and a 28 mm focal length lens. A 60 mm focal length Micro Nikkor lens is used for most of the photomicrography, up to a magnification equivalent to a 10X 4 x 5 Polaroid print. A bellows is used with Zeiss Luminar lenses, 100 mm and 63 mm focal length, to cover the 10X to 50X magnification range. This permits all of the photography and photomicrography of a specimen to be done in a single session without the need for a stereo microscope dedicated for use with the digital imaging system. Mea-

sured resolution test data for macro lenses used on camera bellows is apparently known only by the manufacturers of these lenses because this information is not requested by the users of these lenses. Consequently, appropriate quantitative resolution test standards and results are not readily available for stereo microscopes and the lower power microscope objectives. The European manufacturers of stereo microscopes will furnish resolution performance data when it is requested, but do not use this information to their advantage when competing with less capable Asian microscopes. Fortunately, there is a resolution test pattern marketed by Applied Image Inc. of Rochester, New York, for evaluating stereo microscope and macro lens resolution.¹ This chrome on glass pattern is used in our laboratory. Although the pattern can be used with either reflected or transmitted bright field illumination, diffuse transillumination was chosen for the tests in order to maximize the image contrast. Theoretical resolution is calculated from classical equations.^{2,3}

$$\text{Object Resolution in lines/mm} = 3000 \text{ NA} = \frac{1500 \text{ Camera Mag}}{f/\text{number (Camera Mag+1)}}$$

The resolution pattern recorded at 50X with a Zeiss Ultraphot and 0.1 NA objective on 4 x 5 Polaroid Type 55 P/N film was chosen as a basis for comparison with a digital photomicrograph obtained with the same objective and digital photomicrographs recorded at 5X camera magnification. The test patterns were oriented at about 45° to the CCD axes to obtain maximum resolution and avoid alias line effects, caused by undersampling when the spatial frequency in the optical image formed on the sensor approaches the pixel spacing of the CCD. The spacing of rows of pixels touching on the corner diagonals is .707 of the basic spacing of the orthogonal array of square pixels and presumably related to the higher measured resolution with test pattern lines oriented at 45°. The finest

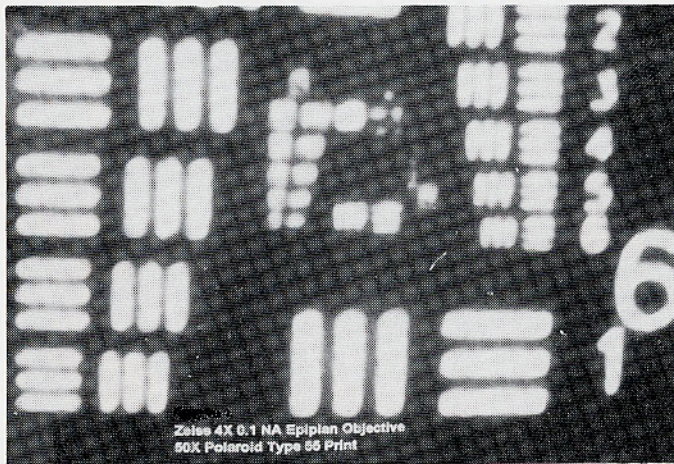


Figure 1

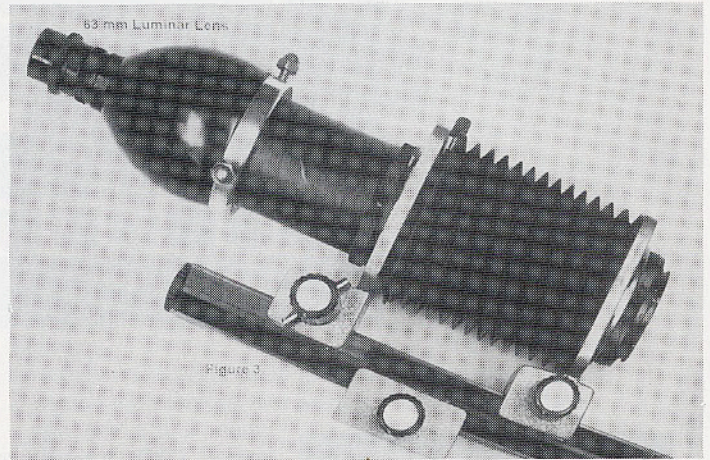


Figure 3

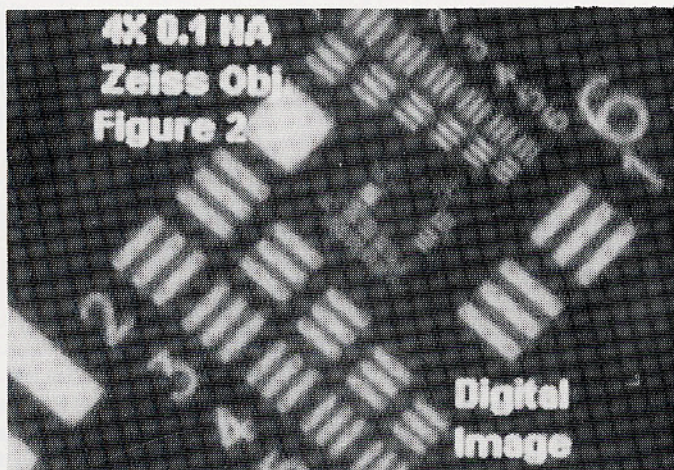


Figure 2

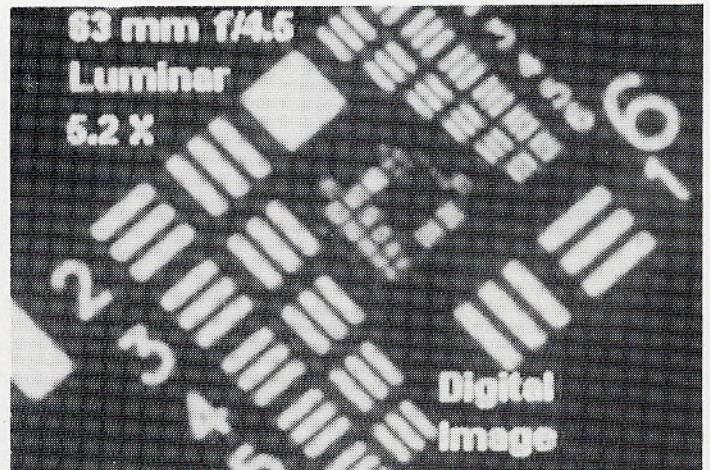


Figure 4