

Set Lighting Technician's Handbook

Film Lighting Equipment, Practice,
and Electrical Distribution

Fifth Edition
Harry C. Box

A Focal Press Book



Set Lighting Technician's Handbook

A friendly, hands-on training manual and reference for lighting technicians in motion picture and television production, this handbook is the most comprehensive guide to set lighting available. It provides a unique combination of practical detail with a big-picture understanding of lighting, technology, safety, and professionalism, essential to anyone doing motion picture lighting.

The fifth edition delves into every aspect of lighting and features vastly expanded sections on controlling LED lights, color science, lighting control systems, wireless systems, Ethernet-based control systems, battery power, and modern set protocol for productions small and large. With a generous number of original images, the book illustrates the use of soft light, the effect of lighting angles, and how the gaffer and DP build an effective lighting plan around the blocking of the actors. This encyclopedic volume of technical knowhow is tempered with years of practical experience and a much-needed sense of humor.

This is the ideal text for professional lighting technicians across film and television including lighting directors, gaffers, DOPs, and rigging crews, as well as film and television production students studying lighting, camera techniques, film production, and cinematography.

It includes a revamped companion website with supplementary resources, forms, checklists, and images.

Harry C. Box has worked in the motion picture and television industry since 1987 with significant experience as a lighting technician and gaffer and later as a camera operator. Harry also works for the industry trade association ESTA focusing on issues relevant to the motion picture/television market.



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

Set Lighting Technician's Handbook

Film Lighting Equipment, Practice,
and Electrical Distribution

Fifth Edition

Harry C. Box

 **Routledge**
Taylor & Francis Group
LONDON AND NEW YORK

Fifth edition published 2020
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

and by Routledge
52 Vanderbilt Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group, an informa business

© 2020 Harry Box

The right of Harry Box to be identified as author of this work has been asserted by him in accordance with sections 77 and 78 of the Copyright, Designs and Patents Act 1988.

All rights reserved. No part of this book may be reprinted or reproduced or utilised in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying and recording, or in any information storage or retrieval system, without permission in writing from the publishers.

Trademark notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

First edition published by Elsevier 1993
Fourth edition published by Focal Press 2013

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
Names: Box, Harry C., author.
Title: Set lighting technician's handbook : film lighting equipment, practice, and electrical distribution / Harry C. Box.
Description: Fifth edition. | London ; New York : Routledge, 2020. | Includes index.
Identifiers: LCCN 2019046122 (print) | LCCN 2019046123 (ebook) | ISBN 9781138391697 (hardback) | ISBN 9781138391727 (paperback) | ISBN 9780429422560 (ebook)
Subjects: LCSH: Cinematography—Lighting—Handbooks, manuals, etc.
Classification: LCC TR891 .B68 2020 (print) | LCC TR891 (ebook) | DDC 777/.52—dc23
LC record available at <https://lcn.loc.gov/2019046122>
LC ebook record available at <https://lcn.loc.gov/2019046123>

ISBN: 978-1-138-39169-7 (hbk)
ISBN: 978-1-138-39172-7 (pbk)
ISBN: 978-0-429-42256-0 (ebk)

Typeset in Times New Roman
by Apex CoVantage, LLC

Visit the companion website: www.routledge.com/cw/box

For my mother and father



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

Contents

Preface	xxi
Acknowledgments	xxiii

CHAPTER 1	Set basics: Your first barbecue	1
	Job descriptions of the lighting crew	1
	Director of photography	1
	Gaffer	2
	Best boy electric	3
	Lighting technicians	3
	Lighting control personnel	4
	Rigging crew	4
	The fixtures person (or department)	5
	Generator operator	5
	Grip department	6
	The company	6
	Production staff	7
	The director's team	7
	Script supervisor	9
	Camera department	9
	Sound department	10
	Locations	10
	Transportation	11
	Art department	11
	The general public	11
	Block, light, rehearse, tweak, shoot	12

CHAPTER 2	Preproduction planning: The package, expendables, personal tools	15
	Preproduction planning	15
	Scouting locations	16
	Production meetings	16
	Wireless spectrum management meeting	18
	The load-in	19
	Prepping lights and stands	19
	The production van	21
	Expendable supplies	24
	Gels and diffusion	24
	Electrical expendables	24

Tools and personal gear	27
Tool belt	27
Meters	29
Other hand tools	29
Personal gear	30
CHAPTER 3 Lighting objectives	31
Storytelling objectives	31
Mood	31
Naturalism	32
Composition	32
Time constraints	33
Photographic objectives	33
Light level	33
Foot-candles	34
F-stops and T-stops	35
Factors affecting light levels	37
Contrast, latitude, and the tonal value	39
Spot meters	40
Calibrated monitor	42
Signal monitoring	42
CHAPTER 4 Lighting strategies	47
Motivating and reactive lighting	47
Lighting faces	49
Rembrandt cheek patch lighting	49
Near- and far-side keys	52
Side light	52
Wrapping the key	53
Front light	55
Bottom light	58
High in front or high to the side	58
The lighting triangle	59
Fill	59
Eye light	60
Backlights, kickers, and hair lights	60
Lighting the acting positions	64
Back cross keys	65
Lighting the space and the background	66
Ambience	67
Backdrops	67

CHAPTER 5	Manipulating light: Tools, techniques, and the behavior of light	69
	Falloff: your friend, the inverse square law	69
	Cuts and patterns	71
	Breakup patterns	73
	Cucaloris	73
	Branchaloris	73
	Tape on an empty frame	74
	Shading and selectively controlling brightness	74
	Movement	74
	Flicker effects: television screen, flame, and fire	75
	Other moving light effects	76
	Soft light	76
	Softness of light	77
	Linear light sources	79
	Bounce light	79
	Diffusion materials	80
	Diffusion on the fixture	83
	Fabric soft boxes	83
	Controlling soft light	83
	Flags and teasers	83
	Grids, egg crates, and louvers	85
	Lanterns	86
CHAPTER 6	Color	87
	Color space	87
	Kelvin color temperature scale	89
	Shifting color up and down the color temperature scale	91
	Using MIREL units to calculate color shifts	91
	Correlated color temperature (CCT)	92
	Green/magenta axis	93
	Measuring color	94
	Colored light	95
	LED full-color	95
	Theatrical gels	96
CHAPTER 7	LED lights	97
	Capabilities of LEDs	97
	Color options	98
	Phosphor white, daylight, or tungsten	98
	Remote phosphor	100

