THE DARKROOM COOKBOOK

FIFTH EDITION

STEVE ANCHELL

30TH
ANNIVERSARY
EDITION

A **Focal Press** Book

ROUTLEDGE

The Darkroom Cookbook

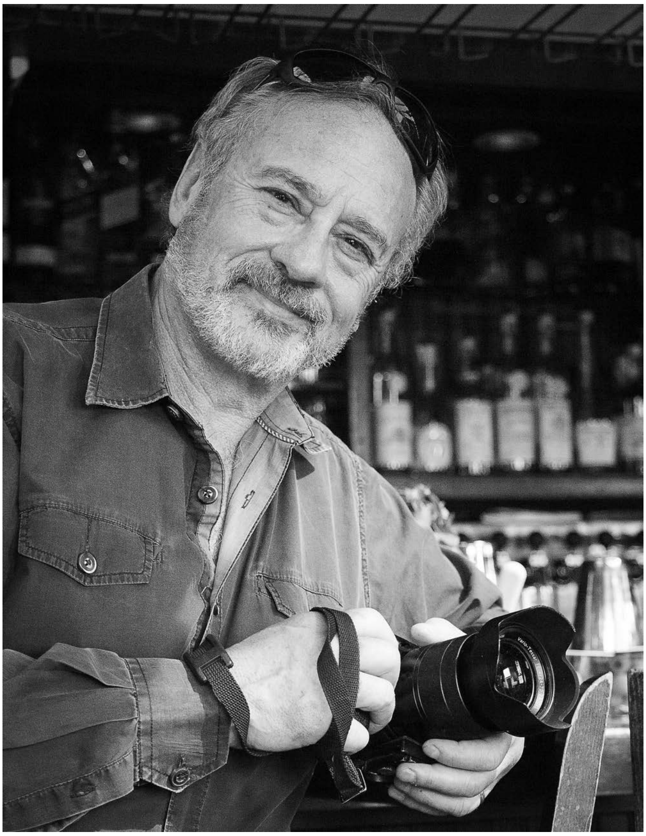
The fifth edition of this comprehensive guide to darkroom photography is fully revised and updated, placing analog and traditional methods into the context of a digital world and contemporary workflows.

Including invaluable analog photography techniques, chemicals, and equipment supported by visual examples, the *DCB5* has 180 updated recipes for darkroom experiments and tips for mastering the darkroom. It includes the chemicals used to develop, stop, fix, tone, and archivally process films and prints. *DCB5* contains invaluable information on making enlarged digital negatives, planning a darkroom, and safely handling photographic chemicals. It features new sections on split-printing, solarization, and making your own gelatin emulsion. The fifth edition includes contributions and stunning black-and-white imagery by established artists such as Bruce Barnbaum, Tim Rudman, Christina Z. Anderson, John Sexton, and more.

This is the essential guide for any practitioner who wants to take the next step to develop a thorough understanding of film and darkroom processes, techniques, and working methodologies, as well as for advanced photography students with an interest in analog and darkroom processes.

Steve Anchell is an internationally published writer, photographer, and teacher with his work featured in more than 61 exhibits. Since 1979, he has taught photography workshops and classes for Oregon State University, Santa Fe Workshops, the International Center of Photography in NYC, Tuscano Photo Workshops, and many others. He is a member of the Freestyle Photographic Board of Advisors.

Steve has authored five books on photography published by Focal Press: *The Darkroom Cookbook, The Film Developing Cookbook, Mirrorless Interchangeable Lens Camera, The Variable Contrast Printing Manual*, and *Digital Photo Assignments*. He also served as the editor of *Photovision: Art and Technique* and *Focus Fine Art Photography* magazines and has written for and worked as a contributing editor for numerous photography magazines.



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5th Edition

Steve Anchell

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Dedication

This book is dedicated to the memory of Grant Haist and Ron Mowrey and to all the selfless photographers who have shared their experiences and darkroom discoveries. We owe a debt of gratitude to these photographers, known and unknown.

I believe the function of the artist in all media is a creation of affirmations, the search for and the realization of beauty.

The function of art includes an establishment of communication, at the imaginative and constructive level, and placing the emphasis of thought and emotion in relationship to an ideal world.

The glorification of decay, filth, disease, despair, and evil succeeds only in blunting our necessary awareness of these negative qualities. . .

I believe the artist can accomplish most on the agenda for survival by creating beauty, by setting examples of beauty in order, by embracing the concept of the essential dignity of the human mind and spirit.

—Ansel Adams

Table of Contents

PART 4 – AFTER PROCESSES

APPENDICES

Thoughts About Traditional Photography

The darkroom is the final tool for bringing your photographic vision to full flower. It all begins in the camera when you expose a negative. But it doesn't end there; the negative is a malleable entity. It can be bleached to remove excess density if it's too dense. If you desire, you can carefully bleach back portions of a negative to remove bothersome items and increase density and contrast in the negative via intensification, and various types of masks can be employed to alter the look of the print. At one time or another, I have used all of these options and others for my "final" negative.

But once you arrive at your final negative, the contrast you choose, the length of exposure, the degree of burning and dodging you employ, and the amount of bleaching determine the final image and any toning you may do to the print. Options abound.

Since the advent of digital photography, I have been besieged by many digital enthusiasts who have encouraged me to switch to digital photography because the controls are vast. There are several reasons for my refusal to switch to digital. First, there is no lack of control options available in the standard darkroom. Therefore, the vaunted digital control has no greater lure to me. Second, although digital imagery has improved markedly over the years, I still do not see it surpassing or even equaling traditional silver prints' quality and glow, especially with today's extraordinary enlarging papers.

Finally, I enjoy the traditional printing process a whole lot more. Once I get into my darkroom to print, I am alone in my fiefdom. Nothing can interrupt me unless I want it to interrupt me. I am in the safelight environment of my darkroom, working slowly and methodically—literally hands-on—toward the print I am seeking. I feel that working in that process is nothing less than a gift.

I'm a professional photographer in the sense that I earn my living through photography exclusively. But I am still a true amateur because I do it for the love of doing it. That is what lured me into photography 45 years ago and is what keeps me in it today. I love the process of working in the darkroom and the final product that it produces, which I feel is unmatched by any digital process.

Even so, if, as a professional, I saw that digital processes surpassed the traditional process in quality, I would be a fool to stick with traditional methods. Even if I enjoyed the process better, I would know I was producing second-rate products. But I'm not. I'm still producing first-rate products, in which today's traditional silver-gelatin print remains the gold standard for the finest quality of fine art photographs.

Bruce Barnbaum

Introduction to the Fifth Edition

> *"Digital is now, AI may be the future, but film is forever."*
>
> —Steve Anchell

The Darkroom Cookbook is based on articles that originally appeared in *Camera & Darkroom* magazine in the 1990s. A brief encounter at a camera store inspired the articles. I was browsing the chemical section, searching for potassium bromide. When I found it, another photographer inquired what it was used for. I pointed to the packaged paper developer she was holding and said, "An ounce of 10% bromide solution in that developer will improve the highlights in your prints."

"Oh, my goodness! That sounds too technical to me!" She exclaimed.

This made me realize that one photographer's basic craft is another photographer's "Oh, my goodness!" For me, adding bromide or carbonate to a developer is about as technical as exposing for the shadows. Every photographer should know that!

What we are witnessing today is similar to the transition from platinum/palladium printing to silver printing in the 1920s. It was oft said that silver-based emulsions could never replace platinum printing because of the inherent beauty of the platinum print. Yet it was not long before platinum/palladium printers of the stature of Ansel Adams, Imogen Cunningham, and Edward Weston were printing exclusively on silver-based emulsions.

This is not to say that silver printing will disappear. Platinum/palladium printing is still with us. As are gum dichromate, cyanotype, albumen, and printing out paper, among other alternative processes. But is a digital print better than silver? Is it as good as platinum? Gum? In every case, it's not a matter of being better than the other. It is simply a matter of difference. It is good to remind ourselves that it's not how you get there; it's what's on the wall that counts.

It comes down to how you wish to spend your creative time. Those of us who work in silver choose to spend our time in the cool quiet of the darkroom (okay, some of us like to blast the stereo) under the subdued otherworldly glow of orange light, hearing the flow of water, experiencing the solitude that is near impossible to find outside the creative darkroom space, padding softly from the enlarger to the trays and back again, watching the miracle of the image appear on the surface of the paper.

In the darkroom, each print we make is unique and precious. You will never see a pile of darkroom prints being casually walked over on the showroom of a photography convention the way I have seen digital fine art prints walked on; the "artist" is blithely aware that s/he can press a button on the printer and instantly create a new print and pass them out like hotcakes—the fast food of art. Collectors of fine art prints understand this as well.

Historically, many photographers, especially in editorial and commercial photography, have never printed their images; one of the most famous was Henri Cartier-Bresson, a proponent of capturing the "decisive moment."

However, consider that the camera only captures a moment in time. The moments recorded by Cartier-Bresson became iconic images only after they were developed and printed in a way that allowed them to be presented and shared in magazines, books, or exhibits.

Brett Weston, one of the most outstanding practitioners of the West Coast School of Photography, pioneered by his father, Edward Weston, destroyed almost 70 years' worth of negatives on his eightieth birthday because he refused to allow anyone else to print his work. Why? To paraphrase Brett, there may be someone who could print his work better, but then it wouldn't be his.

Wynn Bullock, a close friend of Edward Weston, Brett, and Ansel Adams, often said that photography was 20% in the camera and 80% in the darkroom. Ansel told me he wasn't as much a photographer as a printer. Imogen Cunningham said that printing was the hardest thing one could do in photography, but she refused to allow anyone else to do it for most of her career. When Edward Weston was no longer able to print his negatives because of Parkinson's disease, he spent 10 years training his sons Brett and Cole to print his work precisely as he would, preparing copious notes for them to follow so there could be no deviation in his prints after he was gone.

If your interest in photography does not go beyond uploading your images to the Web to share with millions of others doing the same, there is no reason to learn darkroom techniques. The question to ask yourself is: Do you want to hold an original, unique print in your hand or proudly see it hanging in a gallery? To fully master the photographic process and become a true creator of images, you must learn to develop and print your work. This applies in equal measure to digital.

In *The Darkroom Cookbook,* you will learn methods to alter and improve film and print developing formulae. Through the use of chemicals and additives, you can fine-tune packaged or published formulas to increase or decrease contrast and enhance tonality. If you take the title of this book literally, you can think of yourself as either a cook or a chef. A cook follows a formula; chefs create their own version by adding or subtracting ingredients according to taste.

Some of the greatest practitioners have been cooks. Edward Weston learned the simple formulas he used throughout his long and prolific career in photography school. Paul Caponigro mixes and matches formulas to suit his taste. Edward could be considered a cook, Paul a chef.

Cook or chef? It is not important, only that you can obtain the desired results. To what end? To give your work a life and expression not always possible and, at the very least, curtailed by dependency on packaged formulas.

But even packaged formulas can be used to great advantage by a chef. Mixing Photographers' Formulary warm-tone Selectol Soft paper developer with neutral-tone TD-3 paper developer in a 3:1 ratio will create a new print tone depending on the paper you're printing on. The manufacturers do not suggest this in their literature, but the manufacturers are not artists.

The formulae and techniques in this book have been chosen to aid the photographer in expressing their vision. It begins with the choice of film developer to emphasize speed, tonality, graininess, or acutance.

Why are so many developing formulae necessary? After all, if you know one or two formulae, what else do you need, right? This is a good idea in the early stages of learning the craft. But notice the headings for each set of developers: high-definition, low-contrast, fine-grain, two-bath, etc. There is a film developing formula to create almost any effect: sharp, clean edges or superfine grain; low-contrast, long tonal scales; or high-contrast and short tonal scales. Complete knowledge of one or two developers is important, but knowing what else is available and how to use them to create an image that expresses your vision is vital.

Paper developers also abound in *The Darkroom Cookbook*. While printing techniques such as dodging and burning affect the emotional impact of a print, the choice of developer can enhance or detract from the image's central message. Developer formulae vary slightly in their rendition of blacks. Selecting one warm-tone paper and one cold-tone paper and testing various print developers is a good idea. Keep a book of the resulting prints, which can be referred to when a given tonality is desired.

When you decide which developer/paper combinations express your vision, try several or all of the toning formulas. Keep a book of these also. These reference sources will enhance your ability to communicate through your images.

In theFormulary, you will find several useful items. Kodak S-6 stain remover, for example, will help remove both oxidation and developer stains from film. I hope you will never need to use it, but I have included it just in case.

In Chapter 16, you will find introductory alternative printing techniques for those interested in trying something different or adding to their creative oeuvre. *The Darkroom Cookbook*, however, is not meant to be an exhaustive study of alternative processes. For that, you should turn to one of several excellent books dedicated to those processes, such as *Jill Enfield's Guide to Photographic Alternative Processes: Popular Historical and Contemporary Techniques* or one of Christina Z. Anderson's monographs on alternative processes.

Intensification and reduction techniques are of value to photographers. Even Ansel Adams required local negative intensification to save his most famous photograph, *Moonrise, Hernandez, New Mexico, c. 1941*. The negative was exposed for the moon's luminance. As a result, the foreground was severely underexposed and difficult to print. Instead of giving up on the image, Ansel intensified the foreground of the 8 × 10–inch negative by dipping it in a tray of intensifier while carefully holding the buildings, sky, and moon out of the solution. Without the necessary darkroom skills, his best-selling image might not have seen light.

The Darkroom Cookbook is meant to be a point of departure for creative photographers to discover and explore new techniques and formulas to create a unique signature. It is also meant to be a potpourri for photographers who want to play with their craft. As I tell my students, when photography ceases to be fun, it's time to find a different outlet for your creativity. To this end, it not only contains many useful formulae for processing film and paper, but it is also a compendium of tips, tricks, and techniques handed down from one photographer to the next.

The Darkroom Cookbook is not about chemistry, darkroom or otherwise. The "complex" chemical formulas are no more than mixtures of powders and liquids. The names of the chemicals are on the bottles. If a scale is unavailable, you can use measuring spoons. It's not much different from mixing flour and eggs with milk to make pancakes.

Despite its seeming complexity and daunting technicality, *photography ain't rocket science*. You must be pretty far off to fail. For example, what would happen if a formula called for sodium carbonate anhydrous and you accidentally used monohydrate? Well, for one, it's not like being on a bomb squad and cutting the wrong wire. The worst that will happen is that the batch of negatives will probably be slightly underdeveloped, and you will have to print on grade 3 paper instead of your preferred grade 2. The next time you will know to increase developing time. Better yet, consult the sodium carbonate conversion table at the back of the *Cookbook*.

INTO THE FUTURE

From the beginning, *DCB* was envisioned with an eye to the future, though nobody in 1994, least of all me, could foresee digital. Digital has displaced film as the primary method of image capture, but it has yet to replace film. On the other hand, everything is driven by money, and there is no money in producing enlargers. What happens when you want to make a 16 × 20–inch silver print from a film negative and there are no enlargers available? Simple, you use digital technology to create an enlarged negative and a contact print on silver paper using a lightbulb suspended from the ceiling like Edward Weston. You use the new technology to allow you to continue to make silver prints, albumen, or platinum/palladium, or gum dichromate. You coat glass plates and expose them in a large-format camera and do the same. That is why I have included chapters on enlarged digital negatives, alternative printing processes, and making your own emulsion. In the end, it's what's on the wall that counts, not how it got there.

~

The *DCB* is meant to be a practical book on darkroom techniques with tips and tricks you will not find elsewhere. *The Film Developing Cookbook*, second edition (*FDCB*2) takes a more scholarly approach by explaining the science and method, with footnotes and references for those seeking a deeper understanding of film development. If you wish to go further, I encourage you to read the *FDCB*2 or at least have a copy on your bookshelf for reference.

If you have questions on darkroom technique that still need to be answered, you may post them on The Darkroom Cookbook Forum, darkroomcookbook.com. If I can't answer your question, perhaps one of the many experts who subscribe to the forum can.

Acknowledgments

Two husband-and-wife photography teams—Frank and Daughtee Rogers and Cornelia and Rodger Davidson—helped me to become a photographer.

Frank and Daughtee unselfishly shared their knowledge, grounding me in basic photography and darkroom techniques. They taught me to respect the craft and made me aware that it was more than a livelihood I was learning; it was a tradition. Daughtee was a master printer and retoucher. Frank did most of the photography. It was also Frank from whom I heard it said, "There are no secrets, only photographers who think there are."

Cornelia and Rodger taught me basic color techniques. Their specialty was color transparency, specifically Kodak Ektachrome E-3, which they processed by hand every evening in their West Los Angeles home for commercial, architectural, scientific, and fine art photographers.

It is safe to say that without Frank, Daughtee, Cornelia, and Rodger's patient guidance and teaching, I would not have survived the first difficult years of my photographic career.

Regarding *The Darkroom Cookbook*, the hero I want to acknowledge is Samy Kamienowicz, owner of Samy's Camera in Los Angeles. In the early 1980s, Samy gave me a present of three Morgan & Lester Photo-Lab Indexes from the 1930s and 1940s. This generous gift sparked my interest in older formulas and darkroom techniques and enabled me to share them with other photographers. Without Samy, there would be no *Darkroom Cookbook*.

This edition of *The Darkroom Cookbook* would not have been possible without the in-depth knowledge and assistance of Bill Troop and Ian Grant, the two most knowledgeable photochemists I have worked with.

Bill Troop is best known in photography circles as a photochemist who has formulated some of the best modern developers and fixers, most of them packaged and distributed internationally by the Photographers' Formulary. He is also the author of *The Film Developing Cookbook*. Outside of photography, Bill has had a career as a typographer with numerous typefaces to his credit. He has also formulated commercial cosmetics. To top it off, he is a concert pianist.

Ian Grant is a British fine art photographer. He spent ten years working as a photochemist, which included photographic research and emulsion manufacture for an independent photo company. He also liaised with Ilford after the company approached him regarding the supply of emulsion, working with members of their research and sales department and testing their emulsion.

In addition to previous contributors, several photographers have contributed new or updated material to the fifth edition. Among them are Tim Bowman, Ed Buffaloe, Paula Chamlee, Jill Enfield, Clayton Harley, Lee Lira, Mark Osterman, France Scully-Osterman, and Kimberly Schneider.

A sincere thank you is due to the publisher, Focal Press. Without their belief in film as a viable medium of expression and faith in *The Darkroom Cookbook* as a conduit for sharing ideas between photographers, the fifth edition would never have been written, much less published.

I would also like to thank Gregory Poulin, Professor of Art at Western Oregon University. Gregory arranged access to the universities printing lab so that I could complete Chapter 15, Enlarged Digital Negatives.

For this revision, special thanks go to Eric Joseph of Freestyle Photographic Sales in Hollywood, California, freestylephoto.com, and Alessandro Franchini of ARS-IMAGO in Italy, ars-imago.com, and Mirko Boeddecker of Fotoimpex in Germany, fotoimpex.de. All three have done more than anyone to keep film materials available. Like the Photographers' Formulary, all three will ship dry and wet chemicals.

I would also like to remind you that Photographers' Formulary, www.photoformulary.com, packages many of the formulas found in the *Cookbook*. I urge you to support companies like Freestyle Photo, ARS-IMAGO, Fotoimpex, and Photographers' Formulary. They are our future.

Contributing Photographers

Christina Z. Anderson

Christina Z. Anderson's work focuses on the contemporary vanitas printed in a variety of alternative photographic processes, such as gum and casein bichromate, cyanotype, salted paper, chrysotype, palladium, chemigrams, chromo, mordançage, lumen prints, and combinations thereof. Anderson's work has been shown nationally and internationally in over 120 shows and 60 publications. She has six print books that have sold in over 40 countries. Anderson is an editor for Focal Press/Routledge's Contemporary Practices in Alternative Process Photography series and a professor of photography at Montana State University. To see her work, visit christinaZanderson.com and @christinaZanderson.

Bruce Barnbaum

Bruce Barnbaum was drawn to photography through his love of the landscape. As time passed, his interests expanded into architectural subjects, abstracts, and anything he considered visually interesting. Although he photographs and prints both black-and-white and color, he is most well known for his black-and-white work, as it is his prime interest. He has taught workshops since 1972, founding the Owens Valley Photography Workshops in 1975 and the Photographic Arts Workshops in 1991.

Three books of his fine art photography have been published: *Visual Symphony* in 1986, followed by *Tone Poems—Book 1*, 2002 and *Tone Poems—Book 2*, 2005 (the latter two produced with a CD of classical piano music in collaboration with pianist Judith Cohen), as well as his noted photography textbook, *The Art of Photography: An Approach to Personal Expression* and his latest book *The Essence of Photography*, all books published by Rocky Nook. More of Bruce's work can be seen at www.barnbaum.com.

Tim Bowman

Tim Bowman has been a darkroom practitioner for most of his life. His primary area of interest is documenting the evolving urban landscape of Winston-Salem using large-format cameras, handmade lenses, and paper negatives. In his professional life, Tim is a VFX artist. His work has appeared in many films, including *The Hunger Games*, *Rebel Moon: Part One, Gravity*, and *I Am Number Four*.

Ed Buffaloe

Ed Buffaloe hales from Austin, Texas. He is mainly self-taught in almost everything, including photography. He has written articles to record his investigations into chemical photography, which can be found on his website, unblinkingeye.com.

Ryuijie Douglas

Born in Otaru, Japan, Ryuijie showed an inclination for the arts at an early age. He learned underwater photography while stationed in Guam, pursuing his long-time interest in scuba diving. An exhibit of Jerry Uelsmann's photographs inspired him to pursue fine art black-and-white photography. Ryuijie has steadfastly pursued his photographic vision and acquired a reputation for his exquisite platinum/palladium prints in addition to his traditional black-and-white work. More of Ryuijie's work can be seen at www.ryuijie.com.

Rod Dresser 1933–2011

Rod Dresser graduated from the United States Naval Academy and served on destroyers and submarines in the Navy. After retirement, he turned his photographic hobby into a career. Rod was an assistant to Ansel Adams, and after Adams' death, he took over the business manager position for the Ansel Adams Publishing Rights Trust.

Rod later spent five years in San Francisco doing commercial photography. His clients included Apple, Union Bank, the University of California, and Harvard University. He returned to the Monterey Peninsula and focused his energy on fine art. Rod's work is in major museums and collections throughout the world.

Jay Dusard

After teaching photography for seven years at Prescott College, Arizona, Jay Dusard was awarded a 1981 Guggenheim Fellowship to create view-camera portraits of working cowboys from Canada to Mexico. His solo publications include *The North American Cowboy: A Portrait* (1983) and *Open Country* (1994).

Jay is uniquely a master of both the landscape and portrait genres. Known for his skill at print bleaching, Jay has earned the nickname "Dr. Ferricyanide" from his students and contemporaries. One of the finest black-and-white darkroom printers, he is now concentrating on the presentation of his rarely seen abstractions.

Jill Enfield

Jill Enfield is a fine art photographer, educator, and curator. Her concentration is historical techniques and alternative processes, with workshops and lectures in locations worldwide.

Her books, *Photo Imaging: A Complete Guide to Alternative Processes*, published by Amphoto, and *Jill Enfield's Guide to Alternative Processes: Popular Historical and Contemporary Techniques*, published by Focal Press, are award-winning works used in schools worldwide.

Enfield has taught at Parsons The New School of Design since the 1980s and for workshops worldwide. Her fine art images can be seen in museums and private collections.

Patrick Gainer 1927–2015

Patrick Gainer see-sawed his first roll of Verichrome Pan in a tray of MQ developer. The darkroom was a large closet in his Webster Groves, Missouri, home. At about the same time, he began taking oboe lessons. His photographic hobby waxed and waned through moves to New York City; Parkersburg, West Virginia; a short stint in the Army Corps of Engineers; and back to his birthplace in

Morgantown, West Virginia, to study engineering. It was put to good use during his employment as an aeronautical research engineer by NACA-NASA at Langley Research Center.

Patrick was also the first oboist with the Norfolk Symphony Orchestra. His photographs of conductors, musicians, and guest artists appeared in many program booklets.

Richard Garrod 1924–2022

Richard Garrod majored in photography at Pasadena City College and studied at private workshops with Ansel Adams, Brett Weston, and Minor White. In 1953, Richard met Edward Weston and, in 1956, visited Brett Weston in his home in Garrapata Canyon. In 1955, he was a student at Ansel Adams's first postwar workshop in Yosemite. In 1961, *Art in America* magazine selected Garrod as a top-40 "New Talent USA" member and one of the seven featured photographers. In the introduction to *Garrod and Gilpin Photographs*, Ansel Adams referred to Garrod's work as displaying "A great solidity and constant awareness of beauty."

Garrod taught photography workshops for over 30 years, including for Ansel Adams's workshops at Yosemite. His photographs have been printed in photography publications, including books, magazines, catalogs, corporate annual reports, cards, calendars, posters, and appointment books. They have also appeared in more than 50 solo and group exhibitions and are held in many private and institutional collections.

Henry Gilpin 1922–2011

Henry Gilpin's photographic life began in 1959 at an Ansel Adams workshop in Yosemite, where he viewed firsthand the work of Paul Strand, Walker Evans, Edward and Brett Weston, Ansel Adams, and other early masters. Since that workshop, he has seen photography expand in many intriguing directions, including electronically generated images. But Henry's first love is the full tonal range, unmanipulated, silver image to which he remains faithful.

Henry made photographs for his enjoyment and considered himself the audience. His work kept him seeking the light, the design, and the order that was important to him.

Henry instructed students in using the Zone System at Monterey Peninsula College from 1963 to 2000, for the Ansel Adams Yosemite Workshops, and many others.

Clayton Harley

Clayton Harley is an analog photographer in New York City who has worked in the television news industry and the world of art video. For Clayton, analog processes open avenues of unexplored expression.

Gordon Hutchings

Gordon Hutchings began taking pictures when he was eight with a plastic camera acquired with a cereal box top and 25 cents. He was given a 5 × 7 revolving back "Cycle Graphic" with an uncoated Berlin Dagor in a most uncertain compound shutter while in high school. He set up a primitive darkroom in the cellar and was soon making contact prints. This kindled a lifelong love of black-and-white photography.

In the late 1970s, Gordon was dissatisfied with the diminishing supply and quality of classic paper and film and felt a better developer might help. After much experimentation, he created a new pyro developer he named PMK. Circa 1980, he had a one-man show, and photographers who saw it immediately began to clamor for a workshop with his new developer. Gordon taught many workshops during the 1980s and decided there might be enough interest to write a book on the subject. *The Book of Pyro* was published in 1992.

Since that first workshop in 1980, Gordon has expanded his subject matter and taught workshops in various subjects. He has taught many on his own and for others, including the Photographers' Formulary Workshops in Montana, the Ansel Adams Workshops in Yosemite Valley, Maine Photographic Workshops, California State University in Santa Cruz, and Sacramento. Gordon has written for various photography magazines, including *View Camera* magazine. He has had numerous shows around the country, and his work has been published here and in Europe.

Sandy King

Sandy King is an educator and fine art photographer who is especially interested in the handmade photograph. He is an expert in several different historical printing processes, including carbon transfer, Vandyke, and platinum/palladium. He also experiments with developer formulations, especially pyro staining developers. His writings on this subject can be found at www.pyrocat-hd.com.

Sandy's work has been exhibited widely in the United States, China, Canada, Mexico, and Turkey and published in *Photovision, Silvershotz*, and *View Camera* magazines, among others. He has conducted many group and one-on-one workshops on carbon printing. He has written extensively on alternative printmaking, including carbon transfer, kallitype, and Vandyke, as well as the history of Spanish pictorialism. His latest book on alternative printmaking is *Handcrafted: The Art and Practice of the Handmade Print*, coedited with Christina Z. Anderson, Zhong Jianming, and Sam Wang.

Sandy's work and writings can be seen on his website, www.sandykingphotography.com.

James R. Kyle

At the age of thirteen, James Kyle's mother gave him a Kodak Hawkeye Brownie. Since then, he has maintained an overwhelming interest in the art and science of Photography.

His first darkroom for developing film and making contact prints was made of cardboard taped up to be lightproof. He took his negatives to a friend's house where he was able to print his negatives using a Federal enlarger.

James apprenticed to photographer Walter Smith, working as his "darkroom monkey." It was Smith who gave him his foundation in photography along with the gift of two large format cameras, a 1941 Ansco 8 × 10-inch view camera and a Crown Graphic 4 × 5-inch press camera. He still uses both cameras in his work.

After a brief foray into digital, James is once again heavily involved with both nontraditional and traditional photographic processes.

Lee Lira

Melbourne-based photographer Lee Lira's analog photographic journey began in 2011 when he developed his first roll of 35mm Fomapan R100 reversal film. Since then, he has progressed to making silver gelatin dry-plate emulsions and palladium Ziatype prints using calibrated digital negatives.

Lee has formulated a chemical developer that transforms a silver gelatin dry plate into a direct positive that is captured in the camera.

Lee's inspiration and motivation are his immediate surroundings, from Melbourne streetscapes to objects around his house or that grow in his garden. You can follow Lee on Instagram, @leelira.

Les McLean

Known for his fine art black-and-white printing skills, Les has traveled throughout the United Kingdom for 20 years and the past 10 years in the United States and Canada, leading workshops in traditional black-and-white printing and many other areas relating to the craft and art of photography. For 15 years, Les has taught masterclasses in black-and-white darkroom practice and, more recently, digital imaging and printmaking in colleges throughout the United Kingdom.

Since 1988, Les has regularly written for many popular UK photographic magazines and currently writes for *Black-and-White Photography* magazine. His black-and-white prints are held in museums and private collections throughout the world. Les's work can be found at www.lesmcleanphotography.com.

Saïd Nuseibeh

Dubbed a "Master Printer" by *Photo District News*, Saïd Nuseibeh has received a Watson Fellowship and a Fulbright Senior Scholar award. Saïd's photographic archive demonstrates deep spiritual and personal engagement with his Palestinian and Arab heritage. It includes images of faience (fine tin-glazed pottery) in the Alhambra, Umayyad mosaics, and the Dome of the Rock dating back to the seventh century, as well as the Huweitat Bedouin with whom he lived in the 1980s.

Mark Osterman and France Scully-Osterman

Mark Osterman and France Scully-Osterman established Scully & Osterman in 1991. They work as artists, teach workshops, and give talks on early photographic processes in their Rochester, New York, studio and international locations.

Widely recognized as the foremost expert in the technical evolution of photography, Mark Osterman was the photographic process historian at George Eastman Museum, Rochester, New York, from 1999 to 2020, where he conducted primary research and taught early photographic processes for the international conservation community. He is best known for his research in the wet and dry collodion variants and for creating masterful bodies of work with these techniques. Through his research, writings, exhibitions, teaching, and work as an artist, he has been an important influence in the current revival of collodion and other techniques used in fine art photography.

France Scully-Osterman is an artist and educator. She teaches and gives talks at universities, museums, and art schools in the United States and internationally. As an educator, she is recognized for her extensive knowledge of early photographic processes, including wet- and dry-plate collodion, photogenic drawing, cyanotype, albumen, and salt print methods. For more information, go to the Scully & Osterman website at www.collodion.org.

Tim Rudman

Tim Rudman has an international reputation as a photographer, printer, and expert on darkroom techniques. His four critically acclaimed books on printing, toning, and lith printing are widely regarded as essential reading in their fields. His name has become inseparably linked with toning and the lith printing process, which, through his books, has become accessible to all and now enjoys widespread popularity as a creative printing process.

Tim has conducted darkroom workshops in the UK, Ireland, Spain, Canada, America, and Australia. He is widely published and exhibited, with his prints in public and private collections worldwide. His newest book, *Iceland, An Uneasy Calm*, following an exhibition of the same name, was released in September 2015. More of Tim's work can be seen at www.timrudman.com.

Kimberly Schneider

Kimberly Schneider is a visual artist, educator, and master printer who is dedicated to the art of handmade (darkroom) prints.

Specializing in true infrared film, spiritual landscapes, and experimental photograms, she holds a BFA in photography and a minor in philosophy from Colorado State University. Her work has been exhibited by Scott Nichols Gallery, Photo Forward Los Angeles, The Camera Obscura Gallery, The Photographer's Eye Collective, San Diego Art Institute, ZIA Gallery, Foto Nostrum in Barcelona, and shown virtually at the Louvre.

Her monograph, *Equivalence*, will be published by Veritas Editions. Visit her site, www.kimberlyjschneider.com, to view Kimberly's work.

John Sexton

John Sexton, International Photography Hall of Fame inductee, is recognized as a photographer, master printmaker, workshop instructor, and lecturer. He is the author of four books: *Quiet Light*, *Listen to the Trees*, *Places of Power*, and *Recollections*. Sexton is best known for his luminous hand-crafted traditional silver gelatin black-and-white photographs of the natural environment.

He has conducted hundreds of photography workshops, seminars, and lectures around the globe. From 1979 to 1984, Sexton served as a photographic assistant and technical consultant to photographer Ansel Adams. His finely crafted large-format photographs have appeared in countless publications and are included in permanent collections and exhibitions worldwide. In 2005, Sexton was honored with a Lifetime Achievement Award from the North American Nature Photography Association.

John still finds magic in exposing and processing film and making silver gelatin prints by hand in his darkroom at his home and studio in Carmel Valley, California.

Michael A. Smith 1942–2018

Michael A. Smith began photographing in 1966. In 1967, he began photographing exclusively with an 8 × 10–inch view camera, committing himself to the contact print. Later, he added an 8 × 20–inch and an 18 × 22–inch view camera.

His 52-year commitment to the medium resulted in over 200 exhibitions. He twice received fellowships from the National Endowment for the Arts and significant commissions to photograph five American cities.

His photographic journeys took him to every state in the continental United States, western Canada, Mexico, and Europe. The results of these remarkable odysseys are included in the permanent collections of over 130 museums in the United States, Europe, and Asia, and his photographs reside in hundreds of private collections.

In 1981, Smith's first book, the two-volume monograph *Landscapes 1975–1979*, was awarded Le Grand Prix du Livre at the Rencontres Internationale de la Photographie in Arles, France.

Six additional monographs followed between 1992 and 2015, with his last book, *Inmates at Sheriff Joe's 4th Avenue Maricopa County Jail, Phoenix, Arizona*, published posthumously in 2024. His books can be seen at www.Lodima.org, and his photographs at www.michaelandpaula.com.

John Wimberley

John Wimberley began photographing the landscape in black-and-white in 1969. Since then, he has garnered an international reputation as a master photographer and printer. He has had more than 75 exhibitions, and his work is represented in over 700 public and private collections. His photograph "Descending Angel, 1981" is one of the best-selling images of the past half-century.

In 1970, John began investigating the forgotten developing agent pyrogallol. After seven years of focused research, he published his new formula, WD2D (Wimberley Developer #2, Version D), in the October 1977 issue of *Petersen's Photographic* magazine. WD2D is the first pyrogallol developer formulated specifically for the post-1940 generation of single-emulsion films. It sparked a revival of interest in this classic developing agent that continues to the present. John's work may be viewed at www.johnwimberleyphotography.com.

List of Formulas by Category

Alphabetical Index of Formulas

EV = Environmentally Friendly
MQ = Metol-Hydroquinone
PF = Photographers' Formulary
PQ = Phenidone-Hydroquinone

Part 1

Nuts & Bolts

1

Planning a Darkroom

> *"You get no points for making the image the hard way. You only get points for stopping people in their tracks with great images."*
>
> —Dan Burkholder

The darkroom is many things: It is a place where images are created, a place of magic, and a refuge. When you enter the darkroom, time stands still. The sound of running water, music, or silence replaces the world outside. Everything you do while in the darkroom, from developing film to dodging and burning a fine print, is accomplished in a calm, relaxed, and nurturing manner. The result is what I call a "Zen" experience.

A darkroom should also be a clean, odorless space with ample safelight in which it is pleasant to spend as much, or as little, time as needed to create your art. After all, a photograph is only recorded by the camera. The image you hang on your wall is created in the darkroom.

Photo 1.1 Darkroom. The size or number of enlargers in my darkroom is less important than the ample storage space, cleanliness, and light-colored walls and ceiling. Regardless of the size or amount of equipment, these and good ventilation are prerequisites for a healthy, safe, and rewarding darkroom experience.

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A darkroom has five requirements to process, proof, and print negatives safely and efficiently:

1. Water
2. Light free
3. Ventilation
4. Dust free
5. Electricity

WATER

Water doesn't need to be in the same room; it just needs to be available. The supply should be as clean and grit-free as possible, especially for film processing. If you are processing in a bathroom or kitchen, obtain a screw-on filter that fits on the end of the tap. These filters reduce the risk of spots from dust, dirt, rust, and undissolved chemicals contained in tap water.

A water temperature control (WTC) is a good investment for permanent darkrooms. A WTC can be purchased alone, and water filters can be added later or purchased as a complete, ready-to-install unit.

If you are building a permanent darkroom, install inline water filters. If you use an inline WTC, use two filters: one for the cold side and one for the hot. Two filters will increase the life of the valve. Use wound polypropylene filters. Cellulose filters may come apart with use and contaminate the water.

An alternative to an inline WTC would be the CineStill CS Temperature Control System TCS-1000, see Photo 1.2. Because the TCS-1000 is not plumbed inline, you only need to install one water filter.

If you do not have a WTC, use a water temperature monitor (WTM). A WTM device has a built-in thermometer that attaches below the faucet to monitor temperature, see Photo 1.3. These are indispensable for temporary or portable darkrooms, such as a darkroom in a kitchen or bathroom.

Using Deionized or Distilled Water

Ordinary tap water will prove sufficient for most photo applications. However, in areas where the water is known to be extremely hard (containing lots of minerals and particulate matter) or excessively soft (alkaline), using deionized or distilled water to mix chemicals for developing film or paper is highly recommended.

In the case of hard water, boil the water and allow it to sit overnight in a covered container. The particulate matter will precipitate out within 24 hours. Carefully strain the water through a nonbleached coffee filter or slowly decant, leaving any precipitate at the bottom of the container.

Author's Note: Don't confuse distilled water with drinking or spring water; they are not the same thing. Drinking water should not be used to mix darkroom chemistry.

Photo 1.2 CineStill CS Temperature Control TS-1000. The CS TCS-1000 immersion circulator/thermostat is the simplest solution for precision film processing at home.

Photo 1.3 LynsaTac Shower Thermometer. If you don't have a WTC, install an inline WTM such as the LynsaTac Shower Thermometer shown here. It has a built-in high-precision temperature sensor, a measurement range of 41°F/5°C–85°F/185°C, and ±0.5 accuracy.

NO LIGHT IS GOOD LIGHT

It is not always possible to achieve an absolute light-tight darkroom. Fortunately, the only part of the process in which zero light is necessary is while handling film, a problem that can be solved using a changing bag, see Photo 1.4. Purchase the largest bag you can find—the small bags are of little use.

From a personal point of view, it is not always desirable to have a light-tight darkroom. Brett Weston worked in his darkroom after midnight. He lived in the country where there were no neighbors or city lights. While printing, he opened all the windows and doors to allow the night air to circulate freely.

Leaving the doors and windows open is probably not an option if you don't live in the country. However, making a room light-tight to print is not that difficult. An easy way to block windows is to place a strip of Velcro around all four sides and attach a piece of blackout cloth, available from most photo suppliers. Alternatively, use a piece of black foam core board available from art stores. If your space doesn't have a door that can be closed, cover the opening similarly or purchase an inexpensive hollow-core door from a builder's supply store, see Ventilation section.

Sealing the light around the door is relatively easy. Spend a few minutes browsing in the weather-stripping section of any hardware or building supply outlet, and you will find many self-adhesive products that can be applied to the door frame. A two-by-four nailed to the floor along the bottom edge of the door and a good door sweep will take care of most of the light leakage along

Photo 1.4 Changing Bag. Use a changing bag if you don't have a light-tight darkroom to handle film. Purchase the largest changing bag you can find.

the bottom edge. You can also purchase an automatic door sweep that adjusts to irregular floor surfaces.

Paint the inside door jambs with flat black paint as a final step.

VENTILATION

While making a darkroom light-tight may be desirable, making it airtight can be hazardous. All darkrooms should be well-ventilated. Proper ventilation in the darkroom is the first, and possibly most important, expense, even before an enlarger and lens. Make it a priority to build a darkroom that is healthy and comfortable to work in. Add equipment as you can afford it.

Ventilation is not an issue if your darkroom work is limited to film development in a daylight tank over the kitchen sink. If you have a situation like Brett Weston's, in which all the doors and windows can be left open, no problem. However, proper ventilation is of utmost importance when you enclose a space, be it a closet, bathroom, or specially built room.

Lack of fresh air can cause a buildup of toxic fumes, which, though not usually lethal, can cause drowsiness and headaches. In addition to fumes and stale air, heat from the enlarger lamp, or even from outside if you live in a warm clime, can cause you to avoid spending time in the darkroom.

Current Occupational Safety and Health Administration (OSHA) and Environmental Protection Agency (EPA) studies indicate that proper ventilation means an active exhaust fan to remove toxic fumes and a passive vent, or active fan, to admit fresh air. If possible, the exhaust fan should be placed above the processing sink to draw the fumes directly from the processing trays. The passive vent should be low to the ground preferably, though not necessarily, opposite the exhaust fan. Both need to be light-tight.

