THE EFFECT OF TARGET CONTRAST ON THE FOCUS AND PERFORMANCE OF THE METROGON LENS*

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ABSTRACT

Six Bausch and Lomb 6 inch *f*/6.3 Metrogon lenses were tested at full aperture, using targets of log contrast 0.08, 0.20 and infinity, with the purpose of observing any change in the focal shift depending upon the choice of target contrast.

An average resolving power of 95% of the highest possible photographic resolution was obtained when the plane of best axial visual focus was shifted 0.65 ±0.05 mm. away from the lens.

Assuming that the test lenses are representative of all 6 inch Metrogons used for aerial photography in Canada, the National Research Laboratories have decided to focus cameras containing such lenses at 0.6 ±0.1 mm. behind the plane of best axial visual focus. If the center of the photograph is considered more important than outlying areas, the interval should be changed to 0.3 ±0.1 mm.

It was not concluded, on the basis of the test results, whether or not assessment of lens quality is dependent upon target contrast.

PUBLICATIONS COMMITTEE

INTRODUCTION

LOW contrast in resolving power targets has been introduced to simulate ground brightness conditions as nearly as possible. From a recent survey of ground brightnesses viewed from an aircraft (1), there is evidence that a typical difference of log brightness in fine detail is 0.08. Therefore, it is desirable to make lens tests with a target of log contrast 0.08 and compare these results with those obtained using other established target contrasts. The choice of a new target contrast may re-evaluate the performance of a lens in two different ways. First, it may change the relative assessment of a selection of lenses with respect to their resolving power rating. Secondly, it may redefine the position of the plane of best photographic resolution. The investigation described herein was made to obtain information concerning the latter. In addition an effort was made to find whether practical difficulties of making resolution measurements with the proposed 0.08 log contrast target make it desirable to compromise on a contrast nearer 0.20.

PROCEDURE

It has been established (2) that with the 6 inch wide-angle Metrogon lens using a Super XX Aero emulsion, it is necessary to shift the film plane from the position of best axial visual focus ("minimum fringe") to another position slightly farther from the lens in order to reach the plane of highest average photographic resolving power. (This shift will hereafter be called the "focal shift." It is positive if the photographic focus is farther from the lens than the visual focus.) Tests were made on this lens type, using targets of log contrast 0.08, 0.20 and infinity, with the purpose of observing any change in the focal shift depending on choice of target contrast.

Six Bausch and Lomb 6 inch *f*/6.3 Metrogon lenses were tested at full aperture. The method of making resolving power measurements was an adaptation of the procedure previously employed in this laboratory (3). Briefly, the following conditions were maintained. An annulus type target was placed at the focus of a collimator. Its illumination was diffuse and approximate in quality

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to mean noon sunlight. An operational minus blue anti-vignetting filter was attached to each lens under test. Only a single typical filter in good condition was used in the entire investigation in order to avoid influencing results by filter variation. The exposure was maintained at a single value across the field; this value had been adjusted to give maximum *average* resolving power. The Super XX Aero emulsion used was developed to a gamma of 1.35 ± 0.05. Off-axis curves were plotted to weight each designated angle according to the negative area it represented. Thus, the distances on the abscissa scale were made proportional to the negative area out to the indicated angle. At least three complete resolving power tests were made on each lens for each of the three target contrasts used (viz. log contrast 0.08, 0.20 and infinity).

Results

The results are shown in Figure 1. The abscissa is distance behind "minimum fringe" position. A break near the middle of a bar represents the position of the plane of highest average photographic resolution. The maximum scatter of any single determination of focal shift from the averages plotted was ± 0.15 mm.; the mean variation was ± 0.06 mm. The length of a bar gives the range over which 95% of the peak resolution is obtained. A small vertical line on or near each bar indicates the position of the best axial photographic resolution. This axial position was calculated using the paraxial angles 0°, 5°, and 10°. Its accuracy is substantially the same as that for focal shift.