Bi-color	100
The reasons behind tunable-white and full-spectrum lights	102
Full spectrum	102
LED color control methods	103
Lighting effects	108
Dimming LEDs	108
Dimming curves	108
Bottom of the dimmer range	110
The seven things every lighting technician should know about LEDs	110
Control	111
Soft light fixtures	112
Rigging versatility with lightweight softlights	113
Small “face” lights	114
Larger full-featured heads	115
Green/blue screens, backings, and translights	115
ARRI SkyPanel®	123
Establishing base settings	123
Settings menus	124
Light operation	125
LED tubes	126
Single- and bi-color tubes	127
Full-color tubes	129
Pixel tubes	132
Ribbon and tiles	134
Ribbon	136
Power and control	136
Soldering	137
Other LED form factors	139
Orbiter	139
Automated fixtures	140
Camera-mounted and small LEDs	140
Ring lights	141
Portable wall wash	141
Punchy LEDs	142
Architectural	144
CHAPTER 8 Established lighting instruments	145
Tungsten	145
HMI and other metal halide arc lamps	145
Fresnels	147

Flood/spot control	148
Tilt angle	152
Fresnel beam	152
Fresnel accessories	154
20k and 24k tungsten lights	156
PAR lights	156
PAR lamps	157
PAR cans	158
PAR arrays	159
Axially mounted PAR fixtures	160
Ellipsoidal reflector spotlights	164
Dedolights	168
Beam projectors	168
Area lights and backing lights	169
Space lights	169
Backing lights	169
Cyc strips	171
Open-face lights	173
Tungsten	173
HMI “open-face” lights	173
Tungsten soft lights	176
CHAPTER 9 Operating HMI lights	179
HMI lamps	179
ARRIMAX	179
Double-ended lamps	181
Other notes about HMI lamps	181
Normal HMI operation	182
Striking	183
DMX512-controlled ballasts	184
UV protection and the safety loop circuit	184
Color temperature	185
Operating conditions	186
Troubleshooting	186
Power	188
Cueing for HMIs	189
CHAPTER 10 Stands and rigging	191
Stands	191
Baby stands	191

Junior stands	193
Offsets, side arms, extensions, and right angles	195
Using stands	195
Crank-up and motorized stands	197
Grip stands	199
Booms	202
Rigging hardware	203
Nail-on plates	203
Set wall mounts	204
Clamps	204
Grids and greenbeds	206
Other rigging hardware	207
CHAPTER 11 Set protocol	209
Set protocol	209
Staging area	209
Lighting the set	209
Walkie-talkies	214
Safeties	215
Protecting sets and locations	215
Teamwork	215
Warnings	215
Stingers and cabling	216
Cables crossing the set	216
Cables crossing work areas	216
Stingers	216
Preventing kick-outs	217
Repatching	218
2k plugging policy	218
Labeling stingers and power cords	218
Coiling stingers and cable	218
Circuit balance and capacity	219
Overheating and short circuits	220
Smoke, fire, and other bad smells	220
Sprinkler systems	220
Elevated work	220
Ladders	220
Parallels	221
Working at height	221
Aerial lifts (Condors and scissor lifts)	221

Color correction on location 222

 Correcting commercial/industrial fluorescents 222

 Heat protection and gels 222

 Gelling windows 223

Practical bulbs 224

 PH bulbs and photoflood bulbs 224

 MR-16 224

 Mushroom floods 224

 Dimming practical lamps 225

 Wiring fixtures and outlet boxes 225

The wrap 227

 Coiling feeder cable 228

 Inventory 228

Replacing lamps 228

 Matching the lamp to the fixture 228

 Mercury 229

 Replacing tungsten and HMI lamps 229

CHAPTER 12 Lighting control networks 233

DMX512 234

 DMX512 addressing 236

 The patch 238

 Fixture numbers 238

 The cheat sheet, fixtures, and universes 239

DMX values and device personality 240

 General Device Type Format (GDTF) 242

 Multiple DMX512 universes 242

Remote Device Management (RDM) 247

Building wired DMX512 systems 248

 Deviations from the standard 249

 Data termination 250

 Capacity 251

 DMX cable 251

 Optical isolators and splitters 252

 DMX512 testing 255

 Loss of signal 256

Ethernet, Art-Net, sACN, and RDMnet 257

 DMX over Ethernet 257

 Other Ethernet protocols 261

 RDMnet 261

Advantages of Ethernet	262
Lighting control apps	264
Wi-Fi	264
Wireless DMX	266
To be or not to be wireless	267
Wireless DMX transmitters and receivers	269
Satellite™ and Constellation	269
Bluetooth	271
Mesh	272
Wireless system management	273
DMX controllers and lighting consoles	273
Small controllers	273
Consoles	274
Console operations	275
Pixel mapping	277
CHAPTER 13 Electricity	279
The fundamentals of electricity and electrical formulas	279
Volts (electromotive force)	280
Amperes (current)	280
Watts (power)	280
The power formula	281
Resistance	283
Ohm's law	283
Parallel and series circuits	287
How NOT to use electrical formulas	290
AC vs. DC	292
Power systems	293
240/120 single-phase, three-wire plus ground system	294
208/120 three-phase, four-wire plus ground system	297
Single-phase derived from delta-connected, three-phase system	301
480/277 V three-phase system	302
Electrical safety systems	302
Control devices and polarity	302
Overcurrent protection	303
The current-carrying capacity of cable	304
Types of feeder cable	306
Equipment grounding	308
System ground	309
Generators	309

Ground rods	309
Bonding power sources	310
CHAPTER 14 Power distribution equipment	311
Components of a simple portable distribution system	311
208 V vs. 240 V systems	313
Overcurrent protection and cable ampacity	314
Protecting cable at its ampacity	314
Step-down box	314
The 400 percent rule	315
Feeder runs	316
Camlock connectors	316
Reversed ground system	317
Parallel cable	317
Test jacks	317
Camlock spiders	318
Distribution centers	319
Multi-pin connectors and receptacle boxes	320
Stage pin (Bates) connectors	321
Edison	322
NEMA L6–20 and L6–30	324
PowerCON and TRUE1	324
Socapex	324
Adapters	328
Adapters for big lights	330
DMX-controlled distribution and power with data	330
CHAPTER 15 Dimming equipment	333
Color temperature	333
Dimming types and applications	333
Household dimmers	334
Variac dimmers	334
Lunchbox dimmers and silent on-set dimmers	335
Dimmers tailored for LEDs and small incandescent lamps	335
Stand-alone dimmers	336
Dimmer packs	337
Dimmer racks	337
Wireless DMX on-set dimmers	338
Dimmer packs and racks	340
Dimmer rooms	341

