

SPONSORED BY THE
OPTICAL SOCIETY OF AMERICA

HANDBOOK OF OPTICS

DEVICES, MEASUREMENTS, & PROPERTIES

• SECOND EDITION •

VOLUME

II

MICHAEL BASS, EDITOR IN CHIEF

LG Electronics, Inc. et al.

EXHIBIT 1010

IPR Petition for
U.S. Patent No. RE43,106

**DOCKET
ALARM**

Find authenticated court documents without watermarks at docketalarm.com.

HANDBOOK OF OPTICS

Volume II
Devices, Measurements,
and Properties

Second Edition

Sponsored by the
OPTICAL SOCIETY OF AMERICA

Michael Bass Editor in Chief

*The Center for Research and
Education in Optics and Lasers (CREOL)
University of Central Florida
Orlando, Florida*

Eric W. Van Stryland Associate Editor

*The Center for Research and
Education in Optics and Lasers (CREOL)
University of Central Florida
Orlando, Florida*

David R. Williams Associate Editor

*Center for Visual Science
University of Rochester
Rochester, New York*

William L. Wolfe Associate Editor

*Optical Sciences Center
University of Arizona
Tucson, Arizona*

McGRAW-HILL, INC.

New York San Francisco Washington, D.C. Auckland Bogota
Caracas Lisbon London Madrid Mexico City Milan
Montreal New Delhi San Juan Singapore
Sydney Tokyo Toronto

Library of Congress Cataloging-in-Publication Data

Handbook of optics / sponsored by the Optical Society of America ;
Michael Bass, editor in chief. — 2nd ed.

p. cm.

Includes bibliographical references and index.

Contents: — 2. Devices, measurement, and properties.

ISBN 0-07-047974-7

1. Optics—Handbooks, manuals, etc. 2. Optical instruments—
Handbooks, manuals, etc. I. Bass, Michael. II. Optical Society
of America.

QC369.H35 1995

535—dc20

94-19339

CIP

Copyright © 1995, 1978 by McGraw-Hill, Inc. All rights reserved. Printed
in the United States of America. Except as permitted under the United
States Copyright Act of 1976, no part of this publication may be
reproduced or distributed in any form or by any means, or stored in a data
base or retrieval system, without the prior written permission of the
publisher.

1 2 3 4 5 6 7 8 9 DOC/DOC 9 0 9 8 7 6 5 4

ISBN 0-07-047974-7

The sponsoring editor for this book was Stephen S. Chapman, the editing
supervisor was Paul R. Sobel, and the production supervisor was Suzanne
W. Babeuf. It was set in Times Roman by The Universities Press (Belfast)
Ltd.

Printed and bound by R.R. Donnelly & Sons Company.

This book is printed on acid-free paper.

Information contained in this work has been obtained by McGraw-Hill, Inc. from sources believed to be reliable. However, neither McGraw-Hill nor its authors guarantees the accuracy or completeness of any information published herein and neither McGraw-Hill nor its authors shall be responsible for any errors, omissions, or damages arising out of use of this information. This work is published with the understanding that McGraw-Hill and its authors are supplying information but are not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought.

CONTENTS

Contributors xvi

Preface xix

Glossary and Fundamental Constants xxi

Part 1. Optical Elements 1.1

Chapter 1. Lenses *R. Barry Johnson* 1.3

- 1.1. Glossary / 1.3
- 1.2. Introduction / 1.5
- 1.3. Basics / 1.5
- 1.4. Stops and Pupils / 1.8
- 1.5. F-Number and Numerical Aperture / 1.9
- 1.6. Magnifier or Eye Loupe / 1.9
- 1.7. Compound Microscopes / 1.9
- 1.8. Field and Relay Lenses / 1.10
- 1.9. Aplanatic Surfaces and Immersion Lenses / 1.10
- 1.10. Single Element Lens / 1.11
- 1.11. Landscape Lenses and the Influence of Stop Position / 1.17
- 1.12. Two-Lens Systems / 1.19
- 1.13. Achromatic Doublets / 1.23
- 1.14. Triplet Lenses / 1.26
- 1.15. Symmetrical Lenses / 1.27
- 1.16. Double-Gauss Lenses / 1.28
- 1.17. Petzval Lenses / 1.29
- 1.18. Telephoto Lenses / 1.29
- 1.19. Inverted or Reverse Telephoto Lenses / 1.30
- 1.20. Performance of Representative Lenses 1.30
- 1.21. Rapid Estimation of Lens Performance / 1.36
- 1.22. Bibliography / 1.41

Chapter 2. Afocal Systems *William B. Wetherell* 2.1

- 2.1. Glossary / 2.1
- 2.2. Introduction / 2.1
- 2.3. Gaussian Analysis of Afocal Lenses / 2.2
- 2.4. Keplerian Afocal Lenses / 2.7
- 2.5. Galilean and Inverse Galilean Afocal Lenses / 2.14
- 2.6. Relay Trains and Periscopes / 2.16
- 2.7. Reflecting and Catadioptric Afocal Lenses / 2.19
- 2.8. References / 2.22

Chapter 3. Polarizers *Jean M. Bennett* **3.1**

- 3.1. Glossary / 3.1
- 3.2. Prism Polarizers / 3.2
- 3.3. Glan-Type Prisms / 3.9
- 3.4. Nicol-Type Prism / 3.17
- 3.5. Polarizing Beam-Splitter Prisms / 3.19
- 3.6. Dichroic and Diffraction-Type Polarizers / 3.26
- 3.7. Non-Normal-Incidence Reflection and Transmission Polarizers / 3.36
- 3.8. Retardation Plates / 3.46
- 3.9. Variable Retardation Plates and Compensators / 3.57
- 3.10. Half-Shade Devices / 3.60
- 3.11. Minature Polarization Devices / 3.61
- 3.12. References / 3.62

Chapter 4. Nondispersive Prisms *William L. Wolfe* **4.1**

- 4.1. Glossary / 4.1
- 4.2. Introduction / 4.1
- 4.3. Inversion, Reversion / 4.2
- 4.4. Deviation, Displacement / 4.2
- 4.5. Summary of Prism Properties / 4.3
- 4.6. Prism Descriptions / 4.3
- 4.7. References / 4.29

Chapter 5. Dispersive Prisms and Gratings *George J. Zissis* **5.1**

- 5.1. Glossary / 5.1
- 5.2. Introduction / 5.1
- 5.3. Prisms / 5.1
- 5.4. Gratings / 5.3
- 5.5. Prism and Grating Configurations and Instruments / 5.4
- 5.6. References / 5.15

Chapter 6. Integrated Optics *Thomas L. Koch, F. J. Leonberger, and P. G. Suchoski* **6.1**

- 6.1. Glossary / 6.1
- 6.2. Introduction / 6.2
- 6.3. Device Physics / 6.3
- 6.4. Integrated Optics Materials and Fabrication Technology / 6.12
- 6.5. Circuit Elements / 6.20
- 6.6. Applications of Integrated Optics / 6.28
- 6.7. Future Trends / 6.37
- 6.8. References / 6.38

Chapter 7. Miniature and Micro-Optics *Tom D. Milster* **7.1**

- 7.1. Glossary / 7.1
- 7.2. Introduction / 7.2
- 7.3. Uses of Micro-Optics / 7.2
- 7.4. Micro-Optics Design Considerations / 7.2
- 7.5. Molded Microlenses / 7.4

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.