

# **UNDERSTANDING RADIOGRAPHY**



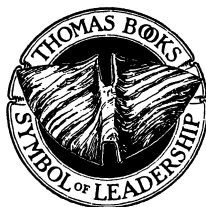
Fourth Edition

# UNDERSTANDING RADIOGRAPHY

*By*

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**CHARLES C THOMAS • PUBLISHER, LTD.**  
*Springfield • Illinois • U.S.A.*

*Published and Distributed Throughout the World by*

CHARLES C THOMAS • PUBLISHER, LTD.  
2600 South First Street  
Springfield, Illinois 62704

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©2003 by CHARLES C THOMAS • PUBLISHER, LTD.

ISBN 0-398-07135-7

Library of Congress Catalog Card Number: 2002032335

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*Printed in the United States of America  
SM-R-3*

**Library of Congress Cataloging-in-Publication Data**

Hiss, Stephen S.

Understanding radiography / by Stephen S. Hiss.--4th ed.

p. cm.

Includes bibliographical references and index.

ISBN 0-398-07135-7 (hard)

1. Radiology, Medical. I. Title.

RC78 .H52 2003

616.07'572--dc21

2002032335

*To my wife Patricia  
and my daughters Kimberly and Laura*



## PREFACE TO FOURTH EDITION

Since the first image of human anatomy was made in the late 1800s, medical diagnostic imaging has contributed significantly to the advancement of healthcare in a most extraordinary and unique manner. Indeed, the developments of new imaging devices throughout the history of diagnostic imaging has made a profound contribution in helping to define how medicine is practiced today by a wide range of physicians. From the first fluoroscopic machine, to the development of nuclear medicine, ultrasound, and more recently CT, MRI, and PET scanners, we have significantly expanded our ability to “see” diseases and make diagnoses at their earliest stages. In many ways this capability has saved lives, and stimulated research among physicians, scientists, and pharmaceutical companies to develop treatments and medications to correct or bring a wide range of serious diseases under control that would have otherwise resulted in increased morbidity and mortality.

This truly unique contribution provides many of us who are intimately involved with radiology services with a strong sense of pride. These advances come from a lineage of gifted, inspired, and demanding physicians, technologists, and physicists who worked together to look beyond the present and sought what only they could imagine. It has been a continuous infusion of creativity, vision, and tough mindedness among these professionals that brought new diagnostic capabilities to everyday clinical use, and further revolutionized healthcare treatments to improve the lives of countless numbers of patients.

In the early 1970s, we experienced a rush of excitement as scientists, technologists, and physicians worked together to integrate computer technology with x-ray producing equipment, and built the first CT scanners. This marvel of mechanical and electrical engineering, medical science, and computer technology opened a new and exciting world of disease imaging capabilities that could not have been imagined only a few years before. Today, the startling images we see with MRI scanners, along with newly developed and complex interventional techniques have allowed radiology services to

actually take the place of routine exploratory and complex corrective surgery—and advanced PET scanning. Techniques are likely to expand our knowledge and understanding of complex brain functions, and will no doubt lead us to other effective treatments that are not currently available.

Today, we are seeing diagnostic imaging technology pass through another threshold that offers additional capabilities and potential. At a time when there is ample justification for excitement about faster and faster MRI and CT that can produce even more diagnostic information—and new images from PET, we are also seeing the implementation of PACS technology. PACS will revolutionize how general diagnostic images are produced, archived, and distributed throughout the healthcare community. Technologists who work with general radiographic equipment are now learning how to use computerized and direct digital technology, and they are seeing how PACS will impact patient care and their everyday professional lives.

The fourth edition of *Understanding Radiography* not only contains updated and refreshed material on familiar imaging technology, it also provides thorough explanations with many original illustrations of high speed CT imaging, PACS networks, and computerized radiography. Further, it contains new insights that will help prepare students as well as experienced technologists on how these technologies can be used to provide the highest level of imaging services possible.

I recently heard someone say that people tend to think of “technology” as something that had been discovered only during their more recent life experience. Indeed, technology seems to be perception rather than reality because we often discount or take for granted what has [always] been available before our time as common and fundamental. Someday, MRI and PET scanners, along with a host of other developments, may also seem to be common and fundamental. For today, [our] new medical imaging technology adds to an already vast arsenal of imaging equipment which places technologists in a unique and commanding position. Despite the excitement of a new piece of equipment, we should always keep in mind that these devices have little merit on their own. The merit in these devices is realized when they are placed in the hands of skilled technologists who have a strong sense of professionalism and an ability to exhibit compassion toward their patients’ best interests.

S. S. H.



## PREFACE TO THIRD EDITION

New information is presented to cover tabular drain film and high frequency generators. Updated and new information is also presented on the subject of radiation protection and x-ray tubes.

A new chapter has been prepared on computerized tomography. This new chapter contains basic information, yet it is sufficiently comprehensive to make it a very worthwhile addition to the text that will orient the student soundly to this very interesting imaging modality. The discussions covering the history, major components, its value to medical diagnostic services, as well as methods of image reconstruction are explained in a fashion that is informative and easy to understand.

Additional updated information is also presented in the chapter covering digital imaging that will keep the student current with essential information on this fast developing technology.

S. S. H.



## PREFACE TO SECOND EDITION

The First Edition of this work provided a firm base of information of radiographic imaging.

Four new chapters have been added which expand considerably the scope of this text.

It has been endeavored to provide, in a very practical format, a devotion to detail as this relates to the day-to-day clinical experience of the technologist. In this expanded edition, each of the four new chapters at the back of the book provides coverage of full and sufficient depth so that accurate insight may be obtained by the reader.

There has now been included a comprehensive chapter on radiation protection, covering complete and necessary details.

There is a complete chapter on radiographic tubes, x-ray production, and the nature and characteristics of x-radiation.