The best way to ventilate a small darkroom is a light-tight exhaust fan. This investment is as important as an enlarger, and you should not cut corners. A darkroom requires active ventilation. The small, round, passive air vents available from retail outlets may be suitable for facilitating airflow in a small space, but do not consider them a substitute for real ventilation.

If the darkroom is in a closet, install a fan at the top of the door, drawing air out, and a passive vent at the bottom, allowing fresh air in. If you're renting a house or apartment, remove and store the landlord's door and replace it with a door of your own. When you move, replace the landlord's original door, keeping your ventilator door intact for the next darkroom.

If a window is available, the fan can be mounted on a removable Masonite board. The Masonite should be attached to a lightweight wooden frame that fits over the window to block light. After a darkroom session, the complete Masonite board and light-tight fan can be removed and stored.

DUST-FREE

While a fresh supply of air is paramount to the health and safety of the darkroom worker, clean, dust-free air is essential to the quality of the work. It is a critical consideration in areas where film is to be dried.

Many photographers dry film by hanging it in a bathroom. This is a perfectly acceptable arrangement with the following precautions:

- Remove all towels and area rugs. These are dust magnets and static generators.
- Ideally, the film should be hung inside the bathtub or shower with the curtain pulled or the door closed.
- To rid the bathroom of dust, run hot water for a few minutes to create steam. When the steam clears, the dust will have settled. After that, it is okay for people to enter the bathroom if they keep the door closed behind them and move carefully so as not to stir up dust.

One method for hanging film in a shower is using a retractable clothesline from a home building or variety store.

Another solution where traffic is heavy or where there is no shower stall is to use a drying cabinet available from many photo suppliers.

Make sure to avoid hanging your film in a clothes closet. You will have negatives that are so full of dust that they will be unprintable.

ELECTRICITY

The electrical demands of a darkroom are not great. One outlet with a four-plug adapter or a good power strip with multiple outlets is often sufficient for a closet or temporary darkroom.

If you are building the darkroom from the ground up, take a moment to tally the total wattage of all the electrical equipment you plan to use—enlarger, timer, lights, safelights, drier, dry-mount press, slide viewer, and so on. Divide the total wattage by 120 volts (or whatever voltage you use). The result is the number of amperes of current drawn if everything were on simultaneously. Add 10–20% for growth. Then install one or more circuits sufficient to carry the current demand in amperes. Standard circuits are 15 amperes. However, you can install 20- or 30-ampere circuits using heavier wire.

Always use reset-type circuit breakers instead of replaceable fuses. If possible, locate the breakers close to the area served by the circuit. It's smart to put the lights on one circuit and everything else on a separate circuit. This way, if a momentary overload trips the circuit breaker, you won't be "left in the dark."

A second circuit dedicated to the enlarger will help minimize voltage fluctuations. If that's not possible, use a constant-voltage transformer between your enlarger and the outlet to prevent variations in printing.

A small darkroom should have at least four outlets, more if needed. Locate two conveniently along the wall, one each above the sink and enlarger bench. If the darkroom is in a basement, locate the outlets high in case of flooding.

On the wet side, locate the outlet high above the sink and use a ground fault interrupter (GFI) outlet in case an appliance is dropped into a solution or develops a short. GFIs are available as separate units to plug into a conventional outlet or as easy-to-install replacements for ordinary outlets. If in doubt, consult a licensed electrician.

Smelly Darkrooms

There is no reason for a darkroom to be a dirty, smelly, unhealthy environment. Frank and Daughtee Rogers were proud of how clean and orderly their darkrooms were. They insisted that everything be washed, dried, and put where it belonged so it could be found in the dark. I have continued that practice. The darkrooms of photographers for whom I have respect were and are similarly kept. These include Ansel Adams, Brett Weston, Wynn Bullock, Henry Gilpin, Richard Garrod, and Frank Rogers.

Having always kept my darkrooms clean and orderly, I was shocked when I visited an associate's darkroom in San Francisco and found it to be a pigsty. It was dark, damp, and dirty. This photographer had been working in the darkroom as long as I have and should have known better. Hard on the heels of this experience, I visited another photographer in Portland and was appalled at the condition of his darkroom. If I had to work in either of these holes, I would give up photography.

PERMANENT DARKROOMS

Establishing a permanent darkroom presupposes the availability of a permanent space. Ideally, there should be enough room for a dry side for enlarging and a wet side for developing and other chemical processes. The two can be on opposite sides of the room or side by side with a splash wall separating them.

The location of the darkroom is important. Unless well insulated, an attic is likely to be too hot in the summer and too cold in the winter. Also, extending plumbing into an attic is usually difficult and expensive.

A dry basement with a drain is an ideal location. If the basement is damp, dry it with a dehumidifier from the appliance store. The optimum relative humidity for a darkroom is between 45% and 50%; the ideal temperature is between 68°F/20°C and 75°F/24°C. Maintaining this temperature range in a basement is often easier than in other parts of the house. Also, hot and cold water and electrical connections are generally available in a basement. Another advantage is the ease with which a basement can be made light-tight.

Alfred Stieglitz (1864–1946) would cover his dining room table with a black cloth and sit cross-legged on the floor under it. He would load his film in this makeshift darkroom or spread developing trays out and develop it. Besides aching joints, the big problem with this was the lack of ventilation.

A portable darkroom tent is a modern alternative to sitting cross-legged under your dining room table. However, many portable darkroom tents are small and have low ceilings.

Another alternative would be a hydroponic tent for growing plants, see Photo 1.5. These are light-tight and come as large as 10 × 20 feet with 9-foot ceilings, high enough for a full-size enlarger. Because they are made for growing plants, they also are equipped with ventilation ports. They include a floor to catch spills. The only downside is that the interior walls are made of highly

Photo 1.5 Hydroponic Tent. This 10 × 10-foot hydroponic tent by Gorilla Grow Tent (www.gorillagrowtent.com) is larger than most darkrooms I have had. It is 6 feet 11 inches high and can be extended to 8 feet 11 inches high. Most of my darkrooms have had 8-foot ceilings.

reflective material that is good for growing plants. You will need to find a way to cover the walls or reduce the brightness of the reflective material. You don't need to use black cloth to cover the walls. Try hanging middle gray cloth from the horizontal cross bars. Or attach the fabric with Velcro. You only have to cover to just below the tabletop.

You don't need a 10 × 20-foot darkroom. Anything 6 × 7-feet would be good depending on your indoor space. If you have the space and this sounds like a solution, check out the Gorilla Grow Tent at gorillagrowtent.com.

Finally, if you have a suitable backyard space, consider installing a prefabricated shed and converting it to a darkroom. You will find excellent instructions written by Dave Miller on the Film and Darkroom User forum.

How Big Is Big?

Bigger is not always better. A large-format photographer converted a 20 × 20-foot room into his version of a dream darkroom. He spends half his time walking from one side to the other.

Another photographer uses a closet. He built shelves, put his enlarger on one side, stacked trays on a tray ladder, and added a paper safe and rotating stool. He turns from his enlarger to his trays and back. When a print is finished, he carries it outside in a tray and places it in a washer, which sits on a plywood board with a 2 × 4-foot frame over the bathtub. The washer and frame are stored in the darkroom closet when he's not printing.

If you have the space, a reasonably sized permanent darkroom would be about 6 x 7 feet. The minimum open space to stand and move about for safety and comfort should be at least 30 inches wide.

Placement of Equipment and Workflow

The main objective in planning a darkroom is to arrange the equipment and materials efficiently and conveniently. The dry and wet sides should be arranged to facilitate the flow of work, from enlarging to developing and back again, with a minimum of steps.

Study the darkroom work pattern in Photo 1.1 and 1.2. You can see the reasons for the recommended arrangement of the benches and equipment. For example, you would place the paper in a paper safe next to the enlarger to make prints. After placing the negative in the enlarger and composing the image, you would expose a sheet of printing paper in the easel. After exposing the paper, you either turn around to face the wet side, see Photo 1.1, or pass it on to the developer on the other side of the splash wall, see Photo 1.2. Everything is carried out with minimal time spent moving from one place to another.

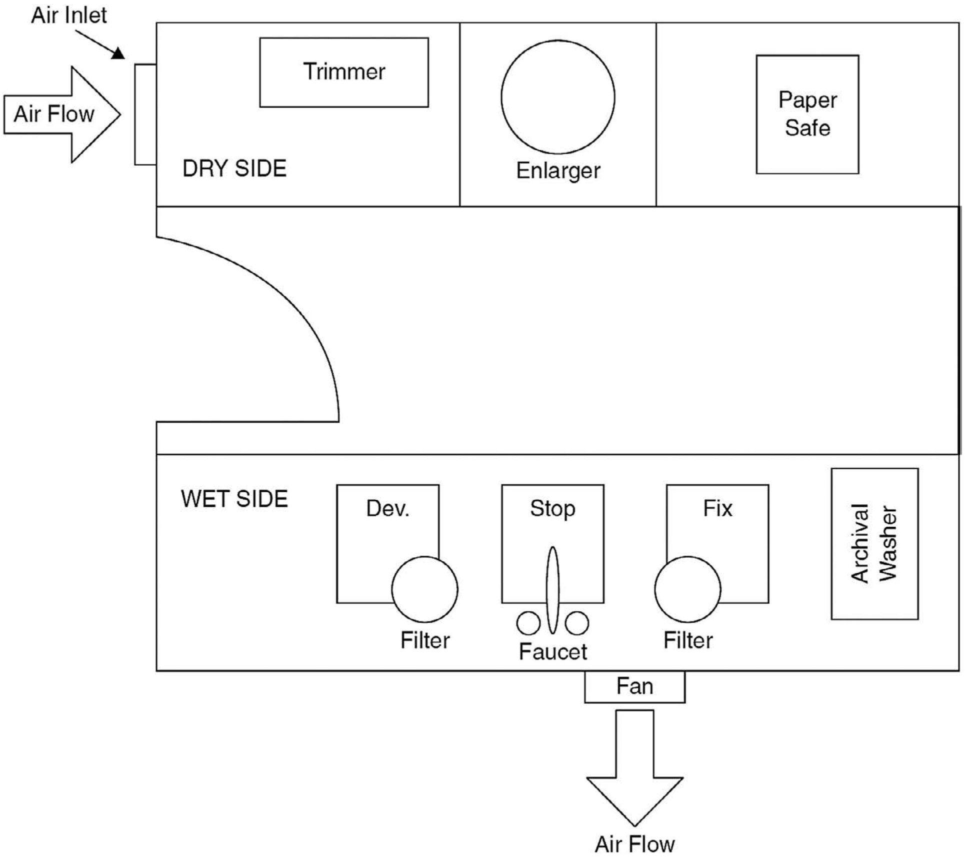


Photo 1.1 Darkroom configuration 1. A possible darkroom configuration. The enlarger may be placed in the middle or at either end, with the trays arranged accordingly. Fresh air should enter from a passive vent over the dry side or in the door. (Thanks to Brian MacNeil of Canada.)

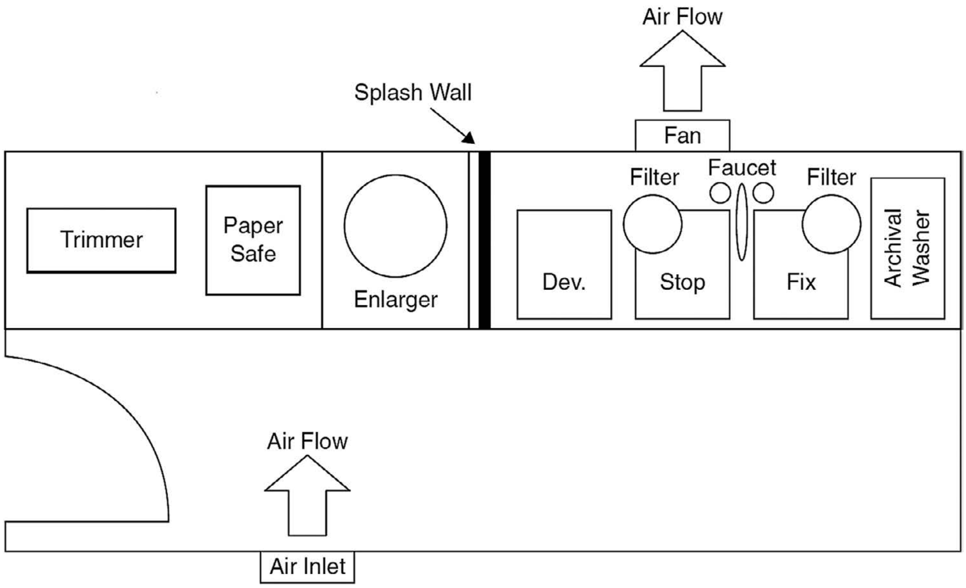


Photo 1.2 Darkroom configuration 2. A second possible darkroom configuration. The enlarger may be placed in the middle or at either end and the trays arranged accordingly. An active slotted fume hood would be well placed above the tray. If possible, fresh air should come in from the wall opposite the hood. (Thanks to Brian MacNeil of Canada.)

TEMPORARY DARKROOMS

Many small spaces can be converted for darkroom use: a bathroom, a closet, or a storage shed in the backyard. Temporary workspaces can be made in a bathroom by placing a 12-inch plywood board from the top of the toilet to the edge of the bathroom sink or by building a frame with a piece of plywood that will cover the bathtub. You can use a stool to sit on. Or you can attach legs to the frame, raising it to a more comfortable work height. These can be folding legs for ease of storage.

You can also use a rolling kitchen island, see Photo 1.6. Chemicals, paper, etc., can be stored on the shelves, dodging tools, and in the drawers. The cart can be wheeled into the kitchen after washing the dishes and into a closet or the garage for storage.

It is easy to build a cart to your specifications using 2 × 4-inch lumber and ¾-inch to 1-inch plywood (do not use ½-inch plywood, as it will not stay flat).

The top of your homemade cart should be about 30–32 inches from the ground, depending on (1) how tall you are or (2) the height of the doorways you need to maneuver through. Attach good-quality rolling casters so that the table with the enlarger moves smoothly across the floor. You can extend the top with a hinged flap on one or both ends with hardware available from a

Photo 1.6 Kitchen Island. The Ewart Kitchen Island pictured here is 44 inches wide and 20 inches deep, large enough for a 4 × 5 enlarger and paper safe. Removing the enlarger column from the baseboard and bolting it directly to the island will increase your workspace and lower the column by an inch or more, making it easier to roll through doorways. Butt the cart against your kitchen sink, where you can lay out your trays. Just remember to do the dishes first.

hardware store. This will allow the cart to take up less room for storage. Attach a piece of plywood across the bottom and add a shelf in the middle—both should be bounded by 2 × 4-inch lumber or strips of excess plywood to keep things from falling off when moving the cart around. Store wet-side materials, such as liquids, trays, etc., on the bottom shelf and dry-side materials, such as powders, focusing devices, easels, and a paper safe, on the middle shelf so they do not inadvertently get dripped on, see Photo 1.3.

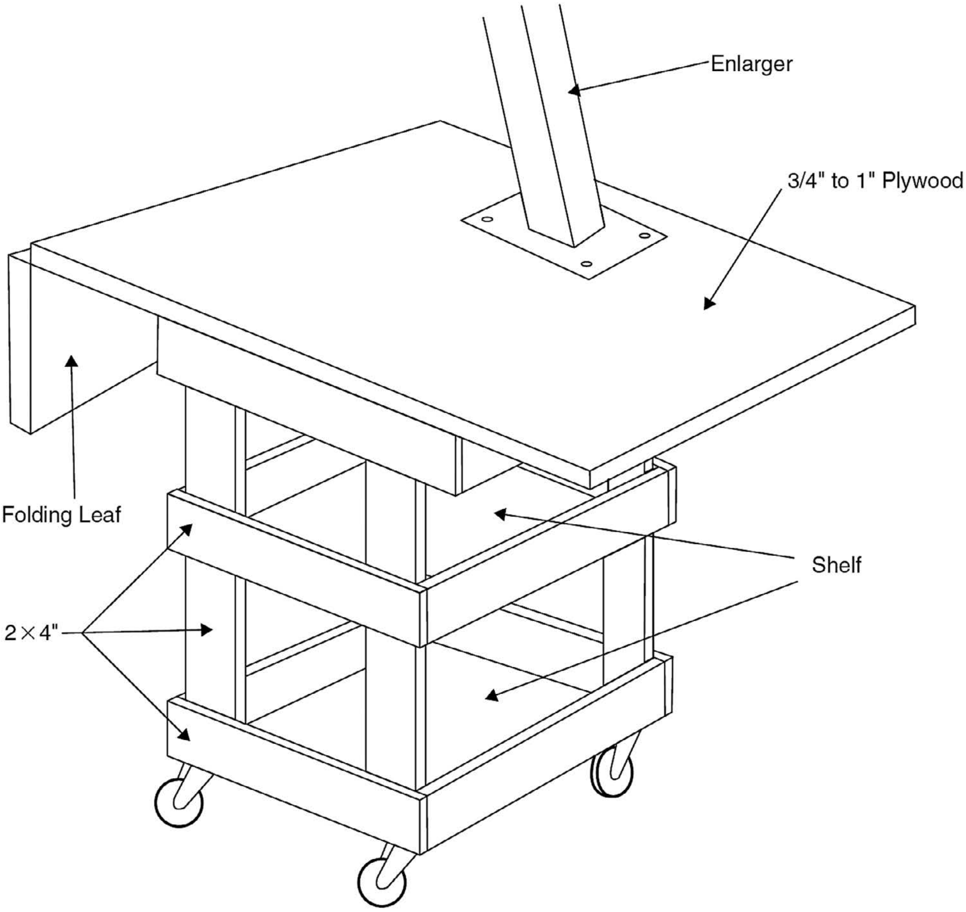


Photo 1.3 DIY Darkroom cart. This is an example of a do-it-yourself roll-away darkroom cart. The enlarger column has been bolted to the plywood to save space and lower the overall height (this is optional).

Developing Film in a Kitchen or Bathroom Sink

If you don't have access to a darkroom, don't let that stop you from the satisfaction of developing your own film. A simple arrangement is to use an inline WTM, see Photo 1.7. In the same photo notice the tray hanging over the sink. I use this for a water bath, though a print washer tray would be preferable. The tray is slightly tilted so water runs toward the sink and is placed as far into the sink as possible to leave a comfortable working space.

To mix the water, with or without a WTM, open the cold-water valve halfway. Allow the water temperature to stabilize by running for about 1 minute. Then slowly open the hot water valve until you reach the desired temperature.

Photo 1.7 Developing in a kitchen sink. A water temperature monitoring device does not control the temperature of the water; it only monitors it. Using one will make development easier, but it won't prevent the temperature from shifting, even if you are the only one home. Keep a close eye on it at all times.

Either do what Brett Weston did, only develop film at 2 A.M. when everyone in the house is asleep, or ask everyone to refrain from running water or flushing toilets until you are finished! Otherwise, the temperature will drop perceptibly and cause damage to the emulsion, usually in the form of micro-reticulation that creates clumping and loss of sharpness.

WALLS AND FLOOR

There has never been a time when a darkroom needed to be painted black. This idea is held over from the—dare I say it? Dark Ages.

Light-colored darkroom walls create a safer and healthier environment with less eyestrain. I have found that the best color to use is a flat, neutral gray. Unless your enlarger is a significant source of light leaks, you can paint neutral gray behind and around it. Use either gray or flat white for the ceiling to better reflect the safelight.

Appeal to Educators

I have guest-instructed darkroom workshops from Los Angeles to New York City and Europe. I have found that in schools everywhere, the walls are invariably painted black, especially around and behind the enlargers. A darkroom with black walls is depressing and oppressive. If I were a high school or college student and faced with spending 3 hours in a black hole or in front of a computer, I would choose the computer. If you are an educator and the walls in your school darkroom are painted black, I urge you to take the next spring break or summer holiday and paint the walls light gray, including behind and around the enlargers and the ceiling. You will change not only your students' attitude toward the darkroom experience but also your own.

Author's Note: Many municipalities have paint recycling facilities. These facilities usually mix all the paint together, resulting in neutral gray paint. Where I live, they will give you as much as you want for free. My darkroom, shown in Photo 1.1, has walls and a ceiling painted with this free paint. This is good to know if you're teaching photography in a school with a budget.

Floors call for special consideration. They need to be protected against moisture and chemical action. The best material is concrete with a chemical-resistant coating. The next best is good-quality linoleum, which should be kept clean and waxed to help prevent the penetration of spilled solutions. This can be underlain with bitumen paper as an extra precaution against liquids getting through and damaging the subfloor. A drain is useful but only partially necessary if the floor is dried after spills.

Another good idea is a chemical-resistant, antifatigue floor mat. An antifatigue mat will help you work longer and more comfortably, especially if your darkroom is in a basement or garage with a concrete floor. The mat will also insulate you from the cold.

CABINETS, BENCHES, AND SINKS

A cabinetmaker can build tables for a darkroom, or they can be purchased ready-made as modular kitchen units or built using 2 × 4 lumber and plywood.

Sinks can also be bought or made. I prefer a sink at least 6 feet long, preferably 8–10 feet. A 4-foot sink will accommodate three 11 × 14-inch trays. A 6-foot sink will accommodate four 11 × 14-inch trays with barely enough room for a vertical print washer. If you do not usually make prints larger than 8 × 10 inches, a 4-foot sink is adequate. If you need additional space, use a set of tray ladders.

If your space is minimal, you may need to run a galvanized wire or clothesline over the sink to hang film for drying—or use the bathroom as previously mentioned. If you use the sink option, the film won't be able to hang straight (a 36-exposure roll is about 5 feet long). Attach both ends to the line via clothespins or film clips. Cutting the strip of negatives between frames 18 and 19 is even better.

STORAGE SPACE

Whereas counter space for the enlarger and room for the sink is essential, ample storage and shelves make small darkrooms efficient.

Use a paper safe to provide quick access to printing paper and eliminate the necessity of opening and closing the paper package.

The sink can be used for mixing chemicals and all processing operations. Storage space for trays and chemical solutions should be beneath the sink. Shelves mounted 2 feet above the sink and the enlarger bench will provide additional storage space for bottles of stock solution, timers, thermometers, and other small equipment. Wooden pegs mounted on the side or splash wall, shown in Photo 1.4, provide a place for film hangers and graduates. A towel rod mounted on or near the sink provides a place to dry your hands.

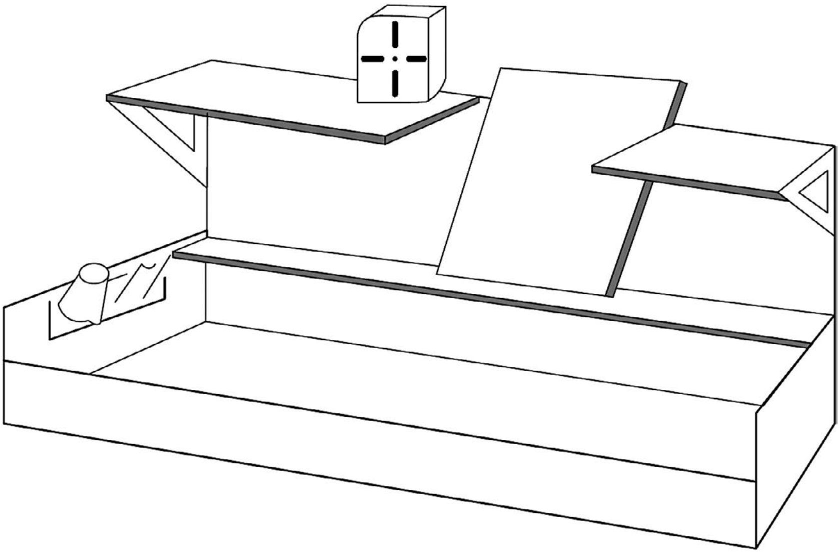


Photo 1.4 Diagram of a sink. The faucet can be placed on the back wall or either end. Pegs on the side, as shown, or the splash wall behind can be used to dry measuring cups, rags, and small utensils.

SAFELIGHTS

Proper lighting is essential for safely handling light-sensitive material in the darkroom. The lighting is a balance between color and intensity that does not fog sensitive materials but enables the photographer to work with minimal inconvenience and eyestrain. The correct safelight filter must be used in an appropriate housing and fitted with a bulb of the correct wattage, see Chart 1.1.

Kodak and Ilford Safelight Filters

Ordinary printing paper can be handled in a relatively high intensity of dark-brown or red light, corresponding to Kodak OC or 1A filters (OC is more commonly used for modern emulsions). Panchromatic papers (for example, discontinued Kodak Panalure Select RC) are sensitive to all light wavelengths and require a low-intensity Kodak #3 dark-green filter. Orthochromatic or red-blind materials such as high-contrast line film, also known as lith film, used in the graphic arts, can be handled using a high-intensity Kodak 1A or 2 red filter.

Except in very small darkrooms, you should use more than one safelight. The primary light should be placed so the illumination is evenly distributed over the entire area. This could be a safelight aimed at a white or gray ceiling.

A second safelight should be placed over the processing sink, at least 4 feet above the sink. If the light is aimed down, use a 15-watt frosted bulb. If it bounces off the ceiling, use a 25-watt frosted bulb. If your darkroom is large enough, place a third safelight over the dry side.

If the size of your darkroom warrants it, use a Thomas Sodium Vapor Duplex Safelight. There is nothing better for silver printing, especially if you have 8-foot or higher ceilings.

Seeing by Safelight

When the white light is first turned off, it can take several minutes for your eyes to adjust to the diminished intensity and limited spectrum of the safelight. However, looking directly at the safelight for a few seconds can considerably shorten the time it takes your eyes to adjust.

Chart 1.1

Kodak and Ilford Safelight Filters

Kodak Wratten	*Ilford*	*Color*	*Use For*
OA		Greenish Yellow	B&W Silver Chloride Contact papers (i.e., Kodak AZO), duplicating materials
OC	902	Light Amber	B&W Contact and enlarging papers
1A	900, SL1	Light Red	Blue Sensitive materials, most B&W papers
2	906	Dark "Ruby" Red	Fast Orthochromatic Materials, Harman Direct Positive Paper, Green Sensitive X-ray Films
3	907	Dark Green	Some Panchromatic Materials (development by Inspection)
10, 10H	908	Dark Amber	Color Papers, Panchromatic B&W Papers, (Panalure), Use Indirect

How Safe Is Your Safelight?

Richard Garrod

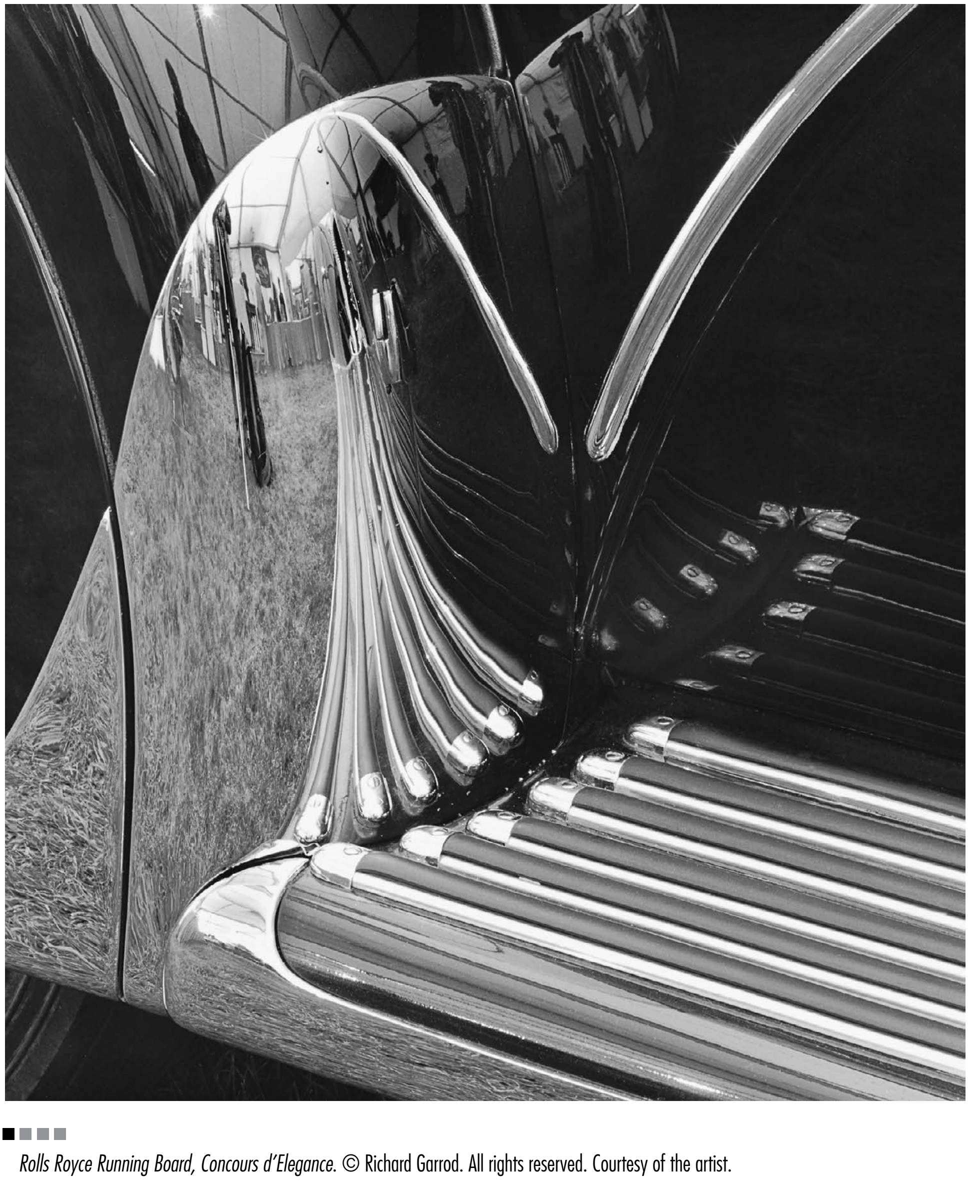
It is important to realize that no safelight is 100% safe because the spectral sensitivity of materials does not cut off abruptly at a given wavelength. The effect on print quality is compounded in the highlight areas when a print is exposed to an unsafe light and then the exposure from the negative is added. This creates a density higher than normal on the print and degrades the highlights. Photographic papers also have a slight sensitivity to colors beyond their sensitivity range. The sensitivity of a paper depends on the nature of its emulsion, so testing is important.

Nothing is more disappointing than to see the high values of an image degraded by a mismatched safelight. A safelight testing procedure is needed.

The procedure I use is as follows:

1. Turn the safelights off without a negative in the enlarger. Using your fastest printing paper and a short exposure, produce a light-gray tone just above paper white. Brief testing will determine the correct exposure to produce this light gray, see Chapter 7.
2. After the base exposure level has been determined, expose a final sheet of paper, but don't develop it yet.
3. Tape the paper emulsion side facing up on a piece of cardboard over the developing tray with all lights still off. Place a narrow, opaque object like a ruler lengthwise along the entire surface of the paper.
4. Cover a 1.inch section of paper and ruler with another piece of cardboard around 11 × 14 inches and give the preexposed sheet 2 minutes of safelight exposure. Extend the cardboard another inch and give the remaining paper 2 more minutes of safelight exposure. Then, extending the cardboard each time, give sections 4, 8, and 16-minute exposures. This will produce a pattern of 0, 2, 4, 8, 16, and 32 minutes of safelight exposure.
5. Process the paper with the safelights off and evaluate the test. Find the exposure time of the area that first shows the ruler's shadow. You should be able to use the safelight for about one half of the exposure time that produced the ruler's shadow.

As a result of this testing, I found it necessary to replace all the safelight bulbs in my darkroom with lower-wattage bulbs placed about 4 feet above the trays. Bouncing the light off the darkroom ceiling, assuming it is painted white or middle gray, is another way to cut down on too much unsafe safelight.



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Rolls Royce Running Board, Concours d'Elegance. © Richard Garrod. All rights reserved. Courtesy of the artist.

SEPTIC SYSTEMS

Very little is written about darkroom chemicals and septic systems. Fortunately, Kodak has done a lot of research on this subject, although it can be challenging to find.

Most black-and-white darkroom chemicals are organic and photo-grade quality. They have little or no impact on the microorganisms in a septic system. Many solutions used in the darkroom, including many developers and fixers, can be used to fertilize plants.

According to Kodak,[1] a properly designed septic tank for a family of four should handle between 13 and 20 gallons of photographic-processing waste and darkroom wash water per day. The primary precaution you need to take is to refrain from releasing large amounts of processing solutions at once, as in dumping a gallon of used fixer down the drain. In this case, parcel out the fixer 1 liter at a time, followed by a brief water rinse. If you dispose of 1 liter per hour or each time you return to the darkroom after an extended break, there should be no problem.

You need to know that silver is present in significant quantities in processing waste. While free silver ions are toxic to microorganisms, they are primarily present as silver thiosulfate, which is not harmful. If you are concerned about the presence of silver in your septic system, you can use various means to recover it from the fixer.

Chemicals that should be avoided are the most caustic, such as sodium hydroxide, a constituent of Dran-O, and those most acidic, such as sulfuric and hydrochloric acid—anything at either end of the pH scale. Chemicals such as mercuric chloride should likewise be avoided. Fortunately, very few formulas require these toxic chemicals.

Other chemicals that should be avoided are sodium and potassium dichromate, which are also hazardous to the bacteria in septic systems. If you must use a dichromate (e.g., for gum printing, chromium intensifier, tray cleaning solutions), you can limit the effect on the system by adding salts such as sulfite or thiosulfate. Any alkaline material (including sanitary waste) can be added to neutralize the acidity and precipitate the chromium. You can combine these steps by diluting the dichromate solution with an alkaline fixer. After neutralizing the dichromate, allow the solid chromium compound to settle and filter it out before disposing of the solution.

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[1] The Kodak Workshop Series: Building a Home Darkroom. Written for Kodak by Ray Miller; New York: Eastman Kodak Company, 1981. Kodak Publication No. KW-14.

The Feminine Touch

Starry, Starry Night

Martha Casanave

I stick glow stars on the ceiling and in other strategic spots so I can navigate in total darkness when tray-developing sheet film. Glow stars can be found at any art supply store.

Ansel would never listen to music in the darkroom, only the persistent ticking of his metronome, but we're all different: I crank up Al Green or James Brown and dance while rocking the trays.

Setting Up a Darkroom

Marie M. Curtis

I work methodically in the darkroom, just as I cook in a kitchen.All my ingredients are laid out neatly in the order I plan to use them (negatives, paper, rulers, dodging and burning equipment, pencils, scissors, cutting board), then in the sink—chemistry, measuring devices, filters, the sieve types, squeegees, tongs.

Always make sure everything is within easy reach or a short stretch.

Alternative Lighting

Jill Enfield

Instead of using a 40-watt bug light for alternative processing, try using a string of Christmas tree lights. I stole this idea from the Maine Media Workshop. I was teaching a workshop where we had to turn off the room lights, and the Christmas lights came on. It was wonderful, and I immediately ran out and got them for my darkroom.

It's important to have your darkroom as comfortable as possible. You should have good music, great lighting, and everything within reach.

2

Equipment

> *"Art does not depend on the tools used, but on how they are used; in the hands of an artist, the camera produces works of art."*
>
> —Paul L. Anderson

The equipment for a darkroom falls into three categories: dry side, wet side, and miscellaneous. The following items are recommended for a well-equipped darkroom.

DRY SIDE

The dry side is where your enlarger resides and negatives are stored and handled. You can load film into daylight developing tanks on the dry side if the tanks are dry on the outside. Liquid or powder chemicals should never be placed on the dry side to avoid possible damage to negatives. The following is a list of recommended and optional items.

Must Have

- Enlarger
- Enlarging lens(es)
- Paper easel
- Grain-focusing device, Photo 2.4
- Multicontrast filters
- Repeatable enlarging timer, Photo 2.2
- Soft brush and blower bulb for cleaning negatives
- Pliable cardboard and dodging wands for dodging and burning

Enlargers and Light Sources

Enlargers are classified by their size and by their light source. A medium format enlarger will accept any negative up to 6 × 7 centimeters. A 4 × 5 enlarger will accept any size negative up to 4 × 5 inches. With a few exceptions, 4 × 5 enlargers are better made; meaning that they will last longer. Beyond that there is no advantage as long as they accept the negative size you are using.

All enlargers go out of alignment sooner or later. The Saunders LPL enlarger was promoted as the only enlarger ever made that wouldn't go out of alignment: ever. Balderdash. I have lost count of how many Saunder LPLs I have had

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to align for school darkrooms. If your negatives are consistently out-of-focus on one or more side, your enlarger probably needs alignment.

But more importantly is the light source. The most common are tungsten, cold light, and diffused. There is also a point light source, but I have known one photographer to have used one. Tungsten light is almost always collimated, whereas diffused and cold light are both well and diffused. Collimated light is focused through the negative, whereas diffused light bounces around inside a mixing chamber or passed through a diffusion disk and randomly passes through the negative. Collimated light will always print at least one contrast grade higher than diffused light. Theoretically, that means negatives meant to be printed using collimated light should be exposed and developed for lower contrast.

Ansel Adams used cold light which gives it a certain cachet. However, Ralph Gibson, W.E. Smith, Margaret Bourke-White, Imogen Cunnigham, Dorthea Lange all used collimated light. In my darkroom I have an Omega D5 with a collimated tungsten bulb and a Beseler V XL with a cold light head. I develop my negatives the same for both types of light and compensate in printing.

Enlarger Bulbs

Thanks to Mark Overton and the Photrio Forum There are four types of bulbs (lamps) in common use, tungsten, halogen, fluorescent (cold light), and LED. Tungsten bulbs are disappearing, the future of halogen is uncertain, and cold lights are no longer being made. Moving into the future, there may become a time when bulbs for legacy enlargers that have non-standard bases, such as the Beseler 23C, will no longer be available. Enlargers such as the Omega D-series, Beseler MX, or Beseler V series that have E26/E27 (EEU/USA) medium Edison standard bases (household bulbs) may be the only legacy enlargers for which you will be able to find bulbs, and these will most likely be LED, or some new technology not yet available. Keep this in mind when choosing an enlarger.

LED bulbs have several benefits for silver–gelatin printing. One is that they don't heat up like tungsten or halogen bulbs, eliminating the problem of the negative popping out of focus, especially prevalent with collimated light. Another is that they have faster printing times, especially using high contrast filters with multigrade/variable contrast (MG) paper. This is a mixed blessing, if the print time is too short there is no time for dodging and burning. The good news is that print time can be extended by either stopping down or using neutral density filtration.

What works for MG paper will most likely work for graded paper, but what works for graded paper may not work for MG. According to Ilford, the LED bulb should have a wavelength spectrum close to 400nm for maximum contrast for use with their MG papers. The wavelength spectrum can be measured using the cell phone App LightSpectrum Pro.

When purchasing a bulb, read the manufacturer's specs and pay attention to the start-up time and how long it takes to reach the final color temperature. If you are making prints that require minutes of exposure this doesn't matter.

But if your exposures are in seconds, start-up time and color temperature can make a difference in repeatability.

LED bulbs are prone to afterglow, although better LED lamps are designed to force the capacitor to discharge quickly. Afterglow is not as big a problem as it may at first appear, as it is consistent and can therefore be factored into the print time. If you find start-up time to be a problem, use a metronome to time your prints, like Ansel Adams and Michael A. Smith Chapter 11. Should you find afterglow to be a problem, have an oversized piece of cardboard ready to place over the print the moment the timer clicks off.

Finally, bulbs for enlargers should be opal/frosted not clear. Any manufacturers identification printed on the bulb should not be in the light path. For a Beseler or Omega this means the top of the bulb for Durst it means the side.

When choosing a bulb, check the specks to ensure the start-up time is <0.5 or less and the wavelength spectrum is close to 400nm for maximum contrast with variable contrast papers as per Ilford. The color spectrum should be around 4000K. Use a bulb rated for conventional (tungsten) lamp power between 60W and 100W.

An 8 × 10-inch or larger piece of pliable cardboard is an invaluable addition to the darkroom. The ideal cardboard should be black on the underside facing the print so it does not bounce light back onto the print. This will degrade the image. The top should be white or light gray to see the area of the print you are trying to cover. An inexpensive white posterboard from a stationary or art supply store works well. Just purchase an extra-large black Marks a Lot permanent marker and paint the side facing the print black.

Optional

- Safelight
- Four-bladed paper easel (highly recommended)
- Canned air for cleaning negatives
- Contact proofer
- Enlarger alignment tool
- Negative carrier(s)
- Paper safe
- RH Designs Paper Flasher

You can make your own contact proofing frame using an 11 × 14-inch piece of plywood, 11 × 14-inch piece of glass (beveled and with rounded corners so you don't cut yourself), 11 × 14-inch black velvet, gaffer's tape, the cardboard core of a roll of paper towels, and rubber cement, Photo 2.1.

Glue the velvet to the top of the plywood. Start at the center and carefully rub any air bubbles out the sides. If any bubbles remain, poke a hole in them with a sewing needle and smooth them out.