Electronic dimmer designs	341
Forward-phase control dimmers—SCR	341
Reverse-phase control dimmers	343
Sinewave dimmers	345
Strand CD80 dimmer packs	345
Installation and setup	346
Troubleshooting	348
ETC sensor dimmer system	350

CHAPTER 16 Electrical rigging 355

The role of the rigging gaffer	355
Rigging paperwork	356
Layers of an electrical system	358
Hard-power layer	358
Dimmer-circuit layer	358
Control layer	359
Cable and generator loading	359
Sizing neutral conductors	361
Sizing equipment grounding conductors	361
Sizing grounding electrode and bonding conductors	361
Rigging cable	361
Protect your back	362
Traffic areas	362
Fire lanes	362
Identifying cable, labeling circuits	363
Lacing feeders	364
Ventilating and separating runs	366
Waterfalls	366
Placement of distribution boxes	368
The Gak package	369
Root out bad contacts	369
Testing the system before use	369
Testing for short circuits	369
Testing neutral and ground continuity and resistance	370
Making the feeder connections	370
Testing voltage	371
Lugs and buss bars	371
Knots for rigging	372
Loop knots	372
Binding hitches	372

Other useful hitches	375
Bends	376
Strength of rope	377
Rigging lights	379
Rigging aerial lifts	381
Cabling	384
Condor duty	386
CHAPTER 17 Working with electrical power	387
Voltage drop and line loss	387
Causes of voltage drop	388
Allowable voltage drop	389
Mitigating voltage drop	390
Simple line loss calculations	390
Single-phase voltage drop calculations	392
Finding the voltage drop	393
Finding cable gauge	394
Finding the maximum current	395
Finding the maximum length	395
Three-phase voltage drop calculations	396
Single-phase loads	396
Three-phase loads	397
Cable resistance	398
Power factor	399
Power factor correction	400
Non-linear loads and harmonics	402
Switch mode power supplies	402
Harmonics	403
Additive neutral current	404
Skin effect and proximity effect	405
Strategies for coping with large non-linear loads	406
Measuring electricity	407
AC Circuit Load Tester	408
Circuit testers	408
Testing continuity and testing for shorts	409
Voltage meters	410
Measuring amperage	412
Wattmeter or power meter	412
Power quality meter	412
Measuring frequency (Hz rate)	413

Circuit breaker finder 413
 Meter categories 414
 Electrical shocks and muscle freeze 414

CHAPTER 18 Power sources 417

Rechargeable batteries 417
 Battery types and mounts 417
 Voltage 420
 Current 421
 Battery capacity, run time, and charging 424
 Charge time 426
 Combining batteries with plates and power stations 426
 Options for powering lights with batteries 427
 Shipping and flying with batteries 430
 Battery chemistry and care 431
 Inverters 434
 Large battery packs 435
 Using available outlets 435
 Getting organized 435
 240 V receptacles 436
 Putt-putts (small portable generators) 437
 Retrofits and alternative configurations 437
 Parallel generators and step-down transformers 441
 Running the generator 441
 Troubleshooting small generators 442
 How does a generator work? 444
 240-to-120 V transformer 444
 Full-size generators 445
 Electrical configurations 447
 Control panel 449
 Generator placement 450
 Selecting a generator 451
 480 V transformer 451
 Power (kVA) 452
 How transformers work 454
 Using a 480 V system 454
 Line drops from utility power 455
 Tie-ins 455
 Approach protection 456

CHAPTER 19 Special circumstances and practices	457
Shooting on moving vehicles	457
Poor man's process and other techniques	458
Lighting in and around water	459
Working with electricity around water and damp environments	459
GFCI protection	460
GFCI devices	461
Testing equipment	463
Protecting equipment	464
Lighting rain	466
Underwater lighting	466
Electricity in water	466
Modern underwater fixtures	467
The underwater lighting arsenal	468
Features of underwater fixtures	469
Surface support	469
Lighting for matte photography	469
Pure screen color and density	470
Lighting the foreground	470
CHAPTER 20 Specialty lighting equipment	473
SoftSun	473
Lighting balloons	474
Lightning effects	476
Lightning Strikes!	477
Control units	478
Power requirements	479
Running Lightning Strikes! on generators	479
Thundervoltz battery packs	479
Automated lights	480
Selecting moving lights	482
Working with moving lights	485
Remote pan and tilt for conventional lights	486
Media servers and video projectors for lighting effects	487
Xenon lights	489
Follow spots	491
Preparing the follow spot	493
Operating the follow spot	494
Black lights	496
Black light fixtures	496

Photographing with black light	497
CHAPTER 21 LED color science and technology	499
Systems for evaluating color rendering	500
What's wrong with CRI?	501
Extended CRI, CRI 15	501
TLCI-2012 and TLMF-2013	503
Spectral Similarity Index (SSI)	504
What to watch for	505
Why different cameras see the same colors differently	506
Gamut	506
Selecting the color space of a light	508
Matching colors, ANSI E1.54	508
LED technology	509
LED power supply, controller, driver, and dimming	510
LED useful life	510
APPENDIX A Photometric calculations and tables	513
APPENDIX B Lamp tables	523
APPENDIX C Flicker-free frame rates	535
APPENDIX D Electrical tables	539
APPENDIX E IP and NEMA equipment ratings	543
APPENDIX F Equipment suppliers and manufacturers	545
APPENDIX G Gels and diffusions	551
APPENDIX H LED lights	563
Glossary	571
Index	589

Preface

Lighting practices for film and television production have undergone many transformations since the summer of 1991, when I first began making notes for what eventually became the first edition of this book. At that time, the conversion from vintage DC distribution equipment to AC was still taking place. Lots of different distribution systems had popped up; there was no dominant standard for connectors and junction boxes. SCR dimmers were suddenly becoming a big part of motion picture lighting for the first time, bringing with them the attendant issues of harmonic currents. Electronic HMI ballasts were new to our industry and were pretty shaky at first. It took a few years of burning out different parts of the ballast before manufacturers arrived at the bullet proof reliability we have come to expect today.