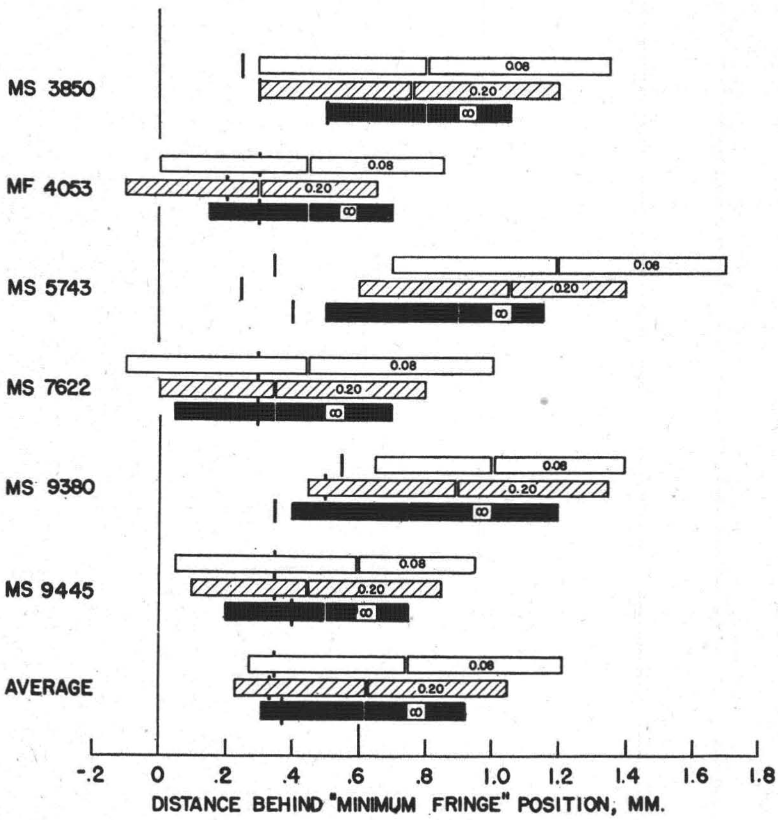

FIG. 1. Focus performance of test lenses for each target contrast used.

Considering the graphs representing the performance of individual lenses it appears that for two of the six lenses there is a significant change of focal shift depending on target contrast. For all other lenses the variations of focal shift with target contrast are not significant, their graphic representation being accurate to ± 0.1 mm. Since only in certain lenses does the target contrast affect the focal plane position, it is possible that these lenses may have some defect. There is some evidence to support this since one of the two lenses which show the effect has the lowest resolution of the group tested.

The graph representing the average performance of the lenses indicates that there is no significant change in the focal shift depending on the use of log contrast 0.20 and infinity. However, it appears that the focal shift is increased by an average of 0.1 mm. when the 0.08 log contrast target is introduced. Yet because this shift increase is small compared to the lack of uniformity among the lenses tested, it is doubtful if it is sufficiently important, in the case of the Metrogon, to justify the adoption of 0.08 log contrast targets. This conclusion is supported also by the fact that the extremely low contrast made the reading of film strips (especially in planes which are slightly out of focus) a great deal more difficult and time consuming. However, the per cent inaccuracies involved in the 0.08 log contrast tests did not exceed those of the other tests.

Best Metrogon Focus

The results of this investigation provided adequate data to determine the average focal shift of the Metrogon. It seems reasonable to avoid the complexity of individual photographic focussing since, on the basis of these results, a uniform focal shift of 0.65 ± 0.05 mm. will ensure an average resolving power of 95% of the highest possible resolution. This is substantiated by results of an earlier independent investigation by Baird (4) using 0.20 log contrast annulus targets and making single tests on ten 6 inch Metrogon lenses. His data (Figure 2) indicated a focal shift of 0.55 mm. Assuming that these lenses are representative of all 6 inch Metrogons used for aerial photography in Canada, the National Research Laboratories have decided to focus cameras containing such lenses at 0.6 ± 0.1 mm. behind "minimum fringe" position.