To make a hinge, first stack two pieces of double-weight photo paper in the center of the velvet. This will allow the glass to lie evenly across the paper. Slice the core of a roll of paper towels long ways to create a hinge. Use gaffer's tape to attach the hinge to the underside of the plywood and wrap it around to overlap the top of the glass. Use most of the core under the plywood so you don't cover too much of the glass. Pull the cardboard snug and tape it to the glass.

Notice the stripes on the velvet made with a white Sharpie. This will help you make more accurate 1-inch test strips.

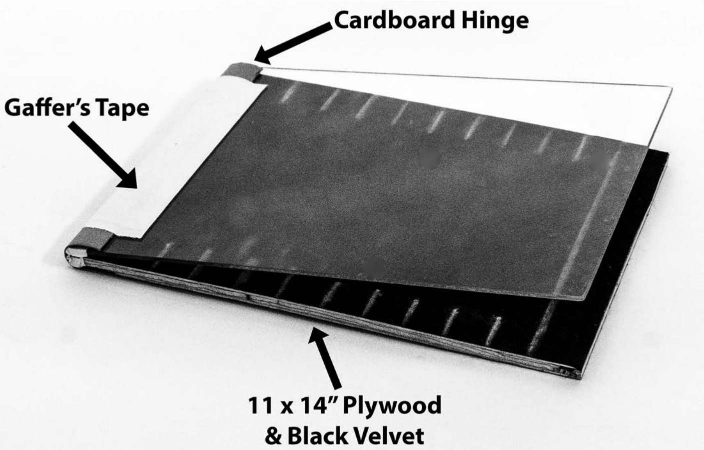

Photo 2.1 DIY contact proofer. A contact proofing frame is necessary unless you own a scanner to make proof sheets.

Photo 2.2 RH designs timer. The RH Designs Stopclock print timer is the best available.

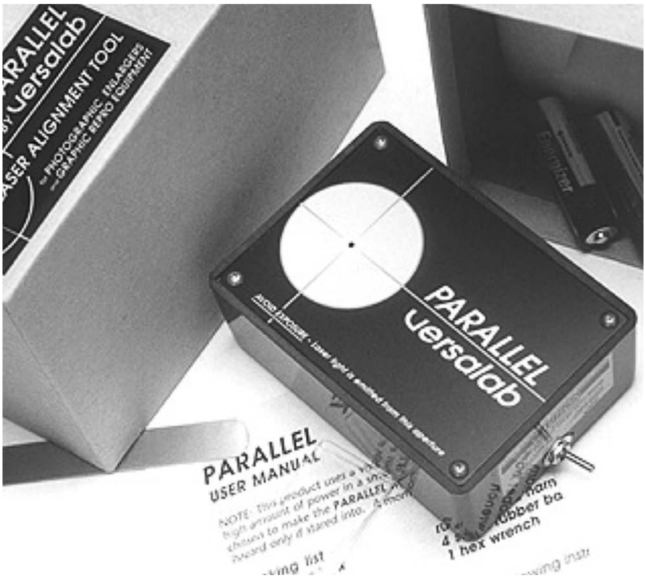

Photo 2.3 Versalab Laser Enlarger Alignment Gauge. It is important to keep your enlarger in alignment to ensure sharp prints from corner to corner. The Versalab Laser Enlarger Alignment Gauge is the best enlarger alignment tool I have ever used.

Photo 2.4 Grain focuser. It is only possible to critically focus a negative with a grain focusing device such as this one. Avoid grain focusing devices made of plastic and focus finders that don’t specifically say “grain focuser.” These focus on the image, not the grain, and while they are better than nothing, they are not as accurate.

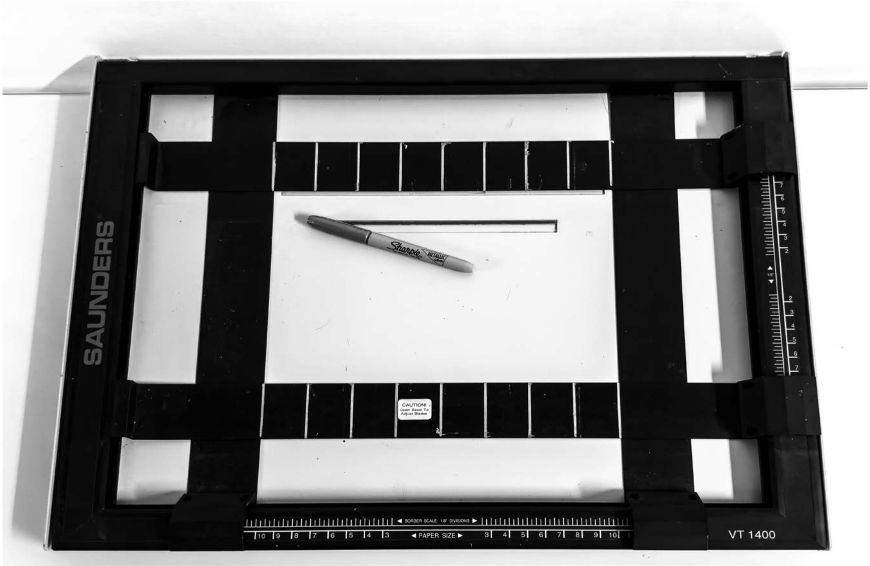

Photo 2.5 Four-bladed easel. There are many different types of easels for printing. The best is a 4-bladed easel. An old trick is to use either a white indelible marking pen, such as a Sharpie, or white removable artists' tape, aka graphic arts tape, to mark regular intervals on your easel. This will make it easier to create and read test strips. Make the intervals at least 1 inch, or there won't be enough information to read.

WET SIDE

The wet side includes the sink and an area to mix chemistry. If there is no place other than the sink to mix chemistry, you can place the mixing vessels and powders into a dry tray. Gloves should be worn when handling chemicals, see Appendix 1. The following is a list of recommended and optional items.

Must Have

- Developing tank and reels
- Thermometer (an adjustable dial thermometer is recommended)
- Assorted graduates and beakers
- Chemical-resistant gloves
- Developing trays
- Film-drying bag, cabinet, or a clothesline in the shower
- Film-hanging clips
- Film washer with hose attachment (the developing tank can often be used)
- Funnel
- Glass or photo-grade plastic storage bottles
- Print washer
- Print drying screens
- Stainless steel tongs
- Stirring rod for mixing chemicals

Optional

- 1/4-inch white Plexiglas for viewing and squeegeeing wet prints
- One-sided film squeegee
- Process timer (e.g., GraLab 300), see Photo 2.12
- Water temperature control valve or water temperature monitor

Stainless Steel or Plastic Developing Tank

Recently, I read on a popular Facebook darkroom users group a discussion as to which is better: stainless steel or plastic tanks and reels, with fervent arguments by proponents of both. *Balderdash*. Having used stainless steel for the first 30 years of my career and plastic for the last 25, I can definitively say that it makes absolutely no difference, there are advantages and disadvantages to both. The only thing that will improve the quality of your negatives is the volume of developer per roll of film and the agitation method, see Chapter 6.

Stainless steel tanks are designed to hold 250 mL of developer per 35mm roll of film. Paterson System 4 plastic tanks are designed to hold 290 mL per 35mm roll. As I recommend using between 300 and 500 mL per roll, neither the standard stainless steel tank nor the Paterson System 4 achieves my minimum recommendation for optimum development of every frame on every roll of 35mm film, though the Paterson comes close.[1] This means never use a one-reel 35mm tank, always develop at least one fewer roll than the tank will hold, and fill the tank with developer. Always place an empty reel at the top of the stack as a spacer so the other reels don't slide up and down, as this will adversely affect agitation.[2]

One downside to using stainless steel reels is that they are more difficult to load. However, once you learn how, they can be loaded wet or dry as quickly as plastic reels. Stainless steel reels don't absorb chemistry and are durable—unless you drop them, in which case the outer spiral may bend, and they can no longer be loaded properly.

The advantage of plastic reels is that they can be adjusted to accommodate almost any film size from 35mm to 120. Another benefit is that they use oversized plastic tanks with wide mouths that are fast to fill and empty. This is important, as you want the film to be completely immersed and drained as quickly as possible, see Chapter 6. One downside to plastic reels is that they can't be loaded wet. No problem, dry them with a hair dryer; it only takes a couple of minutes and you're back in the saddle See Photo 2.6.

Thermometers

A thermometer does not need to be accurate, but it does have to be consistent. It should be compared to a fever thermometer, like those available at

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[1] 500 mL of developer is required to cover 120 film, regardless of which tank system you use.

[2] Paterson tanks come with a nylon ring that slides over the post to prevent reels from sliding. If you didn't throw the ring away, you can use it instead of an extra reel.

Photo 2.6 Developing tanks. It makes no difference which type of tank you use; use the one you are more comfortable with. It is the volume of developer per 80^2 inches of film and the agitation method that will change the quality of your negatives. I highly recommend at least 300 mL per roll.

pharmacies, to test how many degrees off it is, if any. Fever thermometers must be accurate, as the patient's life may be at stake.

The traditional method is to adjust your water so that the fever thermometer reads 100°F/38°C and then compare the temperature on your darkroom thermometer. It's okay if it's off if it is always the same number of degrees and you remember to compensate for the difference each time you use it.

The best thermometer for darkroom use is an adjustable dial thermometer; that way, if it is off, you can adjust it and not worry about compensating. You can purchase an adjustable dial thermometer that will last your lifetime for $20 from Freestyle Photo Sales, see Photo 2.7.

Graduates and Beakers

You will find it convenient to have a selection of measuring graduates, beakers, and mixing containers. A graduate is a tall cylinder with markings on the side. A beaker is wider and sometimes has a handle; it may or may not have units of measurement. Graduates are used for accurately measuring liquids; beakers can be used for measuring, but they are less accurate; they are more useful for mixing large volumes and pouring, see Photo 2.8.

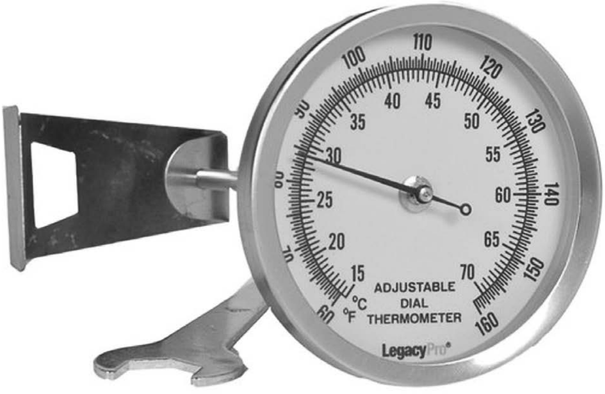


Photo 2.7 Adjustable dial thermometer. This may be one of the best investments you will make for your darkroom.

Photo 2.8 Graduate and beakers. A graduate is a tall cylinder for accurately measuring volume. A beaker is a wide vessel for mixing chemicals. If you want volume, use a beaker; if you want accuracy, use a graduate.

You should eventually obtain at least four graduates—25 mL, 100 mL, 500 mL, and 1-liter for the utmost convenience. In additon to the graduates, a 2-liter and 4-liter beaker are almost indispensable.

Using a Cell Phone Timer

There are two downsides to using a cell phone for timing your processes. The first is that if your finger is wet, or if you're wearing a nitrile glove, it may not respond to your touch. The second is that if it gets wet, you're on your way to the cell phone store to buy a new one.

If you do prefer to use a cell phone, there are several Apps available for timing film development. For the iPhone you will find Film Developer Timer Pro and for Androids there is Dev it—Darkroom Timer. For print development, you can use the default timer that comes with your cell phone.

While these work as well as a process timer, there are precautions you must take. Do not place the phone on a counter-top where there is liquid. Always place the phone on a shelf above the water level, preferably attached to a device that will hold it securely. Be certain that your cell phone is securely backed up to Cloud storage.

Film and Print Washers

Film Washer Film can just be washed with a plastic hose down the center of the spindle of either a stainless steel or plastic developing reel, and the results are as good as or better than those of a dedicated film washer. The JOBO Cascade Film Washing Hose for plastic reels is made for this purpose, see Photo 2.9). If you are using metal tanks, push a soft hose through the core of the reels as far as it will go. For more about washing film and prints, see Chapter 5.

Print Washer If you use a water bath instead of an acid stop bath, place a paper washing tray, like the Premier Print Washing Tray shown in Photo 2.10, between the developer and fixer. I use a second print washer in line after the fixer as a holding bath until I am ready to place them in an archival washer. You can make a washing tray by drilling a hole in the center of one end of a deep tray (a restaurant busing tray works well) and attaching a hose that can be connected to your faucet. On the opposite side, drill two or three rows of small holes. Place the first row just above the center and the second and third rows a half-inch above and below.

Vertical standing archival washers are the best and most convenient method of archivally washing prints, but they are not necessary. If you don't own an archival washer, wash your prints for 1 half-hour in a print washing tray, shuffling three or four times through your prints at least once every 5 minutes.

Photo 2.9 The JOBO Cascade Film Washing Hose is an inexpensive device for efficiently washing film.

Photo 2.10 Print washer tray. You only need one of these placed between the developer and the fixer. Once the printing session is over, this can also be used for the final wash.

Author's Notes:

1. Washing time begins when the *last* print is placed in the washing tray.
2. Always place your prints in the tray back to back and emulsion to emulsion.
3. At the end of each shuffling cycle, try to have a different print on the top and bottom.

4. Too much washing can weaken the paper fibers and affect the longevity of your print. The longest you should wash your prints is an hour, with shuffling every 5 minutes. If you are using an alkaline fixer it is not necessary to wash more than 10 minutes, 30 being the maximum, Photo 2.11.

Photo 2.11 Nova Washmaster ECO. Vertical standing archival print washers are the best and most convenient method to wash prints archivally.

Photo 2.12 Gralab 300. A process timer like the Gralab 300 is invaluable for timing film development. It can also be used to time printing.

MISCELLANEOUS

The following items will prove helpful. Some, such as the film cassette opener and safelight, will prove indispensable:

Must Have

- Film cassette opener or bottle cap opener
- Negative storage pages or sleeves
- Scissors
- Trash can (extra-large)

Optional

- Air cleaner or purifier
- Antifatigue mat
- Light box for viewing negatives
- Magnifying loupe for negatives
- Measuring spoons
- Mortar and pestle (glass, porcelain, or dense plastic)
- Paper trimmer
- Scale or balance beam
- Tape—drafting, black photographic, litho, and clear
- Teaspoons for measuring
- Untreated coffee filters

Balance Beam and Scales

The easiest way to use *The Darkroom Cookbook* is to invest in a scale. The scale does not have to be state-of-the-art, but it should have readability to 0.1 grams and contain a counterbalance system, or tare, to compensate for the weight of the measuring container.

Scales are available in either mechanical or electronic models. If you enjoy working low-tech, the Ohaus Triple Beam Balance is the best mechanical scale for the money. The Ohaus will weigh up to 610 grams in 0.1-gram increments.

When *The Darkroom Cookbook* was first published in 1994, digital scales with 0.1 grams of accuracy began at over US$100. Today, inexpensive and accurate electronic scales are readily available. It is difficult to recommend a particular scale, as the models are always changing. However, check out online sites such as affordablescales.com. If counter space is an issue, check out the Brecknell EPB-3000, which has a readability of 0.1 grams and a capacity of 3000 grams, see Photo 2.13 and 2.14. If you require additional accuracy for measuring small amounts of chemicals such as Phenidone, you will need a scale with a readability of 0.01 grams; check out the EPB-500.

A standard-issue, 2-pound, spring-loaded postage scale found in most stationery stores is handy for quickly weighing large amounts where accuracy is not critical—for example, weighing 1 pound of sodium thiosulfate for a standard hypo bath. I use a 2-pound Pelouze postage scale for this purpose, see Photo 2.14. The best part is that you don't have to worry if the postage rates increase!

Photo 2.13 Brecknell EPB-3000 pocket scale with readability of 0.1 grams and a capacity of 3000 grams.

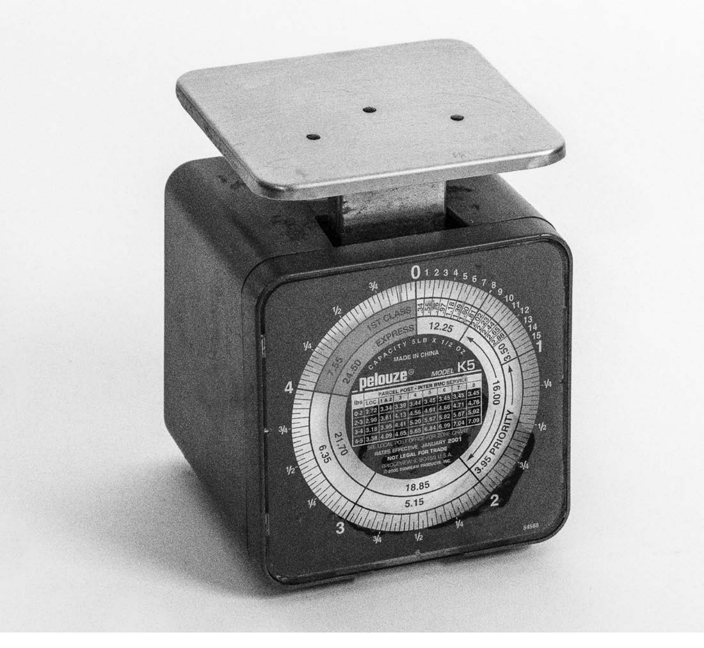


Photo 2.14 5-pound (2.3 Kilograms) postage scale.

Teaspoon Measurement

Scales measure weight, while teaspoons measure volume. Accurate weight-to-volume conversion is not possible due to water absorption, which changes the chemical's weight but not its volume; arguably this means teaspoons are potentially more accurate.

Even so, consistency in your working methods is more important than accuracy. So, if you consistently use a level teaspoon in a particular formula, you will have consistent results. If you are consistent in your work habits, teaspoon measurement should be as reliable as a scale, perhaps more so.

Negative Storage Pages

Do not make the mistake I made when I developed my first roll of film. I didn't realize I needed a place to store them once they were dry. They sat on my desk until I was able to purchase negative sleeves, by which time they were covered with dust and scratches.

The easiest-to-use storage pages are made from high-clarity, archival-quality polyethylene or polyester, see Photo 2.15. You can make proof sheets without taking the negatives out of the page. However, you cannot determine sharpness or focus by looking at a proof sheet made through a plastic page. Leave the negatives in the page, hold them up to a light source or light table, and use a magnifying loupe to determine sharpness and focus. The reason not to remove them from the page is to minimize handling the negatives.

Storage systems that use a combination of plastic and archival paper sleeves are also available, see Photo 2.16.

Be certain the plastic does not off-gas, as gases from plastic will destroy your negatives. You can tell if something is off-gassing simply by smelling it. If you can smell the plastic, it is off-gassing, and in a relatively short time it will destroy your negatives and/or prints. Avoid anything with polyvinyl chloride (PVC).

Archival storage can be obtained from Print File, University Products, and Archival Methods.

Glassine Negative Storage

Glassine negative storage sleeves will absorb moisture unless your negatives are stored in a dehumidified space or you live in a dry area, such as a desert. If there is any moisture present, they will adhere to the emulsion side of your negatives. Once this occurs, there is no known way to salvage your negatives.

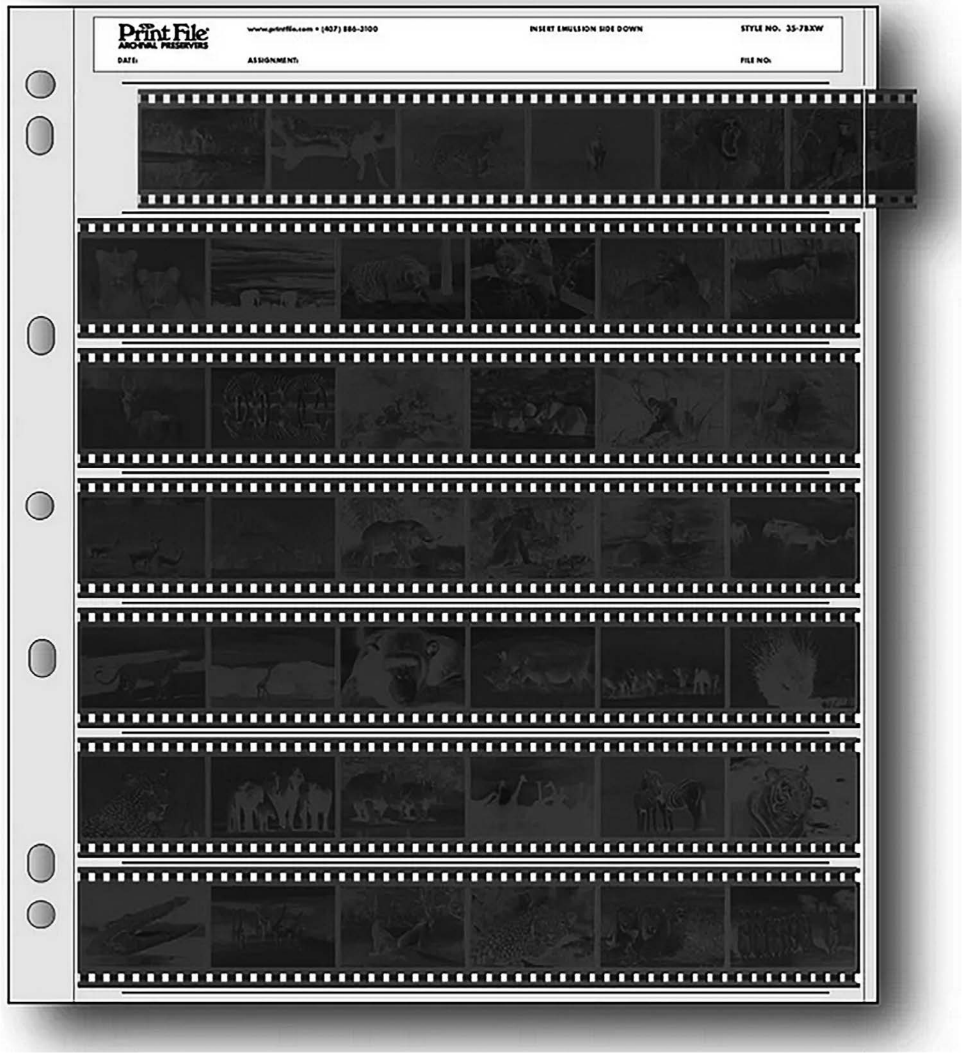


Photo 2.15 PrintFile plastic pages. Single-sheet negative pages, such as these from PrintFile, are the easiest to store, proof, and archive negatives.

Storage Bottles

Maintain a good selection of photo-grade storage bottles, see Photo 2.17. Start with 250 mL, double the size, and have several containers that are 500 mL, 1 liter, 2 liters, and 4 liters. Photo storage bottles can be purchased from many photography stores, any chemical outlet, and online. A list of chemical outlets is found in Material Sources.

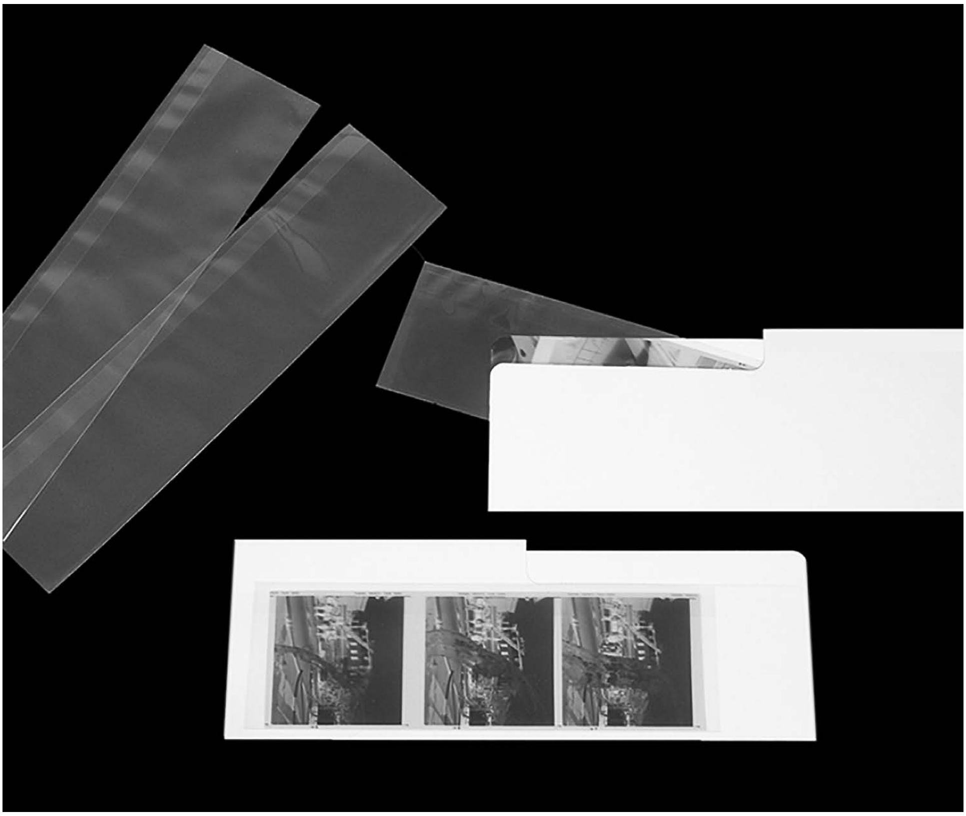


Photo 2.16 Slide Lock Film sleeves from Archival Methods.

Developers should be kept in tightly sealed brown glass bottles, particularly if stored for more than a few weeks. This is because developing agents oxidize and lose their potency when exposed to air or light. Plastic bottles are advertised to be impermeable, but they are not; they breathe and will speed up the rate of developer oxidation. High-density, polyethylene storage bottles are suitable for fixer, stop bath, bromide, carbonate solutions, and just about anything except developers.

Label your chemistry and formulas with white graphic arts tape, available from many photo suppliers and art stores (the same tape mentioned earlier to mark easels). You can write on the white tape with an indelible marking pen, such as a Sharpie, or an ordinary pen or pencil. Graphic arts tape peels off without leaving residue should you need to change the label.

When labeling, include information such as the date the formula was mixed. I also include the development time(s) and temperatures currently used. Notice on the bottle of Formulary TF-5 Fixer I keep count of every 80^2 inches of film or paper I process. A 1-liter bottle will easily fix 20 of either.

Photo 2.17 Brown glass storage bottles. They are available in many sizes from Amazon or photo suppliers. Unless a formula specifies otherwise, the only liquids that require a brown or amber bottle are film and paper developers that you want to last a while. Even so, it is a good idea to test a developer that has been on the shelf for more than a month before committing valuable negatives to it.

Photo 2.18 Good film squeegee. Use a single-sided shower squeegee. Notice the depth of the blade. The more blade that sticks out in front, the more flexible the edge, which is what you want. The squeegee in Photo 2.18 cost less than $US20 and is a lifetime investment that will also keep your shower doors clean—just be certain to wipe the edge clean before using it on your film.

THINGS TO AVOID

Many popular items sold for darkroom use should be avoided. In general, they will contaminate your prints or scratch your negatives. Even so, they can be found on essentially every site that sells darkroom equipment and in school darkrooms worldwide. These include the following.

Accordion Bottles

Although they are widely used, plastic accordion storage bottles can trap chemistry in the folds and cause chemical contamination. This is especially critical when storing developers.

Film Wipers

- Sponge or rubber film squeegee tongs, see Photo 2.19
- Photo sponge for film
- Chamois cloth for film

All three of these can scratch your film. Never trap wet film between two surfaces, such as a film squeegee or even two fingers.

A better option is to use a soft rubber shower squeegee, see Photo 2.18. Wipe the blade clean before each use and run it lightly down each side with no pressure. The blade should always be wet with wetting agent.

The very best squeegee to use is a 12-inch rear windshield wiper blade. Use one that is perfectly straight, not curved. See the 2018-2023 Subaru Crosstrek Impreza blade for an example.

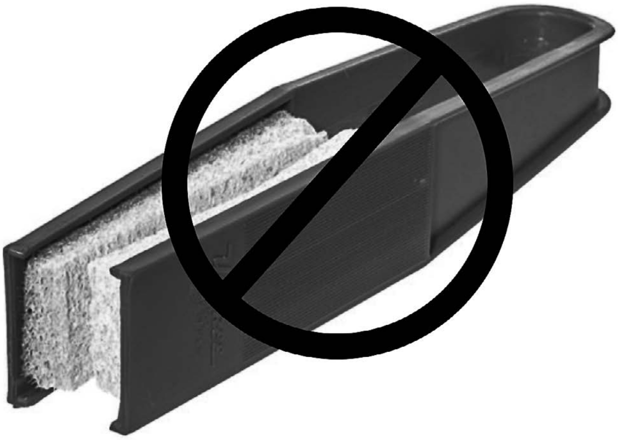


Photo 2.19 Bad film squeegee. A big no-no. How fast can you spell scratched film?

Bamboo and Plastic Tongs with Rubber Tips

Bamboo tongs absorb chemistry, and the rubber tips on either plastic or bamboo tongs trap chemistry between the rubber and the tong. As the chemistry builds, it will slowly leach out and soak into your photo paper, contaminating the developer and streaking your prints. This is almost always invisible, but a discoloration will appear on your otherwise archival print months, sometimes years, later. Use either plastic tongs without rubber tips or stainless steel tongs. Both take some getting used to, but once you do, you'll find they are as easy to use as rubber-tipped bamboo tongs, see Photo 2.20.

Author's Note: If you prefer to use bamboo or plastic with rubber tips, replace the tongs monthly.

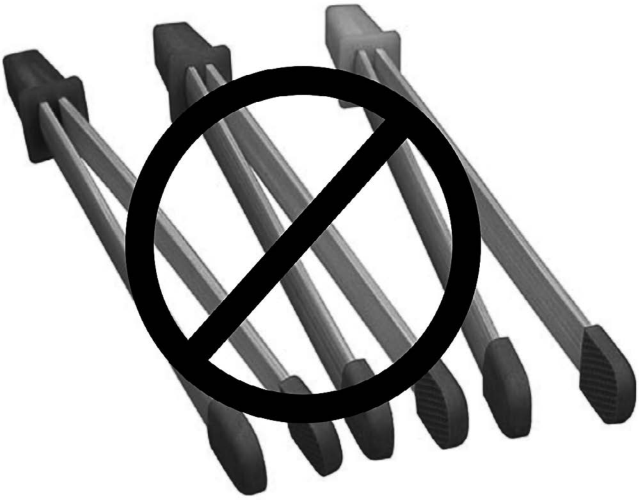


Photo 2.20 Bamboo tongs. Another big no-no.

Taylor & Francis
Taylor & Francis Group
http://taylorandfrancis.com

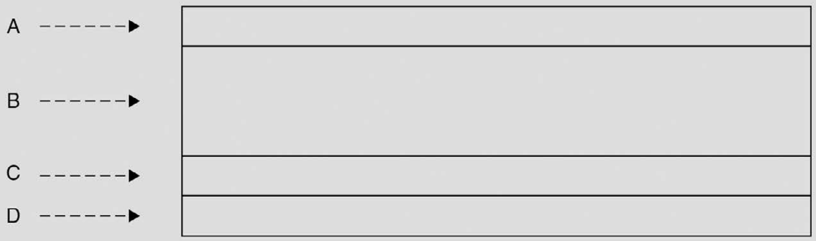
Part 2

Film

3

Film

"With a good negative and good sense, a good print is inevitable."
—William Mortensen



A. Protective coating, dissolved during development.

B. Emulsion, light-sensitive silver bromide crystals suspended in gelatin. The size of the crystals (granules) controls speed, grain, contrast, and resolution. All can be altered to some extent in the development process.

C. Base, usually some form of pliable, clear acetate.

D. Antihalation backing, which absorbs excess light that penetrates the emulsion and base and prevents it from bouncing back and scattering in the emulsion, thereby fogging and degrading the image. Also dissolved during development.

Photo 3.1 The Anatomy of film. This is a partial diagram of modern film. The layers shown in this diagram are essential in most film negatives. Modern emulsions may have several more layers specific to their design.

Definitions

- Acutance is when two objects are next to one another on a negative; it describes how sharp the line between them is. All the things that cause graininess can lower a film's acutance. In addition, halation, see antihalation backing, above, irradiation (the spreading of light as it passes through the emulsion), and grain size affect acutance.
- Slow, thin emulsion films, such as Ilford Pan-F, developed in high-definition developers, such as Windisch Extreme Compensating Developer, will produce negatives, even from 35mm, of extremely

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high acutance with the ability to enlarge to mural size. The trade-off is an extremely low exposure index (EI).

- Grain or granularity is the measurable grain size of any undeveloped film. Generally, slower films have smaller grains; faster films have larger grains. The manufacturer predetermines grain size.
- Graininess (grain aggregation) is the clumping together of individual grain particles during development. It can be induced by exposure to excessive heat before or after exposure (graininess does not change after development is complete). The choice of developer can reduce or increase graininess. It does not affect individual grain size.
- Factors that can increase graininess are overvigorous agitation during development with old-style classic emulsions, solutions that vary more than ±2 degrees, film storage at high temperatures, and overexposure in the camera.

  The appearance of grain and graininess can be either emphasized or reduced by the choice of enlarger light source (cold light and diffusion light sources suppress grain; condenser and less commonly found point-light sources emphasize grain).
- Resolving power is the emulsion's ability to record fine detail. It is determined by photographing a line graph. Although the lens's quality affects the resolution power of the film, most lenses made today have higher resolving power than the film can reproduce. Both fineness of grain size and graininess affect the smoothness of tonality and the resolving power of the film.

EMULSION TYPES

Classic old-style emulsions are films coated using technology from the 1960s or 1970s. The grain in old-style emulsions appears like microscopic pebbles, known as cubic crystal grain. Classic emulsions often have less hardener in the emulsion and must be handled carefully when wet.

Author's Note: Cinestill BwXX and ImagoXX are respooled and rebranded Kodak Double-X film. Introduced as a motion picture film in 1959 for the movie industry, it is still used for filmmaking. This may be the only true classic emulsion still being produced.

Flat-grain emulsions use flat grains of silver that have almost no depth. Instead of appearing like grains of salt or pebbles, like cubic grains, these flat grains appear more like microscopic flagstones. Flat-grain emulsions rely on color dye sensitization to minimize the use of silver. The least amount of silver and the flattest grains are found in Kodak T-Max films. These emulsions are the least responsive to zone system contraction and expansion and changes in developer and often lack good micro contrast, see And in This Corner: Tri-X vs. T-Max.

Most flat-grain films have now been redesigned with cubic grain and may almost be considered to be conventional-grain. Typical of these are Ilford Delta 100, 400, and 3200; Fuji Acros 100 II; and Kodak T-Max 100 and 400.

Conventional-grain emulsions use a hybrid of cubic and flat grain—the individual grains are neither flat nor cubic, but something in between. To varying degrees the films in this category utilize color dye sensitization to replace some of the silver in the emulsion, but not to the extent of flat-grain films. These films respond to chemical manipulation but not as much as classic old-style emulsions. Conventional-grain films generally have more hardener in the emulsion than classic films and are not as easily damaged when wet. Conventional-grain emulsions include Ilford Pan F+, FP4+, HP5+, and Kodak Tri-X.

And in This Corner: Tri-X vs. T-Max

When Kodak introduced Tri-X film in 1954 in 35mm and 120 formats, it was the first Kodak fast film made for general use. Even though the cubic grain of the original Tri-X was characterized as being the size of golf balls, it became an immediate success with photojournalists who had only just finished recording an entire world war and the Korean conflict with films rated at ISO 100 and 200.

In the 1980s, Kodak introduced T-Max tabular grain films. These films were based on flat silver halide crystals with the flat surface of each crystal facing the surface of the film to collect light more efficiently.

At first, many photographers, myself included, anxious to be at the forefront of new and better film technology, fell for the marketing hype. Kodak executives watched as the sale of Tri-X dropped precipitously and the sale of T-Max 400 soared. Kodak planned to discontinue Tri-X when sales reached a predetermined baseline.

Unfortunately for Kodak, it did not take long for photographers *worldwide* to realize that T-Max was inferior to Tri-X. There were two reasons: Editorial photographers preferred the coarse, gritty street look that made Tri-X great. The second reason is that the thin, flat grains do not have the depth of rounded pebble-shaped grains, which enables them to record microscopic variations in contrast. That makes T-Max films a good choice for landscapes with few midtones and controlled lighting, such as studios, where the luminance range can be kept to 5-stops or less. Almost overnight, the sales figures reversed, and T-Max 400 nearly fell off the sales charts. Kodak's response was to increase T-Max's advertising budget.

But the story does not end there. Excited by the increased profit that flat-grain emulsions could bring if only photographers would cooperate and buy them, Kodak reengineered all its films, including Tri-X, to use semi-flat grains along with advanced coating technology. And even though Tri-X has the midtone separation that T-Max lacks, it has no distinct characteristics other than being a fast film with "superfine grain."

COLOR DYE SENSITIZATION

Color dye sensitization is a necessary component of film and paper. Without color dyes, film would still be primarily blue-sensitive, as it was prior to the introduction of panchromatic films. For example, before 1904, if you were to expose for a blue sky with clouds, the foreground in your image would be grossly underexposed. If you exposed for the foreground, the sky would be so overexposed that it could only be printed as white without clouds.

To compensate, photographers collected hundreds of photos of clouds. If they had a bald-headed sky, they would search their files for clouds with shadows that matched the direction of the foreground and double-print them. Today, we can do the same with digital. Many digital editing programs provide cloud presets to add to an image.

ISO vs. EI

ISO (pronounced eye-so) stands for International Organization for Standardization. Why it isn't IOS nobody knows, at least not within my circle of friends. But ISO or IOS, the ISO sets standards for measuring, weighing, and testing for technology, scientific testing processes, working conditions, societal issues, and more. They are the ones that determine the testing method for film speed. The manufacturer presumably determined the ISO marked on your film using the highest-quality testing procedures in a controlled laboratory. The goal for the manufacturer is to squeeze as high an ISO as they can out of a film. However, that does not mean you will achieve that ISO, as your shutter speeds or light meter might be off, the film developer you use might increase or decrease the speed, and so on.

Author's Note: Prior to 1974, there were two different standards for rating film speed: ASA and DIN. ASA was the American arithmetic standard and DIN was the German logarithmic standard. Using Ilford FP5+ for the example, ASA and DIN looked like this on the film box: FP5+ ASA 125/DIN 22°. The ISO took matters firmly in hand and combined the two standards, so now it looks like this on the film box: FP5 ISO 125/22°.

EI stands for exposure index. EI is whatever ISO you choose to use; you don't even have to test it. If you decide to use the ISO printed on the box, for example, ISO 400, your EI is 400. If you arbitrarily decide to use a lower ISO, with or without testing, say, ISO 250, your EI is 250. So, ISO is what the film manufacturer determines in the lab, and EI is what you choose to use in the field, even if it is the ISO printed on the box.

PANCHROMATIC FILMS

Most black-and-white films are panchromatic, which are more or less sensitive to all colors of visible light. This means they closely render a tonal scale as it would appear to the human eye were all colors removed. However, no film is truly panchromatic; they are all partially blind to at least one part of the visible spectrum.

Through the use of color dye technology, pioneered in the late 1800s, we have panchromatic films, though these did not come about until 1904. Even though modern developments in dye sensitization go beyond expanding color sensitivity, all general-use films made today require some degree of color dye sensitizing, whether classic, conventional, or flat grain.

Most panchromatic films are more sensitive to blue than to other colors, especially red. A light-yellow filter, such as a Wratten #8, will balance out the tonal scale in a landscape by absorbing some of the blue, allowing the other colors in the scene a chance to fully expose without washing out the sky. A more saturated Wratten #12 will absorb even more blue, darkening the sky and creating more drama.

ORTHOCHROMATIC FILMS

Orthochromatic films were first produced in 1873. Known as "color blind," they are primarily sensitive to blue light in the 450–500 nanometer (nm) range of the visible spectrum and, to a lesser extent, green. They have either little or no sensitivity to red light. This is why dramatically dark areas that in reality red are often a distinctive sign of an ortho look. This means that to achieve enough exposure to record red hues, the other hues will be overexposed. This is why skies appear to be white and cloudless in early landscape photographs: the film was primarily sensitive to blue; exposure had to be extremely long to record reds, browns, and flesh tones resulting in overexposed skies. Were you to expose for the blue sky with clouds, almost everything else in the image would be underexposed. Early photographers, including my mentor in the 1970s, Frank Rogers, created massive collections of clouds and double-printed them into otherwise cloudless images. This can now be done seamlessly using AI in most software editing programs.

Ortho films have high acutance and superfine grain. They are particularly suitable for technical-scientific applications, copy work, and dramatic portraiture. Current orthochromatic films include Arista Ortho Litho film, Ilford Ortho Plus, Ferrania Orto 50, Rollei Ortho 25, and Svema's Blue Sensitive film.

Ortho Portraits

During the heyday of the Hollywood film industry, the 1930s to the 1950s, ortho films were used to create dramatic portraits of movie stars. The style became popular with portrait studios such as Karsh of Ottawa, who used ortho film for some of its most famous portraits, such as Winston Churchill scowling into the camera.