At that time there was little or no formal training for lighting technicians. Electricians learned from each other on the job. For many old-school electricians, three-phase AC systems, power factor, current harmonics, and even grounding, were new concepts. At that same time, a much larger percentage of production in Los Angeles was non-union. Necessity being the mother of invention, these thriftier productions spawned many innovative lighting techniques that have since become common practices, but they also often resorted to methods that were actually potentially hazardous. One way and another there was a great deal of confusion and misinformation being circulated. It was in this context that I first undertook writing a book for lighting technicians in the film and television industry, with the goal of thoroughly researching the many issues I was aware of, in order to offer lighting technicians an authoritative source of information and guidance.

This book has existed in a time frame spanning a massive shift toward greater awareness and education for lighting technicians. To some extent, it has been a part of that shift. The fourth edition of the book reflected the formalization of training and rethinking of safety that occurred since the early 90s. Risks that were once casually accepted were now addressed with better technology and work practices. Things like using flammable materials or non-UL-listed parts, use of electricity around water, proper grounding, these are just a few of the areas where safety was improved in our daily work.

Revising a book is a great way to take stock of the impacts of technological change. The industry has just completed two enormous leaps forward—first the painful transition from film to digital capture in the early 2000s, and second, the LED revolution in the 2010s. What topic in this book has *not* been touched by this technology? It has given us a nimbler way to color light, which forced more sophisticated control technology. It has spawned new data/power management solutions. It has vastly increased our use of small power, like batteries, small generators, and house power. It has made rigging smaller and lighter and the production footprint not quite as deep. LED technology has changed the crew roles. Juicers now need to be IT technicians and RF engineers. It brought us systems techs, fixtures techs, and elevated the lowly dimmer board operator to full wizard status as lighting console programmer.

It has changed the way lighting technicians and gaffers work on set. It has taken light that was once static and breathed life into it, enabling it to move, morph, sputter, and travel. Built-in lighting effects, creative use of pixel mapping, the ability to fade between colors and to change the look, time of day, and atmosphere within the duration of a shot, DPs are finding exciting ways to harness the technology as tools for visual storytelling. Never before has so much been so relatively easy to do. While in some ways the changes have made things easier and increased the efficiency of production, they have also raised the expectations placed on DPs and on their lighting crews. The changes have added substantially to the knowledge base that lighting technicians need to master. So, with all that going on, we are clearly due for a new edition.



Taylor & Francis

Taylor & Francis Group

<http://taylorandfrancis.com>

Acknowledgments

While writing the fifth edition, I was very fortunate to have the support of many top professionals in production as well as experts in the manufacturing sector. Their generosity, insights, and perspective make this book possible.

I gratefully acknowledge the many manufacturers who provided technical information, photographs, and illustrations. The manufacturers are listed in Appendix F.

I am very grateful to Mike Bauman for his generous input and terrific photographs. The man is an amazing wealth of creative talent and knowhow. Thanks to my friend and colleague Mark Doering-Powell for his ongoing advice and terrific artwork and photographs that appear in the book. I truly appreciate the continual feedback of Ted Hayash, Mark Weingartner, and Mike Ambrose, who also contributed photos. Thanks to programmer Scott Barnes for his thoughtful input, as well as the hospitality of Jared Wellman, Jason Young, Mark Hartman, and Jay Yowler who had me over for a set visit and shared their experiences.

Max DeMayo took the photo for the cover of this book. Thanks also to Al DeMayo, John Clisham, Paul Royalty, and Sean Goossen at LiteGear for supporting the project. Thanks to John Cini and the good folks at High Output, Boston for their generous hospitality. The fifth edition benefited greatly from those who read and commented on certain sections of the manuscript: Craig Brink and Adam Knapp at RatPac, Mark Wofford and Gary Murck at PC&E, Atlanta, Zack Shannon at CORE SWX, and Brian Doran and Jane Rein at ARRI. Guy Holt contributed his photos and perspective from his ongoing research into power quality issues. Frieder Hochheim and his team at Kino Flo shared research on LED color science.

For their contributions to the fourth edition, I owe a debt of thanks to Richard Cadena, Josh Thatcher, Jeff Levi, and John Amorelli for their input on the subject of lighting control technology and moving lights. Thanks to Mike Wood (Mike Wood Consulting), Rob Gerlach (Selador/ETC), Ryan Fletcher (ARRI), David Amphlett (Gekko), Jim Sanfilippo (NILA), Richard Lund (Philips), and Lee Ford Parker (JiffyFX.com) for their valuable contributions to the chapter on LEDs. Thanks to the terrific team at ARRI Lighting, John Gresch, Mike Jones, Aeron Weller, and An Tran for their continuing support, and contributions especially in regard to HMI troubleshooting. Other experts in the field helped shape this new edition: Steve Terry (ETC), Michael Lay (Strand) lent their expertise on dimming; Bob Cookson (Illumination Dynamics), Russle Saunders (Saunders Generators), and Ron Dahlquist (Dadco) on transformers and generators; John Parkinson (Power To Light), Paul Tipple and Phil Ellems (Power Gems) on HMI electronic ballasts; Stewart Lennox (battery packs); Michael Skinner on entertainment industry applications of the National Electrical Code; Andy C. Huber on underwater lighting; and my old friend and colleague Brian O'Kelley lent an AD's perspective to the opening chapter. Other lighting professionals who contributed include Erik Messerschmitt, Dave Devlin, Dwight Campbell, Martin Weeks, and many others. My thanks to the Local 728 Safety Training Program and Contract Services, especially Allan Rowe, whose comprehensive work developing Skills Training courses for Local 728 plays no small part in helping the membership remain the best trained, most experienced lighting technicians in the world. My sincere thanks to the many individuals who gave me feedback and suggestions for the fourth edition: Daniel Aleksic, David E. Elkins, John Gates, Michael Hofstein, Seth Jason, and Stephen Lighthill.

This book was first published in 1993. I am deeply indebted to many individuals for their generous contributions to this book over the years: Darryl Murchison, whose discussions during the early stages of writing the first edition helped set the book on course; Doug Pentek, Earl Gilbert, Larry Parker, Cyrus Yavneh, Russ Brandt, Dean Bray, Herb Breitling, Michael Kaiping, Scott Toland, and Jon Bart, all of whom read and improved sections of the book in its first and second editions; Richard Mula and Pete Romano, who shed much light on the subject of underwater lighting; Frank “the Dinosaur” Valdez and Gary Scalzo, who lent their expertise to the section on rigging; and Vance Trussell, whose suggestions and ongoing interest and encouragement were invaluable to me. My thanks to Eric King, who shared his expertise on HMIs and electronic ballasts. My thanks to Bernie Kret at Strand, who helped upgrade the section on electronic dimmers for the second edition. I owe a debt of gratitude to Chris Barratt, without whose generosity and vast experience I could not have created the section on generator troubleshooting, and whose legacy lives on.