The advantage of using a 0.6 mm. focal shift rather than focussing at

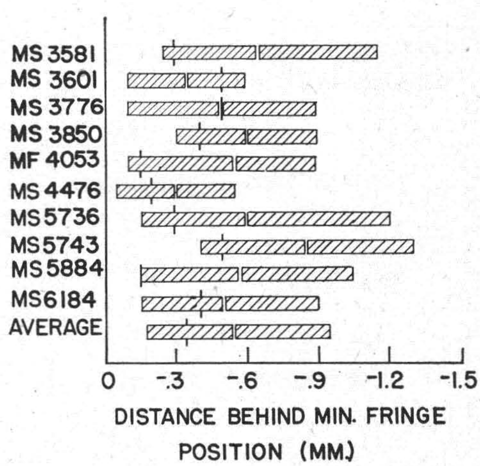

FIG. 2. Focus performance of lenses tested by Baird using 0.20 log contrast targets.

"minimum fringe" can be appreciated by referring to Figure 3. On this graph the percentage increase of the resolving power for a 0.6 mm. focal shift over the R.P. at "minimum fringe," each averaged for the six lenses, is plotted for each angle in the field. It has been calculated (also for the six lenses) that at the 0.6 mm. position the average ground resolving power is 8% higher than at "minimum fringe" and even the axial resolving power is 2% increased. (Baird's data (4) give 9% and −1% respectively.)

Graphs for individual lenses MS7622 and MS9380 showing the reduction of averaged film strip readings are presented in Figure 4. Lens MS9380 is typical of those lenses whose ideal focus position is greater than 0.6 mm. behind "minimum fringe." It shows a 26% improvement of average resolving power for a 0.6 mm. focal shift over that at "minimum fringe." It can be seen that the axial resolution reaches a peak very near the 0.6 mm. shift, and that at high field angles the peak resolution occurs at almost twice this distance behind "minimum fringe." This is not the case with lenses (such as MS7622)

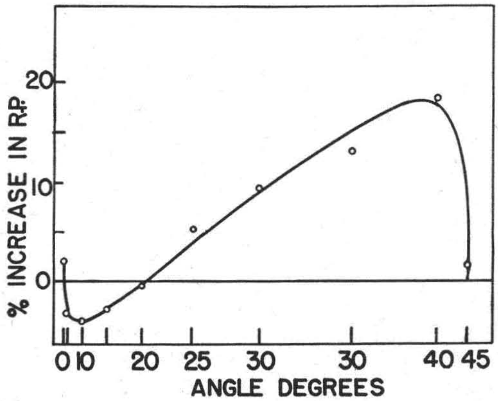

FIG. 3. Percentage increase in resolving power for 0.6 mm. focal shift over resolving power at "minimum fringe." Target log contrast is 0.20.

whose ideal focus position is less than 0.6 mm. One observes from the performance graphs of MS7622, that while the average resolving power is 3% increased for the 0.6 mm. focal shift over that at "minimum fringe," neither position offers any decided improvement in resolution either in the paraxial region or at moderately high field angles. From this comparison it is clear that with lenses like MS7622, no resolution is sacrificed when the 0.6 mm. focal shift is adopted, and that with lenses like MS9380, a considerable improvement is obtained by using the shift.

It can be seen from the graph in Figure 1 that the positions of best axial resolving power do not change as much as the positions of best average focus. If the center of the photograph is considered more important than outlying areas (a case which has not been assumed here) the interval should be changed to 0.3 ± 0.1 mm.

Figure 5 shows the resolving power of each lens tested for each contrast of target used. The bars indicate the peak average photographic resolving power plotted as log ground resolving power. The small line above each bar indicates the peak axial resolving power which was obtained. These peaks referred to do not necessarily occur in the same photographic plane. (Since the exposure time