Using ortho film anything red, such as red lipstick, would be underexposed and appear dark and dramatic. The choice of makeup hue can control just how dark. Deep red lipstick would record darker than, say, pink lipstick. Makeup artists on movie sets would use green and blue makeup to alter the tonality of the stars and starlets.

Modern ortho films don't create the same dramatic effect as early formulations. To replicate the Hollywood look of the 1930s, try adding a cyan filter such as a Kodak Wratten 44A blue/green or a B+W Infrared Blue-Green 489 filter and experiment with various shades of lipstick and rouge. To increase contrast, try developing with Kodak D-19. If the contrast is not high enough, try continuous agitation for the first 60 seconds with 10 seconds every 30 seconds thereafter.

Lighting was also part of the process. If Hollywood lighting intrigues you, study the work of Hollywood photographers of that era, such as Horst P. Horst and George Hurrell, as well as that of portrait photographers Karsh and Arnold Newman. An out-of-print book still available online is *Hollywood Portraits: Classic Shots and How to Take Them*, published in 2000 by Amphoto Books.

Hollywood portrait: This studio portrait of my mother, Janice Ruth Anchell, was made in 1947. The dark lips and drama are typical of red lipstick and ortho film. The photographer used classic 45-degree lighting, popular with MGM Studios (Paramount Studios preferred butterfly lighting). A soft-focus portrait lens, probably a Rodenstock Imagon, was used on a large-format camera. The photographer is unknown.

DOCUMENT FILMS

Document films, also known as high-contrast copy or microfilm, are slow, extremely high-contrast, panchromatic black-and-white films with ultra-fine grain and super high acutance. These films were designed for copy work, specifically black-and-white reproduction of line drawings and text. However, it was soon discovered that these films could reproduce a nearly full tonal scale with extremely low-contrast developers, such as POTA, T/O XDR-4, and TDLC-103. The resulting 35mm images could be enlarged to 20 × 24 inches without appreciable loss of sharpness. The drawback was the lack of good microcontrast in the midtones.

Kodak Tech Pan was considered the gold standard for document films, though many users complained of an unnatural tonal scale. This is likely due to increased sensitivity to infrared light. If you encounter this issue with any of the three films listed here, try using the same Kodak Wratten 44A or B+W Infrared Blue-Green 489 filter recommended for Ortho films.

Three document films are currently available: Adox CMS 20 II, Rollei ATP 1.1, and Agfa Copex Rapid.

INFRARED FILMS

Infrared (IR) films are formulated to record invisible light in the IR spectrum. The higher the spectral sensitivity of the film, the further into the IR spectrum it can record. FPP BW IR claims it can record as high as 850 nm (discontinued Kodak HIE film claimed to record as high as 900 nm). This would make FPP BW IR the only true IR-sensitive film currently available.

Ilford SFX 200 and Rollei Infrared are considered near-infrared films as they only record in the 650–750 nm range. Their lower sensitivity makes them somewhat easier to use, although the results are not as dramatic as those obtained with films of higher sensitivity.

To get the most from IR film, including SFX 200 and Rollei IR, it is necessary to use an IR filter to block out visible light but allow the IR to pass through to the film plane. Otherwise, the results will appear to be similar to those captured using ordinary panchromatic film, only not as good. You will note that IR film is also sensitive to other wavelengths of light, so without a filter, it will record them, too, and the IR effect will be lost.

The standard 720 nm IR filter (B+W 092) allows some visible light to pass while still rendering good contrast between bright foliage and darker skies. The 850 nm filter (Tiffen 87) blocks almost all visible light, rendering green vegetation stark white and blue skies inky black. However, if your film is only sensitive up to 750 nm, anything beyond that will not record with or without a filter. If you do not have an IR filter, try using a Wratten 25A + Polarizer filter.

Other considerations include:

- The IR effect occurs in bright light. The more sunlight, the more IR.
- Load IR film into your camera under subdued light. Do not expose a film cartridge to sunlight, even if you use the shade of your body or a tree to protect it. If you use IR film, carry a changing bag with you.

Photo 3.2 IR-Engraving on Lens. If there is an IR focus point engraved on your lens, focus on your subject, then move the focus point to the IR focus point. The focus point is often designated by a dot, as seen on this Nikon lens. Some lenses have a short red vertical dash, or there might be the letter "R." In this image, the lens was focused at 7 feet. The 7-foot mark was shifted to the IR indicator for correct focus.

- Because an IR filter only passes IR light, you cannot see through the filter, as your eyes cannot see IR. Focus on your subject first, then attach the IR filter.
- If the lens has an IR engraving, focus on your subject, then shift your focus to align with the engraving, see Photo 3.2.
- If your lens has no IR engraving, use a small f/stop, such as f/11 or f/16.
- Bracket your exposures. There are no meters made that can read IR.
- Use a tripod. Depending on the IR filter and the spectral sensitivity of the film, exposures can range from ½ second to 10 seconds or more.

Wratten Filters

The Wratten filter classification was created by Dr. C. E. Mees (1882–1960) at the dry plate and filter manufacturer Wratten & Wainwright in Croydon, England, where he became a director. In 1909, Dr. Mees visited Rochester, New York, and was shown around Kodak Park by George Eastman. In 1912, Eastman visited the Wratten factory and Mees's small research facility; the following day, he invited Dr. Mees to set up and direct a new research facility in Rochester. Dr. Mees agreed on the condition that Eastman buy Wratten & Wainwright. The Wratten filter classification soon became the industry standard.

CHROMOGENIC FILMS

Chromogenic films are black-and-white films designed to be processed in C-41 color chemistry, making them a good choice for someone who doesn't want to develop their own film.

The only chromogenic film currently available is Ilford XP2 Super. XP2 has a wide exposure latitude with an EI from 50/18° to 800/30°. Based on color negative film technology, it can be processed by 1-hour photo labs, and the resulting negatives can be either printed using an enlarger or digitized for digital reproduction.

ART FILMS

With the decline of the big three filmmakers (Kodak, Agfa, and Ilford) and the move toward digital, small filmmakers have increasingly moved to creating boutique black-and-white and color films with little attempt at maintaining quality, consistency, or full tonality.

This is a good thing. It indicates that today's photographers are willing to step outside the bounds of tradition and explore new ways of seeing and creating.

Most companies that market these films don't have coating facilities to make them. They create a formula or technique, such as leaving the antihalation backing off the film and arrange for a film coating plant to make a special run. If the film is successful, they make a second run. If not, they try something else or go into trading cryptocurrency.

Other experimental art films will be available by the time you read this. Look for them from companies such as Freestyle Photo, CineStill, ARS-IMAGO, Lomographic Society, Film Washi, Revolog, and many more, and have fun.

Experimenting with X-Ray Film for True Light Photograph Image Making

James R. Kyle

Large format film can not only be expensive, but there are places in the world where it is almost impossible to get. One option is to use X-ray film. Not only is X-ray film available in most third world countries where it is still used for medical purposes, but it is relatively inexpensive compared to panchromatic films made for pictorial use.

X-Ray films create a unique low contrast image; the contrast can be increased by scanning. The ISO rating can vary from one type to another. Testing must be done to determine the ISO for each brand of film you are using. I use an EI of 100 for Fujifilm HR-U "green" film and EI 50 for Fujifilm Super RX "blue" films.

Most X-ray films can be handled under a red safelight—of course a safelight test is a requirement. I found that the red KKOANA brand 12V

Flexible Sign Neon Lights work very well. They passed a safelight fogging test of 30-minutes. They are available online from multiple sources.

X-ray film comes in 8 × 10-inch sheets. It can be cut down to 4 × 5 or 5 × 7-inch sheets using a paper cutter or rotary trimmer. Because most X-ray films are double sided, there is no problem getting the emulsion in the holder correctly.[1]

When dry, it can be handheld, but when wet, the emulsion is very soft and can be scratched. This is the reason I prefer to develop the cut films in a tank. The less one handles the better. I have two tanks that I use for development.

The formula I have found that works best for the "look" of my X-ray negatives is the original Ansco 30 formula for machine development. The formula works too fast for the best quality negatives so I reformulated it and use a different dilution.

Ansco-30 (JK Reformulated)

Stock Solution

Water at 125°F/52°C, 750.0 mL
Metol, 3.0 g
Sodium Sulfite, 70.0 g
Hydroquinone, 4.0 g
Sodium Carbonate, 20.0 g
Potassium Bromide, 5.5 g
Water to make 1.0 L

Dilute 1 + 24

Working Dilution

Develop for 5 minutes at 68°F/20°C

Agitate for 15 seconds every minute. Use the working solution only once. The stock developer is good for about two months if it is kept in a dark bottle in a cool place.

Where to Obtain X-Ray Films?

Many medical facilities in the United States and the EUU are switching to digital X-ray technology and are either tossing their film stock, or have it stored in a broom closet. If they do, tell them you will take it off their hands. If that doesn't work, check out eBay.

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[1] Because X-ray films are coated on both sides, they do not have an anti-halation backing, see The Anatomy of Film at the beginning of this chapter, see Photo 3.1. Be certain the center septum of your film holder doesn't have any black paint scraped away exposing the silver beneath. The silver can increase the light scatter in the emulsion.

■■■■

Alexander McNair's House, Missouri's First Governor, 2024. © James R. Kyle. All rights reserved. Courtesy of the artist. Mamiya M-645, 70mm lens, 1⁄60 second at f/8, Fujifilm HR-U at ISO 100.

4

Film Developers

> *"Substances as diverse as human urine, old red wine, anaerobic cultures of bacteria, polluted river water, or citrus fruit juice have been reported as suitable for developing a latent image."*
>
> —Grant Haist, From *Modern Photographic Processing*, Volume 1

Film developers are a complex subject that have been discussed, dissected, and argued over since the discovery of photography. The purpose of this chapter is not to exhaustively cover every aspect of film developers but to provide you with a basic understanding of how they work. For the chefs among the readers of *The Darkroom Cookbook,* this will provide you with most of the information you need to create your own developers, as have Sandy King, Patrick Gainer, Gordon Hutchings, and John Wimberley, among others, or to tweak the ones you are currently using.

For those who wish to go even deeper on this subject, throughout this and other chapters, you will see my recommendation to reference *The Film Developing Cookbook*, coauthored with photo chemist Bill Troop. The *FDCB* covers the subject of film developers far more extensively than is possible in the *DCB*.

Both film and paper developers are made up of four basic components:

- Developing agent
- Preservative to slow the rate of developer oxidation
- Accelerator to energize the developer
- Restrainer to restrict excessive fog and/or slow the rate of development

All four components are necessary for the development process to succeed. Often, however, one chemical will serve more than one function. For example, sodium sulfite is usually used as a preservative to prevent oxidation. However, in the film-developing formula Kodak D-23 the large amount of sodium sulfite creates an environment sufficiently alkaline that the developing agent, metol, can reduce the silver halide without an additional accelerator. As development progresses, soluble bromide is precipitated from the film, acting as an effective restrainer. D-23 has only two chemicals, metol and sodium sulfite, yet it has all four of the required components of a developer!

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DEVELOPING AGENTS

Author's Note: The information here applies to both film and paper and will not be repeated in the paper section.

For the nonchemist, development is a reduction process; for the chemist, it is more complex than simple reduction. As a nonchemist, I will continue to use the term reduction when referring to the action and results of the development process.

Silver halide crystals include silver bromide, silver chloride, and silver iodide. Film emulsions consist of silver bromide with small amounts of silver iodide. Paper emulsions can be either silver bromide, silver chloride, or a combination, almost always with silver iodide. Silver halides are selectively reduced through the developer's action to metallic silver. To be reduced, the silver halide must first be exposed to light. Exposure to light changes its electrical charge and makes it sensitive to the developer's action. When light is sharply focused by a lens, either on film or paper, certain areas receive more exposure than others. The more light an area gets, the more silver halide is reduced to metallic silver. The more metallic silver in an area of the film or paper, the darker it appears.

Many chemical agents will reduce silver halide to metallic silver, but developing agents are a special kind of reducing agent, as they act only on silver halide that has been exposed to light.

THE FOUR MOST COMMON DEVELOPING AGENTS IN USE TODAY

- Ascorbic acid is vitamin C and the least toxic developing agent today. It is superadditive with Phenidone and metol. With Phenidone, it produces higher image quality than with hydroquinone.
- Hydroquinone is a high-contrast developing agent. As a standalone agent, it is very slow-working, though its reaction products serve to speed up development, especially when combined with either metol or Phenidone.
- Metol is a low-contrast developing agent. It is the most versatile agent and is used in both fine-grain formulas such as D-23 and high-acutance formulas such as FX 1. It has superadditive qualities when combined with Phenidone or hydroquinone.
- Phenidone is an efficient substitute for metol in developers with hydroquinone, though the results are usually not as sharp. However, when combined with ascorbic acid, it is capable of producing high-acutance developers such as Kodak XTOL and Ilfotec DD-X. Phenidone has many derivatives. The most useful in modern practice is Dimezone. Phenidone and Dimezone should usually be dissolved after the sulfite and alkali have been completely dissolved.

Other agents used in the past are:

- Amidol was the favorite agent of photographers such as Edward Weston for developing prints. It is the only developing agent that functions well at a neutral or acid pH. If you do choose to use amidol, do so with an older-style silver chloride paper, such as Lodima Fine Art Silver Chloride Paper, or a graded paper that is not overhardened, such as David Lewis Bromoil paper. You will not see exceptional results with most variable contrast (VC) papers.
- Chlorohydroquinone (CQ) at one time was a widely used developing agent. It is five times more active than hydroquinone and is less superadditive than hydroquinone with metol and Phenidone—a desirable characteristic. It is more soluble

than hydroquinone and has been used to formulate concentrated developers. It was used in paper developers to produce brown to red tones by direct development. Unfortunately, it is both dangerous and expensive to make and is no longer used by commercial developers. A few chemical manufacturers still make it, but the price is prohibitive, as much as US$200 per 100 grams.

- Glycin is one of the most overlooked developing agents. By itself it is slow acting, but it can be combined with either Phenidone or metol, or both, as a third developing agent. Among its more desirable characteristics, it is stable and resistant to aerial oxidation, making it a good choice for open tray development of sheet films, rotary processing, and stand development. Glycin can help prevent bromide streaking when used with continuous agitation. It should always be dissolved last.
- *p*-Aminophenol is used in the oldest continuously made film developer, Rodinal. At high dilutions it produces sharpness-enhancing edge effects. It is also noted for producing low base fog.
- *p*-Phenylenediamine (ppd) and its derivatives are silver solvents, making them ideal developing agents for fine-grain development on pre-WWII films. Ppd has a special ability to maintain delicate highlight detail. The downside is that due to the solvent effect, it is difficult to formulate developers with ppd that create sharp images, and there is a great loss in emulsion speed.
- Pyrocatechin (catechol, pyrocatechol) is a high-contrast developing agent, though it has been used in some famous low-contrast developer formulas. It is superadditive with Phenidone. As with pyro (pyrogallic acid), pyrocatechin can stain and tan images when the sulfite content is low, less than 5 grams/liter of working solution.
- Pyrogallic acid (pyro) is the oldest developing agent still in use. Pyro is superadditive with Phenidone and its derivatives and ascorbic acid. As with pyrocatechin, it can stain and tan images proportionally when the sulfite content is low.

All the developing agents have unique characteristics, and some have a particular purpose. Shortening the list of common developing agents has more to do with ease of manufacture, storage, and shipping than with their usefulness. The superadditive effects of hydroquinone, metol, Phenidone, and ascorbic acid have increased their popularity with manufacturers, see Superadditivity.

Developing agents for film can be used for paper and vice versa. In practical terms, some developing agents are more advantageous to use in one process than another. For example, ppd is only used for film development, while chlorohydroquinone was more often used for paper than film. Hydroquinone, metol, ascorbic acid, and Phenidone are well suited for either film or paper.

DEVELOPER EXHAUSTION

From the moment the accelerator/alkali is added to any developing agent, it begins to break down; this is true even in powder form. However, the developing agent's decomposition could take an hour to several months. In the case of Rodinal-type developers, it could take years.

The decomposition rate has much to do with the volatility of the developing agent. High-energy developing agents such as pyro and catechol may break down within an hour of mixing. Others, such as *p*-aminophenol and glycin can last much longer. Commercial products often use additives to slow or inhibit decomposition to increase shelf life, especially in liquid form. While necessary for commercial products, adding additives may affect how the developer performs.

An example is the original Kodak D-76 formula, which contains four chemicals. To increase shelf life, increase dissolvability, and keep the ingredients from caking, Kodak adds several ingredients. The Ilford commercial version of ID-11 is D-76 divided into two packages, one with the developer and one with the alkali; this allows for fewer additives, making ID-11 closer to the original formula. Does this make a difference? Not if you get the results you want with packaged D-76 or ID-11. If not, try mixing your own. I highly recommend D-76H.

DEVELOPER CATEGORIES

There are two distinct categories of developers: solvent and nonsolvent. Every developer falls into one of these two categories, with some belonging to both. An example would be D-76, which when undiluted, is a solvent, fine-grain developer, but when diluted, 1+3 becomes a nonsolvent high-definition developer.

Solvent Developers

A solvent developer uses physical development to etch silver halide crystals in the emulsion, producing finer silver halide grains and precipitating silver ions alongside the chemically reduced silver always present in the development process.

Solvent developers are used to create fine grain because they reduce the appearance of grain and prevent clumping, which causes graininess. They do this by dissolving some of the silver grains and isolating them from other reduced grains, making them appear smaller and more uniform.

Generally, a solvent developer requires a low alkalinity. This is accomplished by using more salt, in the form of sodium sulfite, as much as 100 grams per liter—125 grams in the case of Kodak D-25—while reducing or altogether leaving out an alkaline accelerator, such as borax and carbonate.

Solvent developers are best used for fine and superfine grain development, see Photo 4.1. See Table 4.1 for examples of solvent developers and their use.

Nonsolvent Developers

Nonsolvent developers, also known as high-definition developers and high-acutance developers, use a chemical reaction to reduce the silver halides to a visible image. This is the class of developer to use when the highest degree of resolution (sharpness) is desired, see Photo 4.2.

All nonsolvent developers have some solvent effect on the grain, but it is minimal. The increased sharpness that results from both grain aggregation—clumping—and the higher alkalinity of nonsolvent developers can create images of stunning sharpness and clarity to an extent not possible with solvent developers. However, in large areas of density lacking detail, the appearance of

Table 4.1

Solvent Developers		
Solvent Speed Decreasing	*Solvent Speed Maintaining*	*Solvent Speed Increasing*
D-25	Adox MQ-Borax	+Acufine
*DK-20	Rodinal + 6% sodium sulfite	FX 10, 11
FX 5	Ansco 47	ID-68
+Perceptol undiluted	D-23, D-76/ID-11	+Microphen
Most ppd developers	+Perceptol 1:3	+Xtol

Notes: *This developer can be found in *The Film Developing Cookbook*.
+ This developer is commercially available.
Source: Reproduced Courtesy of *The Film Developing Cookbook*, Bill Troop with Steve Anchell.

Photo 4.1 *Ceramicist Sue Mason in her studio, 2024.* © Steve Anchell. All rights reserved. Arista EDU 400 developed with MCM 100 Superfine grain developer, 14 minutes @ 72°F/22°C. Solvent developers are a good choice for portraits.

graininess can be obtrusive. This can be mitigated somewhat by the choice of developer. For example, FX 1 can overwhelm the image with the graininess in a sky or out-of-focus area, whereas Rodinal 1:100 can create a pleasing pattern that can go unnoticed.

What distinguishes a high-definition developer from a nonsolvent developer is the formation of adjacency effects that enhance sharpness. Nonsolvent developers should be used when a high degree of sharpness is required. See Table 4.2 for examples of non-solvent developers and their use.

Photo 4.2 *Fallen Tree, King's Highway, Ore., 2024*. © Steve Anchell. AristaEDU 100 developed with Beutler's High-Definition Developer, 11 minutes at 72°F/22°C. High-definition developers create edge effects that are good for rendering fine lines using edge effects.

Table 4.2

Non-Solvent Developers		
Non-Solvent Speed Decreasing	*Non-Solvent Speed Maintaining*	*Non-Solvent Speed Increasing*
Most pyro-only developers Most glycin-only developers D-72	D-76/ID-11, D-23 (all 1+3) HC-110 Rodinal Pyro-metol & metol glycin	Beutler High-Definition FX 1, FX 2 PMK, Pyrocat HD +Xtol 1:3 to 1:5 Windisch Extreme Compensating Developer

Notes: *This developer can be found in *The Film Developing Cookbook.*
+ This developer is commercially available.
Source: Reproduced Courtesy of *The Film Developing Cookbook*, Bill Troop with Steve Anchell.

Metol-Phenidone

Most general-purpose developers in use today are metol-hydroquinone (MQ) based rather than Phenidone-hydroquinone (PQ) based. This is partly because Phenidone has not been around that long as a developing agent and also because Phenidone is more expensive.

To substitute Phenidone for metol, start with 10% of the amount of metol, by weight, of Phenidone. Develop a test roll, inspect the results, and add more or less as needed until your formula produces the desired results.

Eco Alert: Hydroquinone

For the most part, the organic chemicals most used in the black-and-white darkroom are safe to handle. For example, the most common darkroom chemical, sodium sulfite, is used as a food preservative and antioxidant. Sodium carbonate is used as a food additive for anticaking and acidity regulation. Borax is often used in laundry detergent.

Perhaps the most environmentally hazardous chemical commonly used in most darkrooms is hydroquinone (HQ). Hydroquinone is used in film and paper developing formulas. It is anaerobic, that is, it absorbs oxygen from water; too much HQ can harm algae and fish. The good news is that the trace amounts of HQ used in a home darkroom are not enough to be measured in the environment. A pro lab is a different matter.

ASCORBIC ACID AND SODIUM ASCORBATE

Although they are not the same, ascorbic acid and sodium ascorbate—collectively referred to as ascorbate—are interchangeable in developing formulas. In many formulas, you can substitute either ascorbate for hydroquinone (HQ). Start by using 1.8 times the amount of ascorbate for the HQ called for in the formula.

Experiment with test rolls of film, keeping in mind that HQ and ascorbate are used to increase contrast.

Paper is less critical. If the results aren't pleasing, add or reduce the amount of ascorbate. If the amount you use is wrong you will only have lost a sheet of paper, not irreplaceable negatives.

Properly formulated, combining Phenidone and ascorbate makes for a superior developer, such as Paul Lewis's Mytol. Unfortunately, most, if not all, Phenidone/ascorbate formulas are prone to "sudden death." That is, they stop working for no apparent reason. You can successfully develop a few rolls in a fresh batch of XTOL, return a day later, and the next batch of film will come out as if they had been developed in plain water.

Before developing film using any Phenidone/ascorbate developer, expose a piece of silver-gelatin paper to light, tear off a small piece, and immerse it in a small amount of the developer. If it turns black, the developer is working and safe to use on film. Test each time before developing film. You can keep the remainder of the paper in the darkroom for this purpose, tearing off small pieces as needed.

Ascorbic Acid: Developing Agent or Antioxidant?

Patrick A. Gainer

We know it as vitamin C, an antioxidant essential to human life. Photographers consider it a secondary developing agent in superadditive pairs such as metol-ascorbate or Phenidone-ascorbate. These have been known for years but were recently popularized by Ilfotec DD-X and Kodak XTOL film developers.

The traditional synergistic or superadditive developer solution has four active ingredients: two developing agents, sulfite, and an alkali. We take the sulfite for granted for control of grain and pH, but don't try leaving it out, as it is also the preservative—antioxidant—that keeps the developer from going flat partway through development. This is possibly, although not proven e, the cause of developer "sudden death." Sodium sulfite is used as a preservative in nearly all developers, both film and paper.

However, a developer can be made without sulfite using Phenidone or metol, ascorbic acid, an alkali, and water. I learned of this quite by accident in 1993 when I ran out of sodium sulfite. The nearest supplier was a 100-mile round trip! Knowing that ascorbic acid is an antioxidant and having some in my medicine closet, I decided to chance it. My escapades that day were described in *Darkroom and Creative Camera Techniques*, Nov/Dec 1994—reprinted on unblinkingeye.com: Articles: Film and Film Developers: Vitamin C Developers.

Gainer 76

Hot water, 250.0 mL
Ascorbic acid, 2.0 g or ½ tsp
Metol, 0.2 g or 1⁄16 tsp
Sodium carbonate, 5.0 g or 1 tsp
Water to make 1.0 L
Use this formula as if it were D-76 undiluted

It is best to purchase either ascorbic acid or its isomer erythorbic acid for photographic use. Other perfectly legitimate forms of vitamin C are not legitimate for photo use, such as calcium ascorbate, especially if it is to be dissolved in propylene glycol or triethanolamine.

Editor's Note: Gainer 76 may be used as if it were D-76, but it is not a substitute. It creates a higher-contrast negative. It is a good choice if you need fine grain and high contrast to expand a low-contrast subject.

Alicia De Larrocha soloist, Russell Stanger conductor, and members of the Norfolk Symphony Orchestra at rehearsal, Virginia, 1971.
© Patrick Gainer. All rights reserved. Courtesy of the artist.

SUPERADDITIVITY

According to Grant Haist, superadditivity is "the cooperative action [by] which two developing agents produce more silver. . . than the sum of the silver developed by the agents used individually." Simply put, superadditivity occurs when the combined result of two developing agents is greater than either one of them working alone.

Metol is fast acting, with good low-contrast shadow detail but weak highlight density. Hydroquinone, on the other hand, is a slow-acting agent that, when used alone, can create strong highlights and high-contrast images.

Combining metol with hydroquinone can result in a faster developer than metol alone and produces contrast equal to, or greater than, that of hydroquinone alone. Developers of this kind are known as MQ for metol and Quinol—Quinol is Kodak's trade name for hydroquinone. The optimum quantity of metol to hydroquinone is 28% metol to the total amount of hydroquinone in the formula.

The phenomenon of superadditivity is even more pronounced when Phenidone and hydroquinone are combined (PQ). Phenidone on its own is almost useless as a developing agent, as it is fast acting but produces extremely low-contrast negatives. By adding a comparatively small quantity of hydroquinone, Phenidone retains its high activity and combines the higher contrast of hydroquinone with it. The optimum amount of Phenidone to hydroquinone has been said to be 7%.

Under most conditions, Phenidone is about 18 times more efficient than metol. An optimized PQ developer is 50% faster than a comparable MQ developer. However, this increased efficiency has its downside. PQ developers tend to produce more fog and are less sharp when compared to MQ equivalents. The excess fog can be controlled by the addition of benzotriazole in the amount of 0.1–0.2 g/L. Because of the difficulty in measuring tiny amounts, it is easier to use 5.0–10.0 mL of a 2% benzotriazole solution, see Appendix 2, depending on the pH of the developer.

Other superadditive combinations are pyro-metol, metol-ascorbic acid, Phenidone-ascorbic acid, and Phenidone-glycin. The superadditive effects are similar, while the resulting negatives exhibit their own unique qualities.

Trouble in Paradise

From the previous discussion, it seems that the best developers to use are those with superadditive characteristics. Most general-purpose developers fall into this category, as do many other formulas. However, there is a flip side. Most developers that utilize this effect tend to yield greater hard to print high-value density than those that rely on one developing agent.

With the average MQ or PQ developer, the high-value densities may be too severe by the time the required shadow density is reached. On the other hand, stopping development just when the desired high values are reached may not produce sufficient shadow density. For this reason, many photographers who use MQ or PQ developers use them as one-shot developers, diluted 1:1 or more.

This provides additional highlight compensation without significantly increasing the development time and without loss of emulsion speed.

Because superadditive formulas result in shorter development times, usually 5–10 minutes, the advantage of prolonged development times, 15–30 minutes, is often not appreciated by photographers accustomed to using superadditive developers. However, extended development in a semi-compensating developer, or developers of low pH or alkalinity, will often produce negatives of incomparable scale if photographers are willing to take the additional time.

PRESERVATIVES

The developing agent is oxidized during development, eventually rendering it useless. However, developing agents will oxidize even without the development process. A preservative is added to the developer to prevent this, or at least inhibit the oxidation rate.

The most commonly used preservative is sodium sulfite. Potassium sulfite is only occasionally used in highly concentrated formulas such as Ilfotec DD-X.

Sodium bisulfite[1] is often preferred in pyro developers and Phenidonee concentrates, see Appendix 3. It is often used in formulas divided into two solutions, as its weak acidity helps to inhibit the oxidation of the concentrated developing agent. When carbonate, contained in the "B" solution, is added to make a working solution, the bisulfite is broken down into sulfite and bicarbonate, producing a useful buffering effect.

Potassium metabisulfite is sometimes used in formulas. There is no practical difference between potassium and sodium metabisulfite for photographic purposes except that the potassium salt is more expensive. They can be exchanged weight for weight in most formulas.

ACCELERATORS (ALKALI)

As a rule, developing agents have weak developing powers in an acidic or neutral solution and require the presence of an alkali, known as an accelerator, to make them practical for use. Without an accelerator, most developing agents would require several hours to reduce the silver halide. Even then, the results would be low contrast with excessive fog buildup. Adding an accelerator greatly reduces development time and increases the contrast.

There are three general categories of accelerators:

- Mild alkali—pH value around 8–10 (borax, sodium metaborate, sodium sulfite)
- Moderate alkali—pH value around 10–11 (sodium carbonate, potassium carbonate)
- Caustic alkali—pH value around 12 (trisodium phosphate, potassium hydroxide, sodium hydroxide)

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[1] Sodium bisulfite and sodium metabisulfite are identical and are often the same chemical.

Increasing the amount of accelerator in a developer will increase the contrast. This is because it creates a more active environment where the developing agent can reduce additional silver halide in the exposed areas. However, too much accelerator will increase fog levels, necessitating the addition of bromide or some other form of restrainer. While paper developers should always contain some restrainer, when formulating a film developer, it is better to decrease the accelerator rather than add more restrainer.

Borax is the least active accelerator; metaborate is about double the strength of borax; carbonate is about double the strength of metaborate. Hydroxide is the most active of the alkalis and the least controllable.

pH

The pH of a developer plays a significant role in how fast the developing agents will cause an image to be formed on film or paper. The higher the pH, the more active the developer.

Also, the higher the pH, the faster a developer will oxidize. To prevent oxidation, developers often are stored in separate A and B solutions that are mixed just before use. Developers using caustic alkali should always be formulated in this manner. Developers containing easily oxidized developing agents, such as pyro, should also be stored this way, regardless of which accelerator is used.

pH Scale

The pH scale ranges from 1 to 14, with the neutral point being pH 7. Any solution with a pH higher than 7 is considered alkaline; a pH lower than 7 indicates an acid. Soap is an example of an alkali, and lemon juice is an example of an acid. Mild acids and alkalis fall close to 7 on the scale, while stronger acids or alkalis are found at either end of the scale.

Although the differences between the pH values may seem small, remember that the pH figures are logarithmic values. This means that a solution of pH 10 is 10 times more alkaline than a solution of pH 9. Thus, a slight change in pH indicates a sizeable variation in alkalinity.

It is not possible to give precise pH. For example, depending on various factors, including temperature and dilution, sodium carbonate can have a pH between 10 and 11.5, whereas sodium bisulfite could be between 3.6 and 4.6. An inexpensive meter that will enable you to monitor pH levels is the pHep made by Hanna Instruments, see Material Sources. The following are some examples of the pH value of chemicals used in developing and a few common liquids for reference.

- 14.0 – Sodium hydroxide (4%)
- 13.0 – Sodium hydroxide (0.4%); liquid bleach
- 12.0 – Developers containing caustic alkali, trisodium phosphate (TSP)
- 11.0 – Ammonia (11–12)
- 10.5 – Developers containing carbonate (10–11); sodium metaborate

- 10.0 – Triethanolamine (TEA) (1%)
- 9.0 – Borax, fine-grain developers; alkaline fixer (8.5–9.5)
- 8.0 – Sodium sulfite (5%), blood
- 7.0 – NEUTRAL: Deionized water; potassium bromide
- 6.0 – Milk
- 5.0 – Black coffee
- 4.3 – Sodium bisulfite
- 4.2 – Fresh acid fixer
- 4.0 – Stop baths
- 3.0 – Grapefruit and orange juice
- 2.0 – Lemon juice; vinegar
- 1.2 – Sulfuric acid (1%)
- 1.1 – Hydrochloric acid (3-4%)
- 0.8 – Normal solutions of strong acids

pH has another implication for photographers: acid and alkali neutralize each other. Except for amidol-based developers, developing formulas are alkaline, and almost all fixing formulas are acid. That is the reason if you place a print in an acid stop bath or acid fixer, you cannot return it to the developer—it will neutralize the print developer.

The opposite is also true. If you take a print or negative from an alkaline developer and place it directly into an acid fixer, the fixer will rapidly become neutral in pH and no longer work.

Buffering

A buffer keeps the pH of the solution constant. A buffered developer will maintain a constant pH, whether diluted 1:1 or 1:3. A nonbuffered developer may change its pH as it is diluted. Most alkalis used in developers have some buffering ability.

Carbonate and sodium metaborate are the most stable alkalis. Borax does not buffer well against a rise in pH, and hydroxide loses its alkalinity rapidly as the solution is diluted.

Mild Alkalis

Mild alkalis produce less contrast and take longer to work, but they remain stable for a longer period in a working solution, especially in large concentrations.

Sodium metaborate, also known as metaborate, Balanced Alkali, and Kodalk, is found in many developing formulas. Metaborate is more alkaline than borax and more easily soluble but less alkaline than carbonate. As metaborate contains no free carbonate, there is no danger of carbonic gas bubbles forming when an acid stop bath is used, see the next section, Moderate Alkalis. Metaborate can be substituted for sodium carbonate, see Conversion Tables: Alkali Substitutions.

Borax is the mildest common alkali. It is most often used in low-contrast and fine-grain developers, where it is preferred as a decahydrate. Sodium sulfite, though most often used as a preservative, can also be used as a mild alkali. In Kodak D-23, it serves both purposes.

Moderate Alkalis

Sodium carbonate, referred to as "carbonate," is available in three forms: anhydrous (desiccated), monohydrous, and crystalline. The difference between the three concerns the number of water molecules attached to each molecule of sodium carbonate. Anhydrous has no water molecules attached, monohydrous has one, and crystalline has ten.

The more water molecules there are, the greater the weight of the chemical necessary to provide the same activity in solution. For example, the equivalent of 35 grams of anhydrous would be 41 grams of monohydrate, see Conversion Tables: Sodium Carbonate Conversion.

Anhydrous vs. Monohydrous

The prefix an- is from Greek and means "without." The word hydrous means "containing water," so anhydrous means "without containing water."

The prefix mono- means "one." Monohydrous or monohydrate refers to substances containing one molecule of water.

Anhydrous, having no water, is quicker to absorb moisture from the air and must be stored in an airtight container to prevent deterioration. The crystalline form, which loses its water molecules rather rapidly, is rarely seen in current photographic practice. With its single molecule, the monohydrous form is the most stable of the three and is the most desirable.

Carbonate has an important drawback. When a large amount is used, carbonic gas bubbles can form in the film or paper emulsion when transferred to an acetic stop bath, resulting in pinholes and/or reticulation. A less acidic stop bath, such as Kodak SB-1 Nonhardening Stop Bath, or a running water bath, should prevent this.

Potassium carbonate is available in both anhydrous and crystalline forms. Depending on the grade, the crystalline contains 1.5 water molecules and a small amount of bicarbonate buffer. The potassium salt readily absorbs water from the air and must be kept in airtight containers.

Potassium carbonate is far more soluble than sodium carbonate, hence its use in highly concentrated solutions. The two should not be interchanged, although they may be intentionally mixed in some cases, see *The Film Developing Cookbook*.

Trisodium phosphate (TSP) is more alkaline than carbonate and less alkaline than hydroxide. It can be used as a strong alkali. It has not been used extensively to replace either or both because it has been known to interfere with hardening acid fixers. If you use alkaline fixers, TSP is a viable alternative to hydroxide or carbonate.

Caustic Alkalis

Potassium and sodium hydroxide are far more energetic than the alkali carbonates and are used only when a powerful, fast-acting developer is required.

Developers compounded with caustic alkalis have poor keeping properties and are soon exhausted.

The only practical difference between potassium and sodium hydroxide is that 10 parts by weight of sodium are the equivalent of 14 parts by weight of potassium. Also, potassium hydroxide is more soluble, meaning more will go into solution than sodium hydroxide. The limit of sodium hydroxide in water is 50%; the limit for potassium hydroxide is much higher.

PHOSPHATES

Sodium and potassium phosphate approach the pH of the hydroxides without being quite as dangerous to handle.

One reason phosphates have been little used is that they can cause scum if the film is plunged directly into a fixer that contains alum hardeners. Since the use of alum hardeners is waning, this may no longer be a major concern. In powder form, the phosphates may be less stable than other alkalis.

RESTRAINERS

Restrainers are necessary to prevent excess fog in print developers. Whereas a degree of base fog is permissible in a negative, no amount of fog, which would appear as gray highlights, is acceptable in paper. For this reason, paper developers always require a restrainer, often in significant amounts.

Restrainers should be used sparingly in film developers. Some photochemists recommend that they not be used at all. In the *FDCB*2, Troop writes, “A film developer should not need to use a restrainer—if it does, then the alkali is too strong.” Even so, many film developing formulas rely on restrainers, partly to prevent fog and partly as “insurance” against errors in the formulation.

Potassium Bromide

Potassium bromide, usually referred to as “bromide,” is the primary restrainer found in most developers. It holds back the developer’s overall action, reduces the film’s effective sensitivity, and diminishes the amount of useful density created in the shadow areas. Bromide also increases contrast by inhibiting the reduction of silver halide. This action varies with different developers.

As the film is developed, soluble bromide is produced and passed into the developer solution. This buildup of bromide adds to the already existing restrainer. If too much bromide is initially present in the form of a restrainer, the combined amounts can considerably affect the contrast and sensitivity of the film.

Another consequence of this reaction is “bromide drag,” which occurs when either too much bromide builds up in the developing solution or agitation is unidirectional, causing streaks across the negative. This can be prevented by sufficient agitation and randomly altering the direction of agitation.

Bromide is generally used in paper developers when a warm or neutral tone is desired. The more bromide, the warmer the tone, though too much bromide will inhibit development in the shadow areas.

Benzotriazole

Benzotriazole's (BZT's) antifogging effects are greater than bromide's weight for weight, especially in developers of high pH. As a result, BZT is especially useful for salvaging outdated papers or when blue-black tones in prints are desired.

To salvage outdated papers, use a 0.2% solution—2.0 grams in water at 125°F/52°C to make 1 liter. Add 15.0 mL of this solution to every liter of developer. If 15.0 mL does not do the trick, add 15.0 mL at a time and make tests until you get a clear paper without fog.

To test, develop a small piece of unexposed paper for the full time; after fixing, it should show no signs of gray when it is held up to a white surface, such as the back of another piece of paper.

It is advisable with all outdated papers, even those not exhibiting fog, to keep development times between 45 seconds and 1.5 minutes—the longer paper develops, the more likely it will exhibit fog.

While BZT is often used in PQ formulas, especially those of medium to high alkalinity, bromide is a superior restrainer in PQ formulas of low alkalinity. As a substitute for bromide, BZT is generally used at 1/10 the solution concentration of the bromide.

Potassium Iodide

Potassium iodide is sometimes used as a restrainer. It is more potent than bromide by as much as 100 times. It can also occasionally be used with bromide in some historic formulas.

Kodak photochemist Ron Mowrey theorized that micro amounts of potassium iodide may cause buried iodide in older emulsions to migrate to the surface, enhancing edge effects and increasing sharpness. According to Mowrey, this would be less likely to occur in modern emulsions due to advanced emulsion coating methods that allow the iodide to be precisely layered at the surface. This is further discussed in *The Film Developing Cookbook.*

WATER

One of the primary reasons for poor negative quality is impure water. In *Champlain on Fine Grain*, Harry Champlain writes that one of the primary causes of negative development failure is "impure water."

Water varies in quality depending on where you live and the additives used by your local water district. For example, if water flows through lime rock, it will have an excess of alkali. Depending on the water district, it may have excess chlorine or sulfur or a host of other chemicals, and if it does, it may be unfit for use in developing solutions. If the water pipes delivering water to your darkroom are old or galvanized, you may experience high amounts of mineral deposits that can scratch your film when removing water to hang and dry.

When hard water is used for mixing developers, milkiness is sometimes produced. This is caused by the action of alkali and sulfite on the lime salts in the water. If the lime is excessive, calcium carbonate and sulfite precipitate may be deposited on the film. Should this occur, the scum is soluble in acid stop baths and in fresh acid fixing baths, especially if the film is well agitated. It is slowly soluble in water and may also be wiped or sponged off wet film, although light deposits may not be noticed until the film is dry. If necessary, Kodak SB-5 Non-swelling Acid Rinse Bath is recommended for removal. Of course, the problem can be avoided by using distilled, deionized, or reverse osmosis (RO)-treated water.

General Thoughts on Darkroom Chemicals

Alan Fischer, Photo Systems, Inc.

Good water means repeatable results, and repeatability is the foundation of good darkroom practice. For this reason, all darkroom chemicals should be mixed with known good water. For example, at PSI, our process water is deionized, but users can use reverse osmosis or distilled water for equally consistent results.