A special note of thanks to the illustrators, Shawn Murphy and Lisa Cyr, who created the hand-drawn illustrations for the first edition and who may well have been inking drawings on their wedding night to make the publication deadline. Thanks also to John Huey, who created additional artwork for the second edition. For new illustrations in the third edition, I thank Dan Haberkorn. Thanks to Laura Mancini and Keith Morgan.

I am grateful to the publishing team at Taylor and Francis for their patience with me, and their care and professionalism in preparing this book.

I am thankful, once again, to Joan Box, my faithful and talented (unofficial) copyeditor who has taken an interest in my writing since I was first able to form letters. It is a true testament to a mother’s love that she endures all this techno mumbo-jumbo, but it is always a joy to work together on it.

Finally, my love, thanks, and appreciation go to my loving wife, Stacey, and to my family, who are officially completely sick of this book at this point, and with good reason. Thank you for your patience and support.

Set basics: Your first barbecue

1

All the technical aspects of filmmaking—cameras, lighting, sound, visual effects—involve a myriad of small details that, taken as a whole, seem impossibly complex. As with any craft, to become a master requires years of experience and exposure to many different situations. It has been my experience, however, that no single piece of equipment, procedure, or technique is really complicated; there is no one thing that cannot be explained and understood in less than 10 minutes. Making movies is the artful application of millions of relatively simple details. This book helps with some of those details, describing procedures that save time and promote safety, clarifying aspects of the craft that are confusing and often misunderstood, and supplying a wealth of information about the hundreds of gadgets of which lighting technicians are so fond.

Starting with the basics, we begin with a summary of the role of the lighting crew on a film set.

JOB DESCRIPTIONS OF THE LIGHTING CREW

The electric, grip, and camera departments fall under the supervision of the *director of photography* (DP). The *gaffer* and *key grip* are the DP's lieutenants. The gaffer is the head of the electric department, in charge of the lighting crew. The gaffer's crew consists of a *best boy electric*, *lighting technicians*, and often a *lighting control programmer* or *dimmer board operator* and a rigging crew.

Director of photography

Q: How many directors does it take to screw in a lightbulb?

A: One; no, two . . . no, no one.

The DP is the director's right hand. It is the DP's responsibility to create in images what the director has envisioned for each scene; to evoke the proper time, place, and atmosphere by means of lighting; and to help choose camera angles and camera movement that will be most effective in telling the story and covering the scene. He or she designs the lighting, balancing realism against the dramatic potential of more stylized effects, as called for by the script and the director. The DP's responsibility for lighting and photographing the actors requires careful attention to how their face takes light. The DP must maintain proper screen direction (a responsibility shared with the script supervisor) and lighting continuity between setups so the film can be edited seamlessly. The DP has a say in the design and color of the sets and the wardrobe and in the selection of locations. The DP works closely with the *assistant director* (AD) to schedule scenes at the right time of day for the best light.

The DP usually shoots tests prior to the beginning of photography. He or she may experiment with lighting effects, with different color casts, levels of contrast and saturation, filters, and lenses that combine to create specific looks, which answer the special requirements of the script. The DP may also conduct his or her own research prior to production to ensure the authenticity of a period look and to inspire ideas for the cinematography.

The DP holds a position of immense responsibility, creatively and financially. The producer and director both depend on the DP to achieve photographic excellence within the constraints of the production's budget and schedule. The DP always faces conflicts in fulfilling the needs of the script, director, schedule, and budget and meeting his or her own aspirations for the photography. The lighting crew fights the DP's battles on the front lines. Their ability to light the set in a time-efficient manner directly affects the DP's ability to produce great work.

Gaffer

Q: How many gaffers does it take to screw in a lightbulb?

A: How many do we have on the truck?

The gaffer is the chief lighting technician (CLT), the head of the lighting department. He or she works directly with the DP to implement the lighting plan and help achieve the photographic look of the film. The DP, the gaffer, and the key grip attend preproduction meetings together and scout the locations where filming is to take place. They discuss the DP's approach to each scene and determine what lighting preparations and equipment are required. Gaffers are problem solvers. They often have to design a special rig, fabricate a gadget, or implement technology in some idiosyncratic way to give the DP something he or she is looking for, or to provide time efficiency during production. It falls to the gaffer and key grip to research possible solutions, source the materials, design all the specifics, and if necessary, present the plan to the DP and to the production manager for approval, and then see the plan to fruition.

On the set, the gaffer is responsible for the execution of the lighting scheme and the organization and operation of the lighting crew. The DP and the gaffer discuss the lighting. Typically, when talking about the actor's lighting, the DP may specify the placement of each fixture to accomplish a particular effect. Sometimes the DP may leave it to the gaffer to translate general ideas into specifics. The DP may express the goals in terms of the motivating sources of light for the scene, the mood, and the f-stop at which to shoot. The gaffer then instructs the crew and sees to the exact placement and focus of each light to accomplish the DP's instructions. Once the gaffer has executed the lighting, the DP may "sweeten" it to taste, with a few adjustments.

The gaffer must have a very strong eye for lighting and a solid knowledge of which lights to use to create any desired effect. As the lighting starts to come together, the gaffer functions as a second pair of eyes for the DP, always on the lookout for problems—inadequate light, overexposure, hot spots, ugly shadows, and so on. Together, the DP and gaffer look for opportunities to make the scene look more interesting. The gaffer has a critical eye for the balance of light and shade, the modeling of facial features, and the separation of foreground from middle ground and background. He or she may carry a light meter on their belt for measuring light levels. The gaffer is often next to the DP, viewing the monitors, watching for lighting issues and calling for adjustments over the walkie-talkie.

A very important part of the gaffer's job is organizing and running the lighting operations. He or she must constantly be cycling through the many tasks at hand, pushing forward the progress of each project, keeping an eye on the performance of the lighting crew, thinking ahead so that the lighting technicians will have power and lights readily at hand for subsequent shots, and forestalling delay.

