14th International Congress of ISP Hamburg 1980

Commission I Working Group -

Presented Paper

Dr.-Ing. Gerhard W ü r t z
JENOPTIK Jena GmbH., DDR - 69 Jena, Carl-Zeiss-Platz 1

New photogrammetric camera lenses from Jena

Abstract

A report is given on the new developed photogrammetric camera lenses Lamegon PI 4,5/150 B for the MRB 15/2323 aerial camera and the Lametar lenses 8/200 and 11/300 for the terrestrial UMK 1318 camera system, the quality of which can be judged by the presented test results of MTF, resolving power, distortion and light distribution.

The Jena optical works recently succeeded in completing some new designs, which had been started with the aim of increasing the performance and effectivity for the photographic technique in photogrammetry. These new developments include the Lamegon PI 4.5/150 B wide-angle lens for aerial photogrammetry and two lenses of the normal-angle and narrow-angle type for terrestrial photogrammetry, Lametar 8/200 and Lametar 11/300, the performance of which shall be described in the following.

1. Lamegon PI 4.5/150 B

The lens so far used in the MRB 15/2323 aerial camera is replaced by this Lamegon type, in which the fundamental optical parameters, such as focal length, field angle and relative aperture and, in addition, the light distribution in the image plane have been left unchanged. On the other hand, considerable improvements in the image quality and freedom from distortion have been achieved compared with the former lens. Relevant results on the modulation transfer function (MTF), photographic resolving power, and distortion are available.

The test equipment for the MTF determination on the basis of the slit image analysis was described in /1/. Figures 1 to 3 show MTF curves for the f-numbers capable of being set in the MRB camera and for a spectral range from 500 nm to 700 nm, whose characteristic has been well adapted to that of panchromatic commercial emulsions behind a yellow filter with half transmission wavelength of 500 nm. The focussing of the lens was carried out by applying the criterion of the maximum modulation transfer factor M(R) in the photo centre at the spatial frequency R = 15 l/mm and the f-number 4.5. This setting plane was retained for the measurements with other f-numbers. It is simultaneously the plane of maximum Strehl intensity. The curves drawn in Fig. 2 in thinner lines refer to the earlier lens. The achieved increase in quality is clearly visible.

For comparison, the MTF curves are shown in Fig. 4 for the three f-stop settings of the MRB camera referred to a spatial frequency of R = 30 l/mm. Accordingly the optimum f-number is 8, differing insignificantly from the result at 5,6 .

The effect of defocussing is shown in Fig. 5. Even at a defocussing of ± 0.1 mm modulation transfer compared with the size of the influenced image areas is still satisfactory. For the MRB 15/2323 aerial camera lens adjusted to infinity a defocussing value of - 0.1 mm results at a flying height of 225 mm. This corresponds to an image scale of 1 : 1500, which does normally not come into question for wide-angle cameras.
The photographic resolving power was determined according to the ISP Recommendations /3/ with radially and tangentially oriented three-line test groups of high and low contrast and by means of a yellow filter. The test emulsion used was Kodak-Plus X-Film. Particularly noticeable compared with the results reported in /2/ is the improvement of the tangential image elements in the corners of the picture (Figs. 6 and 7).
As a whole, the area weighted average resolution (AWAR) for f/4.5 compared with the earlier lens increased at high contrast from 38 l/mm to 52 l/mm and at low contrast from 19 l/mm to 28 l/mm, this being equivalent to an increase of 37 % or

47 %, respectively. For f/5.6 AWAR is 61 l/mm for high contrast and 31 l/mm for low contrast. It does practically not change when using f/8.

The standard distortion (Fig. 8) in the whole area of the image format is ≤ 4 µm.