Most chemical manufacturers include anticalcium chemicals in their formulations. While this works well for calcium, it is generally not a good solution for heavy metals, which can cause unforeseen problems with developers.

The second most observed problem is cross-contamination. Very few users are careful about cleaning between mixing various solutions. While we see this less in black-and-white, it is often seen in color processes like E6. Cross-contamination can occur during mixing or as a result of improper washing between steps.

I think each user should learn what the developer and fixer actually do in a visual way. Fog a piece of film and process it—is it totally black? Take a piece of film that is unexposed and place it in fixer—is it totally clear? Simple experiments like this take relatively little time and give new users firsthand knowledge of “how the process works.”

Alan Fischer is the founder and owner of Photo Systems, Inc., the largest manufacturer of photographic chemicals and formulas in North America.

OTHER CONSIDERATIONS FOR DEVELOPERS

All developing agents in developer solutions will oxidize when exposed to air. MQ and PQ developers that contain high concentrations of sodium sulfite are slower to oxidize than most other developing agents. High-energy developers containing caustic alkali and developers containing pyrogallol, pyrocatechin, and amidol, among others, oxidize quickly. These should be used immediately upon diluting to a working solution.

Dark brown or amber glass bottles are best for storing developers. Always fill the bottle to the top to prevent oxidation.

CREATING YOUR OWN FORMULA

The Darkroom Cookbook is meant to be a point of departure for photographers desiring to take control of their craft. At any time, you should feel empowered to "interpret" any formula, design a new one, or adapt an existing formula to a new purpose. In doing so, keep these six aspects of the process in mind:

1. The developing agent—its nature, concentration and, where more than one is used, the ratio between them.
2. The alkali or accelerator—its nature and concentration. Also, remember that with film, you have too much alkali if you have too much fog. Reduce the alkali content *before adding* a restrainer. You may find you don't need a restrainer.
3. The restrainer—its type and quantity.
4. The preservative can significantly affect the developer's graininess and compensating effect.
5. The percentage of each component in the formula.
6. Never compare stock solutions of formulas. Compare working dilutions only.

The following is a way to manipulate developing formulas and learn the effect of different chemicals. Start with a general-purpose paper developer, such as Kodak D-72, and dilute as you would for a normal print. Choose a full-scale negative that prints well on grade 2 paper or with a #2 multicontrast filter. Make a good print and write "control" on the back using a pencil. Make 13 more identical prints and put them in a light-tight box without developing them. The prints do not have to be large; 4 × 5 inches or 5 × 7 inches will suffice.

- Mix a fresh batch of developer using only the metol and sulfite in 1 liter of water, then dilute and develop the first print for the same time as the control print. Add the carbonate and develop the second print. Add the bromide and develop the third print. Be sure to mark the back of each successive print with a number, such as "1," "2," and so on.
- Mix a fresh batch of developer using only the hydroquinone and sulfite in 1 liter of water, diluting as before, and then adding the other chemicals in succession. Be sure to mark the back of each print.
- Mix a fresh solution of D-72; this time, use half the amount of carbonate—40.0 grams—and develop another print. Then add 80.0 grams more carbonate to bring the amount to half again norma—total carbonate = 120.0 grams. Add 40.0 grams more carbonate to double the normal amount—total carbonate = 160.0 grams.
- Mix another solution of D-72; this time, use the normal amount of carbonate—80.0 grams—and no bromide to start with. Then add bromide to bring the total to 1 gram, 2.5 grams, and finally, 4.0 grams.

Compare each print to the test print and become familiar with the results. You can repeat this test with any paper developer. Doing this test in its entirety will familiarize you with the full range of effects and controls possible with any developer. It will also help you learn how to create your own formulas.

Using Coffee to Develop Film (aka Caffenol)

Jill Enfield

Developing your film in coffee is more about having fun than getting technically flawless results. Different films will have different developing times. Some may develop perfectly in 12 minutes; others may take up to 20 minutes.

To get started, expose an entire roll of your favorite film to the same subject. In total darkness, cut it in half, and then in half again. Store three pieces in a light-tight container and develop one strip for 12 minutes. This will be your base time.

If the first strip of negatives is too thin, the film needs more development time; add 40% to the next strip. If the negatives come out opaque, the film needs less time; subtract 20%.

A fun fact: If you do this with color film—negatives or transparencies—you'll end up with black-and-white negatives.

You will need:

- Instant coffee—regular (not decaf)
- Vitamin C powder—aka ascorbic acid (found online or at health food stores)
- Washing soda—aka sodium carbonate or soda ash

Caffenol Developer

Solution A

Water at room temperature, 750.0 mL
15 level teaspoons of instant coffee crystals (or 5 level tablespoons)
1½ level teaspoons vitamin C powder
Water to make 1.0 L

Stir until all the crystals and gritty bits are completely dissolved.

Solution B

Water at room temperature, 750.0 mL
10½ teaspoons washing soda
Water to make 1.0 L

The water temperature is not critical but, if possible, should be kept between 68°F/20°C and 75°F/24°C. Warmer water = shorter developing time.

Mix the two solutions in a large container to hold all the liquid.

Develop as you would using a regular film developer.

For more coffee recipes, check out www.caffenol.org.

Flat Iron Building, NYC. Developed in Caffenol. © Jill Enfield. All rights reserved. Courtesy of the artist.

5

Types of Film Developers

> *"If a day goes by without my doing something related to photography, it's as though I've neglected something essential to my existence, as though I had forgotten to wake up."*
>
> —Richard Avedon

There are hundreds of developing formulas meant for a particular purpose, such as extreme compensating developers for scenes of extreme contrast, high-contrast developers for scenes of low contrast, low-contrast developers for document films, fine-grain developers for use with slow, fine-grain film, and high-acutance developers for enhancing sharpness.

Find a developer that produces results that please you and make it your go-to. It could be D-76, Rodinal, Pyrocat-HD, Ilfotec DD-X, or any of the developers found in the *Cookbook*. Get to know that developer with a variety of films, and until you find something better, make it the standard by which you judge all others.

DIVIDED DEVELOPERS

Divided developers use two separate baths to develop film. The first bath consists of the developing agent, usually buffered and preserved, and the second bath contains an alkali known as an accelerator. The undeveloped film is soaked for approximately 3 minutes in the first bath. The emulsion soaks up the developer, but minimal development takes place without an accelerator. The film is then transferred to the second bath, where the accelerator activates the developing agent, and development takes place to completion.

Divided development allows a photographer to expose roll or sheet film under many different and difficult situations and still create printable negatives because of the compensating action inherent in the process. Properly formulated divided developers can produce high-quality negatives, resulting in superb prints.

Divided development has several secondary advantages:

- It produces even, consistent development.
- Depending on the choice of developing agents, there may be little or no loss in emulsion sensitivity (speed); often, sensitivity is increased.
- Divided developers are panthermic to some extent. Because temperature has minimal effect on contrast and density, a range of temperatures, usually between 65°F/18°C and 75°F/24°C, can be used. However, all solutions, including wash water, should be kept close to the same temperature.

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Another advantage is that the developer cost per roll of film is less than with single-solution developers. One liter of the first bath can soak as many as 20 rolls of film as long as the solution is not contaminated by the second bath or not allowed to oxidize. The second bath, which contains the less expensive chemicals, should be discarded after processing 10 rolls of film. Divided development can be used for all films except document films.

EXTREME COMPENSATING DEVELOPERS

Compensating developers give proportionally full development to the low density (shadow) and middle densities while limiting the degree of development in areas of high density (highlights). Extreme compensating developers are used to arrest the development of the highlights for recording extremely high-contrast subjects while maintaining as much separation throughout the subjects high density areas as possible. However, this may result in some midtone compression, see Photo 5.1.

To achieve the most compensation and the sharpest image, extreme compensating developers should be used with intermittent agitation. Water bath development can also be used with extreme compensating developers, see Chapter 6.

Photo 5.1 *Highway 10 to Idyllwild, 1979.* © Steve Anchell. All rights reserved. The scene represents a 10+ stop range. The Kodak Super XX negative was developed in Windisch Extreme Compensating Developer. Photographed with an Agfa Ansco 8 × 10-inch view camera and a 360mm f/5.6 Schneider Symmar lens.

FINE-GRAIN DEVELOPERS

Fine grain embedded in the unexposed and undeveloped film by the manufacturer is different from fine-grain development using a fine-grain developer. A fine-grain developer minimizes graininess—the clumping of individual grains during development—regardless of how large the grain is in the emulsion when it comes from the factory.

A properly exposed and developed fine-grain image results in an even distribution of grains in a coherent and pleasing grain pattern. The result is similar to what you would expect of a pointillist painting,[1] only with near-microscopic grain structure. Conversely, the wrong choice of film and developer will create what has been referred to as "an indescribable soup of unknown content" or "mushy grain."

Fine-grain developers often cause a loss in film speed. This occurs because the physical size of the individual grains limits the size of their light-collecting surface. A contributing factor is that underdevelopment is one of the methods used in fine-grain development to achieve fine grain. If you increased the development time, you could reach the film's rated speed, but you would lose the fine-grain effect.

Fine-grain developers also tend to inhibit acutance (sharpness). The main reason is that fine-grain developers do not typically exhaust completely during development; therefore, few sharpness-enhancing adjacency effects are formed. The lack of sharpness can be useful in portraits, where high acutance accentuates wrinkles and other physical defects often thought unflattering.

But as with all things in photography, there are always exceptions to the rule. Rodinal is not a fine-grain developer; it is a high-acutance medium-grain developer, but with the right film and working dilution, it can create a pleasing fine-grain structure and a relatively high degree of sharpness. Table 5.1 contains five combinations you may wish to try using Rodinal to achieve a pleasing grain structure with minimum loss of sharpness. Note the loss in film speed.

Author's Note: To create higher contrast and maintain the highest speed, use the Agfa agitation method, continuous for the first 30 seconds followed by 5 seconds every 30 seconds after that. This will help prevent the visual effect of grain clumping, see Chapter 6.

Table 5.1

Fine Grain Development Times for Rodinal

	EI	*Light*	*Dilution*	*Temp*	*Time/min*
Agfa APX 100	50	Sun	1+49	75F/24C	12
Fuji Neopan 1600	400	Diffuse	1+39	68F/20C	8
Ilford HP5+	50	Sun	1+25	68F/20C	6
Kodak T-Max 400	125	Diffuse	1+49	68F/20C	11
*Kodak T-Max 3200	1600	Diffuse	1+9	68F/20C	7

*Kodak T-Max 3200 is no longer made. I am including it in Table 5.1 in case you stumble upon a hidden cache and also to give you the idea that despite common wisdom, even fast films can create a pleasing fine-grain structure with the right developer

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[1] For examples of pointillist paintings from the nineteenth century see Georges Seurat and Paul Signac.

D-76: A General-Purpose Fine-Grain Developer

The most widely used developer in the world, Kodak D-76, falls under the category of fine-grain developers. D-76 was formulated in 1927 by J. G. Capstaff of Kodak as a black-and-white movie film developer. However, only a short time after better movie-film developing formulas were introduced and D-76 found use as a still-film developer. Eventually, D-76 became the standard by which to judge all other developers. It was not that D-76 was the best developer ever formulated—it was that a standard was needed, and D-76 had the best all-around compromise of sharpness to grain with a full tonal range from black to white.

It was soon discovered that the pH of D-76 increased with storage. At the pH of fresh D-76, hydroquinone (HQ) is not active. But when the pH rises, the HQ can become active, increasing contrast and grain considerably—not a good sign for a standard! Several solutions were proposed over the next 30 years, including D-76d, but Grant Haist, also of Kodak, proposed the simplest and most elegant. Haist suggested removing HQ from the formula and increasing the metol or the borax to 2.5 grams. The resulting developer, D-76H[2], is indistinguishable from D-76. Not only that, but without hydroquinone, it is less expensive to make and more environmentally friendly.

[2] The name of this developer, D-76H, was coined by me when co-writing *The Film Developing Cookbook* with Bill Troop. I mention this only because of the hysterics that take place on darkroom forums when someone discovers the name wasn't given by the formula's creator.

GENERAL-PURPOSE (AKA UNIVERSAL) DEVELOPERS

This category may prove somewhat controversial, as most developers have distinguishing characteristics or purposes that belong in a more specific category. Even so, certain developers have proven to be useful for developing both film and paper, though usually they will work better with one than the other. For example, Kodak Dektol (D-72) is one of the most used print developers. However, press photographers who require quick turnaround have been known to use it for film development. The result is a grainy image, but from an artist's perspective, it may be what the doctor ordered.

HIGH-CONTRAST DEVELOPERS

These developers are generally used when a high degree of contrast is required, such as in graphic arts and scientific applications. With the introduction of high-quality graded and variable-contrast printing papers, the need for high-contrast developers to expand low-contrast subjects, such as landscapes under subdued light, is not as important as it once was. The formulas are included should they ever be needed.

Giving Infrared Film More Pop

Kimberly Schneider

I like my images to really pop, and I prefer for my highlights to glow in terms of infrared.

When I first began experimenting with infrared film, I was accustomed to using the chemicals the school supplied. D-76 left my infrared falling flat, and I've always been a stickler for contrast, so I started testing other film developers. After multiple tests, I still couldn't find anything that did what I thought infrared could do for my work. So, I asked my professor, Gary Huibregtse, for his advice and he suggested testing D-19, which did exactly what I hoped it would. I've been using it exclusively on infrared negatives for 15 years now.

This is a fast high-contrast developer, typically used for x-ray films and other scientific purposes.

Kodak D-19 is no longer available in stores, but you can mix it from scratch, and the Photographers' Formulary makes something comparable.

Undercurrent. © Kimberly Schneider. All rights reserved. Courtesy of the artist.

HIGH-DEFINITION DEVELOPERS

A high-definition developer—also known as high-acutance—enhances image sharpness through edge effects. Edge effects occur where dark and light densities meet. These do not have to be shadow/highlight regions; they can be any region where one side is denser than another.

High-definition developers contain a relatively low concentration of developing agent, so they exhaust rapidly in the denser areas of the negative where the most exposure and the most development have taken place. As development nears completion, the relatively fresh developer remaining in the less dense regions passes across the border to the still developing areas. There, a border effect is created, consisting of a small region of increased density on the edge of the highlight side. The fresh developer does not spread out across the entire negative; it only goes far enough to create the edge effect.

At the same time, by-products of exhausted developer in the lighter areas diffuse back into the less dense regions, retarding further development. This results in lower-than-normal density at the edge of the darker areas. This is known as a fringe effect. The strong local enhancement of the contrast between bright and dark areas is perceived as higher sharpness.

Adjacency effects are obtained by using a high-definition developer that is low in developing agent, low in sulfite, or both. This allows the developer to quickly exhaust in the denser regions. The developer is also high in alkali, which allows it to continue to develop in the dense regions and along the borders. A high-definition developer's full effect can only occur with intermittent agitation, see Photo 5.2.

Photo 5.2 *Cold Springs Station, Nevada*, 1999. © Steve Anchell. Ilford HP5+ developed in Edwal's FG-7 for 12 minutes at 70°F/21°C. A fast film developed in a high-resolution developer. Photo made with Mamiya RZ67, 65mm f/4 lens.

For in-depth reading on acutance, adjacency, and border effects, see Chapter 6 of *The Film Developing Cookbook*, second edition.

LOW-CONTRAST DEVELOPERS FOR DOCUMENT FILMS

Document films, such as Adox CMS 20 II, are ultra-fine-grain, high-contrast films. Their original intended use was to copy line art and text, which is why they are known as document films. They are also valuable for making low-contrast masks for contrast control and other printing purposes. When developed in a specially formulated low-contrast developer they can produce full-scale images of exceptional resolution.

Developers for document films are similar to extreme compensating developers in their ability to record scenes of extreme contrast. The main difference is that developers for document films are formulated to compress the high contrast of the film, whereas extreme compensating developers are designed to compress the high contrast of the subject to prevent the highlights from being blown out. Many low-contrast developers for document films are simple formulas based on a single developing agent.

MONOBATH DEVELOPERS

Monobath developers combine the process of development and fixation in one bath. With the right formulation, monobaths are capable of high chemical solvency and high adjacency effects, something not typically found using any other method of film development.

Although research on monobaths began in the 1880s, they were not practically possible until the 1950s through the combination of Phenidone and hydroquinone activated by sodium hydroxide, a highly energetic combination that completes development before fixation begins. While there are several published formulas, the best is probably FX 6a by Geoffrey Crawley, which you will find in the Formulary. Another you may like to try is Keelan's. Two commercially available monobaths, ARS-IMAGO MB Monobath and Cinestill Df96, give pleasing results with good contrast.

Monobaths can be used with conventional tray or tank processing. For more information, see Chapter 6.

PYRO AND PYROCATECHIN DEVELOPERS

See Chapter 7 for a full discussion of pyro and pyrocatechin.

SPEED INCREASING DEVELOPERS

A film's speed rating is based on its ability to record shadow detail. The higher a film's ISO speed rating, the better it is able to record shadow detail with less exposure. Despite claims to the contrary, it is almost impossible to increase a film's sensitivity by one stop more than the manufacturer's rating using speed-enhancing developers and additives.

Push processing is not the same as increasing the film's speed. For more on push processing see Chapter 6.

SUPER-FINE-GRAIN DEVELOPERS

The classic super-fine-grain developing agent was *p*-phenylenediamine (ppd), which could produce exceedingly fine grain on pre-WW2 films. It required strong overexposure and a long developing time, and even then, the contrast of the negative was often low. Additionally, ppd is allergenic and stains clothes, fingers, and work surfaces, leaving brown spots that are difficult to remove. When using ppd, cover the work surface, wear an impervious chemical-proof apron and gloves, and try not to spill any!

These disadvantages have led to attempts to discover developing agents and combinations of other agents with ppd that would give super-fine-grain results and shorter development times without the troublesome properties.

Glycin combined with ppd, such as in Edwal 12, makes a fine-grain developer with improved emulsion speed and a faster rate of development. Unfortunately, because of the presence of ppd, it still suffers from the unpleasant side effects mentioned earlier of high toxicity and staining.

o-Phenylenediamine (opd) is one of the more successful replacements for ppd. It has weak developing properties but is a good solvent for silver halide. In Windisch Superfine-Grain Developer, metol acts as the primary developing agent for the silver halide.

Nearly all super-fine-grain developers have a high sodium sulfite content, as sodium sulfite is an effective silver solvent and may work superadditively with ppd. For an alkali, they use small quantities of either carbonate or borax to minimize the energy of the developer to produce finer grain, or just sulfite as an alkali. FX 10 uses a buffering mixture of borax and boric acid, whereas Windisch Superfine-Grain Developer uses sodium metabisulfite to reduce the pH of the sodium sulfite.

The Holy Grail of Photography

There was a time when 2¼ × 3 ¼-inch film (6 × 9 cm) exposed in pocket folding cameras was considered miniature film only suitable for amateurs to take vacation photos and family snapshots. Even war photographers used handheld 4 × 5-inch cameras. Grain was not considered an issue.

This changed not long after 35mm film for still cameras became popular. Suddenly, even professionals, including documentary, street, photojournalists, editorial, and war photographers, recognized the benefit of small handheld cameras. This resulted in many fine-grain and super-fine-grain developers being formulated, as fine-grain film technology had not yet been perfected.

Today, if fine grain is your goal, try overexposing and underdeveloping flat-grain films such as T-Max, Acros, or Delta. Either that, or if you prefer a unique look to your fine-grain images, choose a slow-speed, cubic grain, classic emulsion film with one of the fine-grain or super-fine-grain formulas found in the Formulary section or purchased from Photographers' Formulary, Fotoimpex, Freestyle Photo, or ARS-IMAGO.

DEVELOPER RIPENING

Many fine-grain solvent developers work best when “ripened” before use. Chief among them are ppd and opd super-fine-grain developers and Kodak D-76. Ripening improves the developer’s overall performance and enhances edge effects, improving sharpness.

To ripen a gallon of freshly mixed, unused Kodak D-76 developer, Daughtee Rogers, who taught me much of what I know about the darkroom, would fog a roll of 120 or 35mm film by removing it from its spool and exposing it to light. Then, she would submerge the exposed film in the freshly mixed developer to soak for at least half an hour.

She would use the D-76 with replenishment until it began to look murky. There is no way I can tell you exactly what “murky” looks like, except that Daughtee always knew—a more precise method will be found under Kodak D-76R in the Formulary. To replenish the gallon of used D-76, she would replace 1 ounce of the used developer with 1 ounce of fresh D-76R for every 80^2 inches of film developed.

Les Wellens did things a little differently. He would ripen his first gallon of D-76 using a roll of film, the same as Daughtee. He would mix a fresh gallon when he had nearly replaced the original gallon with replenisher. He would “season” his new batch using 50 mL of the old batch instead of wasting a new roll of film. Sooner or later, for reasons known only to Les, he would start over with a fresh batch of D-76 and a roll of film. I suppose it looked murky.

Author’s Note: Both ripening and replenishment are for use with undiluted developers. For example, do not ripen D-76 if you are going to use it 1:1. Do not reuse diluted developers. Use them once and discard them.

REPLENISHMENT OF DEVELOPERS

Several of the film developers included in *The Darkroom Cookbook* have companion replenishers whose formulas are also given. However, despite what I have related about both Daughtee and Les in the section earlier, I do not recommend the use of replenishment unless you are operating a high-volume lab. There is no advantage or savings in replenishing for most small-volume home darkrooms, and there are numerous disadvantages. Among them is the possibility of bromide buildup, resulting in bromide drag, developer oxidation, and inconsistent results.

If you would like to use a replenisher, follow the instructions that come with it. If you don’t have instructions, the general rule is to replace 30 mL of the developer you want to replenish with 30 mL of replenisher for every 80^2 inches of film.

■ ■ ■ ■

Entrance to the Theatre, Patara. © Ian Grant, all rights reserved. Courtesy of the artist. Wista 45DX, Schneider 210mm Symmar S, 1/30th at f22, Ilford Delta 100 at EI 50. Pyrocat HD 1+1+100, 81°F/27°C for 9 minutes with agitation every 30 seconds.

6

Film Development

> *"They say my print quality is bad. Darling, they should see my negatives."*
> —Lisette Model to Bill Troop

The choice of which film developer to use is the single most important decision a photographer can make. Film developers affect the image's sharpness (acutance), graininess, tonal scale, and contrast. All are interdependent. For example, film developers that maximize sharpness do so at the cost of increased graininess. High-energy film developers shorten the tonal scale of a negative, and soft-working developers, while extending the scale, lower the contrast.

A developer rendering maximum acutance is generally preferred for landscape and architectural work. Portraits often require a softer look, with finer, more rounded grain.

Enlarging equipment must also be considered. Condenser enlargers emphasize contrast and crispness. A photographer using a condenser system may prefer a softer negative with lower acutance. Diffusion enlargers generally work best with negatives that exhibit maximum sharpness. Graininess is less critical with diffusion systems because diffused light tends to mask it. In the following sections, developers will be discussed according to their specializations or unique qualities.

TESTING

The best way to test film is the Zone System. Why? Using the Zone System, you will learn how light, film, development, and printing work hand-in-hand to create silver images. Nothing else will teach you this so comprehensively. There are many good books on the subject, mostly out of print. *The Practical Zone System for Film and Digital Photography: Classic Tool, Universal Applications* by Chris Johnson is the best and easiest to follow.

If you don't have the patience to learn the Zone System, the tried-and-true method used by photographers from the earliest days of the craft is to take some film, walk down the street, and expose it to a range of subjects. Try to include textured whites and some deep shadows. Keep careful notes. Assuming you are using roll film, cut the test roll into two, three, or four equal strips in the darkroom. Develop each strip for a different time. Give at least a 10% increase or decrease in time from your best-guess starting time and round the time off to the nearest 30 seconds.

If you are using sheet film, expose several films to different exposure indexes (EIs) and develop them using the same developer with different times.

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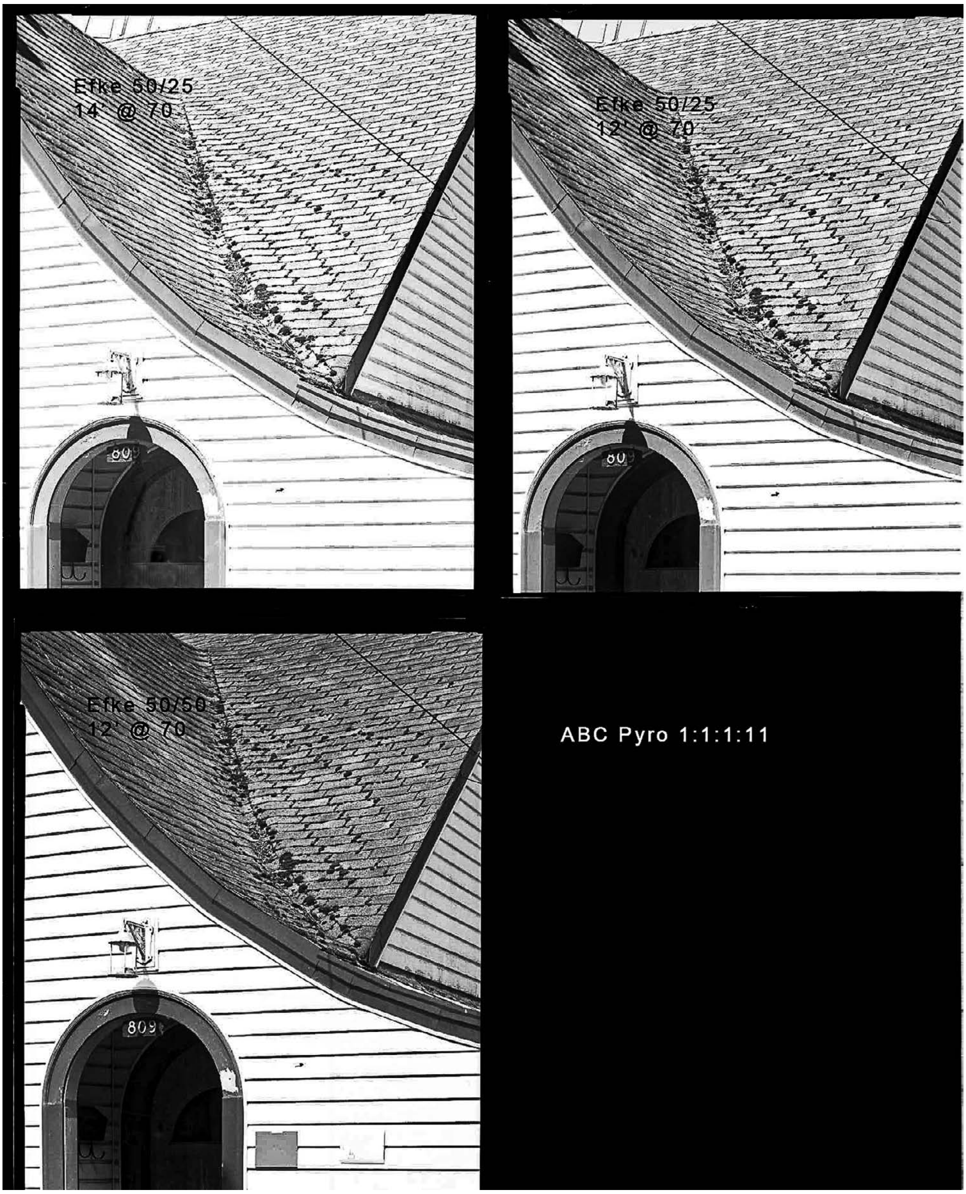


Photo 6.1 Testing film and developer. The three test images seen here were made using 4 × 5-inch Efke 50 and developed in ABC Pyro 1:1:1:11. The lower left is notated "Efke 50/50, 12' @ 70", indicating Efke 50 exposed at EI 50, developed for 12 minutes at 70°F/21°C. The upper left is Efke 50 exposed at EI 25, developed for 14 minutes at 70°F/21°C. The upper right is Efke 50 exposed at EI 25, developed for 12 minutes at 70°F/21°C. The proof sheet was exposed for maximum black, see Appendix 3.

Once you have exposed and developed your test roll or individual sheets of film for testing, the next step is to proof them for maximum black, see Appendix 3. This will determine which EI to use and the development time for each film and developer combination. When studying your proof sheet remember that **exposure is for the shadows; development is for the highlights.** That means:

- If the shadows contain printable detail but the highlights are gray, more developing time is indicated.
- If the highlights are white with detail but the shadows are thin and lacking detail, then more exposure is indicated. Use a lower EI—more exposure—and maintain the same developing time.
- If the shadows are gray with detail and the highlights are also gray, use a higher EI—less exposure—and increase the developing time.

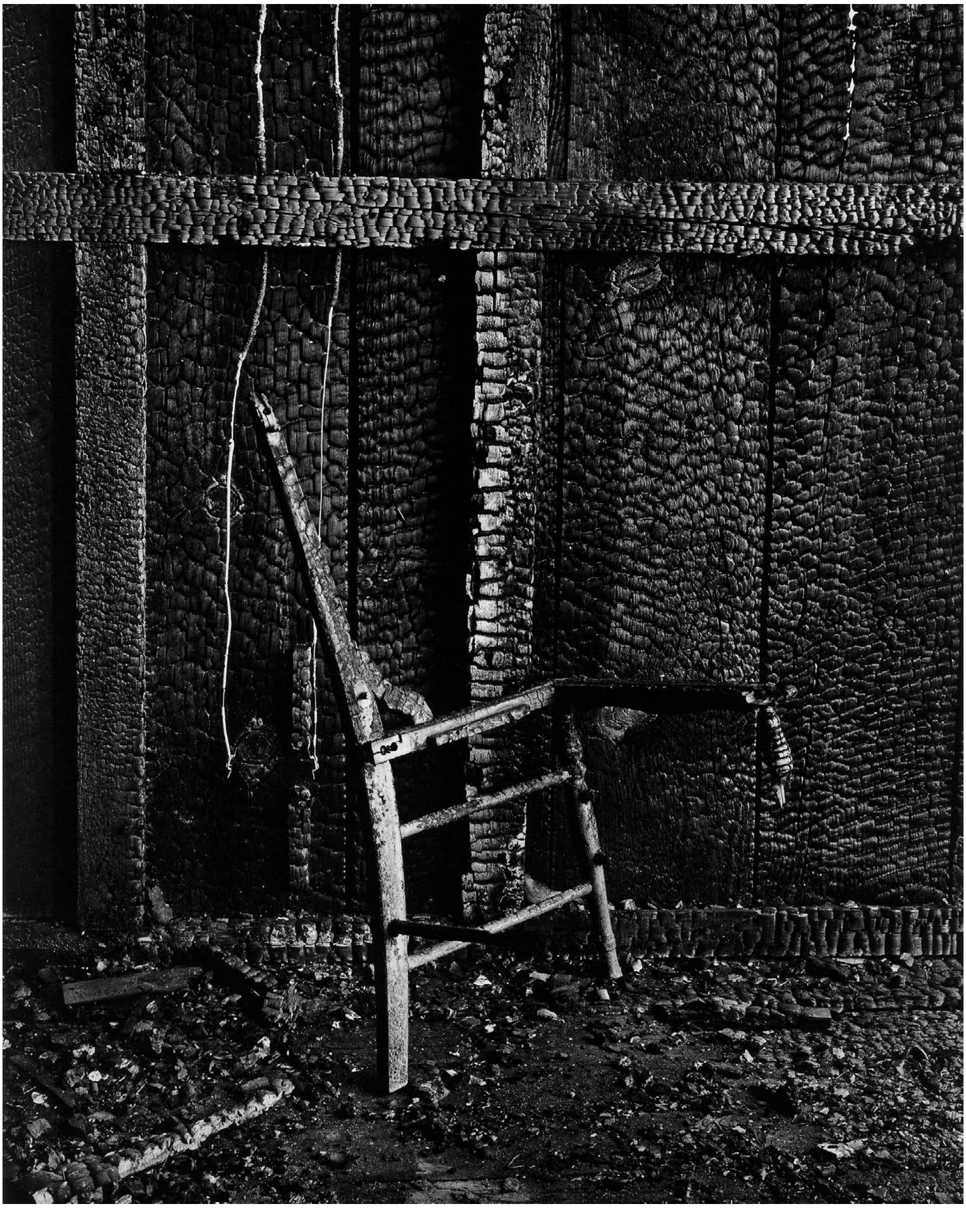
See Photo 6.1 for an example.

Wynn Bullock and the Zone System as Told by Edna Bullock

Wynn Bullock was a contemporary and good friend of Ansel Adams. While Wynn was renowned for his print quality, he rarely used a light meter, and when he did it was in the most rudimentary fashion—aim at the subject and take a reading. Ansel was often seen coercing Wynn to learn the Zone System. Finally, Wynn acquiesced and purchased a spot meter and densitometer. Ansel told him what to do, and Wynn began testing his materials.

Wynn's small darkroom was behind the detached one-car garage below his home, which was accessed by wooden stairs outside the house's back door. One day, his wife, Edna, was in the kitchen working on her own project. Looking down, she saw Wynn fling the darkroom door open, followed by the sound of "clunk and clang" as Wynn tossed something into the circular metal trash can near the back stairs. She overheard him say, "To hell with this damn testing! I'm going out and make some pictures!"

After he had left with his camera and tripod, Edna went out to see what Wynn had thrown away. There in the trash can were Wynn's spot meter and densitometer. She fished them out, and later, Wynn gave them to Ansel.



Burnt Chair, 1954. © 1954/2024 Bullock Family Photography LLC. All rights reserved. Courtesy of Barbara Bullock-Wilson.

DEVELOPER VOLUME

The one thing all photographers can do to improve the quality of their negatives and guarantee optimal development of every negative on a roll of film or batch of large-format negatives is to increase the volume of developer. You will find your negatives more consistent and easier to print.

According to the Kodak Research Lab, under certain conditions it only takes 150 mL of developer to cover the surface of 80^2 inches of film and to develop that film. What is missed is that the research that led to this finding was carried out to determine the *bare minimum* of developer that could be used in a Kodak Versamat machine processor to maximize profits. What is also missed is that there is a difference between minimal development and full development of an 8 × 10-inch negative or 36.exposure roll of film. What is further missed is that Kodak concluded that while 150 mL *could* develop 80^2 inches of film, better results would be obtained by using a minimum of 250 mL of *undiluted* developer; more would be needed were the developer diluted, for example, 1:1 or 1:3.

It is entirely possible to follow Kodak's recommendation, 250 mL per 80^2 inches of film and obtain acceptable results with undiluted developer (e.g., Kodak D-76 undiluted). When the developer is diluted (e.g., 1+1, 1+3, etc.), you must increase the volume of developer per 80^2 inches due to the increased oxidation rate of the developing agent.

My recommendations for developing 80^2 inches of film are:

- Undiluted developer (D7-6 undiluted): 250 mL minimum, 350 mL optimum.
- Dilute developer (D-76 1+1, Rodinal 1+50): 350 mL minimum, 500 mL optimum.
- Very dilute developer (D76 1+3, Rodinal 1+100): 500 mL minimum, 1000 mL optimum.

The easiest way is to develop fewer rolls than the tank will hold. For example, if you are developing two rolls of 35mm 36-exposure film in a two-reel stainless steel tank, you will use 250 mL for each roll of film. You will obtain consistently better results if you remove one roll, replace it with an empty reel on top as a spacer, and use the full 500 mL of developer for the one roll.

You may be tempted to use a lesser volume of developer to save time or money. In the first case, always remember that good work takes time. In the second case, the extra bit of money spent on the developer will be well worth the results.

80^2

One roll of 36.exposure 35mm film contains *approximately* 80 square (80^2) inches of film surface. Likewise, one roll of 120 film contains approximately 80^2 inches of film surface. Four 4 × 5-inch negatives or one 8 × 10-inch negative has approximately 80^2 inches of film surface. You can verify this for yourself by placing any of these on an 8 × 10-inch piece of enlarging paper. For this reason, when discussing the amount of developer required to develop a negative or roll of film, it is customary to refer to 80^2 inches of film regardless of the film format.

SOLUTION TEMPERATURE

When developing film, the solution temperatures should be kept to within a few degrees to avoid subtle image degradation due to stress on the emulsion. Maintaining a consistent temperature is relatively easy if all solutions are mixed at the same time and kept close to room temperature. The problem occurs when there is no temperature control device to prevent running water from fluctuating.

If you have difficulty with temperature fluctuations using running water[1] as a stop bath–and don't wish to use an acid stop bath–keep one or more bottles of plain water nearby at the same temperature as the other solutions. After pouring the developer from the tank, pour in fresh water, agitate for 1 minute, renew the water, agitate for another minute, and then move to the fixer. Use an alkaline fixer to reduce swelling. Then, use a method of washing, such as the Kodak washing system discussed in the "Washing" section, later in this chapter.

If you are tray developing, fill the stop bath tray with water at the same temperature as the other solutions. Agitate for 1 minute, replace the water, agitate for another minute, then move the negatives to the fixer.

If you still have difficulty with temperature control, one possible solution would be to use TH-5 Prehardener. A second solution would be to use a tanning developer such as pyro or catechol. Either will harden the emulsion in the first bath, minimize swelling, and prevent damage caused by fluctuating temperature.

PRESOAKING FILM

There is nothing wrong with presoaking film prior to development—it just isn't necessary in most cases. With or without presoaking, any change in the overall development time can be compensated for when the photographer determines the best time for development through either testing or trial and error.

However, presoaking should *always* be used for the following:

- Tray development of two or more sheets of large-format film using the traditional tray shuffle method.
- With development times less than 5 minutes. Presoaking will facilitate the removal of the antihalation backing with short development times; otherwise, unevenness may occur.
- With stand development, see later in this chapter.
- When a specific process or developing method calls for presoaking.
- With developing tanks such as the Stearman SP-445 and SP-645.

If you presoak your film, a few drops of wetting agent will facilitate emulsion swelling and removal of the antihalation backing.

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[1] This is likely to occur when you are sharing the water delivery system with other units in a building, or if you can't stop your children from flushing the toilet.

FILLING THE TANK

It is important to fill and drain the developing tank as quickly as possible to avoid uneven development and potential streaks. If you are using plastic tanks, the wide mouth acts as a funnel, and you can fill and drain the chemistry in seconds.

A one- or two-reel stainless steel tank will fill and drain fast enough. But a four-reel or larger stainless steel tank needs a different procedure. Prepare everything ahead of time by pouring the developer in the tank and leaving the lid off. Place it where you can find it in the dark. The film should be on a spindle in a second tank with the lid on or other 100% light-tight storage container that you can easily find in the dark.

1. Turn off the room lights, wait until any afterglow disappears, then take your film and spindle out of the holding tank and lower them into the tank containing the developer.
2. Quickly replace the lid and begin the first round of agitation for 1 minute in the dark. You don't want the film to sit too long without agitation.
3. Turn the lights back on.
4. When you reach the last minute of development, turn off the room lights, remove the lid, and quickly dump out the chemistry a few seconds before the timer reaches zero.
5. In the dark, with the lid off, hold a plastic hose down the center of the reels as far as it will go and rinse the film for 1 minute using the same temperature as the developer. Pour the water out, pour in the fixer, replace the lid, turn on the lights, and complete the process.

AGITATION

The Importance of Agitation

Agitation is an integral part of film development. It prevents chemical defects from occurring, builds contrast in the negative, and significantly affects image sharpness. The first benefit, preventing chemical defects, is accomplished within the first minute of development. This is because certain irreversible chemical defects can *begin* within that time. If allowed to begin, they become worse during the course of development. The solution is to use continuous agitation for the first 60 seconds.

The second, increased contrast, is created by keeping fresh developer in contact with high-density areas of the negative. The problem is that the developing agent becomes exhausted in regions of high density, such as clouds, snow, white clothing, etc., while in areas of low density, such as shadows or dark clothing, the developing agent remains relatively fresh. Through agitation, exhausted developer in areas of high-density is replaced with fresh developer from low-density areas, which continues to develop the highlights.

The third, increased sharpness, is the result of adjacency effects that occur at the boundaries of image detail. Adjacency effects only occur when the negative is allowed to stand undisturbed without agitation for at least 50 seconds.

When fine or superfine grain is the goal, it is better to use 30-second intervals. This method calls for 30 seconds of continuous agitation followed by 5 seconds every 30 seconds thereafter.

There are three standard methods of agitation: intermittent, minimal, and continuous. A fourth method, known as stand development, will be discussed later in this chapter.

Intermittent Agitation

There are two standard methods of intermittent agitation, and you should choose the one that will create the results you are trying to achieve. For fine-grain agitation, use 30-second intervals; for high-definition agitation, use 1-minute intervals.

Thirty-Second Intervals Before adjacency effects were fully understood, most manufacturers, including the big three, Kodak, Ilford, and Agfa, recommended agitating for the first 30 seconds and 5 seconds every 30 seconds thereafter. This method should still be used when fine or superfine grain is desired.

One-Minute Intervals This method should be used when high acutance (sharpness) is desired. Agitate continuously for the first 60 seconds to prevent chemical defects and then for 10 seconds every minute thereafter. Do not use this method if fine-grain is the desired result.

