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# OPHTHALMIC LASERS:

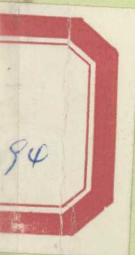
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## A Second Generation

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# OPHTHALMIC LASERS:

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## A Second Generation

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Edited by Wayne F. March, MD

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SLACK International Book Distributors

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John Wiley & Sons Limited  
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Chichester, West Sussex PO19 1UD  
England

*In Asia and India:*

PG Publishing Pte Limited.  
36 West Coast Road, #02-02  
Singapore 0512

*In Canada:*

McAinsh and Company  
2760 Old Leslie Street  
Willowdale, Ontario M2K 2X5

Foreign Translation Agent

John Scott & Company  
International Publishers' Agency  
417-A Pickering Road  
Phoenixville, PA 19460

*In Australia and New Zealand:*

MacLennan & Petty Pty Limited  
P.O. Box 425  
Artarmon N.S.W. 2064  
Australia

Publisher: Harry C. Benson  
Managing Editor: Lynn C. Borders  
Cover Designer: Susan Hermansen  
Production Manager: David Murphy

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Printed in the United States of America

Library of Congress Catalog Card Number: 88-42991

ISBN: 1-55642-057-9

Published by: SLACK Incorporated  
6900 Grove Rd.  
Thorofare, NJ 08086

Last digit is print number: 10 9 8 7 6 5 4 3 2 1



# FOREWORD

*Arnall Patz, M.D.*



The introduction of lasers in ophthalmology has had a major impact on several of the most important disorders encountered by the ophthalmologist. The use of lasers in the treatment of glaucoma and in the performance of posterior capsulotomies represents a revolutionary advance in the management of these conditions. Large-scale clinical trials have documented the beneficial role of laser photocoagulation in the treatment of proliferative diabetic retinopathy and in choroidal (subretinal) neovascularization that occurs in age-related macular degeneration and ocular histoplasmosis. The magnitude of the role of lasers can be appreciated by the impact of panretinal photocoagulation in diabetic retinopathy. The savings in the United States alone by the prevention of blindness in diabetic patients by photocoagulation has been projected to be approximately 440-million dollars annually.

Dr. March has assembled a very distinguished group of scientists who have contributed to this book. Many of these investigators have pioneered the development of the laser treatment which they discuss. Following March's introductory chapter on Fundamental Concepts, Professor G. Meyer-Schwickerath, the father of photocoagulation, has written a fascinating chapter describing his early studies and the introduction of xenon photocoagulation.

The textbook is well organized and provides a very useful description of the various laser modalities. Informative material is presented, giving the basic physics involved in the different laser instruments. This highly technical subject matter is presented in a lucid manner for the general reader who may not be familiar with laser physics. The selection of patients for treatment and the specific methods of treatment are discussed in each section.

Dr. March and his co-contributors to this volume are to be congratulated on this timely text, which provides much new and authoritative information on the very exciting applications of laser treatment in ocular disorders.



# PREFACE

Wayne F. March, M.D.

*"A laser light has been proposed for surgery of surface tissues or to be directed to the eyeball for welding a detached retina"*

— Charles Townes, 1962.

It was only two years after he made this statement that Charles Townes received the Nobel Prize for the development of the laser principle and in Chapter 1, he tells the fascinating story of his work leading to that discovery and to the creation of the word: "LASER". Obviously, the world has changed dramatically as a result. In fact, the advances in ophthalmic laser therapy just in the past five years have been so remarkable that a new edition of this textbook is mandated. Even if the reader feels that he is already familiar with the basic principles of laser application he should at least scan Chapter 2 for new concepts before going further. These "fundamental" principles have doubled since the first edition of this textbook. In Chapter 3, Gerd Meyer-Schwickerath describes his experiments which led to the first use of light to treat eye disease. These experiments pre-dated those of Charles Townes and prepared the way for the immediate application of laser to eye disease. Ophthalmology has thus led the way for other medical specialties in the application of the laser. Perhaps no laser has seen such an expanded use in ophthalmology as the dye laser within the past 3 years. Chapter 4 and 5, therefore, are devoted to the new applications of these versatile lasers. Chapter 6 is written by a true master, Donald Gass, M.D. He outlines carefully the present indications and possible new applications of the krypton laser. In the first edition of this textbook, the place of the krypton laser was unknown. Now, for certain specific applications, the krypton laser is presently the laser of choice. Chapter 7 and 8 describe the newest applications of the excimer laser which is receiving the most attention of any laser at this time. Rather few excimer lasers are currently in clinical use, however, and Michael Berlin describes why this is so.