2. Lametars

Lametar 8/200 and Lametar 11/300 were designed for the two new exchangeable UMK 20/1318 and UMK 30/1318 camera types, which in connection with the well-known UMK 10/1318 provide greater possibilities for adapting the measuring system to the particular taking conditions and thus for more effective work. The optical basic parameters are given in Table 1.
For assessing the image quality the same test equipments and techniques were used as for the aerial camera lens dealt with in the first section. Merely for adaptation to the application purpose orthochromatic ORWO-TO 1 plates and panchromatic ORWO-WP 1 plates of VEB Filmfabrik Wolfen with sensitivities of abt. 3 DIN and 22 DIN, respectively, were used for the determination of the resolving power.

According to expectation the differences in image quality diminish with smaller field angle both for the position of the image elements and for the outer image zones relative to the image centre.

The test results being characteristic of the image quality are represented in Figures 9 to 12. Table 2 shows the AWAR values for the smallest and largest f-numbers settable on the lens. As is expected, the photographic resolution gradually decreases with greater f-numbers. The maximum relative apertures (smallest f-numbers) are at the same time the optimum ratios; in the case of Lametar 8/200 the results for f/8 and f/11 are practically of equal size.

For distortion (Figs. 13 and 14) two standard curves have been given as limit curves for the whole focussing and adjusting range. For the UMK 20/1318 it lies between "∞" and 5.8 m and for the unvariably fixed UMK 30/1318 an adjustment can, on request, be made by the manufacturer within a range from "∞" to 5 m. The different zero transitions of distortion are the result of the radial distances r' increasing with the image distance change. Within the maximum depth of field resulting from the largest f-number and a permissible size of the circle of least confusion of 0.05 mm, distortion is practically stable. Deviations from the distortion values appertaining to the focussing distance are less than 1 µm.
Finally, Fig. 15 shows the light distribution in the image plane for both lenses.

Literature

/1/ Bode, A.; Untergutsch, U.;
Bißmann, B.: Measurement of Modulation Transfer Function (MTF) on Aerial Camera Lenses.
Presented Paper at the ISP Symposium, Commission I, Tokyo 1978

/2/ Würtz, G.: Image quality properties of the new aerial photography lenses form Jena.
Reports of the IIIrd International Symposium of Photointerpretation, Dresden 1970

/3/ ISP-Comm. I: Recommended Procedures for Calibrating Photogrammetric Cameras and for related Optical Tests, collated by P. D. Carman, Division of Applied Physics, National Research Council Ottawa, Canada 1960

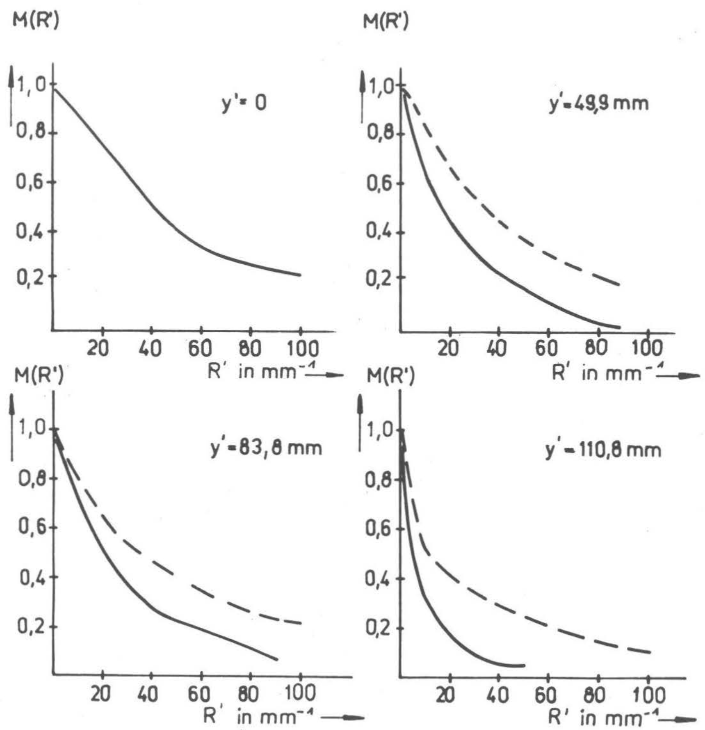

Fig. 1 Lamegon PI 4,5 / 150 B - MTF curves for a spectral range from 500nm to 700nm at f / 4.5