Minimal Agitation

This method will further increase acutance. For best results, use a film with a manufacturers rating of ISO 250 or less and a high-acutance developer. Agitate continuously for the first 60 seconds and then for 5 seconds every 3 minutes after that. Add at least 50% to your standard development time. Testing is advised before committing valuable images.

Continuous Agitation

With continuous agitation, the film is agitated nonstop for the entire development time. The direction of agitation should be varied to avoid streaks or patterns on the film. This means that if you roll a tank in the bottom of the sink, roll it back and forth. Using a tank with an overhanging lid, such as a Paterson tank—stainless steel tank lids are flush with the canister—is also beneficial for rolling. The lid will angle the tank and cause it to roll in a crescent rather than a straight line. This will help randomly distribute the developer.

- Continuous development should reduce the development time by approximately 20%.
- Continuous agitation is suitable for fine-grain development, but not for high-acutances, as it does not allow for the formation of sharpness-enhancing adjacency effects.

The difference between intermittent and continuous agitation may be more apparent with enlargements. For example, a 4 × 5-inch negative enlarged to make a 16 × 20-inch print would be a 4× enlargement. But a 16 × 20-inch

Photo 6.2 If you use continuous agitation, you may wish to invest in a SilverBase Rotary Processor.

Table 6.1

Agitation Effects

Desired Result	
High Acutance	Agitate for 1 minute then 10 seconds or 5 inversions every minute
Higher Acutance	Agitate for 1 minute then for 5 seconds every 3 minutes
Highest Acutance	Stand development
Fine Grain	Agitate for 30 seconds then for 5 seconds every 30 seconds
Superfine Grain	Continuous Agitation

print from a 35mm negative would be a 14× enlargement. In other words, those developing 4 × 5-inch or larger negatives will not need to concern themselves with which agitation method they use, as the lack of sharpness will not be apparent at a reasonable viewing distance. However, those using 35mm should refrain from using continuous agitation if sharpness is their goal.

Agitation Technique

While some photographers like to violently shake the development tank, this has more to do with repressed anger and photo myths that won't die than it does with proper agitation. Shaking a developing tank as though you are mixing martinis is not necessary. This method of agitation only serves to agitate the photographer. All that is required to agitate film or paper properly is a random flow of fresh developer over both surfaces of the material.

When developing film in a daylight tank, slowly and gently invert and twist the tank clockwise and then invert and twist it counterclockwise for three to four inversions in 10 seconds, see Photos 6.3a-6.3d. At the end of either four inversions or 10 seconds, gently tap the edge of the tank on the sink or counter top to dislodge air bubbles. It is not necessary to tap the tank hard, see Photo 6.4.

Photo 6.3a-d Agitation method. (a) Start with the developing tank in a neutral position, one hand below and one on the lid. (b) Invert the tank to one side and twist it clockwise. (c) Return to the neutral position (d) Invert the tank to the other side and twist counterclockwise. Return to the neutral position.

Photo 6.4 At the end of either four inversions or 10 seconds, gently tap the edge of the tank on the sink or counter top to dislodge air bubbles. It is not necessary to tap the tank hard.

WASHING

All that is required for complete and thorough washing of film and paper is a continuous flow of fresh water over both surfaces of the material—unlike agitation, the flow does not need to be random. The speed of the flow is not important if it is continuous and fresh. Washers that create air bubbles are a sales gimmick. Rather than facilitating washing, the bubbles keep the water away from the surface of the film or paper—air bubbles don't wash film; water washes film.

To wash the film, leave it in the developing tank and push a rubber hose as far as you can down the center of the reels, see Chapter 2.

If running water is unavailable, follow this procedure recommended by G. I. P. Levenson of Kodak UK in the 1940s:

1. After fixing, fill the tank with water and invert 5 times. Allow the film to sit for 5 minutes.
2. Drain the water and refill. Invert the tank 10 times. Allow the film to sit for 5 minutes.
3. Drain and refill. Invert 20 times. Allow the film to sit for 5 minutes.
4. Drain the water.
5. Rinse in wetting agent for 1 minute with agitation.

For tray development, substitute 1 minute of continuous tray agitation for each five-tank inversions. So, 10 inversions of the tank would mean 2 minutes of continuous tray agitation, and 20 inversions would mean 4 minutes of continuous tray agitation.

In the 1970s, Ilford proposed its own washing system based on the Kodak system. The important difference between the Kodak and Ilford systems is that in the Kodak system, the film is allowed to sit for 5 minutes between each set of inversions. This is an extremely important difference, as during these 5 minutes, the wash water can penetrate the emulsion and facilitate the important interactions that result in an archival wash, including removing residual chemistry. In essence, the standing water leaches chemicals out of the emulsion, the water is dumped, fresh water is introduced, and more chemicals are leached out. The Ilford system does not allow for this all-important step.[2]

TIPS ON DRYING

Assuming you are in the field without access to a drying cabinet, you can hang the film in a bathroom. Remove all towels and cloth materials, which will act as dust magnets and static generators. Run the hot water in the shower for a few minutes to create steam. This will settle any remaining dust. Hang the film using a film drying hanger hung from an adjustable shower curtain rod, see Photo 6.5.

If you do not have access to a place to hang the film, you can quickly dry film by using a rapid film dryer, such as the one suggested by Paul Lewis, see Formulary: Rapid Film Dryer. When you return home, rewash and dry the film to remove the rapid film dryer chemistry to ensure long-term preservation.

DEVELOPING BLACK-AND-WHITE FILM

I developed my first roll of film in a walk-through clothes closet. I purchased what I needed from a camera store, mixed the chemicals, loaded the reels, opened a copy of the Time/Life Photography series that had step-by-step instructions, and proceeded to develop two rolls as I read each step. I didn't even bother to read the instructions ahead of time. The only preinstruction I had was the salesman at the camera store teaching me how to load film onto stainless steel reels.

The Darkroom Cookbook does not include an illustrated step-by-step procedure for developing film. The techniques and methods found here are meant to take you beyond the basic steps of developing film and introduce you to new possibilities to improve your darkroom technique and broaden your horizons.

If you have not yet processed a roll of film, you will find excellent instructions in any one of the following four books:

- *The Darkroom Handbook*. Langford, Michael. Random House: London, 4th edition, 1992.
- *Handbook of Photography*. Folts, James, Ronald P. Lovell, Fred C. Zwahlen, Jr.; Cengage: New York; 6th edition, 2006.

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[2] It is significant that Ilford quietly stopped recommending their washing system after several years of agressively promoting it. It is also interesting that many photographers still use it.

Photo 6.5 Drying film. Use an adjustable shower curtain rod to hang your film from a film drying hanger. Notice the shower squeegee hanging on the wall of the shower, as mentioned in Chapter 2.

- *Photography*. Horenstein, Henry, Russell Hart. Prentice Hall: New Jersey; Revised, 2004.
- *Photography*, London, Barbara, Jim Stone, John Upton; Prentice Hall: New Jersey; 10th edition, 2011.

Even though I recommend the development procedures outlined in all four of these books, there are several things I disagree with.

In *The Darkroom Handbook* by Langford, *Photography* by London, and the *Handbook of Photography* by Folts, it is recommended to use a sponge or rubber double-sided squeegee to wipe your film clean. This is a big no-no that has the potential of scratching valuable negatives. Don't do it.

Hornstein suggests using a wetting agent and hanging the film to dry without skimming the water off; this is perfectly acceptable. However, when using Kodak Photo-Flo, be certain to use the precise dilution. Otherwise, you may experience water spots that cannot be removed. I have only experienced this problem with Photo-Flo.

All four authors recommend a 30-second agitation cycle. This is perfectly fine if the end game is fine grain. However, it is not okay if you are trying to achieve high acutance, in which case a 1-minute or longer agitation cycle should be used.

All four books recommend the use of an acid stop bath. While the use of water rinse followed by an alkaline fixer is not a new concept, it was not well known or practiced prior to the first edition of *The Darkroom Cookbook* in 1994 and *The Film Developing Cookbook* in 1998.

Six Steps for Film Developing

Develop—Rinse—Fix—Wash—Wetting Agent—Dry

1. Develop for the time and temperature recommended by the manufacturer.
2. Agitate for either 30 seconds or 1 full minute depending on your intended outcome—fine grain or high acutance.

Author's Note: At the end of each agitation cycle, *lightly* tap the tank on the sink to dislodge air bubbles.

3. Rinse in running water: 1 minute.
4. Fix using an alkaline fixer: 3 minutes.
    - Agitate for 30 seconds.
    - Let sit for 30 seconds.
    - Repeat.
5. Wash in running water: 3–5 minutes.
6. Wetting agent: 1 minute with occasional agitation.

After one minute in the wetting agent, hang the film to dry. Then wipe each side of the film with a soft bladed squeegee dipped in wetting agent. Do not use any pressure on the squeegee, simply skim the surface.

Acid Stop Baths

In the event you use an acid stop bath, do the following:

1. Develop the film.
2. Rinse the film in an acid stop bath with continuous agitation for 30–60 seconds.
3. Fix using a rapid acid fixer according to the manufacturer's instructions.
4. Rinse in running water for 1 minute.
5. Rinse in Hypo Clearing Agent (aka HCA or Fixer Remover) for 1–2 minutes with agitation.
6. Wash in running water for 5–10 minutes.

Increasing Film Speed

A film's speed is measured by its ability to respond to low levels of light and record detail in shadow areas. Using normal development, some developers will increase the manufacturer's film speed rating (ISO) by as much as one stop. These are known as speed-increasing developers.

D-76H undiluted increases film speed by 60%. Many Phenidone developers will also increase the film's rated speed, chief among them Ilfotec DD-X, Diafine, and FX 11. DD-X is a proprietary developer. The formulas for FX 11 and Diafine can be found in the Formulary under Speed Increasing Developers, and D-76H can be found under Fine Grain Developers.

Almost any modern panchromatic film made today can be rated for a one-stop EI increase and overdeveloped by 20–30% with only slightly discernible loss of shadow detail, if any. This is a *true* speed increase, not pushing. Beyond one stop, you will be pushing the film, not increasing the speed.

Pull Processing

There are times when you may wish to reduce the film development time. Typically, this is when you overexpose for shadow detail and then underdevelop to maintain the highlight detail. Some photographers do this routinely to ensure shadow detail and highlight texture.

The general rule for pull processing is to reduce the ISO on your camera by 1-stop (e.g., EI 100 to EI 50) and the development time by 10% per 1/3 stops of EI reduction (30% per stop).

Suppose you are using a film with an EI of 100. You decide to give an extra stop of exposure to the shadows, or perhaps you wish to make this your normal working method. Change the ISO on your camera or meter to EI 50 and reduce the development time by 30%.

Push Processing

Push processing is a technique used to create handheld images in extremely low light by setting an EI higher than the recommended ISO and overdeveloping the film. The result is underexposed shadows and blown-out highlights, not a true speed increase.

However, done properly, push processing is a way to record images in situations where you could otherwise not photograph without a tripod or using an auxiliary light source, such as an electronic flash.

While it may seem sensible to use a high-energy, speed-increasing developer, the necessary increase in time and/or temperature may result in increased fog levels, graininess, and, paradoxically, loss of speed. Developers that do work well for push processing are Kodak D-76 and its variants, Kodak T-Max developer, Kodak XTOL, and Ilfotec DD-X. What is important is to use an ample volume of developer to ensure the developing agent maintains potency throughout the extended developing time, see Developer Volume earlier in this chapter.

DD-X is the best developer for pushing conventional films. I recommend Ilford HP5+ rated at EI 2400 or 3200 developed in Ilfotec DD-X diluted 1+4 for 18 minutes at 75°F/24°C.

Yvette at the Coffee House, 2007. © Steve Anchell. All rights reserved. Ilford HP5+ exposed at EI 3200 and developed in Ilford DDX for 18 minutes at 75°F/24°C. This is a 3-stop push. Notice the lack of detail in the shadow areas. However, had I not pushed the film by underexposing and overdeveloping, there would be no image at all. Leica M7 rangefinder with a 35mm f/1.4 Summilux-M lens.

Table 6.2

Developing Time Factors for Push Processing Film

General Recommendation	**Speed Increasing Developer*	*TMax Films*
1 stop push = × 1.5	1 stop push = × 1.4	1 stop push = no change
2 stop push = × 2.25	2 stop push = × 1.85	2 stop push = × 1.33
3 stop push = × 4.5	3 stop push = × 2.5	3 stop push = × 1.66

*Speed-increasing developers include any developer that increases the manufacturer-rated film speed using normal development times. This is determined by the amount of detail recorded in the shadows. The above are only starting points; you may find more or less development time is required.

Push Processing Guidelines The general rule is that a 50% increase in development time will produce an approximate one-stop increase in the midtones and highlights; the shadows will increase considerably less. Note that this is a general rule and can only be verified with your film and developer through testing.

The push processing times in Table 6.2 are general guidelines. To use this chart, multiply the published developing time for the recommended ISO by the factor in parentheses. For example, Tri-X, rated at ISO 400, is normally developed for 6.75 minutes at 68°F/20°C in D-76, undiluted. When Tri-X is pushed three stops to EI 3200, the adjusted development would be 6 × 4.5 = 30 minutes. Use these recommendations as starting points only. Please note separate data for T-Max films.

Author's Note: If 30 minutes is too long a time for you to stand at a sink and process films, increase the temperature and use the Film Development Temperature Conversion Chart to determine a shorter time.

Stand Development

Stand development is a method of film development used by many early photographers. After initial agitation, the film is left in a tray or tank of developer for extended periods of time without agitation, which can be anywhere from 30–90 minutes.

Author's Note: I recommend not using film with an ISO higher than 100 because modern fast films may form dichroic fog. That doesn't mean you can't try a faster film, especially classic or hybrid emulsions, but if you do, I recommend using times less than 30 minutes.

There are stories of the French photographer Eugéne Atget, who left his large-format negatives in separate trays of developers while he entertained guests. Every half-hour or so, he would pop into the darkroom and inspect his negatives under a safelight, moving some to the fixer or to be washed and leaving the others to continue to develop.

Stand development maximizes adjacency effects, creating negatives of the highest acutance. It also has a compensating effect on highlights, which develop rapidly at first and then slow down as the developer exhausts. Meanwhile, low-density areas continue to develop. While macro gradation remains normal, there is an improvement in micro gradation, which gives a print more dimension.

Stand development should be used with developing agents that do not rapidly exhaust. An ideal developer would be one containing glycin, which is clean and long-lasting. Crawley's FX 2 works well for stand development, as does Photographers' Formulary TFX-2, which is a modification of FX 2. Either of these should be used at half their working strength.

To use stand development, presoak the film for 1–3 minutes to prevent air bubbles. A few drops of wetting agent may help with uniform development. Transfer the film to the developer and agitate for 1 full minute. The film is left in the developer without agitation for the remainder of the time, though some photographers recommend agitating the negatives for about 10 seconds every 20 minutes.

Classic emulsions can tolerate as much as 90 minutes without defects forming. Even so, start at 30–45 minutes when learning to use this technique. When complete, move the film to a running water rinse for 1 minute and fix and wash it in the usual manner.

The rate of development is so slow that noticeable changes in contrast take at least 10 minutes. Once the developer exhausts in the highlights, additional time will continue to bring in the shadows until they are developed to completion or the developer exhausts. Because developer exhaustion can result in streaking, the film should be developed by inspection to avoid leaving it too long, see the section Development by Inspection.

Divided Development

With divided development, place the film in the first bath, where the emulsion absorbs the developing agent; do not use a presoak. Because the pH in the first bath is low, little or no development takes place. The film is transferred directly to the second bath without rinsing, as you don't want to remove or dilute the developing agent.

Development takes place in the second bath until the developing agent from the first bath is exhausted. The shadow areas, where less exposure to light has been received, will continue to develop even after the developer has been exhausted in the highlight areas. The result is a compensating action mentioned in Chapter 5.

After the second bath, use a 1-minute water rinse before placing the film into the fixer. This will help to preserve the fixer.

Although agitation is not as critical as with single-solution developers, it should always be gentle. In the first bath, agitation may be intermittent after continuously agitating for the first 60 seconds. After that, agitate for 10 seconds every minute. Continuous agitation is usually recommended in the second bath.

The temperature of development is not as critical for divided development as it is for single-solution processing, but for best results, keep the temperature of all solutions as close as possible between 68°F/20°C and 80°F/27°C.

Flower Composition, 2007. © Steve Anchell. All rights reserved. This image was made using Ilford FP4+ film exposed for approximately 1 hour and stand-developed in Photographers' Formulary TFX-2 1:1 for approximately 90 minutes. Notice the extremely high acutance as a result of minimal agitation. Photographed with an Agfa Ansco 5 × 7-inch view camera and a Schneider Symmar 360mm f/5.6 lens.

Waterbath Development

Water bath development is useful for reducing overall contrast while maintaining density in the key shadow areas. It is primarily used for extreme contrast situations, for example, scenes with a tonal range of 10 stops or more. Most general-purpose developers can be used for the water bath method, but for extreme contrast situations, use one of the extreme compensating developers.

The timing sequence for water bath development varies with different developers, but generally, it is something like this:

1. Immerse the film in a tray of developer for 2–3 minutes with continuous, gentle agitation.
2. Move the film to the second bath, which will consist of plain water. The film should be completely immersed in the water bath and left motionless for 2–3 minutes.
3. Drain and return the film to the developer, where it is agitated for 1 minute, then transferred back to the water bath.

Only the first immersion in the developer should last 2–3 minutes. Subsequent immersions slowly build density, a minute at a time. Repeat as many times as necessary to achieve the desired contrast or density. The water bath method is best used with development by inspection.

Water bath development usually results in a loss of film speed. Overexpose your film by one or more stops.

Author's Notes:

1. Streaking is sometimes experienced with conventional and modern emulsions. It may be possible to eliminate the problem by using a 3% sodium sulfite solution instead of plain water in the second bath. This will create somewhat less compensation but is better than ruining the negative.
2. Though not an extreme compensating developer, D-23 has been used for water bath development. The timing sequence for D-23 is in the Formulary.

Development by Inspection

Both stand and water bath development are often used in conjunction with development by inspection, using a Kodak #3 dark-green safelight filter with a 15-watt standard incandescent bulb to check the progress of development—a 1.5-watt light-emitting diode (LED) bulb is equivalent. Beginning with the second or third immersion in the water bath, turn the light on briefly and hold the negative up to the safelight at a distance of 3–4 feet for 20 seconds or less. With stand development, wait for at least 20 or 30 minutes before the first inspection, then every 10–20 minutes after that.

Inspect the base side of the film only, as the emulsion side will be covered with a milky white coating. This is the undeveloped silver halide that will either be developed as the process continues or removed during fixation.

When you can discern significant detail in the shadows, and before the highlight areas are too dense to see through, move the film to a fresh tray of running water for 1 minute or with agitation to clear the negative of any developer residue—don't use acid stop bath—and finally fix and wash. Only time and experience will allow you to properly judge when the film is fully developed.

Monobath Film Development

A monobath is a single solution that combines the actions of development and fixation. It eliminates the need for separate stop and fixing baths and for hardening solutions. Moreover, it does not require precise timing of development and decreases the effect of variations in agitation, temperature, and other processing conditions.

Solutions of this type were first proposed in 1889, but the difficulties associated with their formulation have only been overcome relatively recently. The main problem has been the loss of emulsion speed, which results when the exposed silver halide is dissolved by the fixation process before full development can occur.

For a monobath to work, it must combine a developer that acts so quickly that development is finished before fixation begins. But even after fixation has begun, a process of concurrent physical development can further assist development. For this to happen, developing agents producing high activity and a short induction period are required. The combination of Phenidone and hydroquinone paired with sodium hydroxide meets this requirement.

In devising a monobath, several points must be considered. The first is the concentration of the monobath developer. For acceptable results, the developer concentration has to be increased an average of five times. At the same time, the pH has to be raised to 11 or 12.

The composition of the monobath determines the target point of development and cannot be varied by changes in dilution, time, or developer temperature. However, it is possible to obtain a wide gamma range without loss of film speed by varying the hypo content. In Crawley's FX 6a, the use of 70–125 grams of hypo is recommended to increase or decrease the contrast of the film. Less hypo results in higher contrast. The rate of fixation is also influenced by the amount of hypo.

The alkali content can be used to control the speed of development. Sodium hydroxide is usually used for monobath development. Most monobaths that use hydroxide will develop a medium-speed film in 3 minutes at 75°F/24°C. Testing is advised.

Working with the two variables of hypo and accelerator, monobath formulas can be modified for different films. Grant Haist, in *The Monobath Manual*, has concluded that no monobath can be formulated that will work equally well with all films. However, it is possible to design a monobath for individual films to produce results comparable to normal processing. If you want to experiment and create a specially balanced formula for each group of similar emulsions—for example, modern flat-grain emulsions, conventional emulsion films of similar speed, etc.—the variations in monobath formulation and processing conditions, summarized by Haist, may be used to modify the results, see Table 6.3.

Table 6.3 Modifying Monobaths

To Increase Contrast	Raise the pH Increase the concentration of hydroquinone Reduce the concentration of the fixing agent
To Increase Emulsion Speed	Increase the concentration of Phenidone
To Reduce Contrast or Emulsion Speed	Lower the pH Increase the concentration of the fixing agent Increase the salt content or viscosity Use more vigorous agitation, increasing the rate of fixation

Commercial Monobaths There are at least three commercially available monobaths, CineStill Df96, ARS-IMAGO two-solution Monobath MB, and single-solution Monobath Eco.

All three monobaths are designed for traditional cubic-grain films like BwXX, TriX, and HP5+. CineStill says that tabular grain films, such as T-Max, will work well in Df96 but require double the processing time to clear and may come out of the bath with pink/purple dyes in the emulsion. Kodak claims that the pink/purple dyes will not affect the film.

The ARS-IMAGO Lab-Box is a daylight-loading film developing tank. Using the 120-module attachment, the Lab-Box can be used to develop one roll of either 35mm or 120 film. This method works very well for most films.

ARS-IMAGO LAB-BOX

The ARS-IMAGO Lab-Box is a self-contained film developing system that can be loaded and used in daylight—no darkroom or changing bag required. Based on the design of the Leitz Agfa Rondinax 35 Daylight Film Developing Tank introduced in the 1930s, the Lab-Box can be used to develop one roll of 35mm or 120 film.

The Lab-Box can be used with continuous or intermittent agitation. Unlike the original Rondinax, which had a maximum capacity of 200 mL of developer, the Lab-Box can use a minimum of 300 mL and a maximum of 490 mL. ARS-IMAGO recommends 300 mL of developer for continuous agitation. I recommend using the full 490 mL., regardless of the agitation method.

Use the Lab-Box with CineStill Df96 monobath developer or ARS-IMAGO Monobath Eco for a complete film developing system without a darkroom. All you will need is a source of fresh water for washing and a place to hang your film. There has never been an easier way to develop film with the lights on.

Depoe Bay, Oregon, 2024. © Steve Anchell. All rights reserved. This image was made from a negative developed using a Lab-Box and Monobath Eco developer for 8 minutes at 68°F/20°C. The film is Arista EDU 100. Nikon F3, Nikkor 35–80mm f/4, f/8 @ 1/30 sec.

High Temperature Development

Bill Troop

Color film is made to be processed at temperatures up to 100°F/38°C Most black-and-white films are not. We understand that all modern Kodak films may safely be processed at these high temperatures, but always check first. Unless otherwise specified by the manufacturer, most films should not be processed above 75°F/24°C to avoid reticulation and other problems.

Prior to WWII there was a whole school of processing called tropical processing. It involved:

- Developers that were as nonswelling as possible.
- Adding sodium sulfate to developers and stop baths.
- Using chrome alum stop baths.
- Occasionally using chrome alum stop baths followed by conventional potassium alum fixing baths.
- Occasionally using formalin either as a prehardener or in the developer.

All these techniques were cumbersome and produced additional problems and risks, including reticulation from overhardening by chrome alum or by formaldehyde.

When Harold Russell devised the Versamat and Xomat automated processing systems of the late 1940s and beyond, he found a new solution, which was to use glutaraldehyde as a prehardener or as a developer addition. My formula for a glutaraldehyde hardener, TH-5 Prehardener, is given in the Formulary section.

Note (BT): Although glutaraldehyde is believed to be safer than formaldehyde—which is widely present in many household products—and is considered an essential medicine, avoiding skin contact or frequent inhalation is strongly advised. See page 182 of *The Film Developing Cookbook*, second edition (*FDCB2*), for more detailed warnings. For those who are curious, the tropical formulas and methods are contained in previous editions of *The Darkroom Cookbook*.

FILM DEVELOPMENT SYSTEMS FOR LARGE FORMAT

The traditional method for developing large-format sheet film is shuffling up to eight sheets at a time in a tray. If you wish to learn how to develop large-format film in trays, see *FDCB*2, pp. 46–47, where I provide a complete step-by-step description of my method.

Today, several tank systems are available to develop up to 8 × 10-inch sheet film, such as the Darkroom Compact Developing Tank and Reel, Photo 6.6, the

Photo 6.6 Darkroom Compact Developing Tank and Reel for 4 × 5-inch film. This tank will develop two sheets at a time.

Photo 6.7 Paterson MOD54 Large Format Film Processor for six sheets of 4 × 5-inch film.

Paterson MOD54 Large Format Film Processor, Photo 6.7, and the Stearman system, Photos 6.8 and 6.9.

Warning: Do not use the JOBO 2520 Multi Tank 2 for hand-developing 4 × 5-inch film. This tank was designed for use with the JOBO processor with *minimum* developer and continuous agitation. When used for manual processing, it does not hold enough developer solution to cover the entire sheet of film, and the top edge of the film will not be developed and cannot be recovered.

Stearman Large-Format Developing Tanks

Stearman Press has introduced two unique tanks for developing sheet film in daylight. I have used them both to develop large-format films and have not found an easier or better way to safely develop negatives from 4 × 5-inch to 8 × 10-inch. The SP-8 × 10 allows the use of 500 mL of developer, sufficient to fully develop 80^2 inches of film. It can be configured to develop four 4 × 5-inch sheets, two 5 × 7-inch sheets, or one 8 × 10-inch sheet.

With the SP-8 × 10 you can begin development with one to three sheets and, during the process, turn off the lights, remove the lid, and insert additional sheets in the empty space for less development time. The same is possible with the SP-445/645.

Photo 6.8 The Stearman SP-8 × 10 is easily loaded in a dark bag or darkroom and used to process film in daylight. It can be configured for 4 × 5, 5 × 7, or 8 × 10-inch film.

Photo 6.9 The Stearman Press SP-445/645 are two straightforward tank systems for developing as many as four or six sheets of film at a time. Both these tanks should be used with a presoak, preferably with a wetting agent.

7

Pyrogallol and Pyrocatechin

> *"A good photograph is one that communicates a fact, touches the heart, and leaves the viewer a changed person for having seen it; it is, in one word, effective."*
>
> —Irving Penn

Although pyrogallol (pyro, pyrogallic acid) and pyrocatechin (catechol, catechin, pyrocat) are developing agents, it is common to refer to them as if they were developers. Photographers often say "I developed this in pyro" instead of "I developed this in Kodak D-1." The same applies to pyrocatechin; it is as if the remaining constituents were unimportant.

Negatives developed in catechol and pyro exhibit an extremely high degree of acutance. The effect is greatest in areas that have achieved the most exposure.

PYROGALLOL

It has been said that there is nothing that can compare to a full-scale black-and-white negative developed in properly formulated pyrogallol developer. Whether this is true or not, negatives developed in a pyro developer can exhibit exceptionally sharp edges and delicate highlight detail.

There was a time when pyro was the developer of choice used by professional photographers. However, the advantages of pyro were often offset by the disadvantages of using it. Besides being subject to rapid oxidization, pyro can cause inconsistent staining and streaking during development. Also, formulas that rely upon pyro as the sole developing agent tend to lose at least one stop of film speed.

With the advent of packaged developers and the relative ease of using MQ and PQ as primary developing agents, pyro became all but forgotten. Thanks largely to two photographers working independently of each other, John Wimberley and Gordon Hutchings, pyro as a developing agent has regained renewed popularity among photographers. Both John and Gordon have created formulas, WD2H+ and PMK, respectively, that work well with modern emulsions.

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PYROCATECHIN

Even though it has been in use since 1880, pyrocatechin is one of the most overlooked developing agents. The working properties of catechol are similar to those of hydroquinone, with the added ability to produce fine grain when used as the sole developing agent. Pyrocatechin can be used as a substitute for hydroquinone in many formulas. Because it is more volatile than hydroquinone, it works more rapidly.

Dilute catechol is often used in formulas for subjects of extreme contrast. Using minimal preservative with catechol produces an image stain that enhances the image's silver density in the shadow regions, effectively increasing the speed of most films. At the same time, the developing agent rapidly oxidizes, preventing the high values from overdeveloping.

Pyrocat HD and its variants is a high acutance pyrocatechin/Phenidone-based developer designed by Sandy King that is compatible with modern formulas.

TANNING DEVELOPERS

Tanning developers harden the film's emulsion surface. This allows development to occur only on the surface, thus minimizing the effects of halation and irradiation, see Chapter 3. Tanning also minimizes the swelling of the emulsion, lessening the impact of variations in solution temperature and protecting the emulsion from abrasion. A low concentration of sulfite or its complete absence enhances the tanning process.

While other developing agents, chief among them hydroquinone, will tan the emulsion of film, pyro and catechol are the two most commonly used for this purpose.

Because of pyro and catechol's self-hardening properties, it is not necessary to use fixers containing hardener.

IMAGE STAIN

One feature of pyro and catechol is the creation of an image stain. Image stain adds contrast and printing density to the shadow regions and enhances areas of micro-contrast. Image stain is proportional to the amount of silver in a given area. The color of the image stain can vary from chartreuse (yellow-green) to brown.

General vs. Image Stain

General stain is not the same as image stain. General stain affects the entire negative equally, both image and negative edge; it serves no useful purpose except to increase base fog and printing time.

Not all pyro or catechol formulas are designed to produce image stain. An example of this would be Kodak D-7, which produces minimal or no stain. However, emphasizing the stain has two benefits. It fills the space between film grains, becoming an inherent part of the image density, and also masks the film grain, particularly in highlight areas. Film speed and negative printing quality are improved. A properly stained negative exhibits acute sharpness and reduced visible grain effect (graininess).

If the maximum degree of image stain is desired, use a fixer that contains a minimal amount of sodium sulfite or no sulfite at all. Plain hypo is an example of a fixer with no sulfite. Alternatively, use an alkaline fixer such as TF-2 that contains only 15 grams of sulfite.

Removing Stain

Image stain can be removed by bleaching in Kodak S-6 stain remover and then redeveloping in a non-staining developer such as Kodak D-7.

SECOND STAINING BATH

It has been suggested that image stain can be increased after fixing and before rinsing or washing by immersing the negative directly into the used developer for 2 minutes with 30 seconds of agitation every minute. However, the usefulness of this procedure is questionable, as it appears to create a general stain that only affects base fog without enhancing the image stain.

A supplementary staining bath should not be used if an alkaline fixer is used. In any event, avoid using a hypo-clearing agent (HCA) when using pyro or catechol developers, as the high concentration of sulfite will remove the stain.

PRINTING WITH A STAINED NEGATIVE

Enlarging and contact printing paper both react to image stain as density. Thus, the total density of a stained negative consists of the silver density plus the stain density.

Because of the stain's color, most black-and-white densitometers will not give an accurate reading unless fitted with a Wratten 47B filter. A color densitometer set on the blue filter channel will give a more accurate reading for silver gelatin printing.

As alternative processes have most of their sensitivity in the ultraviolet (UV) range—for example, platinum/palladium—a densitometer that reads UV would be the most accurate.

Know Your ABCs

The classic pyro formula, ABC Pyro,[1] is the oldest published formula still in use, dating to the 1880s. The formula was used by Edward Weston, Brett Weston, Ansel Adams, and almost every large-format photographer working in the first half of the twentieth century. There are several variations, the most notable being Kodak D-1, Ansco 45, and Defender 1-D.

ABC is usually recommended for large-format negatives because of graininess issues. However, when used properly with classic emulsion films, the results are high acutance, subtle tonal gradation, and delicate highlight separation.

The first problem is that pyrogallol is highly volatile. When used as the sole developing agent, especially with low concentrations of sulfite—sulfite is used as a preservative to prevent premature breakdown of the developing agent—it rapidly exhausts in solution. As a result, the negative is more susceptible to aerial oxidation than in formulas that also contain metol, such as WD2H+ or PMK. The problem mostly occurs in tray development of multiple large-format negatives or with continuous agitation in a JOBO processor. In both methods, the film is removed from the developer and exposed to oxygen during processing. As the developing agent exhausts, aerial oxidation occurs in seemingly random areas of the negative but mostly in the highlights.

The second problem is that the sodium sulfite in solution B of ABC Pyro eventually changes to sodium sulfate when stored. This results in decreased protection from aerial and auto-oxidation.

Three things can be done to avoid aerial oxidation and other forms of undesirable stains associated with pyro formulas:

1. Develop one sheet of film at a time in a tray, and do not lift the negative from the developer until it is time to move it to the stop bath, preferably a water rinse.
2. Use a daylight developing tank for 4 × 5–inch film, see Chapter 6.
3. Use at least 500 mL of developer per 80^2 inches of film.
4. Mix the developer fresh as a working solution immediately before using, see later in this chapter.

By following these precautions, you will avoid many, if not all, of the problems associated with pyro.

---

[1] It’s called ABC Pyro because it has three stock solutions, A, B, and C.

Pyro and the JOBO Processor

Because the JOBO processor is designed to use minimal amounts of developing agent, it is susceptible to aerial staining when using pyro as the negative rotates in and out of the developer and is exposed to oxygen.

The remedy is to increase the amount of developing agent in solution so that it will not exhaust during the development cycle, even in areas of high density. To do this, use an AB or ABC pyro formula. Add 30% more of the A solution than the formula calls for to ensure the pyro is not fully exhausted before the process is complete. Test to adjust the development time due to the increase in pyro.

A second solution is to use Harald Laban's ABC+ Pyro—available from the Photographers' Formulary as Rollo Pyro. Adherents claim that due to the use of ascorbic acid as a preservative and a large quantity of pyro, Rollo Pyro does not oxidize like traditional pyro formulas and can safely be used with JOBO rotary processing.

USING ABC PYRO

Tray Development Using Stock Solutions of ABC

Author's Note: The following information applies to the original formula in three parts. The original ABC formula can be found in the Formulary.

Combine the water and solutions B and C in a tray. Measure Solution A separately and place it where it can be found in the dark.

With the lights turned off, presoak the film to achieve more uniform development. A drop or two of wetting agent or a 3/4 teaspoon of sodium metaborate in a liter of presoak water will prevent the individual sheets of film from sticking together in the developer. Shuffle through the stack of negatives for 1-2 minutes.

Leave the negatives in the presoak while you locate the A solution and pour it into the tray containing B and C. Rock the tray for at least 30 seconds to ensure that all three solutions are thoroughly mixed before introducing the film. Lift the negatives to drain and move them to the tray of developer and begin your shuffling routine.

***Warning*:** Do not place the film in solutions B and C and then pour A on top! A streak will appear across every sheet of film with which the undiluted A solution comes in contact.

Daylight Tank Development Using Stock Solutions of ABC

When using a daylight development tank, it is not necessary to presoak the film, though there is nothing wrong with doing so. With or without a presoak, thoroughly mix solutions B and C together and add A with gentle stirring just prior to pouring into the tank. Because the film is safely in a daylight tank, the three solutions can be mixed with the lights on.

ABC Pyro Dry Mix Method

Traditionally, ABC Pyro is mixed in three separate stock solutions mixed in various proportions immediately before use I have found a far easier and consistent approach is to mix ABC from scratch as needed. This is known as the dry mix method. With this method, you can also eliminate sodium bisulfite, which is used as a preservative for pyro in solution A. This will lower the amount of salt in the formula, allowing for more image stain.

The formulas given in Table 7.1 are shown as three separate working solutions, 1:1:1:7, 1:1:1:11, and 1:1:1:14, along with their recommended use. If you want the maximum image stain, use 1:1:1:14. The original formula for Kodak D-1 can be found in the Formulary.

Table 7.1

ABC Pyro Working Dilutions–Dry Mix Method

	1:1:1:7	*1:1:1:11*	*1:1:1:14*
	Water between 65F/18C and 70F/21C, 750.0 ml		
Sodium sulfite, anhyd.	11.5 g	8.2 g	6.6 g
Pyro	6.0 g	4.3 g	3.5 g
Potassium bromide, 10% solution	10 mL	7.0 mL	6.0
Sodium carbonate, mono.	9.0 g	6.5 g	5.2 g
	Water to make 1.0 L		
Developing time at 68F/20C	5–7 minutes	6–12 minutes	8–14 minutes

Notes: **1:1:1:7** is the traditional dilution for tray development.
1:1:1:11 is the traditional dilution for tank development. I recommend this dilution for tray development.
1:1:1:14 I recommend this dilution for tank development and the most image stain.

VARIATIONS ON ABC PYRO

Alternate Dilutions

It has been accepted practice among photographers that contrast with ABC can be controlled by altering the amount of carbonate (solution C). However, changing the quantity of the carbonate has more of an effect on film speed and development time than on contrast.

A more effective method of controlling contrast when using ABC Pyro is to alter the amount of solution A and adjust solution C to keep the time constant. As an example, if normal contrast is achieved by using solution A: 50 mL, solution B: 50 mL, and solution C: 50 mL, contrast can be increased by using 75 mL of solution A, 50 mL of solution B, and 25 mL of solution C.

Lower contrast could be achieved with 25 mL of solution A, 50 mL of solution B, and 50 mL of solution C. However, pyro's tendency to rapidly oxidize means there is a minimum amount of developing agent in the working solution to maintain activity throughout the development cycle. For this reason, I do not recommend using less than one part solution A. Alternatively, use the normal ABC amounts and add more water, for example, 1:1:1:18 for tank development, while keeping the development time the same. With all of the above variations, testing is recommended prior to committing important negatives.

Ansel Adams's Variation

Ansel Adams used a slight variation of the Kodak D-1 formula. While his solution A is the same, his B solution calls for 75 grams of sodium sulfite instead of 105 grams. His C solution calls for 87.75 grams of sodium carbonate instead of 90 grams. The difference between 87.75 and 90 grams in the C solution is insignificant. The 30 gram difference in solution B, the preservative, would probably make a difference in the amount of image stain. It also could make a difference in the life of the working solution and the overall sharpness-to-grain characteristics of the negative.

Edward Weston's Variation

The difference between standard ABC Pyro and Edward Weston's variation is the dilution ratio. Weston diluted the formula with 30 parts of water, resulting in a softer-working developer with a longer-than-usual tonal scale.

To keep the developing time within workable limits and prevent the developing agent from exhausting completely before development was complete, he increased the developer to three parts instead of one. His resulting dilution was 3:1:1:30, with a developing time of 15–20 minutes at 70°F/21°C with continuous agitation in a tray.

Aerial oxidation does not appear to be as serious with Edward Weston's dilution since the amount of developing agent has been increased three times, allowing the process to be complete before the developer reaches a point of exhaustion conducive to staining.

WD2H+

John Wimberley

WD2H+ is a pyrogallol/metol/sodium carbonate developer formulated to achieve superb results at normal contrast levels. WD2H+ maximizes the beneficial effects of pyrogallol to produce negatives that are easy to print. The formula displays the following beneficial characteristics, even with some modern emulsions:

- Noticeably improved acutance caused by edge effects at tonal boundaries.
- A long tonal scale.
- Unmatched tonal separation in highlights.
- Hardening of the film emulsion, reducing susceptibility to scratching.
- Fine, unobtrusive grain because of grain masking by the dye mask.
- Because of its special spectral characteristics, a WD2H+ negative may be printed on either silver-gelatin or platinum/palladium paper.

Normally exposed and processed WD2H+ negatives have significantly lower silver density than is possible with conventional or many other pyro developers. This results in noticeably finer grain and higher sharpness. When high contrast is desired, the additional density of the dye mask raises printing contrast beyond the level possible with conventional developers.

The yellow-orange color of the dye mask is also more effective at increasing print density than the green mask produced by pyrogallol developers that use sodium metaborate as an alkali. Also, with WD2H+, the full color density of the dye mask is achieved during development and is not reduced by acid stop baths and fixers.

Crystal Springs #659, 2002. © John Wimberley. All rights reserved. Courtesy of the artist.

PYROCATECHIN (CATECHOL)

As mentioned elsewhere, pyrocatechin is one of the least explored developing agents. Although catechol has been around since 1839, until recently, most of the formulas were a result of research done by Hans Windisch. More recently, Sandy King has formulated several developers using catechol.

***Warning*:** Catechol is a toxic chemical used in pesticides but oddly enough, it is also found in flavorings and fragrances.

Pyrocat Film Developer

Sandy King

Pyrocat-HD is a pyrocatechin/Phenidone-based film-developing formula that can be used in tanks or trays. A variant, Pyrocat-MC, is recommended for JOBO and other rotary-type processing in tubes and drums. Originally meant for sheet film, Pyrocat is an excellent developer for use with 35mm and medium-format films because of its high acutance and tight grain pattern.

