

PATENT REVIEW OF MINIATURE CAMERA LENSES  
AND  
A BRIEF COMPARISON OF TWO RELATIVE DESIGN PATTERNS

by

Luxin Nie

---

A Report Submitted to the Faculty of the

COLLEGE OF OPTICAL SCIENCES

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

2017

## STATEMENT BY AUTHOR

The master's report titled *Patent Review of Miniature Camera Lenses and a Brief Comparison of two Relative Design Patterns* prepared by *Luxin Nie* has been submitted in partial fulfillment of requirements for a master's degree at the University of Arizona.

Brief quotations from this report are allowable without special permission, provided that an accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the copyright holder.

SIGNED: *Luxin Nie*

## APPROVAL BY REPORT ADVISOR

This report has been approved on the date shown below:

---

*José M. Sasián*

*Professor of Optical Sciences*

*Professor of Astronomy*

*Nov 29, 2017*

Date

## ACKNOWLEDGEMENTS

I would like to thank my family for their consistent support.

I would like to thank Prof. José Sasián for his beneficial advices in writing this report, his enlightening teaching in optics without reservation, and his life-changing influence of living as an ideal lens designer.

I would also like to thank my committee, Dr. Jim Schwiegerling and Dr. Dae Wook Kim. Their enthusiasm and devotion in education are very respectable and make me thankful.

Thank other professors, staffs and classmates. They together make the experience of studying in OSC enjoyable and unforgettable.

# TABLE OF CONTENTS

Abstract .....	7
Patents Review .....	8
Representative Patterns .....	13
A Quick Evaluation .....	16
Two Relative Designs .....	19
Four Parameters Evaluation .....	20
RMS Wave-front Error As Criterion .....	23
Tolerancing By Element .....	26
Monte Carlo Analysis .....	28
Conclusions .....	31
References .....	33

# LIST OF FIGURES

<b>Fig. 1</b> Numbers of patent publication in different years .....	9
<b>Fig. 2</b> Element number changing of miniature lenses over years .....	10
<b>Fig. 3</b> Focal length changing of miniature lenses over years .....	11
<b>Fig. 4</b> F/# changing of miniature lenses over years .....	12
<b>Fig. 5</b> FOV changing of miniature lenses over years .....	13
<b>Fig. 6 (a)</b> Parameters $W$ and $S$ of sixteen lenses in Table 1 .....	18
<b>Fig. 6 (b)</b> Parameters $CS$ and $AS$ of sixteen lenses in Table 1.....	18
<b>Fig. 7 (a)</b> Layout of the selected 6-element lens .....	19
<b>Fig. 7 (b)</b> Layout of the selected 7-element lens .....	19
<b>Fig. 8</b> Parameter $w$ of each element of two compared lenses .....	21
<b>Fig. 9</b> Parameter $(cs + as) / 2$ of each element of two compared lenses .....	23
<b>Fig. 10</b> RMS wave-front errors over HFOV .....	24
<b>Fig. 11 (a)</b> Histogram of RMS changes at center field .....	29
<b>Fig. 11 (b)</b> Histogram of RMS changes at zonal field .....	29
<b>Fig. 11 (c)</b> Histogram of RMS changes at edge field .....	30

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.