— radial — — — tangential

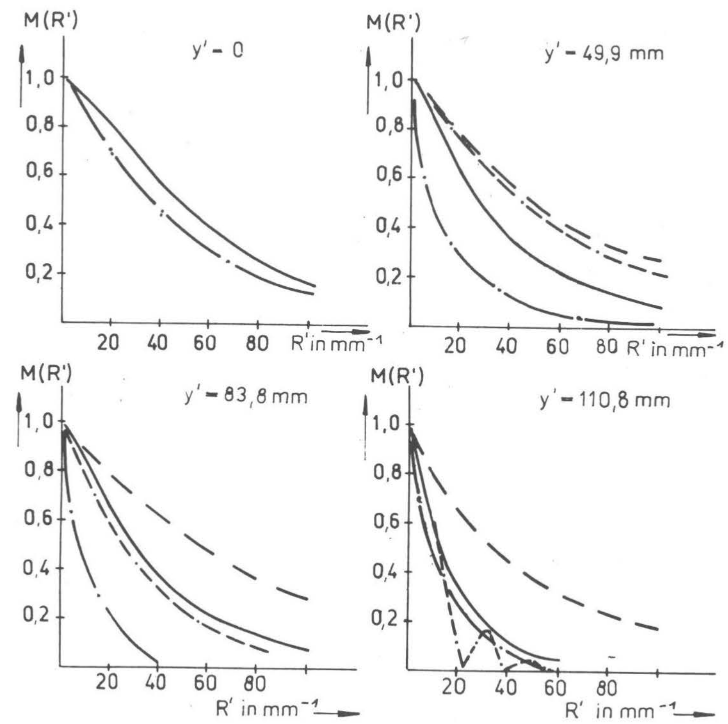

Fig. 2 Lamegon PI 4,5 / 150 B - MTF curves for a spectral range from 500 nm to 700 nm at f / 5,6
The earlier lens for comparison

— radial — — — tangential

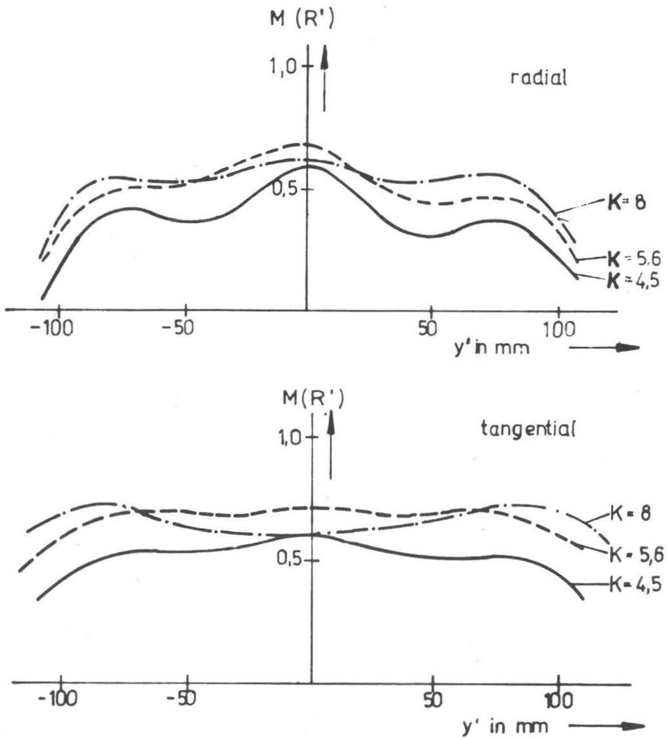

Fig. 3 Lamegon PI 4,5 / 150 B - modulation for R = 30 l/mm as a function of image position and diaphragm setting