The gaffer should never have to leave the immediate area in which the action is being filmed. He or she must rely on the crew to be close at hand to make lighting adjustments and fetch equipment when it is needed. Once the lighting is complete, the grips and electricians clear the set, but remain nearby, in case a tweak is called for between takes. The lighting crew is always under time pressure. A technician who stays near the action, listens, and thinks ahead can do a lot to help the gaffer and DP win their daily battle against time.

Best boy electric

The best boy electric is the assistant chief lighting technician. He or she is in charge of personnel and equipment for the electrical department—a vital role in the smooth running of the lighting crew. One of the best boy's duties is scouting locations with the gaffer, making scouting notes to help the gaffer compile the list of equipment needed. The best boy supervises the equipment inventory from the load-in at the beginning of the show, through each day of the shoot, and through the wrap and return. The best boy orders expendable supplies. He or she coordinates equipment orders, returns, subrentals, and special orders with the production department and transportation departments as necessary. The best boy supervises the loading of the truck at the rental house before the first day of production, organizes the equipment and supplies in the truck for easy access, makes sure that no equipment gets lost at each location, and keeps track of damage. The best boy supervises maintenance and repairs when possible. The best boy is in charge of hiring and laying off additional lighting technicians when needed. The best boy supervises the electrical crew's startup paperwork and time cards. When there is no rigging gaffer hired, the best boy may also plan the routing of the feeder cable and supervise the distribution of electrical power to the lights.

Most important, the best boy is the emissary of the electrical department, communicating and coordinating with other departments, with the fire marshal, and with rental houses, and other equipment suppliers. A best boy who maintains good relations with each department can get cooperation when it is needed. For example, when the best boy needs to put a light on the roof of a building, the locations team must make the necessary contacts to secure that spot. When the best boy needs some extra equipment delivered quickly, his or her relationships with the transportation department and the contact at the rental house come into play. The best boy's diplomacy is key.

Lighting technicians

Q: How many electricians does it take to screw in a lightbulb?

A: It's not a bulb, it's a globe.

Affectionately known as *juicers* or *sparks*, electricians are officially titled *set lighting technicians* or *lamp operators*. The electrician's primary responsibility is placing and focusing lights according to the wishes of the gaffer. At each location, the electricians unload and reload the lighting equipment from the trucks, run cabling, and run the distribution of electrical power for the lights. On the set, electricians are responsible for placing and focusing (aiming) the lights; manipulating the intensity, direction, color, and quality of light; wiring practical lamps (such as table lamps and wall sconces), switches, and wall outlets on constructed sets; and anticipating the needs of the gaffer so that equipment is at hand when needed. Lighting technicians secure lights and stands; however, the grip department also plays a role, such as hanging pipe or truss for the lights, securing a stand with straps, or screwing it down with grip-chain.

There is a Zen to the job of the lamp operator. An experienced lamp operator handles the equipment with deft speed and economy of movement that comes with familiarity. Through the exchange of a few words or hand signals, or by clairvoyance, the electrician grasps the gaffer's intention and manipulates the lamp to create the desired effect. His or her focused concentration is on two things: the activities of the lighting crew and the behavior of the light. The lamp operator is constantly attentive to the DP and gaffer and to fellow electricians who might need a hand. Simultaneously, the electrician is aware of the light falling, blasting, leaking, and spilling onto the faces and the surfaces around the set.

The set lighting crew may be asked also to provide power for fellow crew: camera, sound, dolly, and video village. Lighting technicians typically relinquish responsibility for powering vehicles at the base camp to the transportation department. Although powering the base camp is technically within the union jurisdiction of lighting technicians, being trained to handle electrical distribution equipment, most of the time the gaffer simply does not have the personnel to spare for anything extraneous to the set. Despite the nickname, movie electricians are very rarely licensed journeymen or master electricians. They are not qualified to wire buildings or work inside electrical panels. Their job is lighting movies.

Lighting control personnel

Lighting control refers to controlling lighting remotely via a control console, dimmer board, laptop, tablet or other device. A person who operates a computerized control console is called a *lighting control programmer*. A person who operates a dimmer board is called a *dimmer board operator*, or *board op*.

The importance and sophistication of this position on the crew has evolved drastically as lighting devices have gone from having one controllable parameter, via dimming, to having many parameters of control including color temperature, hue, saturation, and special effects. On a good-sized set, it is common for the programmer to have several thousand control channels under their command. The programmer is responsible for organizing the system including supervising assignment of DMX channels to lighting devices, selecting control modes and other device settings, running data lines, setting up wireless networks, and protecting these systems from failure and interference.

The programmer is responsible for grouping and organizing the devices on the control console so that even a large number of lights can be controlled in an intuitive and functional manner. The programmer must be able to respond quickly to instructions from the gaffer or DP to set levels and colors, write lighting cues, and execute the cues during the take. The programmer typically saves important lighting setups as cues so the levels can be recalled for future setups, so the task of organizing and archiving the data is also part of the job.

On a big production, responsibilities are delegated to one or more *systems techs* (also called *DMX techs* or *control techs*). There may be any number of people organizing and addressing DMX512 devices or assisting in other aspects of setting up and maintaining communication networks and control systems. When a lot of moving lights are used, the production may also have one or more *moving light techs*.

Rigging crew

A rigging crew is an important part of almost any project, be it a feature, episodic TV series, or even a television commercial. The rigging crew works ahead of the main unit, installing cable and distribution boxes, hanging lights, and taking care of any work that will be time-consuming for the main unit

to accomplish on the day of filming. The electric rigging crew works in tandem with the grip rigging crew. This may involve weeks of work to rig a major set or half a day laying in some cable on location.

A rigging crew consists of a rigging gaffer, rigging best boy, and rigging electricians. A rigging crew is invaluable to a production, especially to the DP and gaffer. The thought, planning, and careful, unrushed work, testing, and troubleshooting put in ahead of time translates into smooth sailing for the shooting crew. A properly rigged set means that the lighting will look better and the unit lighting technicians can work with greater efficiency. *Unit* lighting technicians are the *on-production* team, as opposed to the rigging crew who are *off-production*. *First unit* and *second unit* refer to separate film crews working on the same production. First unit typically works with the principal actors, while a second unit typically works on setups that would be too time consuming for the first unit, such as visual effects, miniatures, animals, establishing shots, beauty shots, but sometimes actual scenes with actors as well. The rigging crew usually also wraps out the set after the unit crew has finished with it.

The fixtures person (or department)

More and more, sets that require a futuristic or otherworldly high-tech look or a whole lot of razzle-dazzle are lit mostly by LED light engines that are built into the set. The set essentially lights itself. Often built-in lighting is selected to create a wide variety of colors and looks, so the look can change radically and be adaptive to whatever dramatic action is taking place.