Pyrocat has the following characteristics:

- Very high acutance.
- Tight grain pattern.
- Oxidizes slowly.
- Does not suffer from uneven staining or streaking when used with a JOBO rotary processor.
- Can be used with dilute solutions and minimal agitation for pronounced adjacency effects and enhanced apparent sharpness.
- The chemicals go into solution easily.
- It is very long lasting.
- Pyrocat is economical to use.

This is Sandy King's preferred version. The original formula can be found in the Formulary. It has several variants, but the two given here, HDC+ and MC+, are the most useful.

With all Pyrocat variants, the stock solution A is stable in partially full bottles for up to a year. When mixed in propylene glycol, it has a shelf life of several years. Stock solution B has an indefinite shelf life.

The mixing directions for Pyrocat stock solution B are the same for all variants and can be found next. Mixing instructions for stock solution A may vary.

Pyrocat-HDC + Glycol

Stock Solution A

Propylene glycol at 150°F/66°C, 750.0 mL
Pyrocatechin, 50.0 g
*Phenidone, 2.5 g
Ascorbic acid, 4.0 g

*25 grams of metol may be substituted with a slight loss in film speed.

Mixing Directions for HDC+ Part A

1. Weigh out all of the chemicals for solution A.
2. Preheat 750 mL of propylene glycol to about 150°F/65°C in a water bath, using an immersion heater, or on a hot plate with stirring.
3. Add the pyrocatechin to the warm glycol and stir until dissolved. This should take no more than about a minute.
4. Add the Phenidone and stir. This should dissolve completely in about a minute.
5. Add the bromide and sodium metabisulfite to about 50–75 mL of hot distilled water at about 125°F/51°C. Stir until completely dissolved, and then add this solution to the propylene glycol solution.
6. Top off the solution with glycol to 1 L.

Stock Solution B

Distilled water, 750 mL
Potassium carbonate, 750 g
Distilled water to make 1 L

Mixing Directions for Solution B for All Pyrocat Variants

1. Start with 700 mL of distilled water.
2. Weigh out 750 grams of potassium carbonate and add the chemical very slowly to the water, with constant and rapid stirring. If you add the carbonate too fast or don't stir enough, it will be impossible to dissolve all of it in the water. As you add the chemical, an exothermic reaction takes place, and the solution will warm up appreciably.
3. Add distilled water to 1 L.

Author's Note: In most localities, it is safe to mix the working solutions with tap water. However, if you see any unusual development artifacts, such as streak marks or uneven staining, the use of distilled water is recommended.

Pyrocat-MC + Glycol

Pyrocat-MC is a variant for rotary processing. It can only be mixed with propylene glycol.

Stock Solution A

Triethanolamine (TEA), 8 mL
Metol, 2.5 g
Propylene glycol at 150°F/65°C, 750.0 mL
Pyrocatechin, 50 g
Ascorbic acid, 4 g
Propylene glycol to make 1.0 L

Mixing Directions for Part A

Start with about 8 mL of TEA at room temperature and a spoonful of water. Add 2.5 grams of metol and stir to make a slurry.

After the slurry becomes fluid, add 15–20 mL of warm propylene glycol. Transfer the metol slurry to the remaining 750 mL of warm propylene glycol and stir until dissolved. Now add 50 g of pyrocatechin and stir until dissolved. Add 4 g of ascorbic acid and stir until dissolved.

Stock Solution B

Distilled water, 700.0 mL
Potassium carbonate, 750.0 g
Distilled water to make 1.0 L

For stock solution B mixing directions, see earlier in the section Mixing Directions for HDC+ Part A.

Working Solution Dilutions for All Pyrocat Variants

For negatives intended for printing with silver gelatin papers, mix 1 part A with 1 part B with 100 parts water (1:1:100).

For negatives intended for printing with platinum/palladium (plt/pd) and most alternative processes, mix 2 parts A with 2 parts B with 100 parts water (2:2:100).

Development times for any given film are almost identical with all variants of Pyrocat.

Suggested Agitation

Minimal agitation: Dilution is adjusted to give development times of 14–20 minutes. Moderate agitation for the first minute of development, and thereafter for ten seconds every 2–3 minutes until the end of development.

Table 7.2

Development Times Using Pyrocat

Dilution: 1:1:100 for silver printing
Dilution: 2:2:100 for plt/pld printing

Film	*EI*	*68F/20C*
Acros	100	14 min
Delta 100	125	12 min 30 sec
FP4+	80	11 min
HP5+	320	15 min
TMax 400	400	15 min 30 sec
Fomapan 200	100	12 min

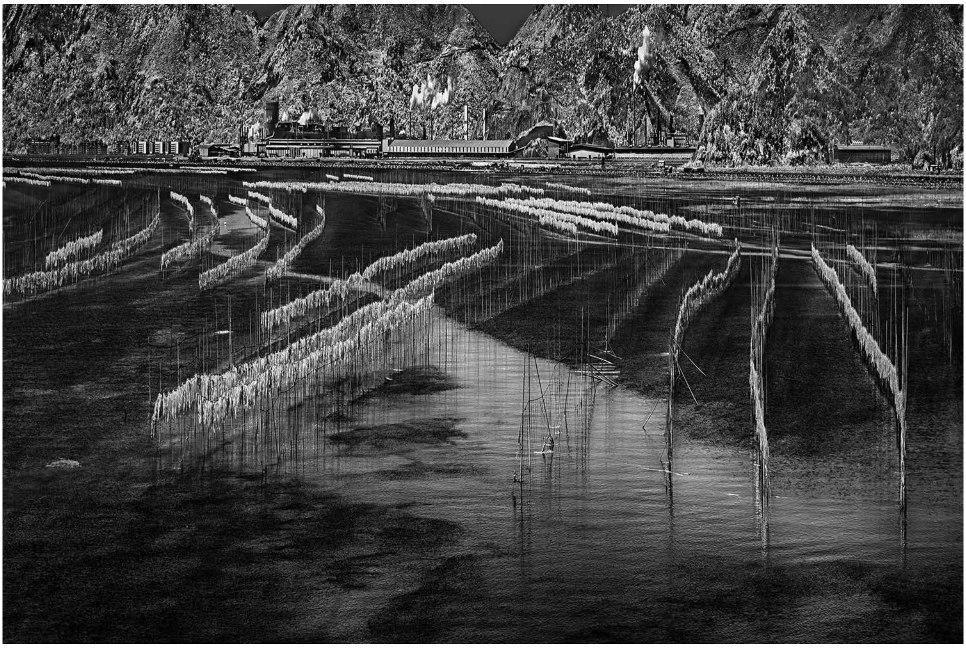
Extreme Minimal Agitation: Development is adjusted for times of 20–60 minutes. Agitation for the first minute of development, then for about 20–30 seconds at the half point of development, then no more.

Stand Development: Agitation for the first minute of development, then no more until the film is pulled from the developer.

Editor's Note: Pyrocat-HD kits can be purchased premixed in propylene glycol from Photographers' Formulary. For detailed information on use, with development times for some films, go to www.photoformulary.com and download the following technical information documents:

Pyrocat-HD in Glycol 01-5091
Pyrocat-MC in Glycol 01-5095

You can find additional information on the Pyrocat HD Users site, see Websites.



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Sea Weeds, South China Sea, 2018. © Sandy King. All rights reserved. Courtesy of the artist. 12 × 18-inch carbon transfer print.

THE DRY MIX METHOD

Whenever possible, I use the dry mix method to mix developers. This allows me to avoid using stock solutions, which not only take up shelf space but also decompose over time. The dry mix method means mixing the constituents as a fresh working solution at the time of use. In Table 7.1 you will find the ABC Pyro formula broken down into a dry mix to make a working solution.

Another photographer who uses the dry mix method is Gordon Hutchings, who formulated the popular PMK developer.

The PMK Dry Mix Method

Gordon Hutchings

Several years ago, I began thinking of using dry developer ingredients in a "spoon" style of mixing. Rather than mixing A and B stock solutions, I mix the dry ingredients, adding them to distilled water just before film development. This helps prevent any decomposition of the A stock solution that contains the two developing agents, pyro and metol.

Because you don't need to concern yourself with the developer decomposing in stock solution on the shelf, you can dispense with the bisulfite preservative and the EDTA and use just three chemicals: pyro, metol, and sodium metaborate, a true PMK formula. Using this dry mix formula, fast film stains perfectly with almost no general stain. The medium-speed film has moderate image stain and clear film margins.

To obtain optimum image stain, the developer solution must age in the tray or tank for a few minutes before adding the film. A convenient process is to mix up the developer first, then prepare the other trays and get the film ready for development. Some experience will soon tell you the optimum aging time for your film and conditions to achieve optimum stain.

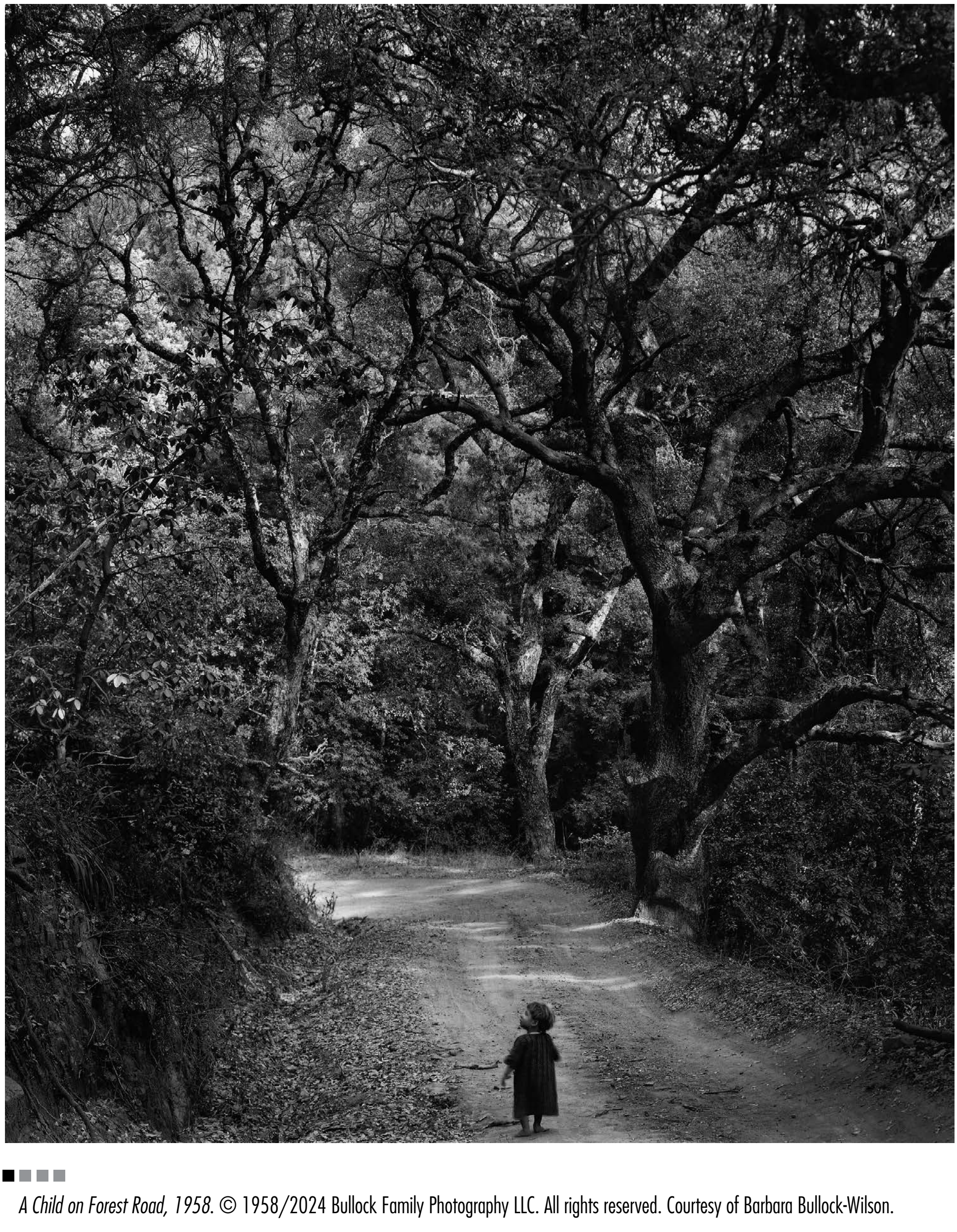
To make the process even easier, I use the "spoon" method for measuring the chemicals rather than weighing them each time. The Lee reloading supply company sells a precise kit of small scoops perfect for teaspoon-style measurements. The kit contains 15 small scoops graduated from 0.3 cc to 4.6 cc.

The pyro and metol are kept in one jar, the metaborate in another. Pyro will deteriorate in plastic containers, so be sure to use a glass jar for the developing agents. Sodium metaborate won't age, but it will cake in plastic and require breaking up before measuring. You may safely use a glass jar for the metaborate.

You must mix the dry pyro and metol chemicals thoroughly. There is only a small amount of metol compared to the pyro, and mixing is critical. I stir the two chemicals in the jar for at least one minute; a plastic rod works well. Do not shake the jar; you don't want any dust floating around and settling on things, including you. If you are unfamiliar with pyro, be sure to read about its toxicity. My book, *The Book of Pyro*—now out of print—has a section on the safe use of pyro.

I have used this "dry mix PMK" method for about two years. It is so easy and consistent that I will likely never return to using stock solutions.

Grazalema, Spain, 1989. © Gordon Hutchings. All rights reserved. Courtesy of the artist.



A Child on Forest Road, 1958. © 1958/2024 Bullock Family Photography LLC. All rights reserved. Courtesy of Barbara Bullock-Wilson.

Part 3

The Print

8

Print Developers

> *"The biggest problem facing modern printers is making the best negative for the process they plan to use for printing. One must learn both the negative and printing processes together to observe cause and effect."*
>
> —Mark Osterman

DIFFERENCES BETWEEN PRINT AND NEGATIVE DEVELOPERS

Print developers are far more forgiving than negative developers. When formulating and mixing print developers, it is possible to be off a certain percentage and still obtain pleasing results; indeed, you might like the results better!

A print developer differs from a film developer in the following ways:

- A print developer must be sufficiently active and concentrated so that development does not take too long.
- The print developer's composition can affect the paper's image tone.
- Print developers can affect the inherent grain structure of the paper, which can, in turn, affect the tone of the paper, especially when the paper is subjected to further toning processes.
- The action of the developer should be as uniform as possible during extended printing sessions to avoid having to remix fresh developer every few prints. This is especially important when creating editions of prints where both tone and tonality need to be consistent.
- It is necessary to have sufficient restrainer present to avoid veiling (fog). Otherwise, the whites in the print will be gray.

Print Developer Composition

The composition of a print developer is usually as follows:

- Developing agent(s). The most common print-developing agents in use today are metol or Phenidone plus hydroquinone. In recent years, glycin has regained some popularity.
- Preservative, which is always sodium sulfite.
- Alkali (accelerator) is nearly always sodium carbonate, with potassium carbonate sometimes substituted for warm tone results. Sodium hydroxide is occasionally used, mainly to increase contrast; sodium metaborate is sometimes found in universal developers such as Kodak DK-93, see Formulary.
- Restrainer, which is usually potassium bromide or benzotriazole.

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METHODS OF MANIPULATING PRINT DEVELOPERS

None of the paper developing formulas in the *DCB* are written in stone. Many of them were created by photographers experimenting with various proportions of developing agents and alkali. Feel free to alter any of the formulas. If your new brew gives you the color tone, look, and feel you're after, great. If not, you may lose a few sheets of paper.

One suggestion for anyone wishing to become a "chef" and alter or create new formulas is to break existing formulas down into proportionate amounts. Be certain to always compare and modify working solutions, not stock solutions.

Paper Developing Agents

Developing agents often have an effect on print color and gradation. For example, pyrocatechin is often used to obtain warm tones. Glycin is favored for neutral tones and subtle gradations. Amidol is often used in cold-tone formulas. However, there are no hard and fast rules. Agfa 108 is compounded with pyrocatechin, yet the addition of bromide causes it to produce neutral to cold tones on most papers.

As with film, the most common developing agents used today for compounding paper developing formulas are metol, hydroquinone, and Phenidone. While this is expedient for the chemical manufacturers, it is not in the best interest of the darkroom worker attempting to create a signature print style—one of the arguments for creating your own formula.

The Use of Restrainer in Print-Developing Formulas

The amount of bromide or organic restrainer in a print developer should ideally be optimized for the paper being used and the image tone desired. For example, in order to achieve a cold tone, the print developer should contain the smallest amount of restrainer that does not allow the whites of the paper to fog. Similarly, in order to achieve a warm tone, the print developer should contain the largest amount of bromide that will not lead to greenish tones. This optimization is possible when the correct amount of restrainer is determined by experimentation. This can be achieved by adding small amounts of restrainer to the developer until the desired result is obtained.

Bromide and Carbonate

To increase the flexibility of MQ and PQ print-developing formulas, keep a bottle of 6% carbonate solution and a bottle of 10% bromide on your darkroom shelf.

6% Carbonate Solution Adding carbonate solution to paper developer will increase the speed of the developer and create the appearance of greater contrast through stronger and richer blacks. Start with 50–100 mL to each liter of paper developer. As much as 200 mL can be used per liter, but beyond that, your highlights may begin to fog.

To make a 6% carbonate solution, dissolve 60 grams of carbonate in 750 mL of water and add water to make 1 liter.

If you intend to gold-tone a print for blue tones, do not add too much carbonate solution, as it will make it difficult to secure a brilliant blue with gold chloride toner. In fact, you should choose a paper developer that uses a minimal amount of carbonate.

10% Bromide With paper developers, adding a solution of 10% bromide will help prevent fog and slow the speed of excessively fast papers, allowing longer printing times for dodging and burning. Additionally, it will give clearer highlights, slightly extending the contrast range of the paper. Finally, it may enhance or increase warm tones by restraining development.

To make a 10% bromide solution, add 100 grams of potassium bromide to water to make 1 liter.

Add 15–25 mL of 10% bromide to 1 liter of developer. You can add more, but even though bromide helps to prevent fog, after a certain point it will actually cause fogging. This usually appears as a subtle graying of the highlights or print borders.

A simple test for chemical fog is to take a piece of unexposed paper and cut it into four parts. Develop and fix the first, as a control, for the normal time. Then, as you increase the amount of restrainer or antifoggant, develop additional pieces and compare them to the control print. As long as they are as white as the control print, more restrainer may be added.

A Perfect Balance The combination of carbonate solution and 10% bromide balance each other to achieve the best possible results. The increase in speed gained from using carbonate balances the decrease in speed caused by bromide. At the same time, highlights are enhanced by the restraining properties of the bromide, while blacks become stronger and richer with the carbonate. When using them together, begin with one part bromide to three parts carbonate.

It is not a good idea to add bromide and/or carbonate from force of habit. It is better to begin with an unmanipulated developer, observe the results, and then determine if one, the other, or both are needed.

Author's Note: I learned this trick from photographer Edna Bullock, who learned it from her husband, Wynn Bullock. Wynn used this technique with Ethol LPD paper developer, but it works with most print developers. I say most because I have not tried them all.

MQ VERSUS PQ PRINT DEVELOPERS

There are a number of differences between Phenidone/hydroquinone (PQ) and metol/hydroquinone (MQ) print developers, but none of them are significant enough to cause one to be preferred to the other.

Perhaps the most important difference is the longer and more consistent working life of a PQ developer. This is because Phenidone is less sensitive to bromide, so the buildup of bromide precipitated out of the paper during development has little effect on its activity. However, it should be noted that the organic restrainers found in high-pH PQ developers are carried off by each print. While this will not affect the activity of the developer, it will have some effect on the overall contrast of succeeding prints.

Another difference is that it is not easy to formulate a higher-than-normal contrast developer using Phenidone. At the same time, it is relatively easy to adjust the contrast, high or low, of an MQ developer, making the MQ combination easier to work with when manipulating or formulating a print developer.

When formulating PQ developers with a high pH, an organic restrainer should be used. Conversely, when formulating PQ developers of low to moderate pH, potassium bromide should be used. This is because while Phenidone is not very sensitive to bromide at high pH, it is sensitive at low to moderate pH.

PQ developers often produce a colder image tone on prints. This is not caused by the Phenidone per se but is the natural effect of the organic restrainers necessary in high-pH Phenidone print developers.

MQ PRINT DEVELOPERS

Cold Tones with MQ Developers

- Reduce the amount of bromide.
- Reduce the amount of bromide and add benzotriazole.

Eliminating the bromide entirely, without replacing it by an antifoggant, may cause paper to fog. If you wish to replace bromide with benzotriazole and maintain an equivalent amount of fog reduction, substitute 0.2 grams of benzotriazole for every 1 gram of bromide. The easiest way to accomplish this is to mix a 2% solution of benzotriazole—2 grams per 100 mL.

Each milliliter of the 2% solution will contain 0.2 grams of benzotriazole. Ten milliliters of a 2% benzotriazole will equal 1 gram of bromide.

Warm Tones with MQ Developers

- Reduce the amount of sodium carbonate—too little carbonate will result in a flat, muddy print.
- Substitute potassium carbonate for sodium carbonate.
- Increase the amount of potassium bromide. Use a 10% bromide solution. Start with 30–120 mL. After that, increase by 30 mL until the tones suit you or fogging occurs.
- With the right paper and developer combination, increasing exposure and using shorter development times will enhance warm tones.
- Dilute fresh developer with up to 50% used developer. If you like warm tones in your images, keep a bottle of used developer on the shelf.
- The quality of the negative plays an important part in the creation of warm tones by direct development as opposed to toning later. The best results are obtained from negatives of good contrast and printing density.

Neutral Tones with MQ Developers

- Eliminate or reduce the amount of bromide and substitute benzotriazole.

Table 8.1

	MQ Print Developers							
	Ansco 120 1:1 to 1:4	*Defender 55-D 1:2*	*Dupont 51-D 1:5*	*Ilford ID-20 1:1 to 1:3*	*Kodak D-52 1:1 to 1:3*	*Kodak D-72 1:2*	*Kodak D-166 1:1*	*SA Warm-Tone 1:1 to 1:3*
Metol	12.3	2.5	1.5	3.0	1.5	3.0	0.6	1.5
Sodium sulfite, anhyd.	36.0	37.5	22.5	50.0	22.5	45	12.5	22.5
Hydroquinone	-	10.0	6.3	12.0	6.0	12.0	4.2	6.3
Sodium carbonate, mono.	36.0	37.5	17.5	70.2	17.0	80.0	12.5	15.3
Potassium bromide, anhyd.	1.8	13.0	1.5	4.0	1.5	2.0	6.2	1.5
Water to make	1.0 L	1.0 L	1.0 L	1.0 L	1.0 L	1.0 L	1.0 L	1.0 L

PQ DEVELOPERS

There are far fewer published formulas for PQ developers. This may be because Phenidone, being a fairly new developing agent and less expensive to use in volume, is mostly used in proprietary commercial developers.

Cold Tones with PQ

- Eliminate the bromide and replace it entirely with a 1% benzotriazole solution.
- Increase the benzotriazole content up to 15 mL of 1% solution per liter.
- Substitute Phenidone and benzotriazole for metol and bromide.

Author's Note: The more benzotriazole used, the bluer the tone is likely to be. However, if there is too much benzotriazole, paper development will be suppressed.

TRAY LIFE OF PRINT DEVELOPERS

As print developer is used, each print adds bromide to the solution, removes some of the organic antifoggant if one is present, and absorbs some of the developing agent. Although it may not be noticeable from one print to the next, speed is lost, and development time must be increased to maintain contrast. In addition, the excess bromide in a print developer can sometimes change the image tone to a warmer hue.

One method of making a print developer less sensitive to bromide is to formulate it with a large amount already in solution. Then the small amounts that precipitate off each print are a small percentage of the total. Ansco 130 is formulated in this manner. In addition 130 is highly resistant to oxidation because of the use of glycin as one of the developing agents. This further reduces the tendency for streaking or staining when the developer is close to exhaustion.

There is no rule for how long a print developer will last, as this depends not only on the formulation, as noted earlier with Ansco 130, but also on how much silver is reduced to black or gray in the image. As a rough guide, however, 15–20 8 × 10-inch prints per liter is not unusual for most print developers.

It is possible to determine the life of a developer by taking note of how long the image takes to appear in the first print. When the time is noted to be

Table 8.2

PQ Print Developers

	E-72	*ID–62*	*ID–78*
Water at 125°F/52°C		750.0 mL	
Sodium sulfite	45.0 g	50.0 g	50.0 g
Hydroquinone		12.0 g	12.0 g
Phenidone	0.3 g	0.5 g	0.5 g
Ascorbic Acid	19.0 g	–	–
Sodium carbonate, mono.	90.0 g	–	62.0 g
Sodium carbonate, anhyd		60.0 g	–
Potassium bromide	19.0 g	2.0 g	4.5 g
Benzotriazole 1% solution		20.0 mL	–
Water to make 1.0 L			

slightly more than double the first appearance in fresh developer, it is time to toss the developer—for example, if the first print takes 15 seconds for the image to appear, then the developer should be tossed or replenished when it begins to appear at about 30 seconds.

To extend the working life of a print developer, you can add 30–45 mL per liter of stock solution to the working solution in the tray—the actual amount is not critical but use 30 mL as the minimum. This should only be done once in a print session, and the developer should be discarded at the end of the session. This is not a good idea when making prints that are part of a limited edition.

PRINT DEVELOPMENT TIME

Paper that is not overhardened may be developed over a wide range of times. This includes most graded papers. Should you have a paper that is responsive to changes in development time or temperature, the longer it is developed, the richer the gradation and overall print quality. Exposure can be adjusted to allow development from 1 to 7 minutes. Less than 1 minute can result in stains, streaks, and uneven development. However, the changes that take place after 3 minutes are often slight, though they can at times make a difference, especially with underexposed negatives.

Unless otherwise specified, standard development times for all paper developers are 1–1.5 minutes for RC and 2–3 minutes for fiber-base.

PRINTING LIMITED EDITIONS

The fact that print developers are not consistent over their working life is not usually a problem, as small adjustments in density or contrast can be made as you go. The exception is when a limited edition is being made. In this circumstance, it is important that the print developer maintains even tonal and contrast characteristics over its working life. One way to accomplish this is to change the developer often. Another is to use a developer that has a high capacity, such as Ansco 130. Combining the two methods is the best.

MQ Flex

Tim Bowman

MQ Flex is a flexible MQ developer in three parts, particularly suitable for warm-tone papers. Separating the developing agents (metol and hydroquinone), the accelerator (sodium carbonate), and the restrainer (potassium bromide) allows the user to mix several tray-strength developers as needed from the same three solutions.

MQ Flex can be mixed as:

- Kodak D-72 (Dektol) Standard MQ paper developer for normal tones. For normal, use 1+2, or for higher contrast, use 1+1.

- Kodak D-52 (Selectol) warm-tone paper developer.
- Kodak D-156 (No. 2 Warm-Tone Developer) for warmer tones than D-52 or 55-D.
- Defender 55-D slightly warm-tone developer.
- SA warm-tone developer (SA W-T).

Solution A: Contains the developing agents, along with sodium sulfite as a preservative:

- Distilled water at 125°F/52°C, 800.0 mL
- Metol, 3.0 g
- Sodium sulfite, anhydrous, 45.0 g
- Hydroquinone, 12.0 g
- Distilled water to make 1.0 L

Mix the ingredients in order, dissolving each one completely before adding the next.

Solution B: The accelerator:

- Distilled water at 125°F/52°C, 750.0 mL
- Sodium carbonate, anhydrous, 250.0 g
- Distilled water to make 1.0 L

Solution C: The restrainer:

- Distilled water at 125°F/52°C, 400.0 mL
- Potassium bromide, 50.0 g
- Distilled water to make 500.0 mL

Tray-strength dilutions

To mix MQ Flex at tray strength for printing, add the following amounts of solutions A, B, and C to a beaker and then add water to make 1 liter. To make 500.0 mL of tray-strength developer, halve the amounts of A, B, and C (Table 8.3).

Solution A will keep for over 12 months in a full bottle. As certain developers use quite a bit of solution A at a time, it may be convenient to mix it up in 2-liter batches. Solutions B and C last indefinitely.

MQ Flex cannot match the following developers exactly, but can get close and give similar results. If an approximation is not acceptable, it is better to mix up that developer directly.

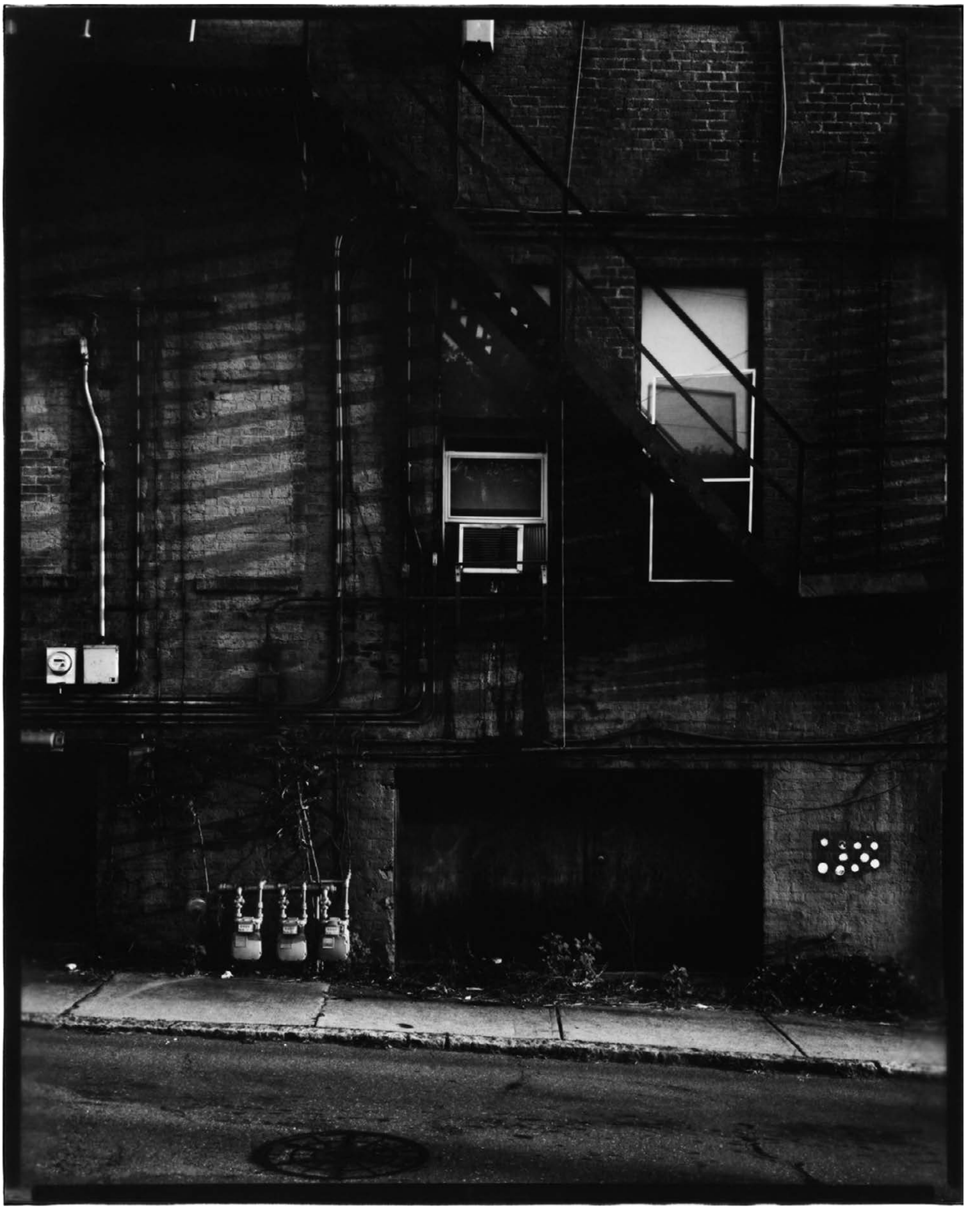
- For Ansco 103, Defender 53-D, and Ilford ID-20, use the Kodak D-72 dilution.
- For Dupont 51-D, use the Kodak D-52 dilution.

MQ Flex would not be possible without *The Darkroom Cookbook*. Also, many thanks to Ian Grant for refinements and corrections.

Table 8.3

	MQ Flex Dilutions						
	D-72	*D-72*	*D-52*	*D-156*	*55-D*	*SA W-T*	*SA W-T*
	1+1	*1+2*	*1+1*	*1+1*	*1+2*	*1+1*	*1+3*
MQ Flex A	500.0 mL	335.0 mL	250.0 mL	300.0 mL	280.0 mL	250.0 mL	125.0 mL
MQ Flex B	135.0 mL	90.0 mL	30.0 mL	30.0 mL	50.0 mL	20.0 mL	10.0 mL
MQ Flex C	10.0 mL	7.0 mL	7.0–15.0 mL	30.0 mL	17.0 mL	5.0–20.0 mL	3.0–12.0 mL

More Bromide may be added if warmer tones are desired.



Black House, West First Street. © Tim Bowman. All Rights Reserved. Courtesy of the artist.

THE AMIDOL CONTROVERSY

Amidol has the highest reduction potential of any print developing agent. It is unique in that it is able to reach exposed silver halides embedded deep in the emulsion, normally undeveloped by other formulas, before reaching exhaustion. With the right paper, amidol is capable of creating the longest tonal range and highest Dmax possible.

According to some photographers, including myself, no other paper developing agent is capable of creating the depth of black and subtle range of tones that can be achieved with amidol. According to others, it is possible to achieve the same or better print quality using Kodak Dektol or Ansco 130. Both are right. The problem is that many modern papers engineered for high-speed and high-temperature machine processing inhibit amidol from reaching the paper base before it loses its developing potential, and the results are a print that looks the same as one made using Dektol.

To get the most from amidol, the best papers to use are old-style, soft emulsion papers such as graded paper with minimal hardener, silver-rich papers, graded bromide papers, and long-scale chloride papers meant for contact printing. Chief among the chloride papers is Lodima Fine Art silver chloride paper. This is a contact printing paper—don't try to print on it using an enlarger. If you are using digital capture or small-format film (i.e., 35 mm, 120), make an enlarged digital negative and then contact print your image on chloride paper, see Chapter 15.

With any other paper than silver chloride, which is to say most modern chlorobromide papers, amidol works just as well, though not necessarily better than most other developing agents or combination of developing agents—thus the controversy. An exception to this may be David Lewis's Bromoil paper. David's paper is chlorobromide based on old-style paper technology with a minimum of hardener and no layering of silver iodide at the surface of the emulsion, a common technique used in modern papers.

Much has been written about amidol's tendency to oxidize rapidly and to stain paper. Amidol print developers do not oxidize any more rapidly than print developers that use conventional developing agents. This is because amidol is not as sensitive to its own oxidation products, as are most, if not all, other developing agents.

My guess is that some printers continue to use MQ/PQ developers past their exhaustion time without realizing it. They don't notice that their prints are taking longer to develop to their full potential unless they're making multiple prints from a single negative and the later prints begin to lose contrast. The result is that they come to believe their MQ/PQ developer lasts longer than amidol, see the earlier section Tray Life of Print Developers.

Regarding staining, like pyro, amidol will stain skin, work surfaces, and clothing, but it should not stain photographic paper. If it does stain your paper, there are three possible reasons. The first is that the amidol powder is old. Fresh amidol should look like fine gray powder or dust with a slightly green tint. If it looks like black or gray grains of sand, it has oxidized and will cause staining.

The second reason amidol may cause stains is the stop bath. Always use either citric acid or a running-water stop bath with amidol, followed by an alkaline fixer if one is available. The third reason is that the working solution is exhausted. Replace with a fresh batch of developer.

Notes on using amidol will be found in the Formulary chapter.

Author's Note: Fresh lemon juice is sometimes useful in removing amidol stains on hands and countertops.

***Caution*:** Amidol is toxic—never put your hands into a solution of amidol; either use stainless steel tongs or rubber gloves. This is good advice for all photographic chemicals, including MQ/PQ developers.

The Weston's Amidol Formulas

All three of the famous Westons—Edward, Brett, and Cole—used amidol paper-developing formulas. All three were famous for their rich blacks and full-scale print tones. There is some confusion as to the formula each one used, and more than one has surfaced for Brett and Edward. It is highly likely they used different formulas during the course of their long careers.

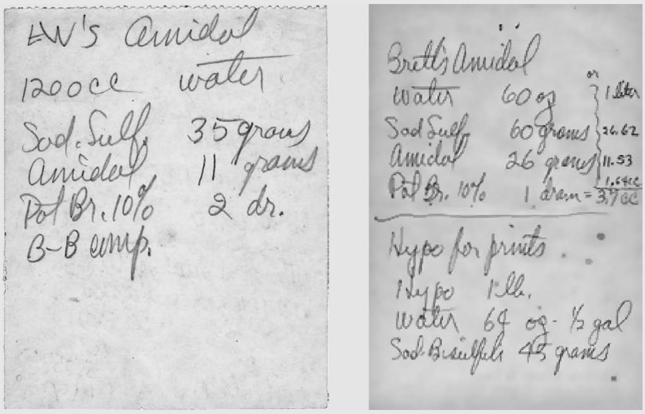
I first came across the Weston formulas when Brett gave me an article by Peter Nabokov that appeared in the November 1982 issue of *Camera Arts* magazine.

I mentioned to Cole that I was going to publish Brett's formula, and he generously provided me with his and a different formula he said Brett used. The late Ira Katz of Tri-Ess Sciences, who was friends with Edward Weston and provided him with his chemicals, also gave me Edward's formula.

While working on the third edition of the *Cookbook* I was introduced to Brett's long-time friend and associate, Richard C. Miller. Richard sent me a copy of a handwritten note—via intermediary Michael Andrews, a friend of Brett and Richard—which he said was Brett's formula circa 1971 given to him by Brett. The handwriting is Richard's, who told Michael he had written it down while visiting Brett in his darkroom. It is different from the 1982 formula that appeared in *Camera Arts*. To make matters more complicated, it is similar to but different from Brett's formula given to me by Cole.

Finally, Richard found a second handwritten note with a formula given to him by Edward, see Figure 8.1. It is nearly identical to the formula published in the first and second editions of the *Cookbook*, which was given to me by Ira Katz. Edward's formula in this edition corresponds to the note found by Richard.

All three formulas use as much or more amidol than any other published formula. Brett used to say he liked to use twice as much amidol as called for in published formulas. He once told me that he would throw in a healthy handful, and if his blacks weren't rich enough, he would throw in more. Perhaps this is the secret to using amidol that the rest of us have missed. More is better.



EW's Amidol
1200cc water
Sod. Sulf. 35 grams
Amidol 11 grams
Pot Br. 10% 2 dr.
B-B comp.

Brett's Amidol
water 60 oz } 1 liter
Sod Sulf 60 grams } 26.62
Amidol 26 grams } 11.53
Pot Br. 10% 1 dram = 3.7cc 1.64cc

Hypo for prints
Hypo 1 lb.
water 64 oz. ½ gal
Sod Bisulfite 45 grams

Figure 8.1 Edward (left) and Brett Weston's amidol formulas as given to Richard C. Miller. The handwriting is Richard's.

Brett Weston on Technique

Brett Weston was considered to be one of the finest black-and-white photographers of his generation. This is an excerpt from an interview I conducted with Brett that appeared in *PhotoPro* magazine, July 1991.

Steve Anchell: You are well known for your lack of interest in technique. Typically, you use one film, one developer, one paper.

Brett Weston: As much as possible. There's a lot of good things out there, you just have to find out what works for you and stick with it. I'm using Oriental paper, HC-110 as my film developer and Ethol LPD 1:4, I think, to develop paper.

SA: You're not sure about the Ethol dilution?

BW: Not really. I don't remember all that stuff. I have a couple of graduates in my darkroom, I always use the same amount of water to the same amount of developer, I just don't pay much attention to the dilution.

SA: For many years you used pyro and amidol. You were famous for the black amidol stains on your fingernails. I noticed when I came in that your fingernails are no longer black.

BW: Pyro is a film developer; amidol is for paper. Amidol makes the fingernails black. Pyro stains too, but you don't get your hands in it as much, it's a different kind of stain. Pyro is a dirty developer but it's very crisp and sharp. I stopped using pyro for about 10 years, but I've decided to start using it again. I just can't get the same results with other film developers.

SA: What caused you to switch from using amidol?
BW: It's a deadly poison; for that matter, so are metol and hydroquinone. LPD contains Phenidone, which is not as toxic.
SA: Henry Gilpin has a formula using LPD as the base, to which he adds carbonate and bromide. Do you add anything to your developer?
BW: No just LPD. I'm no chemist, you know. Although Henry is a good man, and a good friend.

Brett Weston & 11 × 14 Camera, Point Dume, Portrait #1, 02-07-1948. Richard C. Miller. © 2024 Miller Family Trust A. All rights reserved.

Paper

> *"What a great photographer does is they are consistently able to make something in a style that is personal to themselves."*
>
> —Ken Van Sickle

THREE TYPES OF PAPER

Photographic papers are made from combinations of three light-sensitive materials: silver chloride, silver bromide, and silver iodide. Traditionally there have been three combinations available for photographic printing: chloride, bromide, and chlorobromide, with varying amounts of silver iodide found in most papers. Generally speaking, as there are many variables, papers with a higher percentage of chloride have slower printing speed and are usually warmer in tone. Papers with a higher percentage of bromide are faster and colder in tone.

