FIELD CURVATURE CORRECTION BY MENISCUS LENSES

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Summary

This paper deals with variants of meniscus lenses destined for the correction of the residual field curvature where Petzval's sum is commensurable with that of the component lenses of the optical system to be corrected. The application of the field curvature corrector meniscus (FCCM) in a surveying instrument telescope as well as its efficiency in diminishing the residual field curvature in joint application with a conventional telescope will be presented.

Introduction

It is well known that the residual errors (spherical aberration, astigmatism and longitudinal chromatic aberration) of optical systems comprising components limited by spherical surfaces can be modified by inserting a plano-parallel optical plate in the path of rays. Correctors like a plano-parallel optical plate bent arount a suitably selected point on the optical axis, quasi-concentric meniscus lenses (QCM) just slightly differing from the former, as well as Makshutov and Bauwers meniscus lenses, Smith and Schmidt lenses or Schmidt plates have found an extensive application in the past 50 years. Nevertheless, owing to the enhanced requirement for optical quality, of an extended field curvature recently several practical applications were reported in literature (in the order of publication: [1], [2], [3], [4]). All these data provided a sufficient basis for a comprehensive study attempting a systematic treatment of the question [5].

Decreasing the residual astigmatism

One of the problems arising in the initial phase of designing optical systems meeting given requirements of image forming is to obtain lenses with focal lengths of a maximum absolute value and an acceptable magnitude of Petzval's sum. The advantages involved in increasing the absolute values of

focal lengths of the constituent lenses are well known. It is also known that (when applying the same combination of glass compositions) Petzvál's sum of an optical system (that can be characterized by the sign of its component lenses) increases in direct proportion with the absolute value of the focal distances of the constituent lenses. Thus, in solving the problem, the requirements regarding the image angle and relative aperture of the system point out to the designer where to accept a compromise: in the absolute values of the focal distance of lenses (a maximum) or in Petzvál's sum (a minimum).

From the point of view of the purpose set forth in the title of the present paper, the detailed discussion of the middle phase of development work is irrelevant. In the final stage of design, that is, in the fine correction procedure, the aim to attain is to set a value of astigmatism less than the 0.025 mm/sin β' tolerance of image forming, in which β' stands for the angle intercepted between the aperture rays emerging from the system and the optical axis. It should be noted, however, that (owing to the involvement of Petzvál's sum) the above discussed expectation should be fulfilled as a dual requirement. This means that the corresponding meridional and sagittal image points have to be arranged at a distance from each other and from the image plane less than the astigmatism tolerance. Furthermore, it is known from calculation practice that in the fine correction of given complex optical systems the field curvature diagrams can be changed only by "moving together" with the variation of the lens form factor. This means that in solving a high-standard problem, beyond providing a correction for astigmatism, the improvement of Petzvál's sum is also justified.

Field curvature corrector meniscus

With a view to all said so far and owing to the successful and early practical application, the solution of one particular variant of the image field corrector [1] deserves rather detailed mentioning. The FCCM — as its name implies — is a collecting or dispersing lens provided with the required correction for image plane curvature.

The principal point pertaining to the surface of the field curvature corrector meniscus [1] whose radius of curvature is the larger in absolute value coincides with the original image position of the optical system. The position of the image of corrected field curvature formed jointly by the optical system to be corrected and the FCCM appear in the other principal point pertinent to the other surface of the meniscus with a smaller radius of curvature. Owing to the 1:1 magnification ratio of the FCCM, a residual image field curvature of limited extent can be attained while keeping the image size unaltered.

Advantages involved in the application of the FCCM

The application of the FCCM is demonstrated in connection with the surveying instrument telescope depicted in Figure 1. From the figure one can see two further advantages of the FCCM beyond field curvature correction. First: the common, corrected image position of the objective and ocular lenses is formed at the part of the reticle enclosed by the FCCM ensuring thereby its durable, original quality cleanliness. Second: it is also a consequence of the application of the FCCM that the distance between the last surface of the ocular and the exit pupil increases rendering possible a more convenient viewing and eventually the use of spectacles.

The efficiency of correction for residual field curvature of an FCCM is demonstrated in an example given in Figure 2, exhibiting a conventional telescope objective.

For the sake of completeness, it is worth mentioning that the use of an FCCM allowed the designer to produce a distorsion-free optical system for projection purposes of 100 X magnification and 1 μm resolution at the object field. The feasibility of such a system was proved by a successful prototype.

Conclusions

The residual errors of the extended image field can be reduced by a significant degree with the application of suitable corrector meniscus lenses the effect of quasi-concentric meniscus lenses (QCM) [5] the results attainable with the use of a field curvature corrector meniscus (FCCM) [1] are illustrated by the numerical example provided. The latter not merely decreases the field curvature, but it results in a substantial improvement of Petzvál's sum, too.

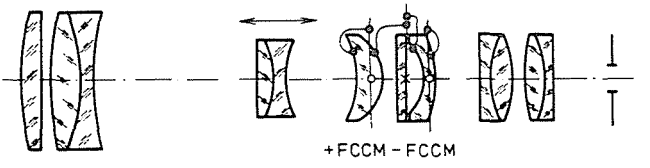

Fig. 1. Application of an FCCM in a surveying instrument telescope

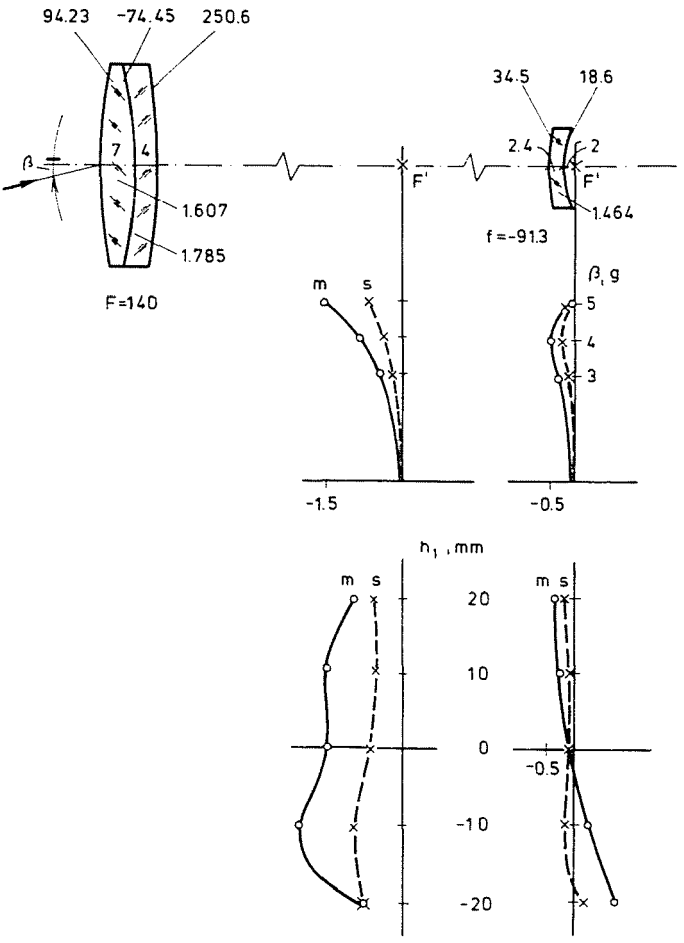

Fig. 2. Graphic representation of the effect of an FCCM decreasing the residual field curvature in a conventional telescope objective

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