On tentpole movies, the fixtures department can be bigger than the rigging crew, filling dozens of universes of DMX with lights throughout the set. The fixtures department is responsible for all the on-camera lighting. To avoid problems like flicker and color temperature issues, and because it needs to be controlled with the rest of the lighting, on-camera light sources need to be selected and supervised by a lighting technician who is a specialist in fixtures. Just like the first unit gaffer, the fixtures supervisor has to work closely with many other departments. For built-in lights they work with set design and construction. For *practical lights*, such as a sconce or table lamp, they work with the set decorator. Sometimes wardrobe has lighting in it like space helmets or underwater helmets, which involves issues of safety, practicality, and comfort for the actor. Like the gaffer, the fixtures person has to be smart, respectful, and collaborative in their conversations. Maintaining good relationships with the producer's team and other departments is essential to keeping things moving smoothly. The right personality is quite critical.

The skillset of top fixtures people has to be pretty diverse. They have to be familiar with fabrication techniques in a variety of materials—metals, fiberglass, plastics. They have to be comfortable specking-out and replacing electronics for practical lights when off-the-shelf electronics are unsuitable. They could be called upon to control any kind of light, which can include challenges like controlling the headlights of a moving vehicle, for example. They have to organize large data networks and work with a variety of control protocols including pixel mapping protocols in addition to standard Ethernet and DMX. Since the lights are to be photographed, there's also aesthetic and design decisions and careful craftsmanship involved.

Generator operator

The generator operator is in charge of the full-time operation and maintenance of the generator. A knowledgeable, experienced generator operator is an extremely valuable person to the set lighting department. Most genny operators today are teamsters. The production van driver typically operates the generators on the tractor. There is no special training, test, or apprenticeship program to be a

generator operator. People who lack the proper experience are of absolutely no use to you when a generator starts to hiccup. Especially when you are on a remote location where a generator cannot be quickly replaced and you encounter issues with climate, fuel, and other conditions that affect the generators, it is especially worthwhile for the gaffer and DP to insist on using a qualified generator operator.

Grip department

Q: How many grips does it take to screw in a lightbulb?

A: Grips don't change lightbulbs. That's electric.

Nonelectrical lighting equipment is handled by our brothers and sisters in the grip department. A grip is affectionately called a *hammer*. Silks, diffusion frames, flags, reflector boards, rigging, dollies and dolly track, cranes, jib arms are all in the domain of gripology. You could say that the lighting technicians do the lighting and the grips do the shading. Each time an electrician sets up a light, a grip is right next to him or her with a *grip package*, which includes a C-stand and whatever flags, nets, or diffusion frames may be needed in front of the light. Lighting technicians graduating from the nonunion world may be used to grips taking charge of placing sandbags on the light stands, providing ladders, and leveling large stands when they are placed on uneven ground. On union jobs in Los Angeles, the electricians generally handle their own ladders, sandbags, and rigging hardware, such as pipe clamps. Grips handle gel and diffusion when used on a frame or applied to windows. An electrician applies the gel and diffusion when it goes directly on a light.

Grips are responsible for the safety of the rigging, and they are often called on to rig support for lighting equipment and backdrops. Truss, I-beam rails, chain motors, speed-rail grids, wall spreaders, and similar rigs are built by the grips. When lights are to be hung from an overhead grid or rigged to the wall of the set, the grips generally rig the support. An electrician then clamps on the light, plugs it in, and focuses it. When lights are mounted on a high platform, on top of parallels, in the basket of an aerial lift, or on an elevated platform, the grips rig and secure the light and light stand. When an interior night scene needs to be shot during daylight hours at a practical location, the grips build big black tents around the windows to create darkness outside, while providing space for lights outside the building. During production the grips are in charge of removing, and reinstalling set walls as needed during filming.

The head of the grip department is the *key grip*. The key grip supervises the grips in the same way that the gaffer supervises the lighting technicians. He or she works for the DP in tandem with the gaffer, supervising the grips in the placement of grip gear in front of each light.

The key grip's chief assistant is the *best boy grip*. The best boy grip coordinates the grip crew in the same way that the best boy electric does the electric crew.

The *dolly grip* is in charge of operating moving-camera platforms, such as dollies and cranes: laying and leveling the dolly track, moving the camera smoothly up and down and to and from exact marks with precise timing. Grips also rig support for the camera when it is placed in unusual places, such as on top of a ladder or on the hood of a car.

THE COMPANY

A film crew is composed of freelance artists, technicians, and actors who are brought together by the production company when the production is ready to be mounted. The producer and director select the department heads: the DP, production designer, sound mixer, editor, and so on. Each department head usually brings his or her own staff to the production. Usually the DP recommends a gaffer, key

grip, camera operator, and camera assistants with whom he or she prefers to work. The gaffer, in turn, recommends lighting technicians he or she knows and trusts.

Each production brings new faces, new locations, and new circumstances, yet you can count on certain constants in relationships between electricians and the other departments.

Production staff

Q: How many production managers does it take to change a lightbulb?

A: None! If you'd just make it a day exterior we wouldn't have to keep screwing around with all these lightbulbs!

Officially, the crew is hired by the producer. Although the gaffer usually selects electricians for the crew, once an electrician is offered a job, it is the *unit production manager* (UPM) with whom he signs the crew deal memo. The UPM authorizes paychecks that are handled by the accounting department and issued through a payroll company.

The duties of the UPM include establishing and controlling the budget, making deals for locations and services, booking the crew, overseeing daily production decisions such as authorizing overtime and making schedule changes due to weather, and managing all the off-set logistics, including housing, meals, transportation, permits, security, and insurance. Because the UPM is responsible for executing the budget, he or she must approve all equipment orders and personnel requests.

Some productions have a *production supervisor* as well as (or in some cases instead of) a production manager. This distinction between production manager and production supervisor is that a UPM has served many years as an AD and has joined the Directors Guild of America (DGA), whereas a production supervisor has not. Typically, a supervisor has previously worked as a production coordinator working in the production office, not on set.

The *production coordinator* assists the production manager. His or her duties include booking the crew, booking and returning equipment, ordering expendables and supplies, monitoring petty cash, distributing production information to the various departments, and coordinating and distributing the shooting schedule and script revisions. The production manager, the production coordinator, and their staff work out of the production office, along with the accounting department.