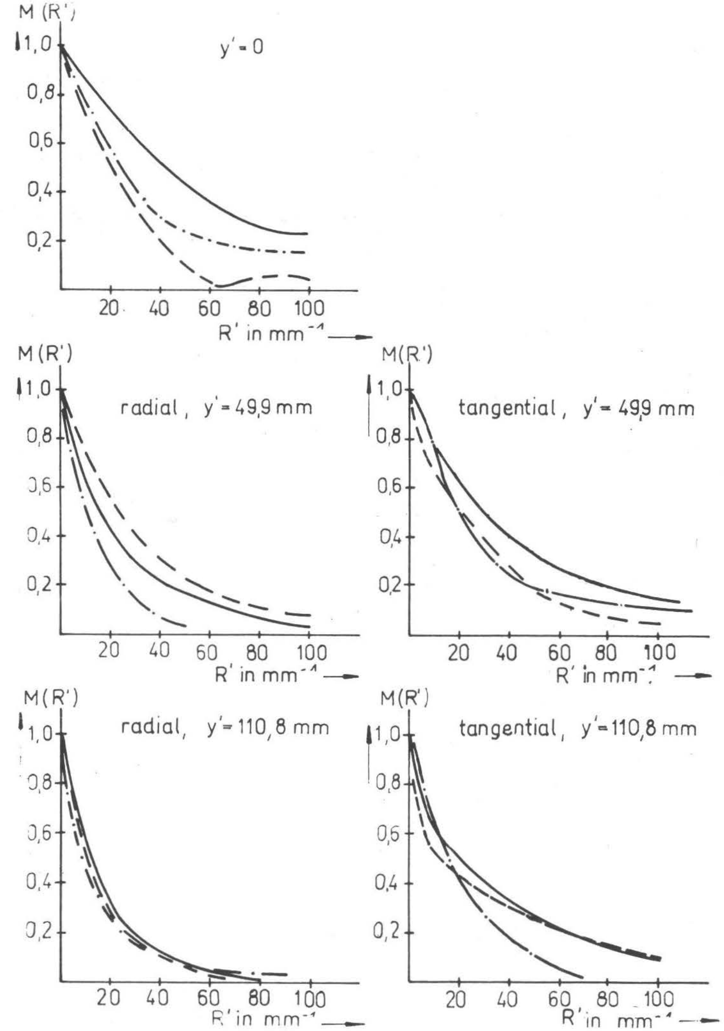

Fig. 4 Lamegon PI 4,5 / 150 B - MTF curves for a spectral range from 500 nm to 700 nm with defocussing Δz at f/4,5
—— Δz' = 0 μm ; —·— Δz' = 100 μm ; ---- Δz' = -100 μm