A chapter on the x-ray circuit utilizes a very clear and practical approach to this potentially confusing subject.

It has seemed important to include, in simple and concise terms, a chapter on T.V. cameras, image intensification, and digital fluoro subtraction.

S. S. H.



## PREFACE TO FIRST EDITION

**D**uring the early planning stages of this text, a few important prerequisites were self-imposed in the firm belief that their absence would yield a publication so similar to those presently available that another text simply would not be justified. The information presented within the following pages is in some instances new ground for even the experienced technologist while, in other instances, old familiar concepts have been reassessed and aligned more closely with current data.

An important goal which had been set is that strict attention and ample time would be given to the many aspects of radiography which have, in the past, been treated perhaps too simplistically. Although complex physical formulae are not contained in this volume, an attempt has been made to not merely present these concepts of modern radiography for purposes of identification, but also to discuss and analyze each issue at hand from more than one perspective. Without this more rounded approach, much of the meaning is often lost, and as a result misconceptions and frustrations take the place of enlightenment.

It has been my intention from the outset that the information within these pages be presented in such a way that it can be readily understood, and that each concept discussed is covered thoroughly enough and with sufficient depth that an accurate insight can be gained to bridge the gap students often feel is present between classroom theory and its practical application.

In the end, it is often the concept of an idea that is most important to remember, because from it one can learn to answer many of his own questions.

The primary intention of this text is to provide those concepts and insights from which the technologist can grow into a competent professional.

S. S. H.



## ACKNOWLEDGMENTS

No undertaking of this type can be accomplished without a considerable amount of encouragement, conversation, advice, and reliable facts. Those individuals who have freely given their knowledge regarding radiography have my warmest and deepest appreciation: A great deal of thanks is heartily given to Mr. Thomas Callear, Mr. Edward Cook, Mr. Lee Erickson, and Mr. Robert Trinkle for their hours of time, valued information, and advice.

A number of commercial representatives also freely gave time from their busy schedules to help me obtain data I would not have otherwise been able to present in these pages. In appreciation for their individual efforts, I would like to thank Mr. Donald Becker, Mr. James Funk, Mr. Gary Goodridge, Mr. Harry Harter, Mr. William Orledge, Mr. Gene Oxley, Mr. Tony Passarelli, Mr. Lin Tiley, and Mr. James Wagner.

I would like to also express my thanks to Mr. B. Gilman Cutting for his help and suggestions.

Much appreciation is given to those who helped in proofreading the typed manuscript. Their opinions and comments weighed heavily in the final preparation of this text. For their effort, I would like to thank Ms. Rosann Allen, Ms. Cathy Blose, Ms. Veronica Brodovicz, Ms. Lynda Callaway, Mr. Ernest Griffith, Ms. Catherine Harbaugh, Ms. Mary Matas, Ms. Joann Newell, and Ms. Deborah Wolf.

I would also like to thank Mr. Michael Martinchick for his time in preparing the negatives used in the text, and for his skill, sincere encouragement, and concern for the success of this writing.

I wish to thank Dr. Albert Salzman, Dr. Sigmond Rutkowski, and the Associates in Radiology for making available important radiographs from the teaching library of the Division of Radiology at The Atlantic City Medical Center. I would also like to thank Mr. Charles Broomall, Administrator at A.C.M.C., for his help and consideration.

Sincere thanks must be given to Mr. Jonathan Law and Carmine Pierno for their interest and effort.

There are moments in one's career when a single choice must be made

regarding the direction of one's career. Mr. Frank Horvath will never be forgotten for the opportunity he afforded by introducing me to radiography and for his unselfish guidance, good will, and trust.

Mr. Jack Cullinan's help and treasured advice have given me a wealth of knowledge and insight into radiography. His thoughtfulness, knowledge, and good will cannot be properly expressed in words, only felt within.

For the help and long hours spent printing the negatives to meet high standards, I very much want to thank Mr. Leroy Knupp, Ocean City Camera Shop, Ocean City, New Jersey.

The illustrations in this text were provided by Ms. Sue Criss. Her talent and cooperation in their preparation are indeed appreciated.

For the opportunity to work with a publisher who expresses sincere interest in the author's well-being without sacrificing quality, I wish to thank Mr. Payne Thomas. His attitude throughout this project was one of support, trust, and the provider of valued guidance. To Mr. Thomas and his staff at Charles C Thomas, Publisher, I wish to express my sincere appreciation for their help and effort.

Mrs. Patricia Donnon deserves a great deal of thanks for laboring through my first set of handwritten notes and putting them into the first typing. Untold hours must have been spent deciphering those scribblings.

In the long run, good will and trust often determine the success of an undertaking. For those gifts, unselfishly provided me throughout my early years, I wish to thank my parents, Nicholas and Sophia.

In the preparation of the third edition, I was fortunate indeed to receive the help of Mr. Robert Murphy, and Mr. Bud Leonard of E. I. DuPont without whom the discussion covering tabular grain film could not have been written.

Special consideration must also be given to Dr. Dev Chakraborty, Ph.D., Chief of Radiation Physician, Hospital of the University of Pennsylvania, whose knowledge and expertise in the area of CT digital image modalities resulted in his coauthorship of Chapter Seventeen. His considerable experience and knowledge provides a comprehensive and easy to understand presentation of CT imaging.

The companion publication, *Lab Book & Study Guide*, has been reformatted and expanded to include: Chapter Learning Objectives, Experiments, and an Overview. These changes are the direct result of a collaboration with Mr. Gary Woogenrich, Program Director, North Hampton Community College. His extensive experience, insight, creativity, and council have resulted in a very useful study of the main text.

The information and council freely provided by Mr. Douglas Pfeiffer, M.S., Radiation Physicist, Hospital of the University of Pennsylvania, also deserves considerable recognition. His work in reviewing and updating Chapter Thirteen is very much appreciated.