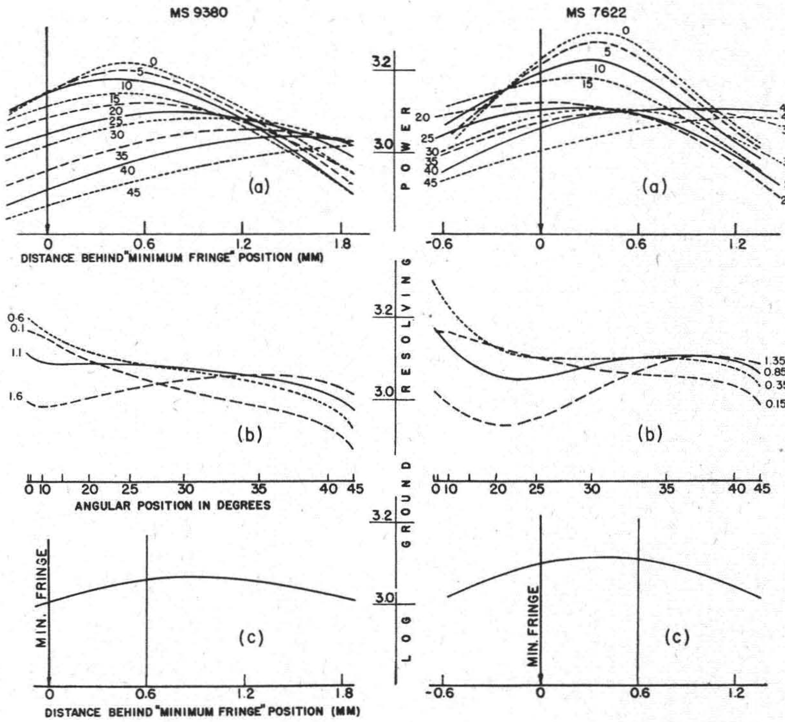

FIG. 4. Curves for two lenses, MS9380 and MS7622, tested with 0.20 log contrast targets. Ground resolving power is defined as RF, where R is the resolving power in lines per millimeter, and F is the focal length expressed in millimeters. (a) gives through-the-focus curves for each angle, plotting averages of film strip readings; (b) gives off-axis curves, plotting ordinate intercepts from graph (a); (c) gives a through-the-focus curve of average resolving power, plotting values obtained from (b) by integrating over each of the curves.

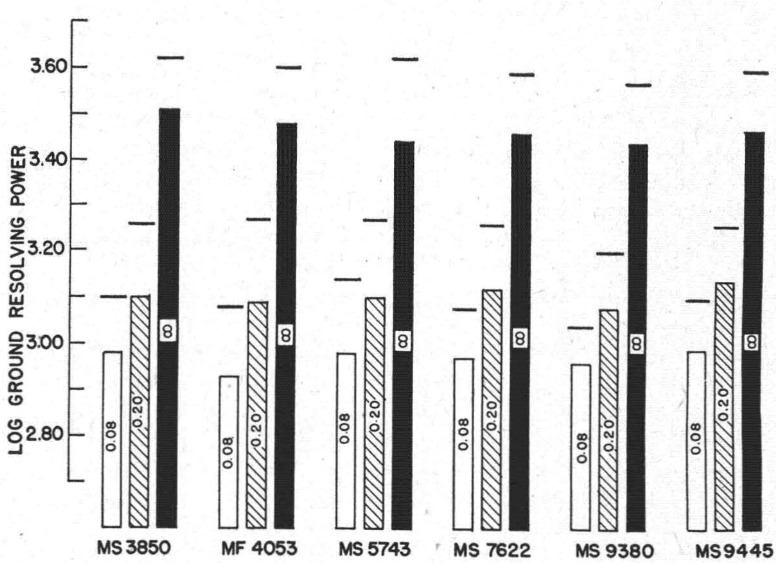

FIG. 5. Resolution performance of test lenses for each target contrast used.

chosen was one which would give the highest *average* photographic resolving power, the axial area is slightly over-exposed. Therefore, the true peak axial resolution is slightly higher than actually represented.) The mean deviation from the averaged experimental results plotted was 10%.

Because the variation in the resolving power among the lenses is of the same order as the experimental errors involved, it is impossible to say, on the basis of these results, whether or not assessment of lens quality is dependent upon target contrast. In order to make this determination, it would be necessary to test more lenses, varying widely in design and resolution, with the three contrasts used here.

References

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3. Howlett, L. E., "Photographic Resolving Power," *Canadian Journal of Research*, vol. A24, pp. 15–40, 1946.
4. Baird, K. M. (private communication).