Chapters 9 through 16 describe in detail both the theory, the present uses, and the limitations of the Neodymium:YAG laser. Chapters 11 and 12 have more than doubled in length since the first edition as our experience and knowledge in these important procedures have increased. The importance of surgical contact lenses is now established and described in two separate chapters. Chapter 14 is a new chapter describing cyclophotocoagulation, which received F.D.A. approval in 1989 and is rightfully receiving more and more widespread use every day (despite the fact that it was originally described by Hugh Beckman twenty years ago). Chapter 16 is a new chapter by Stephen Trokel describing the legal restrictions now in force.

Chapter 17 describes the use of the argon laser through an optical fiber in photocoagulation of the retina during vitrectomy. Although this is a new chapter in this edition, this application has become standard for vitrectomy surgeons. Serge de Bustros and Ronald Michels describe this application expertly but in a practical manner. Chapter 18 by Thomas Stevens, George Bresnick, Suresh Chandra, Matthew Davis and Frank Myers on laser treatment of diabetic retinopathy was considered by all reviewers to be one of the most excellent chapters in the last edition. They have continued this level of excellence in extensively revising the chapter, adding many new photographs, and updating the fine flow chart which has been so great a help to general ophthalmologists and retina specialists, alike.

Chapter 19 has been updated to show the place of argon laser treatment in macular neovascularization now that many specific cases must be treated with the krypton laser (as described in Chapter 6) or the dye laser. Chapter 21 is a remarkably candid chapter describing the historical development of laser trabeculoplasty by David Worthen. This was the last chapter of David Worthen on laser before his untimely death. Sterling Baker has updated his chapter on CO<sub>2</sub> laser blepharoplasty as this procedure receives greater attention. In Chapter 27 an outline summary has been updated of all accepted applications of laser in ophthalmology.

I was surprised at the extent of changes necessitated by the advances of the past 5 years. However, these changes are probably only a hint of what the next 5 years will bring in this rapidly developing, exciting field.

Wayne F. March, M.D.

October 1, 1989

## ACKNOWLEDGMENTS

Karen J. Long is most responsible for this textbook acting as editorial assistant and transcriptionist. Andrew Wheeler and Russ Burris are responsible for most of the photography. Terri Hamby provided many of the illustrations. My wife, Marilyn, was of essential and of immense help in proofreading and encouragement.



# CONTRIBUTORS

**Yvan Abithol, M.D.**, Director, Outpatient Service, Adolphe De Rothschild Ophthalmology Foundation, Paris, France.

**Robert Abraham, M.D.**, Encino, California.

**Daniele Aron-Rosa, M.D.**, Professor, Department of Ophthalmology, University of Paris, Chief of Service, Adolphe De Rothschild Ophthalmology Foundation, Paris, France.

**Sterling Baker, M.D.**, Clinical Associate Professor, Department of Ophthalmology, University of Oklahoma, Oklahoma City, Oklahoma.

**Hal Balyeat, M.D.**, Clinical Professor, Department of Ophthalmology, University of Oklahoma, Oklahoma City, Oklahoma.

**Michael Berlin, M.D.**, Assistant Clinical Professor, Jules Stein Eye Institute — UCLA, Los Angeles, California.

**Norbert Bornfeld, M.D.**, Department of Ophthalmology, University of Essen, Essen, West Germany.

**George Bresnick, M.D.**, Professor, Department of Ophthalmology, University of Wisconsin, Madison, Wisconsin.

**Suresh Chandra, M.D.**, Associate Professor, Department of Ophthalmology, University of Wisconsin, Madison, Wisconsin.

**Matthew Davis, M.D.**, Professor of Ophthalmology, University of Wisconsin, Madison, Wisconsin.

**Serge de Bustros, M.D.**, Assistant Professor of Ophthalmology, The Wilmer Ophthalmological Institute, The Johns Hopkins University School of Medicine, Baltimore, Maryland.

**Georg Eisner, M.D.**, Professor, University of Bern, Department of Ophthalmology, Bern, Switzerland.

**Franz Fankhauser, M.D.**, Professor, University of Bern, Bern, Switzerland.

**Donald Gass, M.D.**, Professor, Department of Ophthalmology, University of Miami, Bascom Palmer Eye Institute, Miami, Florida.

