DESIGN ASPECTS OF SOME BASIC PHOTOGRAPHIC OBJECTIVE CONFIGURATIONS A STUDY

BY

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. . . . to

my parents

and

my grandma

C E R T I F I C A T E

Certified that the dissertation entitled " Design aspects of some basic photographic objective configurations : a study ", which is being submitted to the Indian Institute of Technology Delhi, by SAREPAKA VIZIA RAMA GOPAL in fulfilment for the award of the Degree of DOCTOR OF PHILOSOPHY is a record of the student's own work carried, out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other Degree or Diploma.

Dr.B.N. Gupta

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A C K N O W L E D G E M E N T S

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A B S T R A C T

The scope of this thesis includes study of basic configurations of photographic objectives, right from doublets. Attempt has been made to present analytically the limitations of various design procedures used in the design of achromatic doublets, Cooke Triplets, Tessars, Double-Gauss lenses, Celors, Petzval lenses with a branching-out of study of tolerances in the case of Tessar.

The thesis consists of six Chapters. Each Chapter deals with different lens configurations, with analytical study of the design method employed.

The first Chapter provides with the introduction, historical background and evolution of photographic objectives. It also tests the various types of configurations and their individual merits-limitations in view of aberration correction.

In the second Chapter, the double-graph technique suggested by Kingslake, for design of achromatic doublet is described along with case study of design of achromatic doublet using Schott glasses and Indian glasses. Employing this technique, chromatic aberration and spherical

aberration of the doublet can be simultaneously corrected (by graphic projection) by varying two system parameters. In order to extend this technique into the three-dimensional domain (to account for the offence against sine condition also), the same is firstly used in the two-dimensional frame for the design of achromatic doublet with glasses from the CGCRI catalogue. However, this exercise has exposed the inherent limitations, (viz: the assumption of linearity, while in actuality there is none, thereby causing considerable change in total power of system etc.,) of this technique. An analytical study in this regard is presented in detail and it is concluded that the double-graph technique yields results only under certain conditions and only in modified form.

The third Chapter deals with the study of Cooke Triplet. In the present study, Wynne's method of solving the equations for the Triplet is adopted. Petzval curvature plays a crucial role in the aberration correction of the Cooke Triplet. To study its effect, a 100 mm, f/5.0 Triplet system is considered for case study. The significance of the selection of Petzval curvature is exhaustively studied by choosing seven different values of Petzval curvature. Triplets using these values are designed with the most favourable shapes, their performances evaluated and compared. It is concluded that under stipulated conditions of field and aperture, only certain range of Petzval curvature values provides the Triplet designs with good results. The fact that the Petzval curvature and Triplet performance are not linearly related, lends creditability and substance to this effort.

Chapter four presents a study of Tessar. This exercise aims at investigating the importance of proper selection of two design parameters. The parameters under study are: (a) the ratio of individual powers of the doublet in the Tessar, and (b) the Petzval curvature employed. This study is based on Cruickshank's postulates. As an example, a 50 mm, f/4.5 Tessar is pursued with five different values of ratio of powers of the rear doublet, employing five sets of Petzval curvature values in each case of power ratio. Systems with only the most favourable shapes are then considered. These designs are evaluated in terms of aberration correction and are compared. In each set of power ratio, the best design with appropriate value of Petzval curvature is selected and compared with similar designs from other sets of power ratios. The results thus obtained corroborate with those in the earlier work on Triplet.

In the fifth Chapter, a study of tolerances on Tessar lens is undertaken. The constructional parameters of the Tessar play very significant role in the aberration correction. For a cost-effective mass scale production, it is advisable to study the tolerances on the constructional parameters of the system. The exercise in this Chapter is a pointer in this direction and certain useful guidelines for the workshop environment are formulated.

The sixth Chapter begins with an introduction to the optimization techniques currently used. In the present context, the optimization software used is based on damped least squares method. A comparative study of four photographic lenses (viz: Tessar; Double-Gauss and Celor; Petzval lens) forms the basis of work in this Chapter. Recent studies by Sharma et al suggest that the Triplet derivatives using either CGCRI glasses or Lanthanam glasses provide better aberration correction compared the double-gauss systems with either kind of glasses. In the present context, this comparison includes the study of Petzval lenses also to widen the scope of the work. In this study, 100 mm, f/4.5 and 50 mm, f/4.5 systems with Tessar, double-gauss, Celor and Petzval lens configurations are designed. Their designs are optimized and each is compared with other under similar conditions of field and focal length. The study corroborates with the results by Sharma et al.

C O N T E N T S