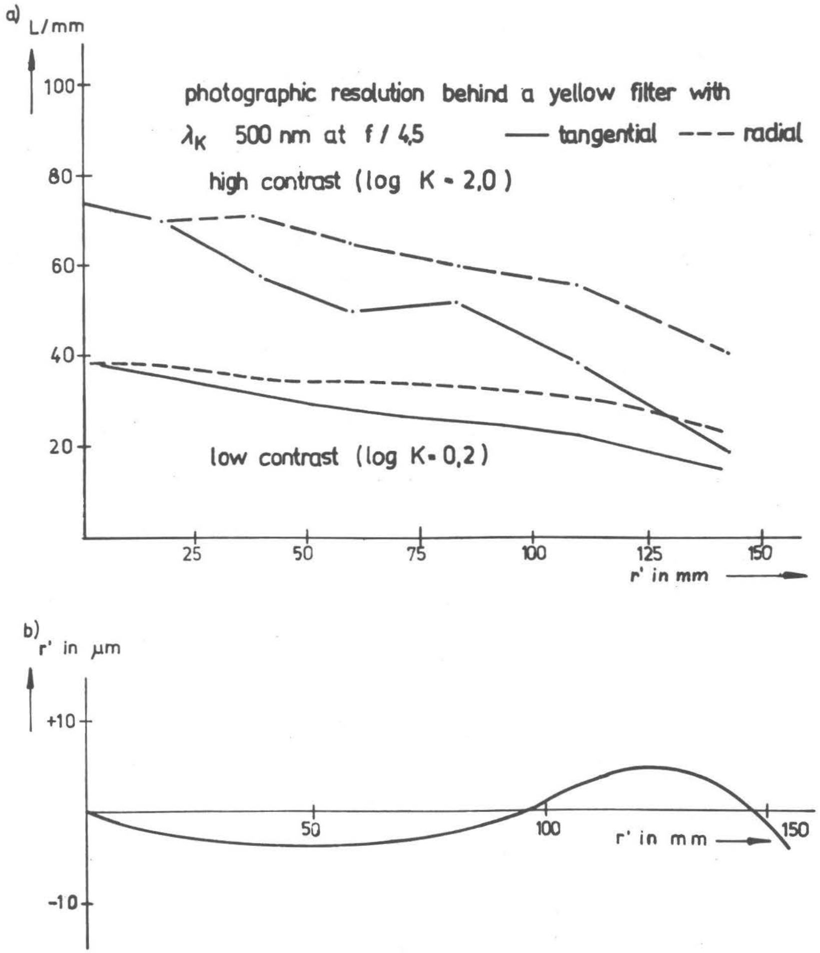

Fig. 5 Lamegon PI 4 5/150B

a) photographic resolution b) standard distortion curve

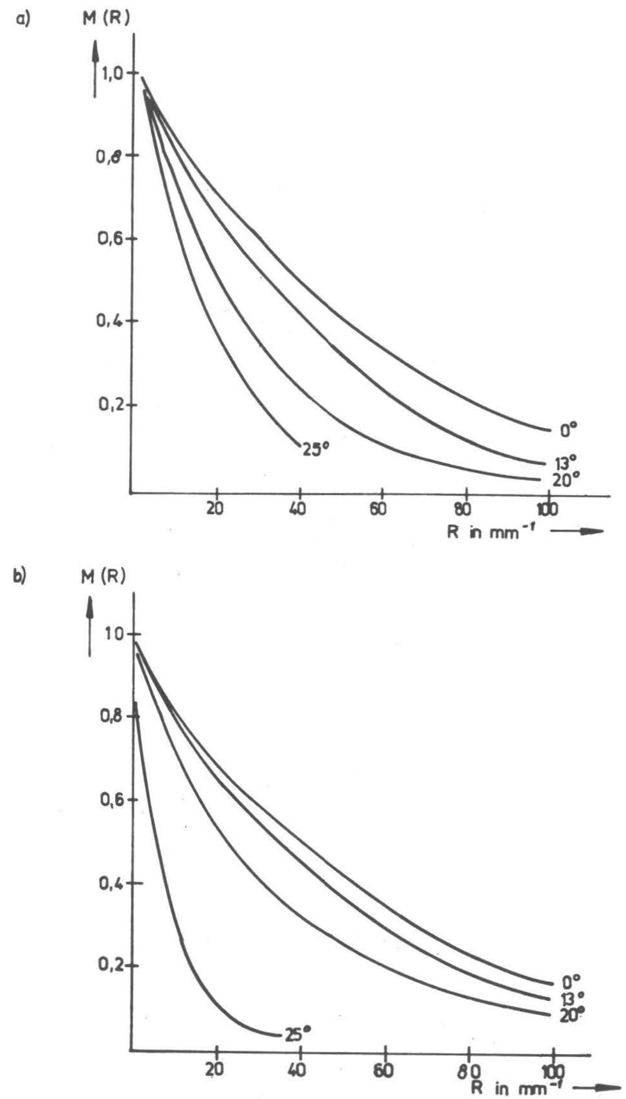

Fig. 6: Lametar 8/200 - MTF curves for white light at different angles and f/8

a) tangential b) radial