## CONTENTS

	<i>Page</i>
<i>Foreword to the Fourth Edition</i> . . . . .	vii
<i>Foreword to the Third Edition</i> . . . . .	ix
<i>Foreword to the Second Edition</i> . . . . .	xi
<i>Foreword to the First Edition</i> . . . . .	xiii
<i>Chapter</i>	
One	
CHARACTERISTICS OF THE RADIOGRAPHIC IMAGE . . . . .	3
Objectives . . . . .	3
<i>Radiographic Balance</i> . . . . .	4
Radiographic Contrast . . . . .	7
Elements of Radiographic Contrast . . . . .	9
Why Different Film Contrasts Are Used . . . . .	11
Radiographic Density . . . . .	12
Elements of Radiographic Density . . . . .	14
<i>Visibility versus Sharpness of Detail</i> . . . . .	16
Sharpness of Detail . . . . .	17
Visibility of Detail . . . . .	17
<i>Sensitometry</i> . . . . .	19
The Location of The H & D Curve . . . . .	21
The Shape of The H & D Curve . . . . .	21
Film Latitude . . . . .	25
Film Contrast . . . . .	25
Determining Film Contrast from The H & D Curve . . . . .	26
Base Plus Fog . . . . .	27
Study Questions . . . . .	28
Two	
RADIOGRAPHIC IMAGING FILM . . . . .	29
Objectives . . . . .	29
<i>A Historical Perspective</i> . . . . .	30

	Film Manufacturing . . . . .	31
	Composition of Medical Imaging Film . . . . .	32
	Film Base and Its Characteristics . . . . .	34
	Base Plus Fog . . . . .	36
	Silver Bromide Grains . . . . .	37
	Film Contrast and Latitude . . . . .	39
	Anatomy of an Image . . . . .	40
	Gelatin . . . . .	42
	Film Speed . . . . .	43
	Tabular Silver Bromide Grains . . . . .	44
	Anti-Cross-Over Layer . . . . .	45
	Film Mottle . . . . .	46
	Today's Highly Engineered Film . . . . .	47
	Processing Film Emulsions . . . . .	47
	User Expectations of Medical Imaging Film . . . . .	48
	Latent Image Formation . . . . .	50
	The Crystal Lattice . . . . .	51
	<i>Developer and Fixer Solutions</i> . . . . .	55
	Chemical Fog . . . . .	57
	Study Questions . . . . .	59
Three	<b>AUTOMATIC PROCESSING</b> . . . . .	61
	Objectives . . . . .	61
	<i>Introduction</i> . . . . .	61
	Centralized Versus Dispersal Processing . . . . .	63
	Early Automatic Processors . . . . .	63
	<i>Safe Light Filters</i> . . . . .	66
	<i>Major Systems in Automatic Processors</i> . . . . .	68
	The Transport System . . . . .	68
	The Margin of Error . . . . .	69
	The Crossover Assembly . . . . .	69
	Artifacts Commonly Linked to Transport Problems . . . . .	70
	The Replenishment System . . . . .	71
	Overreplenishment . . . . .	72
	Underreplenishment . . . . .	74
	Setting Replenishment Rates . . . . .	77
	The Drying System . . . . .	79
	Drying Problems . . . . .	80
	The Recirculating System . . . . .	82
	<i>Troubleshooting Processor Problems</i> . . . . .	85

	Explanation . . . . .	86
	Dark Films . . . . .	86
	Light Films, Poor Contrast . . . . .	86
	Films Have a Brownish Appearance . . . . .	87
	Films Have a Milky Appearance . . . . .	87
	Films Have a Greasy Appearance . . . . .	88
	Jamming . . . . .	88
	Scratches . . . . .	88
	Black, Flaky Marks . . . . .	89
	Increased Fog . . . . .	89
	<i>Routine Maintenance</i> . . . . .	90
	Sensitometric Strips . . . . .	90
	<i>Environmental Conditions</i> . . . . .	90
	Silver Recovery . . . . .	92
	Study Questions . . . . .	93
Four	INTENSIFYING SCREENS . . . . .	94
	Objectives . . . . .	94
	<i>A Historical Perspective</i> . . . . .	95
	Composition of Intensifying Screens . . . . .	96
	The Radiographic Effect of Using Intensifying Screens. . .	98
	Image Resolution . . . . .	98
	Radiographic Density . . . . .	99
	Modulation Transfer Function . . . . .	102
	Quantum Mottle . . . . .	106
	Radiographic Contrast and Intensifying Screens . . . . .	109
	The Phosphor Light Emission Process . . . . .	110
	Screen Artifacts . . . . .	112
	Rare Earth Screens . . . . .	117
	Screen Maintenance . . . . .	118
	Study Questions . . . . .	119
Five	MILLIAMPERAGE . . . . .	120
	Objectives . . . . .	120
	<i>Definition and Function</i> . . . . .	121
	The X-ray Tube Filament . . . . .	122
	Ma, Heat, Focal Spot Size, and Radiographic Sharpness .	124
	Reciprocity Law . . . . .	126
	<i>Milliamperage Calibration</i> . . . . .	128
	<i>Patient Dose and Milliamperage</i> . . . . .	130