**E. Gerke, M.D.**, Department of Ophthalmology, University of Essen, Essen, West Germany.

**Ronald M. Kingsley, M.D.**, Clinical Associate Professor, Department of Ophthalmology, University of Oklahoma, Dean McGee Eye Institute, Oklahoma City, Oklahoma.

**Francis A. L'Esperance, Jr., M.D.**, Clinical Professor, Department of Ophthalmology, Columbia University College of Physicians and Surgeons, New York, New York.

**James Little, M.D.**, Clinical Associate Professor, Department of Ophthalmology, University of Oklahoma, Oklahoma City, Oklahoma.

**Hanspeter Loertscher, M.Sc.**, President, Laser Medical, Inc., Costa Mesa, California.

**Wayne F. March, M.D.**, Professor and Vice Chairman, Department of Ophthalmology, University of Oklahoma, Dean McGee Eye Institute, Oklahoma City, Oklahoma.

**Roy McCord, Ph.D.**, Executive Vice President, Laser BioTech Inc., Beverly Hills, California.

**Gerd Meyer-Schwickerath, M.D.**, Professor and Chairman, Department of Ophthalmology, University of Essen, Essen, West Germany.

**Ronald G. Michels, M.D.**, Professor of Ophthalmology, The Wilmer Ophthalmological Institute, The Johns Hopkins University School of Medicine, Baltimore, Maryland.

**Frank Myers, M.D.**, Associate Professor, Department of Ophthalmology, University of Wisconsin, Madison, Wisconsin.

**Arnall Patz, M.D.**, Professor and Chairman, Department of Ophthalmology, Johns Hopkins University School of Medicine, Baltimore, Maryland.

**George Spaeth, M.D.**, Director of Glaucoma Service, Wills Eye Hospital, Philadelphia, Pennsylvania.

**Thomas Stevens, M.D.**, Associate Professor, Department of Ophthalmology, University of Wisconsin, Madison, Wisconsin.

**Charles Hard Townes, Ph.D.**, Professor of Physics Emeritus, University of California, Berkeley, California.

**Stephen L. Trokel, M.D.**, Associate Professor of Clinical Ophthalmology, College of Physicians and Surgeons, Columbia University, New York, New York.

**W. Gary Wickham, Ph.D.**, electron microscopist.

**David Worthen, M.D.**, (Deceased) Associate Chief, Medical Director for Academic Affairs, Veteran's Administration, Washington, D.C.

# COMMERCIALLY AVAILABLE

## THERMAL DYE LASERS

Manufacturer	Model	Cost	Weight (lbs)	Argon $\lambda$ (nm)	Argon Energy Range (W)	
Biophysics Medical, Inc.	Ophthalas Dye	NS	385	488-514	to 3.5	
Coherent Medical Lasers	920 Argon/Dye	NS	550	488-514 514	to 4 to 1	
CooperVision	1000AKD	NS	375	488-514 514	0.1 to 3	
Meditec GmbH	MDS-10	NS	NS	488-514 514	to 3 to 1.5	
Meditec GmbH	MDS-90	NS	NS	488-514 514	to 10 to 3	
Meditec GmbH	MDS-90A	NS	NS	488-514 514	to 10 to 3	
Meditec GmbH	MDS-90B	NS	NS	488-514 514	to 3 to 1.5	
Meditec GmbH	MDS-90PDT	NS	NS	—	—	
Nidek, Inc.	ADC-8000	NS	530	488-514 514	0.05 to 3 0.03 to 1.3	

## PULSED DYE LASER

Manufacturer	Model	Cost	Weight (lbs)	Argon $\lambda$ (nm)	Argon Energy Range (W)	
Candela	Ophthalmic	NS	NS	None		

## EXCIMER LASERS

Manufacturer	Model	Cost	Weight (lbs)	Wavelength (nm)	
Meditec GmbH	MEL-50	NS	575	193	
Summit Technology, Inc.	ExciMed UV200	\$239,000	1400	193	
Summit Technology, Inc.	ExciMed UV200LA	\$264,000	1400	193	
Summit Technology, Inc.	ExciMed UV300 (Fiber delivery)	\$219,000	1300	308	
Taunton Technologies	LV2000	NS	2000	193	
VisX Incorporated	Twenty/Twenty	NS	NS	193	