The director's team

The “director’s team” consists of the ADs, the production assistants (PAs), and the script supervisor.

Assistant director

During preproduction, the first assistant director (1st AD) prepares the script breakdown and production schedule and coordinates the actions of every department and the cast. He or she plans each day’s schedule and gives final approval to each day’s call sheet, which is usually prepared by a second AD. During production, the 1st AD runs the set. He or she is responsible for keeping the production moving and on schedule on an hour-to-hour basis. The 1st AD keeps everyone informed about the shots, constantly plans ahead and facilitates, coordinates, and motivates the actions of the crew in order to solve problems before they occur. The 1st AD must stay informed of any potential delays or problems. Every production company is required to have an appointed safety officer. On a studio lot, the safety officer is provided by the studio; for independent shows, the 1st AD is the default safety officer. Part of the 1st AD’s job is calling and running safety meetings. An onset safety briefing, for which all the relevant

crew are assembled, is given to alert the crew to the specific safety issues of the shot, the location, or the day in general.

The 1st AD is backed up by a 2nd AD, who in turn are helped by 2nd 2nd ADs and a squad of PAs. The AD staff takes care of the actors: coordinating their schedules, and ushering them through makeup, hair, and wardrobe and to and from the set. The AD staff also directs the action of background artists (extras) and supervises crowd control.

ADs and PAs can be called upon to help coordinate between departments. For example, if a lighting technician needed some furniture moved to place a light and the onset dresser was nowhere in sight, the 1st AD would have him found in short order.

Prior to the first take, the AD calls “last looks,” which alerts the makeup, hair, and wardrobe onset personnel to make final touches. The 1st AD initiates each take by calling “Picture is up,” a warning to everyone to finish whatever they are doing and get ready for the take. This is followed by “Roll sound.” These instructions are broadcast over the walkie-talkie to all the ADs and PAs, who echo “Rolling” throughout the set, so that everyone knows to settle in for the take and be quiet. Following the take, “Cut” is broadcast by the 1st AD, and again, the AD staff echo it for the crew.

Other announcements:

“We’re in” or “We’re back.” Announced at the start of the day and after lunch respectively to call the company to work.

“Going again.” A second take will be rolling immediately.

“Hold the roll.” There has been a momentary delay. This cues the sound mixer to stop recording while the problem is fixed.

“MOS.” Sound will not be recorded for the shot. The term comes from the early days of sound. It is an acronym for “minus optical stripe.”

“Fire in the hole!” Announced before gunfire or explosions. Be prepared for a loud noise to follow.

“Check the gate.” If the project is captured on film, after each shot has been successfully completed and the director is ready to move on, the camera gate must be inspected before the next shot is announced. If there is a “hair” in the gate, the shot may have to be retaken.

“Moving on” or “New deal.” The director is ready to move to the next setup.

“Turning around.” The next setup is the reverse coverage or sees the scene from the opposite direction.

“Company move.” The next setup is at a new location.

“That’s lunch, one half-hour.” The company is at lunch. You can head to the catering truck, or do something else, just be back in 30 minutes.

“Abby Singer is up.” The Abby Singer is the second to last shot of the day. It was named for (former) AD Abby Singer, who always had “just one more shot” after the last shot of the day.

“Martini is up.” The martini is the last shot of the day. (Your next shot will be out of a glass.)

“That’s a wrap.” The last shot of the day has been successfully completed. If filming has been completed at this location, the lighting crew begins wrapping: taking down the lights, coiling the cable, and loading the truck.

“Make it safe,” “Walk away.” When filming will resume in the same place, and things can pretty much stay where they are, the ADs may say “make it safe.”

Script supervisor

The *script supervisor* makes careful notes on the script and keeps a running log that shows scene and take numbers, lenses used, shot scale, movement, eyeline direction, good takes, flawed takes (and the reason why they were flawed), line changes including ad libs and flubs, and so forth. These notes are used to recall matters of continuity and to note for the editor what coverage was taken and which takes the director thought were the best. In a way, the script supervisor is the onset advocate for the editor, consulting with the director on questions of screen direction and coverage. Matters of continuity are often small details that have to be carefully noted—in which hand an actor holds his beer, at what point in the scene he puts out his cigarette, whether his shirt sleeves are rolled up . . . all the things that everyone sees but no one notices. For this reason, it is vital for her (or him) to be able to see the action on every take; if you stand in her way, you risk being jabbed by her sharp little pencil. The gaffer sometimes has the best boy take detailed notes on the placement of the lights, especially if the scene may be replicated at another time. The script supervisor can provide the best boy with the applicable scene numbers for these notes. The camera assistants and sound recordist also get this information from the script supervisor.

Camera department

Q: How many camera assistants does it take to screw in a lightbulb?

A: Five. One to screw it in and four to tell you how they did it on the last show.

The camera department is made up of the DP, camera operator, first camera assistant, second camera assistant, and, when shooting in a film format, a loader. When shooting in a digital format, the camera crew may include a *digital imaging technician* (DIT) and a camera/digital utility person and digital loader.

The *camera operator* sets the shot and operates the camera. The operator is charged with the responsibility of keeping the lights, grip equipment, and microphones out of the shot. If you are setting a light close to the frame line, the camera operator can tell you where it is safe. It is a very good idea that the camera operator set the shot before the lighting crew starts lighting it, as important details, such as the exact placement of the actors, and what background will be photographed, may change during this process. Although this may cause the lighting crew to hold off on the work inside the set for a couple of minutes, ultimately it saves having to set lights twice.

The *first camera assistant* (1st AC) is responsible for the camera, including building it, configuring it (physically and in terms of electronic settings) for each shot, making lens changes and performing regular maintenance as needed. During the take, the 1st AC keeps the camera in focus and may perform any of a multitude of other tasks—zooming, making an aperture change, or ramping the shutter speed or angle. The 1st AC never leaves the camera's side.

From time to time, the 1st AC calls on the lighting crew to help get rid of lens flare—light hitting the lens that may flare on the image. Usually the grips can set a flag or hang a “teaser” to keep the light off the lens.

The 2nd AC aids the 1st AC with lens changes and magazine changes, marks the actors' positions, slates each shot, and keeps the camera reports and film inventory. Almost all camera equipment runs on batteries, but a 2nd AC needs power to run a video monitor. When a director uses a video monitor, it quickly becomes habit to supply power to the monitor as soon as the camera is placed. Similarly, a hot extension cord should be supplied for the dolly at all times.