	<i>The Radiographic Effect</i> . . . . .	130
	Density and Milliamperage . . . . .	130
	Contrast and Milliamperage . . . . .	130
	<i>Exposure Time</i> . . . . .	134
	Exposure Time and the X-ray Beam . . . . .	137
	Exposure Time and Scatter Radiation . . . . .	138
	Automatic Timing Devices . . . . .	139
	Study Questions . . . . .	143
Six	<b>FOCAL FILM DISTANCE</b> . . . . .	144
	Objectives . . . . .	144
	Introduction . . . . .	144
	<i>The Geometric Beam (or Projected Beam)</i> . . . . .	145
	<i>Focal Film Distance and The Inverse Square Law</i> . . . . .	146
	<i>Focal Film Distance and Radiographic Contrast</i> . . . . .	150
	Choosing The Correct Focal Film Distance . . . . .	152
	<i>The Line Focus Principle</i> . . . . .	153
	The Point Source . . . . .	154
	Focal Spot Size . . . . .	155
	Three Ways to Control Penumbra . . . . .	156
	<i>Object Film Distance and Magnification</i> . . . . .	164
	The Magnification Technique . . . . .	169
	Prerequisite for Magnification Technique . . . . .	171
	Object Film Distance and Scatter Radiation . . . . .	176
	Additional Advantages in Using Increased Object Film Distance . . . . .	176
	<i>Distortion of The Radiographic Image</i> . . . . .	178
	Shape Distortion . . . . .	178
	Size Distortion . . . . .	178
	Stereotactic Procedures . . . . .	180
	The Anode Heel Effect . . . . .	184
	Study Questions . . . . .	185
Seven	<b>KILOVOLTAGE</b> . . . . .	187
	Objectives . . . . .	187
	<i>Definition and Function</i> . . . . .	188
	Kilovoltage, Tube Current, and the X-ray Tube . . . . .	188
	Kilovoltage and the X-ray Circuit . . . . .	191
	<i>Beam Quantity and Quality</i> . . . . .	191
	Kilovoltage and Beam Quality . . . . .	192

	Wavelength Distribution . . . . .	193
	Kilovoltage and Subject Contrast . . . . .	196
	<i>Exposure Latitude and Kilovoltage</i> . . . . .	199
	Kilovoltage, Patient Dose, and Beam Efficiency . . . . .	201
	<i>Kilovoltage and Scatter Production</i> . . . . .	204
	Kilovoltage, Radiographic Density, and Contrast Techniques . . . . .	207
	Fixed versus Variable KvP Techniques . . . . .	210
	Study Questions . . . . .	213
Eight	<b>THE HUMAN BODY AS AN EMITTER AND BEAM MODIFIER</b> . . . . .	214
	Objectives . . . . .	214
	<i>Major Absorbers of The Body</i> . . . . .	217
	Some General Facts Regarding Body Habitus . . . . .	217
	Fat Content . . . . .	217
	Muscle Content . . . . .	221
	Water Content . . . . .	222
	Bone Content . . . . .	225
	Evaluating the Patient . . . . .	227
	<i>Important Characteristics of Major Body Regions</i> . . . . .	231
	The Chest Region . . . . .	231
	The Abdomen . . . . .	232
	The Extremities . . . . .	234
	The Skull . . . . .	235
	<i>A Look at Photon-Tissue Interactions</i> . . . . .	235
	Photoelectric Interaction . . . . .	237
	Compton Interaction (Modified Scattering) . . . . .	241
	Summary . . . . .	243
	<i>Filtration and Radiography</i> . . . . .	244
	The Radiographic Effect of Filtration . . . . .	245
	Study Questions . . . . .	247
Nine	<b>CONTROLLING THE REMNANT BEAM</b> . . . . .	249
	Objectives . . . . .	249
	<i>The Concept of Coning</i> . . . . .	250
	Types of Beam-Limiting Devices . . . . .	251
	Basic Construction of a Collimator . . . . .	252
	Uses for Conventional Cones . . . . .	256
	<i>The Radiographic Effect of Beam-Limiting Devices</i> . . . . .	256

	Influences on Patient Dose . . . . .	256
	Summary . . . . .	257
	<i>Radiographic Grids</i> . . . . .	257
	The Concept . . . . .	257
	Construction . . . . .	258
	Grid Ratio . . . . .	258
	Grid Cutoff . . . . .	262
	Stereo Radiography . . . . .	262
	High Ratio Grids and Cutoff . . . . .	263
	Major Types of Grids . . . . .	263
	Nonfocused and Focused Grids . . . . .	267
	Cross Hatch Grids . . . . .	267
	Linear Grid versus Cross Grid . . . . .	272
	Quantity of Lead in the Grid . . . . .	274
	Moving Grids . . . . .	274
	Types of Bucky Assemblies . . . . .	274
	<i>Grids and The General Radiographic Effect</i> . . . . .	275
	Radiographic Density . . . . .	275
	Selecting The Proper Grid . . . . .	277
	Scatter Radiation . . . . .	278
	Kilovoltage . . . . .	278
	Body Part . . . . .	280
	The Environment . . . . .	280
	Focal Film Distance . . . . .	282
	Grid Cassettes . . . . .	283
	Summary . . . . .	283
	Study Questions . . . . .	284
Ten	TOMOGRAPHY . . . . .	286
	Objectives . . . . .	286
	<i>Why Do We Use Tomography?</i> . . . . .	287
	The Basic Concept . . . . .	288
	<i>Making Adjustments for Cut Thickness</i> . . . . .	292
	<i>Excursion Speed</i> . . . . .	296
	<i>Excursion Patterns</i> . . . . .	298
	<i>The Book Cassette and Multiplanography</i> . . . . .	300
	<i>Thick Versus Thin Cuts</i> . . . . .	304
	<i>Zonography</i> . . . . .	304
	<i>Choosing a Starting Point</i> . . . . .	306
	Establishing Exposures for Tomography . . . . .	307