# OPHTHALMIC LASERS

NS = Information Not Supplied by manufacturer

Dye $\lambda$ (nm)	Dye Peak (W)	Hook-up (V)	Air Cooled (AC) Water Cooled (WC)	Special Plumbing	Comments
574-640	1.2	208	WC	No	Choice of slit lamp. Heads-up display
577-630	0.9	—	WC	No	208 415 V or 220 V.
575-627	1.0	220	WC	No	Parfocal @ 50-550 $\mu$ m. Separate tube for full power red output.
570-630	1.2	220	WC	NS	Compatible with Meditec Nd:YAG.
570-680	1.5	220	WC	NS	Choice of slit lamp. Multi-user fiber port.
570-630	1.5	220	WC	NS	Choice of slit lamp. Multi-user fiber port.
570-630	1.5	220	WC	NS	Choice of slit lamp. Multi-user fiber port.
630 cw	2.5	220	WC	NS	2.5 W minimum power output from fiber.
575-630	1.3	208 or 220	WC	NS	Choice of slit lamps.

Dye $\lambda$ (nm)	Dye Peak (W)	Hook-up (V)	Air Cooled (AC) Water Cooled (WC)	Special Plumbing	Comments
666		220	AC	No	Not FDA approved

Energy (mJ)	Hook-ups (V)	Air Cooled (AC) Water Cooled (WC)	Special Plumbing	Comments
150	220	AC	—	Basic research laser system.
adjustable	110	Internal oil cooled	none required	Basic research laser system. FDA IDE approved for glaucoma filtering, astigmatism correction.
adjustable	110	Internal oil cooled	none required	Basic research laser system. FDA IDE approved for photorefractive keratectomy, superficial keratectomy
4 joules/cm <sup>2</sup> (varies with fiber optic length & diam.)	110	Internal oil cooled	none required	Basic research laser system. Potential applications: cataracts.
100 mJ/cm <sup>2</sup>	208	AC	—	Basic research laser system. Liquid nitrogen needed. Can reshape up to 7 mm dia. of corneal surface.
160-180 mJ/cm <sup>2</sup>	220	WC	—	Basic research laser system.

## Nd: YAG LASERS

Approved applications: PC = posterior capsulotomy; PM = pupillary membranectomy;

Manufacturer	Model	Cost	Weight (lbs)	$\lambda$ (nm)	Energy Range (mJ)	Switch
Biophysic Medical, Inc.	Nanolas 15	NS	175	1064	0.5 to 15	Q
Coherent Medical Lasers	7970	NS	195	NS	to 10	Q
Coherent Medical Lasers	7910	NS	195	NS	to 10	Q
Coherent Medical Lasers	7905	NS	54	NS	to 10	Q
Coherent Medical Lasers	9900	NS	215	NS	0.5 to 15	Q
Coherent Medical Lasers	7931	NS	250	NS	to 10	Q
CooperVision	2500LE	NS	220	1064	0.3 to 10	Q
CooperVision	2500	NS	220	1064	0.6 to 10	Q
CooperVision	2300	NS	220	1064	0.6 to 10	Q
CooperVision	2000	NS	105	1064	1 to 10	Q
Lasag	Topaz	NS	375	1064	0.5 to 20	Q
Lasag	Microruptor 2	NS	650	1064	0.2 to 15 2.5 to 50 110 mJ to 8 J	Q Multimode Thermal
Laserex-Keeler	LQ1106	NS	165	1064	0.5 to 10	NS
Marco Technologies	Laseron	\$37,000	89	1064	0.5 to 10	Q
Meditec GmbH	OPL-4	NS	NS	1064	1 to 5	NS
Meditec GmbH	MCW-100	NS	NS	1064 cw	—	NS
Meditec GmbH	MQL-10	NS	NS	1064	2 to 12	NS
Meditec GmbH	MQL-20	NS	NS	1064	1 to 12	NS
Meditec GmbH	MCW-60	NS	NS	1064 cw	—	NS
Nidek, Inc.	YAG-200A	NS	150	1064	0.5 to 10 +	Q
Surgical Laser Technologies	CX8	\$75,000	NS	1064	800-3000	Thermal only
Carl Zeiss, West Germany	Visulas YAG FL	\$53,000	250	1064	0.2 to 30	Q
Carl Zeiss, West Germany	Visulas YAG E	\$45,000	210	1064	0.5 to 30	Q

