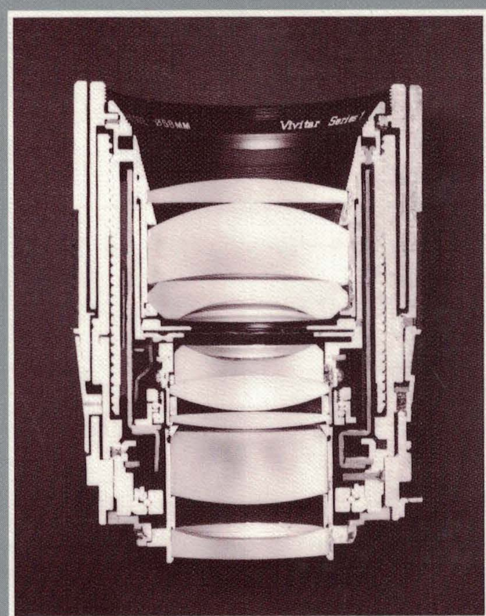
Optics in Photography



f1.4

f2.8

Rudolf Kingslake

f5.6

Library of Congress Cataloging-in-Publication Data

Kingslake, Rudolf.
Optics in photography / Rudolf Kingslake.
p. cm.
"A Publication of SPIE—the International Society for Optical Engineering."
Includes bibliographical references and index.
ISBN 0-8194-0763-1
1. Photographic optics. I. Title.
TR220.K56 1992 92-11861
771.3'5--dc20 CIP

Published by SPIE—The International Society for Optical Engineering
P.O. Box 10
Bellingham, Washington 98227-0010

Design: Matt Treat
Composition: Carrie Binschus

10 9 8 7 6 5 4 3 2 1

Printed in the United States of America

Chapter 6

The Brightness of Images

The relation between the aperture of a lens and the brightness of the image produced by it on the photographic emulsion is often misunderstood, yet it is of the greatest importance to the photographer who wishes to make the best use of the equipment. The tremendous efforts of lens designers and manufacturers that have been devoted to the production of lenses of extremely high relative aperture are an indication of the need that exists for brighter images and "faster" lenses.

In this chapter, we are concerned with the flow of light from an object, through a lens, to the image. Several photometric terms must be understood before we can give a precise statement of this effect, and of the factors that control the brightness of the image projected on the film in a camera.

The *illumination* (illuminance) produced by a lamp at any distance from it is found by dividing the candle power of the lamp by the square of the distance (the inverse square law). Thus, a 50-candle lamp will produce, at a distance of 3 feet, an illumination of 50/9 = 5.6 foot-candles. The illumination in a well-lighted factory or classroom may reach 50 foot-candles, and in motion-picture or television studios, illuminations as high as 200 to 300 foot-candles are common.

The term *flux* is used to express a quantity of light. The unit of flux is the lumen, defined as the amount of light falling on each square foot of a surface under an illumination of 1 foot-candle; hence, foot-candles and lumens per square foot are two ways of expressing the same thing. The convenience of this term may be seen by an example. Suppose we know that a certain 16mm projector emits 550 lumens. Then, if the projected image is 3×4 ft, the average illumination on the screen will be 550/12 = 46 foot-candles; if the image is 5×6.6 ft, the illumination will be $550/(5 \times 6.6)$ = 16.7 foot-candles, and so on.

The *brightness* (lumin
power per unit area. Thus,
lamp has about 2500 candl
is thus about 25 candles pe
brightness, but it is excee
projection, which sometir
millimeter, and by the sur
2000 candles per square m
At the other end of th
under ordinary room light
calculating the brightness

where k is the reflectivity
illumination in foot-candl
the illumination in the ro
brightness of white paper w
This is equal to 14/930 = (
are 930 square millimeters
The formula (6.1) co
surface is not always appl
sandblasted metal, metalli
tends to reflect light some
equal to the angle of incid
brighter than white paper
duller than white paper in
in this chapter (page 135)
The inconvenience of
new brightness unit has bee
to $1/\pi$ = 0.32 candles per s
required to express the brig
of candles per square foot. I

B_L

We conclude, therefo
reflective and perfectly diffu
candles falling upon it.