	Types of Linkages . . . . .	307
	Pluridirectional Tomography . . . . .	309
	Balancing Exposure Factors for Tomography . . . . .	316
	The Selection of Exposure Angle (Arc) . . . . .	318
	Study Questions . . . . .	319
Eleven	CONVERSION FACTORS IN RADIOGRAPHY . . . . .	321
	Objectives . . . . .	321
	<i>Conversion Factors</i> . . . . .	332
	Study Questions . . . . .	340
Twelve	FILM CRITIQUE . . . . .	342
	Objectives . . . . .	342
	<i>Visibility and Definition of Detail</i> . . . . .	345
	The Effect of Contrast on Visibility of Detail . . . . .	345
	Sharpness of Detail . . . . .	348
	<i>An Approach to Film Critique</i> . . . . .	351
	How to Identify a Definition Problem . . . . .	352
	Causes for Blurring . . . . .	352
	Causes of Problems in Visibility of Detail . . . . .	353
	The Correct Procedure . . . . .	354
	Study Questions . . . . .	368
Thirteen	RADIATION PROTECTION . . . . .	369
	Objectives . . . . .	369
	<i>Background Radiation</i> . . . . .	370
	<i>Occupational Dose Limits and Their Calculations</i> . . . . .	373
	Basic Units of Radiation Measure . . . . .	375
	Roentgens to Rads to Rems . . . . .	375
	<i>Radiation and Its Biological Effect</i> . . . . .	377
	The Reaction of Tissue to Radiation . . . . .	377
	Basic Biological Considerations . . . . .	378
	Sub-, Mid-, and Supralethal Doses . . . . .	378
	Long-Term or Chronic Doses . . . . .	380
	<i>Threshold Levels</i> . . . . .	380
	General Reaction of the Body to Radiation . . . . .	380
	<i>Radiation Monitoring Devices</i> . . . . .	381
	Gas-Filled Devices . . . . .	381
	Scintillation Detectors . . . . .	383
	Personnel Monitoring Devices . . . . .	384
	Film Badge . . . . .	386

	Pocket Dosimeter . . . . .	388
	Thermoluminescent Dosimeter (TLD) . . . . .	389
	<i>Structural Shielding</i> . . . . .	390
	Nuclear Medicine Department . . . . .	393
	Patients with Radioactive Implants . . . . .	393
	<i>Characteristics of a Safe Environment for Patient and Personnel</i> . . . . .	394
	Technique Charts versus Patient Dose . . . . .	394
	The Role of the Radiologist and Supervising Technologist . . . . .	395
	Patient Shielding . . . . .	399
	Basic Guidelines for X-Ray Shielding . . . . .	399
	Specific Criteria for Effective Gonadal Shielding . . . . .	400
	Types of Gonadal Shielding Available . . . . .	401
	Pregnant Patients . . . . .	403
	Assuring Safety for the Technologist . . . . .	403
	Who Should Wear Radiation Monitoring Devices . . . . .	409
	The Radiation Health Officer . . . . .	409
	<i>Warning Signs Indicating Radiation Hazards</i> . . . . .	411
	Study Questions . . . . .	412
Fourteen	RADIOGRAPHIC TUBES . . . . .	415
	Objectives . . . . .	415
	<i>The Modern X-Ray Tube</i> . . . . .	417
	Components of the X-Ray Tube . . . . .	418
	The Cathode Assembly . . . . .	420
	Filament Current and the Resulting Milliamperage . . . . .	422
	The Booster Circuit . . . . .	423
	<i>The Anode</i> . . . . .	423
	The Anode Disc . . . . .	424
	The Target Area (Focal Spot) . . . . .	425
	Anode Surface Heat . . . . .	427
	High Speed Anodes . . . . .	428
	Size of the Focal Spot . . . . .	431
	Measuring the Effective Focal Size . . . . .	431
	<i>The X-Ray Tube Housing</i> . . . . .	432
	High Tension Cables . . . . .	433
	<i>Mammographic and Other Special Purpose Tubes</i> . . . . .	434
	Magnification Tubes . . . . .	436
	Grid Pulsed Tubes . . . . .	437
	<i>Proper Handling of X-Ray Tubes</i> . . . . .	438
	Using Proper Exposure Values . . . . .	439



	Physical Abuse . . . . .	441
	Selection of Exposure Values and Rectification . . . . .	443
	Rectification: Single versus Three Phase . . . . .	444
	Normal Life Cycle of the X-ray Tube . . . . .	444
	Tube Cooling Chart . . . . .	448
	Saturation Point . . . . .	449
	Selection of X-ray Tubes . . . . .	450
	<i>Production of the X-ray Beam</i> . . . . .	454
	Characteristics and the Nature of X-ray Photons . . . . .	455
	Bremsstrahlung (Braking Radiation) . . . . .	455
	Characteristic Radiation . . . . .	457
	Summary . . . . .	458
	Exposure Values versus Radiation Production . . . . .	460
	<i>Properties of X-radiation</i> . . . . .	461
	Study Questions . . . . .	462
Fifteen	THE X-RAY CIRCUIT . . . . .	464
	Objectives . . . . .	464
	<i>The Initial Supply of Current</i> . . . . .	464
	<i>The Primary Circuit</i> . . . . .	466
	<i>Maintaining Consistent Incoming Line Current</i> . . . . .	466
	The X-Ray Control Panel . . . . .	466
	The Milliamperage Control . . . . .	469
	The Exposure Timer . . . . .	470
	Circuit Breakers . . . . .	471
	<i>Introduction to the Secondary Circuit</i> . . . . .	471
	High Tension Transformer . . . . .	472
	Transformer Energy Loss . . . . .	474
	The Autotransformer . . . . .	475
	The Milliampere Meter and the Milliampere-Seconds Meter . . . . .	475
	The MaS Meter . . . . .	477
	<i>The Filament Circuit</i> . . . . .	477
	The Filament Amperage . . . . .	478
	Filament Current Control (Ma Selector) . . . . .	478
	<i>Rectifying System</i> . . . . .	479
	Modification of Single Phase 60 Cycle Alternating Current . . . . .	479
	The Spin Top Test . . . . .	480
	Disadvantages of Spin Top Test . . . . .	482