## ARGON/KRYPTON LASERS

Manufacturer	Model	Cost	Weight (lbs)	Argon $\lambda$ (nm)	Argon Energy Range (W)	Krypton $\lambda$ (nm)
Biophysic Medical, Inc.	Ophthalas	NS	325	488-514	to 3.5 to 1.5	647
Coherent Medical Lasers	920	NS	550	488-514 514	to 4 to 1	647
CooperVision	41AK	NS	375	488-514 514	0.1 to 3	647
CooperVision	1000AK	NS	375	488-514 514	0.1 to 3	647
HGM	5	NS	112	488 514	0 to 2	647
HGM	8	NS	120	488 514	0 to 3	647
HGM	20	NS	175	488 514	0 to 8	568
Nidek, Inc.	AKC-4000	NS	360	488-514 514	0.05 to 3.0 0.3 to 1.3	647

I = iridotomy; TC = transscleral cyclophotocoagulation.

Hook-up (V)	Air Cooled (AC) Water Cooled (WC)	Approved Applications	Comments
110	AC	PC	18", 13", 10" cone angles. Heads-up display. Dual burst modes.
—	AC	PC, I	Fundamental mode. Burst mode. 115 V or 220 V.
—	AC	PC, I	Fundamental mode. No burst. 115V to 220 V.
—	AC	PC, I	100/120/220/240 VAC (selectable); 17 x 23 x 11 packed.
—	NS	PC, I	Burst mode. 115 V or 220 V. Self-contained cooling.
—	AC	PC, I	Unit includes argon laser.
110 220	AC	PC, PM, I	Low energy attenuator (FDA approved) for reduced lens pitting.
110 220	AC	PC, PM, I	Fundamental mode. True burst mode.
110 220	AC	PC, PM, I	Fundamental mode. True burst mode.
110 220	AC	PC, PM, I	Dual HeNe aiming. Mag changer.
110	WC	PC, PM, I	Includes automatic malfunction indicator. Left and right hand control. Patient data printer.
110	WC	PC, PM, I and TC	3 modes: Q-switched, multi-mode and free-running thermal mode. FDA approved for transscleral cyclophotocoagulation.
NS	AC	PC, PM	All components integrated in slit lamp arm.
110	AC	PC	Burst mode. Infinitely variable power selection.
110	AC WC	PC	Burst mode. Compatible with argon or argon-dye laser.
220	WC		Power output of 100 W. Treatment fibers available.
110	AC		Burst mode. Dual aiming beam.
110	AC WC		Burst mode. Triple aiming beam.
220	WC		Power output of 60 W. Treatment fibers available.
115	AC	PC, PM, I	Fundamental mode. Burst mode.
NS	NS	TC, Laser Sclerostomy	Must be applied with optical fiber, variable duration in tenths of second
110	AC	PC, PM, I	4-point aiming system.
110	AC	PC, PM, I	4-point aiming system.

Krypton Energy Range (W)	Hook-up (V)	Air-Cooled (AC) Water Cooled (WC)	Special Plumbing	Comments
to 0.75	208	WC	No	Choice of S/L. Heads-on display available. Portable.
to 0.75	220	WC	No	208/415 VAC three-phase available. Choice of S/L.
to 0.75	220	WC	No	Zeiss S/L Parfocal @ 50-500 $\mu$ m.
to 0.75	220	WC	No	Parfocal @ 50-500 $\mu$ m. Upgradable to dye.
0 to 0.75	220	AC	No	S/L indirect ophthalmoscope, endolaser delivery systems available.
0 to 1.5	220	WC	Yes	See comments to HGM 5.
600 mw	220 (3-phase)	WC	Yes	See comments for HGM 5.
0.02 to 0.75	208 or 220	WC	Yes	Water cooled. Choice of slit lamps.