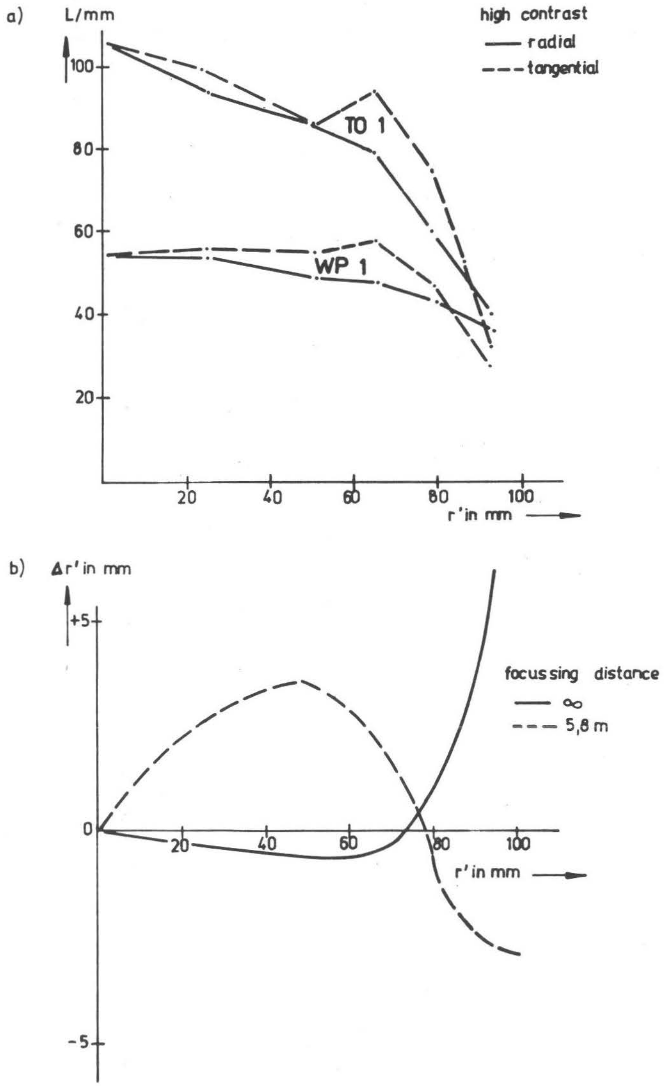

Fig. 7 Lametar 8/200

a) photographic resolution at f/8
b) standard distortion curves

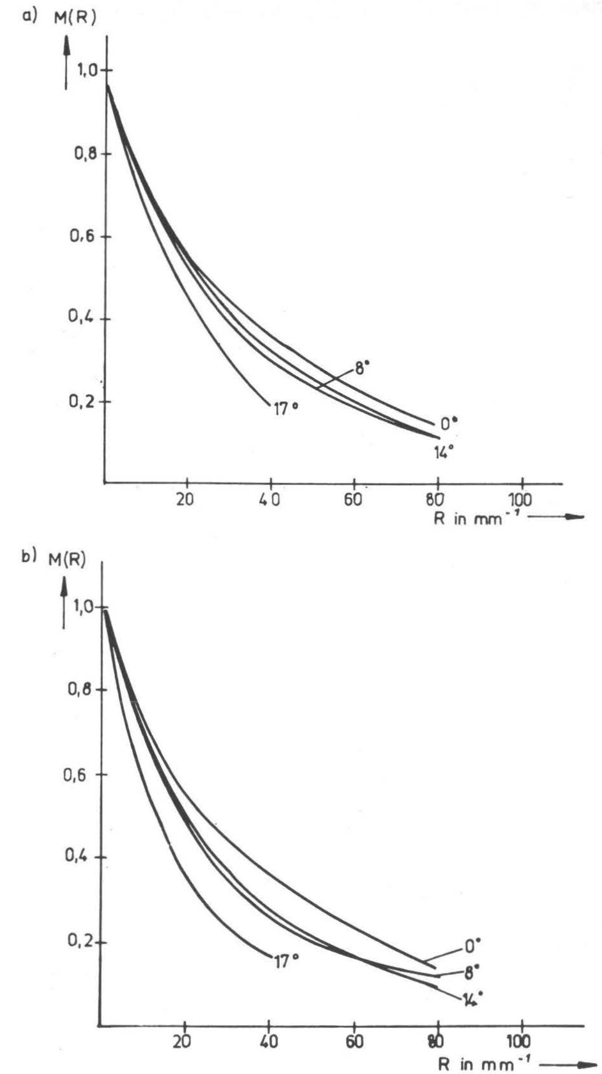

Fig. 8 Lametar 11/300 - MTF curves for white light at different angles and f/11

a) tangential b) radial