	Characteristics of Three Phase Exposures . . . . .	482
	High Frequency Generators . . . . .	484
	<i>The Production of High Frequency Tube Current</i> . . . . .	485
	Patient Doses and Three Phase Equipment . . . . .	486
	X-ray Productivity with Three Phase and High Frequency Equipment . . . . .	486
	<i>Summary</i> . . . . .	487
	Study Questions . . . . .	488
Sixteen	TV CAMERAS, IMAGE INTENSIFICATION, AND DIGITAL SUBTRACTION . . . . .	489
	Objectives . . . . .	489
	<i>Subtraction Technique</i> . . . . .	491
	<i>Digital Subtraction Angiography</i> . . . . .	492
	<i>Basic Components Comprising a Digital Subtraction System</i> . . . .	494
	Fluoroscopic TV System . . . . .	494
	The Image Amplifier . . . . .	494
	The Visible and the Electronic Image . . . . .	497
	TV Lens System . . . . .	498
	The TV Pickup Camera . . . . .	499
	Major Components and Operation of the TV Camera . . . . .	499
	The Electron Gun of the TV Camera . . . . .	501
	Progressive versus Interlaced Scanning . . . . .	501
	Deflector Coils . . . . .	502
	<i>Formation of the TV Signal</i> . . . . .	503
	<i>The Digital Image</i> . . . . .	505
	The Formation of Picture Elements (Pixels) . . . . .	506
	Synchronizing and Blanking Pulses . . . . .	508
	The Digital Conversion . . . . .	509
	Contrast Enhancement . . . . .	510
	<i>The TV Monitor</i> . . . . .	510
	Image Re-registration . . . . .	512
	Image Quality of Digital Fluoro Images . . . . .	512
	The Image Intensifier . . . . .	514
	The TV Pickup Camera . . . . .	514
	The Matrix of the Computerized Image . . . . .	514
	Framing Speed . . . . .	514
	Noise . . . . .	515
	Image Contrast . . . . .	515

	Study Questions . . . . .	516
Seventeen	COMPUTERIZED TOMOGRAPHY . . . . .	517
	Objectives . . . . .	517
	<i>Major Components of CT Scanning Equipment</i> . . . . .	518
	The Generator . . . . .	518
	The X-Ray Tube . . . . .	519
	The Gantry . . . . .	519
	The Detectors . . . . .	520
	Beam Collimation, Thin-Thick Slice . . . . .	520
	The Computer . . . . .	522
	The Viewing Console . . . . .	522
	<i>Evolution of CT Scanning Technology</i> . . . . .	522
	First Generation Scanner . . . . .	524
	Second Generation CT Scanning . . . . .	524
	Third Generation CT Scanner . . . . .	525
	Fourth Generation CT Scanner . . . . .	526
	Detectors Function as a Receptor . . . . .	527
	Computerized Reconstruction of the Scanned Structures . . . . .	528
	Calibrating CT Numbers to Tissue Attenuation . . . . .	531
	Windowing . . . . .	532
	Resolution . . . . .	533
	Image Matrix . . . . .	535
	Overall Sequence of Events for Image Reconstruction . . . . .	536
	Image Artifacts . . . . .	536
	Characteristics of a CT Image . . . . .	536
	Subject Versus Spatial Resolution . . . . .	536
	The Voxel . . . . .	538
	Focal Spot Size . . . . .	538
	Image Filtration . . . . .	538
	Spiral and Helical CT Scanning . . . . .	539
	Multi-Slice Spiral CT Scanning . . . . .	539
	Image Quality Testing . . . . .	540
	Study Questions . . . . .	540
Eighteen	IMAGING NETWORK AND PACS TECHNOLOGY . . . . .	542
	Objectives . . . . .	542
	<i>Digital Information (Bits and Bytes)</i> . . . . .	545

	<i>Structuring a Digital Network</i> . . . . .	547
	Operating Systems . . . . .	549
	Data Traffic Within a Network . . . . .	550
	Local Area Network (LAN), (WAN), and Regional Area Network, (RAN), and Enterprise Systems . . . . .	551
	Network Devices and Components . . . . .	553
	Electronic Viewing Stations . . . . .	553
	Transmitting Images Over a Network . . . . .	556
	Modems (Modulation Demodulation) . . . . .	557
	Image Compression . . . . .	557
	Network Connection and Amplification Devices . . . . .	558
	Megs, Gigs, Teras, and Basic Image Matrix . . . . .	559
	Pixel Depth . . . . .	560
	Standard for PACS . . . . .	561
	Study Questions . . . . .	561
Nineteen	COMPUTERIZED RADIOGRAPHY . . . . .	563
	Objectives . . . . .	563
	<i>An Overview of Two Commonly Used Digital         Imaging Technologies</i> . . . . .	564
	Computerized Radiography (CR) with Photostimulable Phosphors . . . . .	564
	Performance Characteristics of Photostimulable Phosphors used in Computerized Radiography . . . . .	565
	Basic Composition of a Photostimulable Cassette . . . . .	565
	The Phosphor Layer and CR Image Recording Sandwich . . . . .	565
	Scanning the Phosphor Plate and Image Processing . . . . .	566
	Orienting the Scanning Motion of the Laser Beam . . . . .	567
	Electrical Stability of the Electronic Imaging Processing System . . . . .	568
	Converting Phosphor Emission into an Electrical Signal . . . . .	568
	Transferring the Electrical Signal to a Digital Signal . . . . .	568
	Sample Rate and Resolution . . . . .	570
	Image Fidelity . . . . .	570
	Post Processing the Image . . . . .	570
	Image Noise with Photostimulable Phosphor Imaging Cassettes . . . . .	571
	Direct Digital Radiography . . . . .	571