## ARGON LASERS

Manufacturer	Model	Cost	Weight (lbs)	$\lambda$ (nm)	Energy Range (W)	Spot Size ( $\mu\text{m}$ )	
Biophysic Medical, Inc.	Ophthalmic SP	NS	165	488-514	to 3.5 to 1.5	50 to 1000	
Biophysic Medical, Inc.	Ophthalmic Argon	NS	325	488-514	to 3.5 to 1.5	50 to 1000	
Coherent Medical Lasers	920	NS	550	488-514 514	to 4 to 1	NS	
Coherent Medical Lasers	930	NS	250	488-514 514	to 2 to 0.8	NS	
CooperVision	7500	NS	300	488-514 514	0.05 to 2	50 to 1000	
CooperVision	40A	NS	350	488-514 514	0.1 to 3	50 to 1000	
HGM	PC	NS	120	488-514	0 to 1.5	50 to 1000	
HGM	5	NS	112	488-514	0 to 2	50 to 1000	
HGM	6	NS	120	488-514	0 to 3.5	50 to 1000	
HGM	20	NS	175	488-514	0 to 8	50 to 1000	
Meditec GmbH	LPK-80	NS	NS	488-514 514	to 3 to 1.5	NS	
Meditec GmbH	ML-4000	NS	NS	488-514 514	to 3 to 1.5	NS	
Meditec GmbH	DL-5000	NS	NS	488-514 514	to 5 to 1.5	NS	
Nidek, Inc.	AC 4000	NS	340	488-514 514	0.05 to 2 0.03 to 0.87	50 to 2000	
Carl Zeiss, West Germany	Visulas	\$45,000	525	488-514	.01 to 5	50 to 1000	

## DIODE LASERS

Manufacturer	Model	Cost	Weight (lbs)	$\lambda$ (nm)	Energy Range	Spot Size	
CooperVision	STT-EDL	NS	25	810	0.5 to 500 mw	200 $\mu\text{m}$ at probe	

## Laser manufacturers:

Biophysic Medical Inc.  
2440 Estand Way  
Pleasant Hill, CA 94523  
(415) 680-2890

Candela Laser Company  
530 Boston Post Road  
Wayland, MA 01778  
(800) 255-1287

Coherent Medical Lasers  
3270 West Bayshore Road  
Palo Alto, CA 94303  
(800) 227-1914

Nidek, Inc.  
2460 Embarcadero Way  
Palo Alto, CA 94303  
(800) 223-9044

Summit Technology, Inc.  
150 Coolidge Avenue  
Watertown, MA 02172  
(617) 923-9633

Surgical Laser Technologies  
Malvern, Pennsylvania  
  
Taunton Technologies, Inc.  
580 Pepper Street  
Monroe, CT 06468  
(203) 261-4708

CooperVision, Inc.  
Laser Division  
3420 Central Expressway  
Santa Clara, CA 95051

HGM  
3959 West 1820 South  
Salt Lake City, UT 84104  
(801) 972-0500

Lasag Corporation  
6440 Flying Cloud Drive #117  
Eden Prairie, MN 55344  
(612) 941-5703

Laserex-Keeler Instruments, Inc.  
456 Parkway  
Broomall, PA 19008  
(800) 523-5620

Marco Technologies  
11825 Central Parkway  
P.O. Box 16938  
Jacksonville, FL 32245-6938  
(904) 642-9330

Meditec of America, Inc.  
616 E Street  
Clermont, FL 33516  
(800) 237-9603

VisX, Inc.  
919 Kifer Road  
Sunnyvale, CA 94086  
(408) 732-9880

Carl Zeiss, Inc.  
One Zeiss Drive  
Thornwood, NY 10594  
(914) 747-1800

Adapted from Ocular Surgery News, March 1, 1989, pp. 35-36.

Hook-up (V)	Air Cooled (AC) Water Cooled (WC)	Special Plumbing	Comments
208	WC	No	Choice of slit lamp. Heads-up display available. Portable.
208	WC	No	Parfocal zoom. Choice of slit lamp and krypton wavelength upgradable.
220	WC	No	208 415 VAC three-phase available. Choice of slit lamps.
220	WC	No	See Model 920.
220	WC	No	Small footprint. Quick disconnect. Zeiss S/L (slit lamp).
220	WC	No	Zeiss 30 S/L parfocal @ 50-500 $\mu$ m.
220	AC or WC	No	S/L indirect ophthalmoscope, endolaser delivery systems available.
220	AC	No	See comments for HGM PC
220	WC	Yes	See comments for HGM PC
220 (3-phase)	WC	Yes	See comments for HGM PC
220	AC		Choice of slit lamp.
220	AC	—	Choice of slit lamp.
220	AC	—	Variable spot size handpiece.
220	WC	No	Built-in printer, optional closed-loop cooling unit.
208 (3-phase)	WC	No	Slit lamp with micromanip. mounted on joystick.

Hook-up	Air Cooled (AC) Water Cooled (WC)	Special Plumbing	Comments
110 220	Not required	No	Safety shutter. Argon equivalent. Lightweight. Portable. Endophotocoagulation.

# INTRODUCTION

## I



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