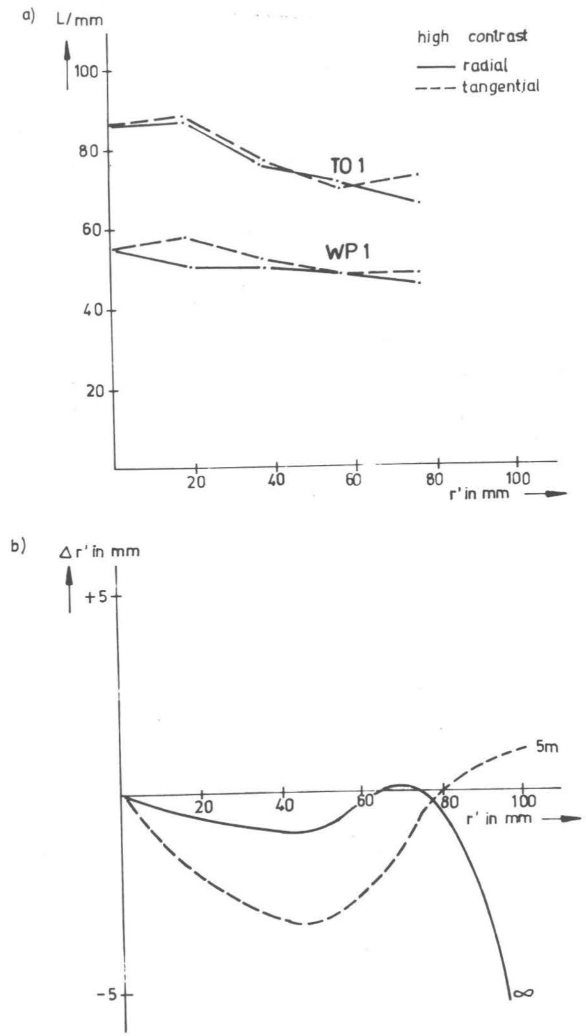

Fig. 9 Lametar 11/300

a) photographic resolution at f / 11

b) standard distortion curves

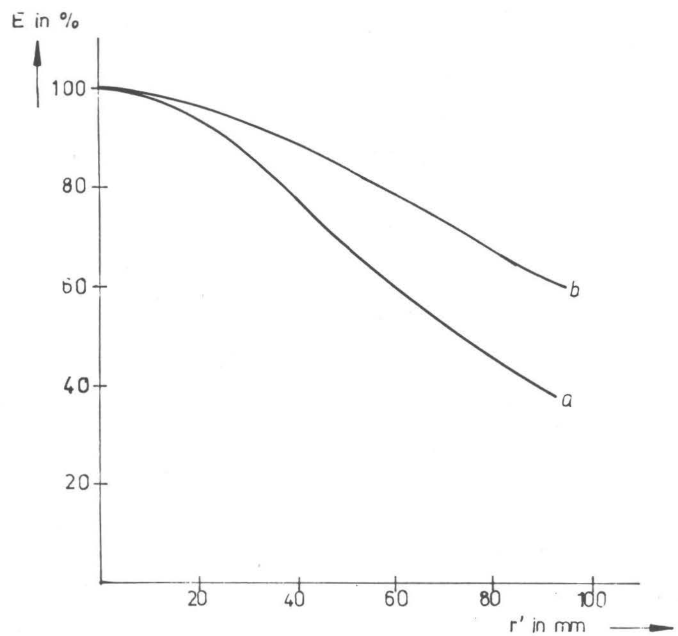

Fig. 10 Light distribution in the image plane

a) Lametar 11/300

b) Lametar 8/200