Basic Composition of Amorphous Plates . . . . .	572
The Selenium Layer . . . . .	574
Orientation of Anatomical Information on the Final Image . . . . .	575
Image Quality with Amorphous Selenium Image Technology . . . . .	577
<i>Conclusion</i> . . . . .	578
Study Questions . . . . .	578
<i>Glossary</i> . . . . .	581
<i>Index</i> . . . . .	611



# **UNDERSTANDING RADIOGRAPHY**





## Chapter One

# CHARACTERISTICS OF THE RADIOGRAPHIC IMAGE

### Objectives

- Understand how basic terminology is used to describe the components of a high quality radiographic image
- Appreciate the difference between the image characteristics of visibility of detail and definition of detail.
- Understand the reasons why a high quality image must possess an optimal balance between visibility of detail and definition of detail.
- Understand the fundamental dependence between body tissue, the x-ray beam, processing, and film-screen combinations in producing a high quality radiographic image.
- Appreciate how x-ray photon-tissue absorption affects the remnant beam and in turn, how the remnant beam affects the final radiographic image.
- Understand what sensitometry is, and how this technique is used to evaluate key radiographic image characteristics, as well as properties of film-screen systems.
- Develop an expectation of how a high quality radiographic image should appear to the viewer.

**T**HE TERM RADIOGRAPH is most commonly used to identify a permanent image produced by x-rays; however, over the years, terms such as *roentgenogram* or *plate* have been used to identify the permanent image. *Roentgen*, of course, is taken from Wilhelm Roentgen's discovery of x-rays, and *plates* was used because the first permanent images were on pieces of plate glass that had been coated with a silver bromide emulsion.

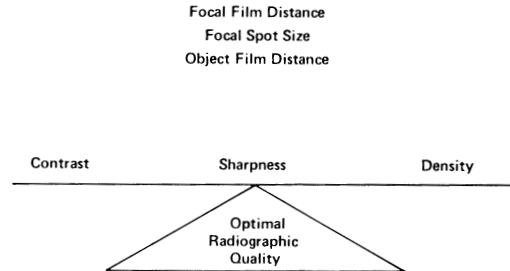
**RADIOGRAPHIC BALANCE**

Figure 1. Contrast and density must compliment each other in order to produce optimal radiographic results. Too much or too little contrast for a given density or vice versa will destroy radiographic quality.

The radiographic image must meet certain requirements to be of any medical value, and although the standards are considerably higher today than they were at some point earlier in time, the specific characteristics desired have not changed. Considering all the desirable properties an image should possess (see Fig. 1), technical balance is perhaps the most important. In a radiographic sense, balance is the relationship between contrast, density, and sharpness. It would be incorrect, however, to associate a specific contrast with a specific density, or sharpness. A balanced radiograph can have short or long scale contrast and can be light or dark. This is an important concept for the technologist to realize because if he can learn to identify a technically imbalanced image he will more easily know when to make technical adjustments or corrections. Figure 2 shows the diagnostic value of a well-balanced radiographic image as compared to one that is not. An imbalanced image may also be too flat or too light, and detail that one ordinarily expects to be present will be absent. It is important that such characteristics as these be identified as separate entities by the technologist so that he will have a basis from which corrections can be made. The author's feeling is that a technologist who cannot appreciate the quality or lack of it in a radiographic image will not be able to affect the appropriate adjustments necessary to correct the problem.

In summary, one can state that overall technical quality of a radiographic image is strongly dependent upon the compatibility that exists between contrast, density, and sharpness, and, if one is not dominant over the other, a certain technical balance has been successfully achieved. Later in the text, much discussion and evidence will be presented as to how such a balance can be obtained by using the various tools the technologist has at his disposal.

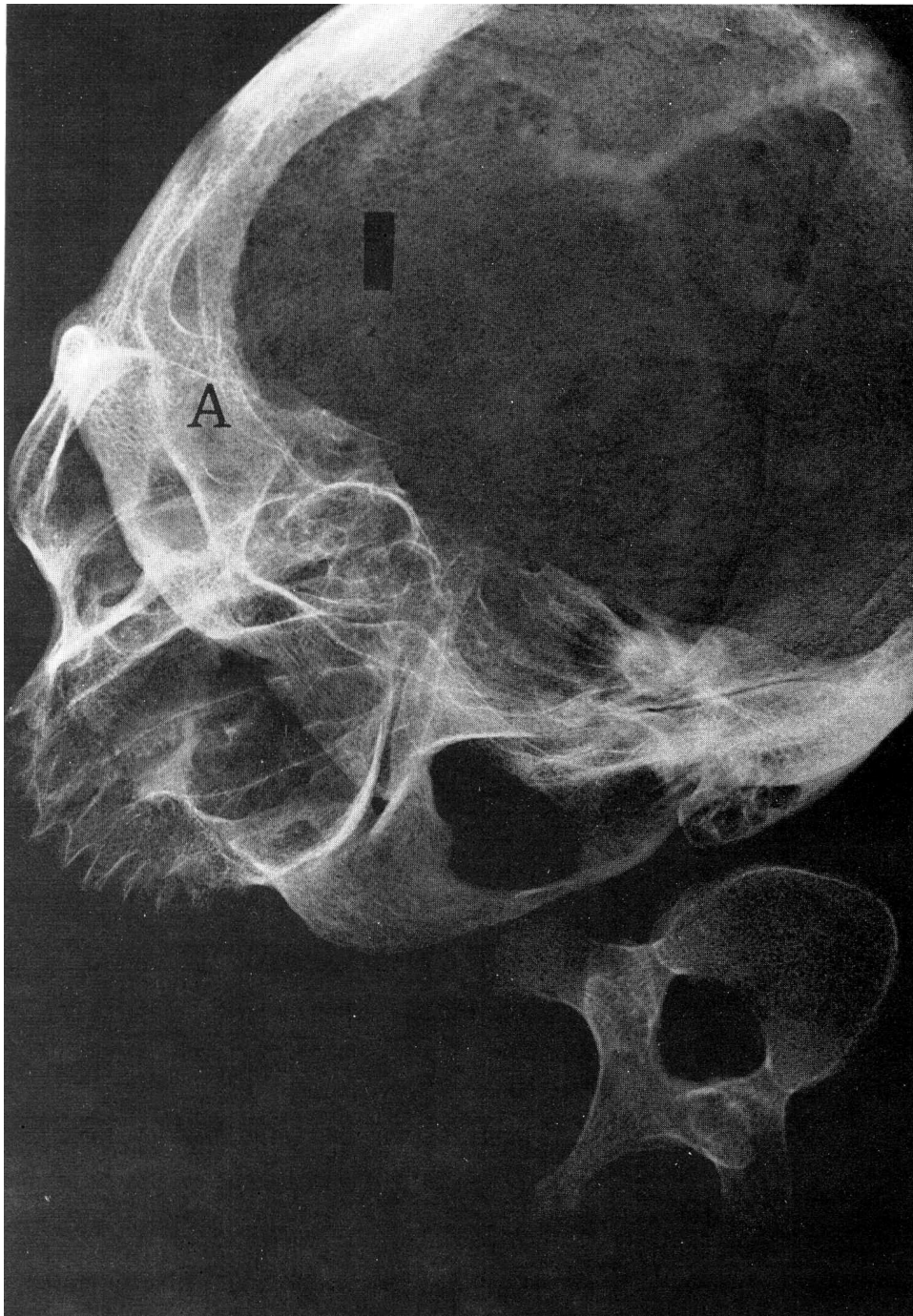


Figure 2A. Visibility of detail is much improved from *A* to *B* as a result of improved density.

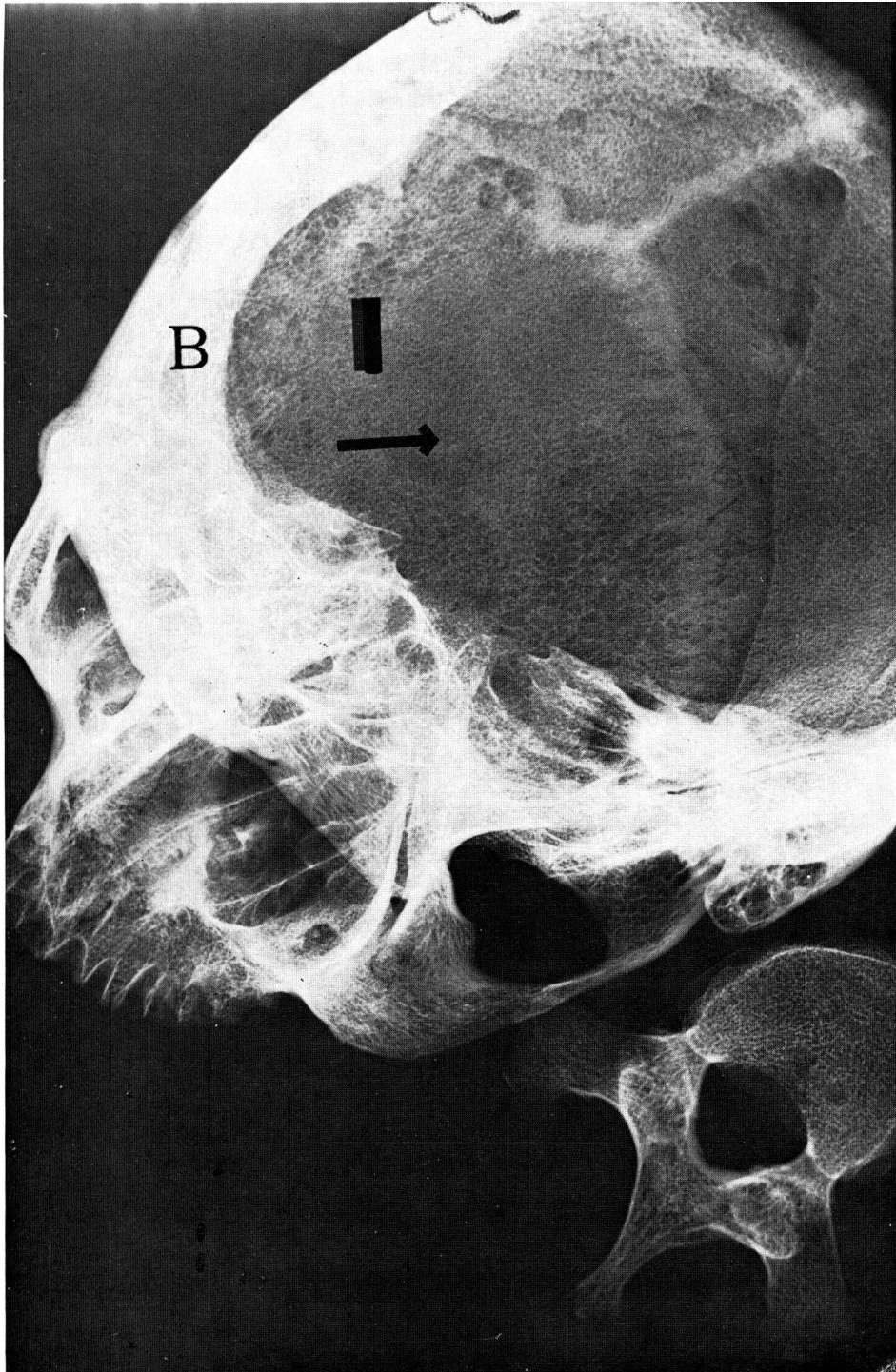


Figure 2B.