Silver bromide and chloride have everything to do with the emulsion's appearance and how well it will respond to Zone System expansion and contraction techniques and to toning with direct development or after development using toners. Silver iodide's primary function is to increase the speed of both film and paper. Too much silver iodide can affect the ability of the paper to respond to manipulation, especially toning.

Bromide papers are generally the most sensitive to light and are the best papers to use for cold tones through direct development, as opposed to toning after development.

There are very few bromide papers still in existence. Two that are reputedly bromide are Slavich Unibrom 160 and Kentmere Bromide. Both respond well to all forms of manipulation.

Slavich Unibrom is available in single- or double-weight grades 2, 3, and 4, and Kentmere Bromide is available in grades 1, 2, and 3. This should not pose a problem if you test your film and development to match the grade of the paper, as photographers did in the era of glass plates and hand-coated emulsions. Use the Zone System and a good light meter app on your cell phone for the best results.

Author's Notes:

1. The available contrast grades and paper weights of Kentmere Bromide and Slavich Unibrom 160 given in the text may not be accurate. It is difficult to get up-to-date information on either one, and there is a question as to whether the same choices are available in Europe as in the rest of the world.

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2. Bromide emulsions should only be used with a red safelight, not orange. If you don't have a red filter, print in the dark as you would if you were printing color.

Chloride papers are meant for contact printing large-format negatives. Combined with amidol paper developers, chloride paper yields a tonal scale unsurpassed in other forms of silver printing.

The downside of chloride papers is they are very slow; projection prints with an enlarger could take 5–10 minutes or longer. Contact prints with the same paper, using a direct light source, such as a bare bulb from about 3 feet away, would require printing times of only 30 seconds to 3 minutes, depending on the type and wattage of the bulb.

At one time the list of chloride papers included AZO, Convira, Apex, Velox, and others. Today Paula Chamlee keeps the tradition alive by commissioning special runs of non-supercoated Lodima Fine Art silver chloride paper manufactured to her exacting standards. According to Paula, the paper is similar to Kodak AZO and Agfa Convira, both papers "that Edward Weston used to make some of the most beautiful prints in the early and mid-twentieth century." You can find Lodima under Smith-Chamlee Photography in Material Sources.

In addition to Lodima, Adox is making Lupex, a slow-speed, contact printing, fiber-based paper made with a silver chloride emulsion that, according to Adox, replaces Kodak AZO. Lupex is extremely fine-grained and yields superior resolution.

Chlorobromide papers are the most used today. As the name implies, they are a compromise between the fast bromide and the slow chloride papers. The percentage of bromide to chloride can allow manufacturers to create either warm- or cold-toned papers with a variety of sensitivities. Most, if not all, multi-contrast papers are made with a chlorobromide emulsion. Examples of chlorobromide papers include Ilford MG IV and Warmtone, Bergger Prestige Variable CB and Warmtone, Arista EDU Ultra FB VC, Fomatone MG Classic 131 VC FB, and Slavich Bromportrait 80.

Although David Lewis' Bromoil paper is chlorobromide, it is distinctive for not being supercoated and containing the minimum amount of hardener in the emulsion. The reason for this is that supercoated papers won't work with the bromoil process, for which his paper is intended.

FIBER BASED VERSUS RESIN COATED

Two kinds of paper bases are used for traditional silver-based printing: fiber based (FB) and resin coated (RC). FB consists of a light sensitive emulsion coated directly on paper, usually with a supercoating that includes hardener to protect the emulsion from scratches while it is wet. Between the emulsion and the paper there is a layer of baryta. Because the emulsion and baryta layer are coated directly onto the paper base, they are ingrained into the paper fibers. This brings out texture in the emulsion that contributes to the illusion of depth in the printed image.

FB papers are generally preferred for high-quality exhibition prints and archiving purposes. These papers require careful processing and handling, especially when wet. However, they are easier to tone, hand-color, and retouch than RC papers.

The downside to FB papers is that they are more expensive than RC and take longer to process and wash. If you search for FB papers online, you will find no end of photographers who lament that it is necessary to use a hypo clearing agent for 5 minutes and to wash for 30 minutes to an hour to fully remove chemical residue stuck in the paper fibers. This is true but only if you are using an acid fixer.

With an alkaline fixer, you use a 1-minute running water bath for the stop bath, 2 minutes in the first fixer, 2 in the second, and a 10-minute wash. You do not need to use HCA and should not use an acid-stop bath.

Baryta

Baryta is composed of barium and strontium sulfate. It isolates the silver-gelatin emulsion from chemical contamination passing through the paper base and helps to brighten the image highlights. The baryta layer can be tinted at the time of manufacture to produce warm or cool tones. Untinted baryta is white.

RC paper is made by laminating a thin piece of paper between a top and bottom layer of polyethylene with the emulsion coated on top. As with FB paper, a supercoating is used to protect the emulsion. The polyethylene prevents chemicals from being absorbed into the paper, decreasing processing time. Whereas FB paper should be developed for 1½–3 minutes, RC paper should not be left more than 1½ minutes, with 45–60 seconds being the normal developing time.

When RC papers were first introduced, they had a short tonal scale, often delaminated during processing, were prone to “bronzing” in the shadows—a form of image degradation that occurs over time—and they looked and felt like placemats for dinner plates.

That was then. Today the best RC papers, for example, those made by Ilford, have a tonal range rivaling many of the best FB papers, and the delamination and bronzing issues have largely been addressed by changes to the resin coating.

The downside to using RC papers is the very thing that makes them so easy to use: the resin coating. This coating is waterproof and impervious to chemicals. Every time you throw a print in the circular file cabinet (aka trash can), you are helping to destroy the environment by introducing more plastic.

GRADED VERSUS VARIBLE CONTRAST

In the early days of photography, when photographers coated their own papers, contrast was controlled in one of two ways. The first was by varying the formula used to coat the paper to increase or decrease the contrast. The second was to match exposure and development of the glass plate or negative to the paper's contrast. The latter was possible because photographers were able to control the development of each image individually. However, with the advent of roll film and later 35mm, both of which could contain multiple images of varying contrast on a single roll of film, the need for graded paper became important.

Graded (Fixed-Grade) Paper

At one time, papers were only made in fixed contrast grades rated from 1 to 6, with 1 having the least contrast and 6 having the highest contrast. A low-contrast negative would be printed on a high grade, such as 4, 5, or 6, and a high-contrast negative would be printed on grade 1, 2, or 3. Paper grade 2 was considered by most manufacturers as "normal." However, there was never an industry standard as to what comprised normal contrast. Even so, grade 2 papers from the various purveyors were reasonably close in contrast. In the heyday of silver printing, most papers only came in two or three grades, usually 2, 3, and 4; some only came in a single grade, usually 2. Only a few papers were ever available in grades 1–5, and only Agfa Brovira was available in grade 6.

Having different contrast grades allows photographers to compensate for errors in exposure or development. A low-contrast negative can be printed on a higher-grade paper, and a contrasty negative can be printed on a lower-grade paper. Contrast can be further controlled chemically during development or with any number of after processes, including toning, bleaching, and preflashing.

The problem with using graded papers is you need to keep a package of each grade on your shelf, as you never know when you'll need a higher or lower grade. And when you do, it is invariably in the middle of a printing session when the stores are closed on a three-day holiday weekend.

The good thing about using graded papers is that they are usually the least hardened or supercoated during manufacture and that makes them more responsive to chemical manipulation, including using low- and high-contrast developers, toning developers, toners, bleaching, and more.

Variable Contrast Paper

Also known as multicontrast (Ilford) and polycontrast (Kodak), variable contrast (VC) papers were first proposed in 1912 by a German scientist R. Fischer. But it wasn't until 1939 that Defender Photo Supply Company introduced the first commercially viable VC paper, Varigam. Defender was later bought out by DuPont, who kept the product name until they stopped making photographic materials in the early 1970s.

VC papers are coated with two emulsions: a soft, low-contrast emulsion sensitive to green light and a hard, high-contrast emulsion sensitive to blue light. If you filter out the green light with a magenta filter, the print will gain contrast. Conversely, filtering out the blue light with a yellow filter will lower contrast. If no filter is used, the paper prints as grade 2 more or less. This is known as subtractive printing because you are filtering out colors you don't want.

VC filter sets contain as many as 12 filters with varying densities from yellow or orange to magenta. The deeper the density, the greater the increase or decrease in contrast. With many papers, filters 1–4 are usually close to the same printing speed, whereas 00, 0, 5, and 5+ are about half the speed of filters 1–4. Filter 4 may also be half the printing speed of filters 1–3½, depending on the filter set (Ilford or Kodak) and the paper used. If your filter set is speed matched with the paper, then if you make a print using a 2 filter and need to increase contrast using a 3½ magenta filter, your exposure time will be the same or very close. If 3½ isn't enough contrast and you need to jump to a 5 magenta filter, you will need to double your exposure time.

As an alternative to using a filter set, you can use just two filters, a Kodak 47B blue and 58 or 61 green, to do what is known as split printing—exposing through the green filter for the highlights and the blue filter for the shadows, see Chapter 10: Printing Methods and Techniques: Split Printing with VC Paper.

There are two advantages to using VC paper. The first is you only need one package on your shelf to obtain a range of contrast from 00 to 5+, with half grades between. The second is that it is possible to use different contrast filters on different areas of the same print. It is like having a palette of black, white, and gray that can be mixed and matched to create your image.

The problem with VC papers is that due to their versatility, they are used almost universally for machine processing. Worldwide, machine processing of photographic materials is still a sizeable industry, especially in South America, Asia, Africa, and the Middle East. While all papers must have some hardener incorporated in the emulsion, VC papers usually contain excess hardener as part of a supercoating meant to protect their surface from machine abrasion. This means they are highly resistant to chemical manipulation.

Grade 2 without a filter is not the same as grade 2 with a filter. For this reason, when printing with VC paper, always use a filter, even for grade 2.

IMAGE COLOR: PRINT TONE VERSUS TINT

The color of a print, though it may be subtle, strongly affects the viewer's response. Warm tones tend to engage viewers, drawing them into the image. Neutral and cold tones tend to create an emotional distance, a sense of looking at the image from the outside. Although there are no rules but your own, which should not be etched in stone, portraits, still life, and nostalgic images—for example, old barns and dusty highways—often appear most pleasing when rendered in a warm tone. Landscapes, abstracts, and modern architecture lend themselves to neutral and cold tones, or at least this is the way in which we have become accustomed to viewing them.

Image tone is determined by varying the amounts of chloride or bromide in the paper's emulsion during manufacture; the more chloride in the mix, the warmer the tone and the slower the paper speed.

The tint of a paper is determined by the color of the paper base. A paper may have a base color that is white, cream, ivory, or some variation of off-white.

Although warm-tone emulsions can be coated on a brilliant white base, most warm-tone papers made today are neutral toned and coated on a base that has a warm-tone tint. This allows the manufacturer to use less silver chloride, thereby increasing paper speed, and still produce a warm-tone paper, even though it is the base tint and not the emulsion tone that you see. To determine if a paper has a warm tint, study the highlights. If they are off-white, the paper has a tint. To determine if a paper has a warm-tone emulsion, study the midtones and shadows.

Any warm tone you see in an RC paper is likely a warm tint of the paper base. There is not much you can do to alter image tint, though you do have some control over the image tone—how much largely depends on the amount of hardener in the supercoating of the paper and how close the silver iodide layer is to the surface.

Often the changes and variations are subtle. The simplest test to determine whether or not an FB paper is cold, warm, or neutral toned and just how much is to develop a control print on neutral-tone chlorobromide paper for 2 minutes in a neutral-tone developer such as D-72 and compare it to prints that you have developed in warm- or cold-tone developers. Keep your neutral-tone control prints in a binder or folder for future comparisons.

Learning to manipulate and control the image tone of a print through the use of toning developers, toning the paper after development, and other processes opens ways to communicate your vision.

MANIPULATING PAPER TONES

Paper, like film, has grain, though unlike film, paper grain is not visible to the eye. When the grain first starts to develop, it is yellow in color and then turns reddish, then brown, and with full development becomes black. You can see this for yourself by pulling a print at various stages of development and fixing it.

This information can be quite useful. For example, giving a print more than the usual exposure and developing it for less than the normal time, say 45 seconds to 1 minute, will often enhance warm tones, especially with chlorobromide papers. Using a warm-tone chloride or chlorobromide paper and warm-tone developer will increase the effect.

Also, when a developer nears exhaustion, it is unable to fully reduce the silver halide in the emulsion. As a result, the print may appear to be red or brown, as it cannot develop all the way to black. Because of this, it is possible to add as much as 50% used developer to fresh developer to achieve warm or warmer tones. This is because the presence of used developer prevents the silver halide from being fully developed to black. The amount of used developer should not be more than that which would allow development to take place within a normal developing time of 2–5 minutes. This technique is especially effective with developers containing glycin, see the Formulary: Ansco 130 and Dassonville D-3.

The most important components in a developer for influencing image tone are the developing agent; whether bromide restrainer or an organic antifoggant is being used in the developer; whether there is a silver iodide layer; and the amount of supercoating.

Developing agents such as glycin or pyrocatechin produce a warm image tone in the absence of an organic antifoggant, such as benzotriazole. Organic antifoggant tends to create a cold or bluish image tone. Also, as the bromide content in the developer increases during print sessions, the emulsion tone tends to become warmer.

Silver Iodide

In the early days of emulsion making, the three silver halides, bromide, chloride, and iodide, were mixed together in various proportions to create the desired emulsion. This was called trough or bucket coating, as everything was mixed together in a "bucket" along with the gelatin emulsion and coated onto the film base.

The technology of emulsion making has advanced so that modern emulsions now use a multilayering technique whereby the three halides are applied in their own individual layers, allowing for precise distribution and control of the results. Advanced multilayering techniques are what have made modern emulsions, film and paper, possible.

Applying the iodide layer on the top of the other two emulsions not only further increases film speed but also changes the nature of the image, especially on paper. This is because the iodide layer is the first to absorb light during exposure and the first to receive—and exhaust—the developer. The result is that iodide-rich films and papers, as they are known, lack many of the desirable qualities derived from silver bromide and chloride, which receive less light and developer that is partially exhausted by the iodide layer. This is why many modern films and papers do not respond as well to exposure, developing time adjustments, and chemical manipulation as did older-style films and papers.

Author's Note: If the paper you are using is resistant to toning, it probably has a layer of silver iodide above the silver bromide and chloride layers. This does not mean it is bad paper—in fact, it may have excellent tonality; it only means you should use a different paper if you want to manipulate image tone or control contrast through extended development.

Excess hardener in the emulsion can also inhibit toning with some paper emulsions, though it has little effect on film. If the paper you are using is resistant to toning, you can try using sodium carbonate to remove some or all of the hardener after the print has been made, see Formulary: Miscellaneous: Dehardener. This may improve the results you get when toning prints after development. It will not help with toning during development, however, as the hardener should not be chemically removed until after fixing.

Redevelopment Method

The type of halide used—chloride, bromide, or chlorobromide—and the composition of the printing paper have some effect on the image tone. If a paper is primarily chloride or bromide, the manufacturer will always want you to know as this is a selling point. For example, Slavich Unibrom, Kentmere Bromide, or Lodima fine art silver chloride paper. If the manufacturer is silent on the subject, you can assume it is chlorobromide.

The technique of redevelopment reduces all halide in the emulsion to silver bromide, which can then be redeveloped and toned. Try this method if you are not getting the promised color from direct development or toners or if your paper is resistant to bleaching. Test on reject prints.

To use this method, expose a print, develop in a neutral-tone developer such as D-72, fix, and wash the print in the usual manner. Next, use either print rehalogenating bleach, DuPont Toning Bleach 6B-1, or Agfa 503 Rehalogenating Bleach to convert all silver metal to silver bromide. Then rinse for 5 minutes and redevelop using any toning developer.

This technique is different from the dehardening method mentioned earlier in the section "Manipulating Paper Tones."

Author's Note: This procedure is not recommended for RC papers due to the excessively long wet time that can delaminate the emulsion from the plastic coating.

IMAGE COLOR THROUGH DIRECT DEVELOPMENT

Direct development means creating a warm or cold tone during development of the paper, as opposed to using a toning bath after the print has been fixed and washed.

Neutral Tones

Neutral-tone developers produce images with the least amount of bias toward either warm or cold tones. Some papers will have a slight greenish cast when developed in a neutral-tone developer. Should this occur, either use less bromide, replace the bromide with benzotriazole, or try using DuPont BB Solution found in the Formulary. After toning, selenium toning will also eliminate any green cast, though it may also create a reddish tone in its place, depending on the dilution.

Warm Tones

There are many ways in which to achieve warm tones, although the results will differ according to the type of paper used, as previously noted. As a general rule, print developers using only hydroquinone produce a warm tone and those using only glycin produce a brown tone. The difference is that brown tone refers to the specific color, brown, whereas warm tone includes those with a red or yellow bias. For the rest of this chapter, I will use warm tone to refer to all shades of brown.

Some methods to create warm tones are as follows:

- Use less carbonate. The less carbonate in the print developer, the warmer the tone. The use of too little carbonate, however, will result in a flat, muddy print.
- Substitute potassium carbonate for sodium carbonate. Besides creating warmer tones, it can be used in stronger concentrations for increased contrast.
- Increase the amount of bromide. If the tones are not warm enough, add between 30 and 125 mL of a 10% bromide solution, see Chapter 8: Print Developers: Bromide and Carbonate. Increase by 30 mL until the image tone is satisfactory or fogging occurs, in which case you will need to back off the bromide. This works with most, but not all, developers.

- Increase print exposure and shorten development times. Often this method will create warmer tones.
- Choose a warm-tone developer. This will enhance any warm tones inherent in the paper.
- Dilute a fresh developer with up to 50% used developer. If you like warm tones in your images, keep a bottle of used developer on the shelf for this purpose. Glycin-based developers work well.
- Tone the print after processing is complete.

Cold Tones (Blue-Black)

There are three ways to achieve cold tones. The first is through direct development of bromide paper. The second is through the gold-toning of a warm-tone chlorobromide paper. The third method is immersion in a blue-toning bath, see the Formulary: Toners: Ansco 241 Iron Blue Toner.

Method #1. The classic developing agent for creating cold tones on bromide papers is amidol. However, PQ developers using organic antifoggant, such as benzotriazole, will also increase the amount of cold image tone in a print, see the Formulary: Paper Developers: Blue-Black Developer. In either case the results are often subtle.

Increasing the amount of benzotriazole and decreasing, or eliminating altogether the bromide content will further help to achieve blue-black tones. This is because bromide restrains development, favoring a warm or neutral tone, while benzotriazole acts as an antifoggant without inhibiting development. Start by reducing the potassium bromide to 1/10 or 1/6 strength and adding just enough 0.2% benzotriazole solution—2 grams in water to make 1 liter—to prevent developer stain or fog.

Method #2. Gold-toning chlorobromide papers is generally considered the most pleasing and satisfactory method for achieving a variety of cold tones. For more on gold toning, see Chapter 13 Toning Prints: Cold and Warm Tones.

Method #3. Blue-toning baths cause the entire print to be blue, including the paper base. This is not a true cold tone; rather, it is overall toning.

A final tip for increasing cold tones, which can be used in conjunction with any of the techniques just mentioned, is to decrease exposure and prolong development to 5 or 6 minutes. With some papers, though not all, the print will exhibit stronger blacks, tending toward blue. Testing individual papers is required.

Saving Outdated Paper and Negatives

Clayton Harley

Once an emulsion reaches a certain age past its stated expiration, it becomes fogged, resulting in a print with low contrast with muddy gray whites and weak shadow densities. Outdated paper has become an industry-wide problem, as more paper is still being manufactured than there are users for it. Additionally, photographers are increasingly coming across stashes of outdated paper that is no longer being used by a photographer who has segued into digital imaging.

Until the mid-twentieth century, many photography greats printed with a gray palette that lacked maximum black density and gray highlights. Among these were André Kertész, Tony Ray-Jones, Robert Capa, Anthony Armstrong Jones, and Harry Callahan, to name a few. But the gray white/weak black, low-contrast print, aka soot and chalk, has fallen into disrepute due to the standard established by West Coast landscape photographers that requires textured whites and maximum black in every print.

While more extreme than the practiced tonality mentioned earlier, some photographers have embraced the highlight fogging and limited tonal range that results from using out-of-date paper. After making a low-contrast print, they take it a step further by either toning the entire print or swabbing or brushing toner on selected areas.

Another technique is to use a lith developer to minimize fogging and create a unique color palette. Lith developers have the ability to distinguish between silver halides that received light exposure and those that are simply fogged from aging. Without going into deep technical detail, suffice it to say that you can get a crisp, clean print on an otherwise hopelessly fogged paper using lith developers. Not only will they be free of fog, but they will also have great acutance, creamy white borders, and highlights reminiscent of the work of Julia Margaret Cameron and Anne Brigman and beautiful, delicate, colorful shadow detail. As an added bonus, these prints often split tone naturally, should you choose to tone them later.

Lith Developer for Fogged Paper

Water, 750.0 mL
Sodium sulfite anhydrous 1.2 g
Hydroquinone 1.5 g
Sodium carbonate 8.5 g
Potassium bromide 0.5 g
Water to make 1.0 L

Use undiluted.

Lith developer, once in solution, needs to be ripened. Submerse a scrap piece of exposed paper or film in the developer and leave it for at least 20 minutes. This will ripen the developer to a working state. When this is done, you can begin printing.

Overexpose your prints by 3–5 stops and put them in the developer. As long as they aren't floating to the surface, you can leave them mostly without agitation. This is a good thing because the first prints will take 5–7 minutes.[1] The first sign of an image can take 5 minutes, the first true black a few minutes more. As the developer is used, things will start to go faster and faster.

Once the developer begins to get dark, you can mix a new batch, pour away 80% of the spent developer—“old brown”—and incorporate the remaining 20% into the fresh batch to pick up where you left off.

Though the times to make prints are longer than for standard paper developers, the prints that result are more colorful and carry a striking balance between crisp blacks and colored shadows. If the slowness of the process at first seems frustrating, increase your alkali by, for example, 11 grams of sodium carbonate. You can also lower the potassium bromide to 0.25 grams or use the standard solution at a warmer temperature—for example, 75°F/24°C instead of 68°F/20°C.

You will never be able to replicate what a paper would have looked like when fresh and processed in standard developers, but the magic of lith is the incredible and unexpected colors that it brings out of the emulsion. Every paper type will react differently. Beautiful unique and colorful prints are made with this method on papers exceeding 100 years of age.

Happy hunting in the dark.

Special thanks to Harvey Yurow, Martin Reed, Tim Rudman, Grant Haist, and Ashley Houston for their tireless work investigating the magic of lith.

For more information on lith printing see Chapter 10: Printing Methods and Techniques: Lith Printing.

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[1] This procedure is not recommended for RC papers due to the excessively long wet time that can delaminate the emulsion from the plastic coating.

Photos 9.1 and 9.2 were both made using out-of-date DuPont Varigam with an expiration date of 1960.

Photo 9.1 Fogged print. *Out-of-date DuPont Varigam expiration date: 1960.* Developed using a standard developer. Notice the muddied whites and flat tonality. © Clayton Harley. All Rights Reserved. Courtesy of the Artist.

Photo 9.2 Lith print. *Out-of-date DuPont Varigam, expiration date: 1960.* Developed using a lith developer for fogged paper. Notice the clean whites and increased contrast. © Clayton Harley. All Rights Reserved. Courtesy of the Artist.

Printing Methods and Techniques

> *"Taking the picture is one thing, but I get excited about how it's going to turn out. I don't want anybody else to print for me, because they wouldn't have the same interpretation that I have."*
>
> —Edna Bullock

The most important skill a photographer can learn is how to adjust a formula to express their personal vision or a subject. For example, fine-art photographer Paul Caponigro has been known to mix varying proportions of warm-tone developer with cold-tone developer to create an altogether new tone for a specific body of work. In printing, more than any other area of the darkroom, the only rules are those you make for yourself.

CHEMICAL MANIPULATION

Controlling Contrast with Print Developers

There are several methods for manipulating contrast either by using specially formulated developers, combining developers, or manipulating exposure and development. The simplest is to use a low-contrast developer with a higher-grade paper. For example, if you need a contrast grade between 2 and 3, use grade 3 paper with Ansco 120 1:1, developing for 3 minutes. This will reduce contrast by about a half-grade.

A specially formulated developer for variable-contrast (VC) control is Dr. Roland F. Beers' Two-Solution Variable Contrast Developer. Solution A of Beers, as it is commonly known, contains metol, and Solution B contains hydroquinone. Mixing the two in various proportions gives a progressive range of contrasts with any grade of paper. Although Beers is usually thought of for graded paper, it works equally well with VC papers for tweaking contrast between filters.

Combining two developers, one high or normal contrast and one low contrast, is another method for obtaining VC results similar to Beers. Either high- or normal-contrast developer is added to a tray of working solution of low-contrast developer. The more added, the higher contrast the developer becomes. Start by adding 25 mL of stock solution of a high- or normal-contrast developer, such as D-72, to each liter of *working solution* low-contrast developer, such as Ansco 120 1:1.

By combining different developers, a variety of image colors can also be achieved. For example, combining D-72 with Ansco 120 will produce one

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image color, while using Agfa 108 and Agfa 105 will produce a different color. Start with 10 mL of undiluted high/normal-contrast developer in 1 liter of soft developer. The color shift will depend on how responsive the paper is to manipulation.

The disadvantage of combining developers is that the high- or normal-contrast developer may exhaust before the low-contrast developer. Much depends on how much of the high-contrast developer is added. For example, were you to add 10 mL of high-contrast developer, the developing agent, usually hydroquinone, would exhaust sooner than if you were to add 25 mL to the same volume of low-contrast developer. This is not a problem if only a few prints are to be made. However, if consistency is important for a large number of prints, make certain there is sufficient high/normal-contrast developer in solution so that the developing agent does not exhaust too soon. This may mean increasing the initial volume of the combined developers and using a larger tray.

Two-Tray Development

A variation of this technique is to use two separate trays of developer, usually a low-contrast formula, such as Ansco 120, and a high- or normal-contrast developer, such as Ansco 130 or Kodak D-72. Development begins in the low-contrast developer and is completed in the high- or normal-contrast developer. For this application, you may wish to dilute the low-contrast developer as much as 1:3 or 1:4 and use the high/normal-contrast developer at 1:1 or undiluted. The time in each developer can be varied, though the *minimum* time in the high/normal-contrast developer is at least 15 seconds if any effect is to be had. A good starting point would be to develop the print for 90 seconds in the low-contrast developer followed by 30 seconds in the high/normal developer, although as much as a 50/50 split may be used. A 10 second drain between developers will help minimize cross contamination.

Water Bath Development

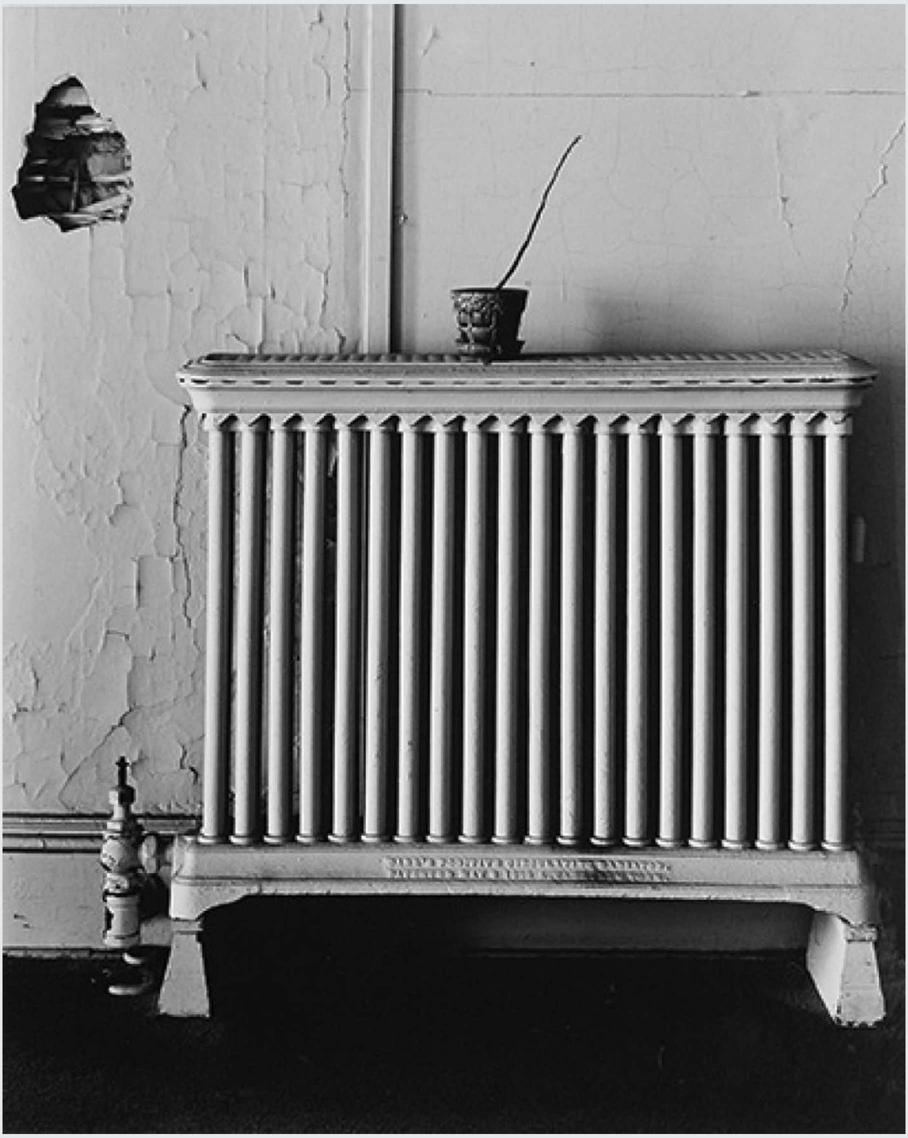
Water bath development is a technique that allows you to split paper grades by placing the exposed paper in a tray of standing water. The developing agent in the dense shadow areas will quickly exhaust, while the developing agent in the highlight areas, where less exposure has occurred, will continue to work.

Because amidol is an exceedingly active developing agent, it is a good choice for water bath development. For a step-by-step method see the Formulary: Amidol Paper Developer: Amidol Water Bath Developer.

Forced Development

Marie Curtis

I always keep a little container of warm print developer handy in case I need to darken an area during development. Sometimes I apply it with my gloved fingertips, sometimes with a little brush.



Evidence of Neglect, 2005. Silver gelatin print. 4 × 5-inch Tri-X developed in pyro; Zone VI camera by Wisner; 210mm Schneider lens. © Marie M. Curtis. All rights reserved. Courtesy of the artist.

PHYSICAL MANIPULATION

Whether you are printing with graded or VC always use the contrast grade or filter for printing the shadows and use exposure time for printing the highlights. Once you are close to the final print, you can tweak either contrast grade or time for either shadow or highlights to fine tune the print. When it comes to controlling contrast using physical manipultation, nothing is more versatile than VC paper. By using VC filters you can control both the overall contrast of a print and local area contrast.

The following are two methods for printing using filters. The first method, multiple-contrast filter printing, is suited for tungsten light sources. The second method, split printing, is best to use with cold light sources. However, either can be used for either light source. In fact, you can begin with split printing and then use multiple contrast printing techniques for contrast control in local areas. Find what works and make it yours.

VC Paper

The original VC filters produced by Defender were yellow to violet in color. The yellow filters lowered contrast, and the violet filters raised contrast. Today, the filters most used are those made by Kodak or Ilford. The Kodak filters are yellow to magenta, and Ilford filters are orange to magenta. It is important to note that all three sets, Defender, Kodak, and Ilford, were designed to be used with tungsten light (i.e., tungsten light bulbs made for photo printing). If you can find them, the best set to use is still the Defender yellow to violet, as they produce the highest contrast with most papers.

If you are using a fluorescent light source, also known as cold light, you will find that none of the filter sets will produce a full range of evenly spaced contrast grades. You will need to filter the fluorescent light using a green filter. The best and most popular cold lights were made by Aristo.

Aristo made two different fluorescent tubes: the W55 and the W45. The difference was in the ratio of the green to blue phosphors in the tube. The number should be printed on either the tube or the casing, unless it has worn off. If you have a W55, use a Wratten CC10 plus CC05 green gelatin filter. If you have a W45, use a CC30 green gelatin filter. Alternatively, use a Roscolux Cinegel R3315 (W55 tube) or R3304 (W45 tube), see Material Sources.

Multiple-Contrast Printing with VC Paper

The ability to use a variety of different contrast filters to make a print gives photographers control of both the overall and local contrast of a print.

The concept and practice are deceptively simple. A base exposure is made with a single filter for overall contrast, particularly in the midtones. Then the shadow areas are burned in with a higher-contrast filter and the highlights are burned in using a lower-contrast filter.

Another approach is to expose only part of the image with one filter while holding back the rest and then expose the remaining areas with additional filters of higher or lower contrast. It makes no difference whether you begin with the higher or lower contrast areas.

The skill lies in determining which areas of the print require more or less contrast. Every area of a print should be examined to determine how subtle increases or decreases in contrast could improve the quality of the image. After all, it is in the subtleties that we find the difference between a good print and a great image.

With practice, determining the overall density, exposure time, and contrast filter or paper grade is relatively easy. Aesthetic choices arise when it comes to determining local contrast.

Although it is often the case that a single contrast filter will suffice for the entire print, just as often a print may require more or less contrast in local areas. For example, Photo 10.1 is a straight print using a 1½ filter.

In Photo 10.2, an overall exposure was made also using a ½ filter. The window and highlight on the wall were burned in also using a ½ filter. The right-front of the bar and areas under and around the tables, were selectively burned in using either a 1½ or 2 filter.

Photo 10.1 This is a straight print made using a 1½ filter.

Photo 10.2 *The Moors, San Luis Obispo, Calif., 1975.* © Steve Anchell. An overall exposure was made using a 1½ filter. The window and highlight on the wall were burned in using a ½ filter. The shadow areas, such as the right-front of the bar and under and around the tables, were selectively burned in using either a 1½ or 2 filter.

Split Printing with VC Paper

To use split printing, discard all previous notions of contrast grades; they are entirely superfluous when using this method. You create your own contrast, high or low, to the limits of the paper you are using. Split printing can be used with any light source. I highly recommend using split printing with Zone VI cold light heads, as they do not work well with any of the three VC filter sets.

Split printing requires the use of two filters: a Kodak Wratten 47 or 47B blue filter and a Kodak 58 or 61 green filter for low contrast. An alternative to the Kodak filters would be a Roscolux Cinegel R80 Primary Blue and R91 Primary Green, see Material Sources. With a tungsten light source, you can use the lowest contrast filter from one of the three sets, 00/–1, and the highest, 5/5+, or you can obtain additional control by using a 0 or 1 filter to lower contrast and a 3 or 4 filter to raise contrast.

The high-contrast filter is known as the shadow or black printer. The low-contrast filter is known as the highlight printer.

Control of contrast comes from adjusting the amount of exposure for highlights and shadows with the two filters. Once the overall contrast is determined, burning in can be done with any contrast filter.

It is a matter of personal preference whether you begin by printing the shadows or the highlights first. Some printers find it easier to determine the minimum exposure necessary to achieve maximum black (Dmax) before printing the midtones and highlights. Others prefer to determine exposure time for the midtones and highlights first and then add the shadows. Following is an example of printing the shadows first. You may reverse the process and print the highlights first—it's simply a matter of which works best for you.

Shadows First This example assumes the use of a single 47B blue filter and a single 58 green filter.

With this method, the shadow densities are laid in first with the shadow printer—blue high-contrast filter—then the highlights and midtones are printed with the highlight printer—green low-contrast filter.

1. Using the high-contrast filter, determine the correct exposure for the shadows. Choose the minimum exposure in which the deepest shadow areas print as black, Photo 10.3. Note the exposure time.
2. Make a second print using the shadow printer with the same exposure time and leave the paper in the easel.

Photo 10.3 Shadow Printer. Using the high-contrast filter, determine the correct exposure for the shadows.

Photo 10.4 Highlight Printer. Once you have determined the best exposure combination of highlight and shadow, make any adjustments to one or both exposure times and make the final print using first the shadow printer and then the highlight printer.

Author's Note: Cover the exposed paper with a piece of cardboard so that it is not fogged by the safelight. Be careful not to move the paper.

3. Remove the 47B blue shadow printer and replace it with the 58 green highlight printer.
4. Make a step test on the paper using the highlight printer. Develop the print.
5. Determine the best combination of highlight and shadow densities and make any adjustments to one or both exposure times.
6. Make a third and final print with the chosen times for each, Photo 10.4.

MANIPULATING EXPOSURE AND DEVELOPMENT

Subtle control over contrast can be gained by manipulating the exposure, contrast grade, and development time. Increasing the contrast grade or filter and shortening the development time will have the effect of maintaining a solid black while not allowing the highlights to overdevelop.

A different effect can be gained by slightly underexposing the print once a correct time has been determined for the highlights and then overdeveloping.

In this case, the contrast grade may not have to be altered. Depending on the paper, fiber-based (FB) papers have a useful range of 90 seconds to as much as 5 minutes in the developer. Resin-coated (RC) papers have a range of about 45 seconds to 1½ minutes. Within the paper's useful range, slight increases in midtone separation can often be achieved.

Dry Down

FB paper swells when it is wet. This includes the gelatin emulsion, which absorbs liquid. The result is that the wet image looks brighter in the highlights and exhibits more detail in the deepest shadows. When the print dries, the contraction of the emulsion causes the highlights to lose their brilliance and the deepest shadows to lose detail. The perfect print you made the night before will be too dark with muddy highlights in the morning.

The only way to avoid the morning after dry-down blues is to reduce the final exposure time between 8% and 12%. Just how much can be determined with an easy test. Each paper you use should be tested as the test is paper dependent and not affected by processing solution or temperature. The size of the print doesn't matter either. A specific gelatin emulsion will swell the same regardless of size. Unless the manufacturer changes the paper formula you should not have to test again.

Dry Down Test Make a print that looks great while it is wet; fix and wash. Don't dodge or burn—it will only confuse the results. Make a second identical print. While the paper is still dry use a soft lead pencil to mark the back of the first print #1 and the back of the second print #2. If you forget to do this while the paper is dry, simply cut a corner of the first print. This print will be used as the control print.

Make three additional prints from the same negative using –8%, –10%, and –12% less exposure, fix, and wash. Be sure to mark the reduction percentage on the back of each print. Leave print #1 in the wash water and force dry the other four—including print #2. A microwave oven works well for this purpose.

Author's Note: If you don't have a means to dry the prints quickly, then dry all five, including the control print #1. When it is time to compare the prints, resoak the control print for at least 10 minutes to reswell the emulsion—do not rewet the other prints.

Compare the wet control print #1 with the dry print #2 to see the full effect of dry down for that paper. Then compare the three dry test prints, –8%, –10%, and –12%, with the control print. A good way to do this is to place the test prints, one at a time, between the original wet print, #1, and the #2 dry print. The wet print can be removed from the water bath and placed in a dry tray or on a piece of Plexiglas in the sink.

The dry down factor is the percentage of the paper that matches the original print when placed side by side. From then on, apply this percentage when making the exposure for the final print.

Author's Note: RH Designs Stop Clock Pro timer has a built-in percentage calculator, though you must determine the dry down percentage for each paper using the method above.

LITH PRINTING

Using high-contrast lithography film developers for paper development can lead to interesting and unusual results. Depending on the paper and developer used and development time, the print can be warm tone, cold tone, or a combination of both. According to Tim Rudman in *The Photographer's Toning Book*, "Because of the way in which lith developers work by infectious development, the print can have well-developed cold-tone, coarse-grain, high-contrast shadows alongside very warm-tone, fine-grain, low-contrast light and mid tones."

Lith printing, as it is called, has its own unique technique, somewhat different than straight full-tone printing, and the only way to master the technique is to practice it. With careful note taking and observation, lith printing is a repeatable process—as Daughtee Rogers would say, it's not how you achieve the result, it's being able to repeat it. Even so, you will find there is a learning curve during which you will have both a high degree of failures and happy accidents that can't be repeated.

Most formulas for lith film development, such as Kodak D-85 (Kodalith), contain formaldehyde, a toxic chemical. Others, such as Defender 15-D, contain sulfuric acid. Should you prefer to avoid mixing chemicals such as formaldehyde and sulfuric acid, Freestyle Photographic Supplies makes a premixed formula, Arista Lith Developer. In addition, good results can be obtained by using a high-contrast paper developer, such as Agfa 108 or Edwal 120, or a high-contrast film developer such as Kodak D-19. You can also try Clayton Harley's Lith Developer for Fogged Paper, Chapter 9: Saving Outdated Paper and Negatives.

Agfa 108, Edwal 120, and Kodak D-19 are highly energetic. Use a dilute solution. With Agfa 108 and Kodak D-19, start with a 1:1 dilution. Increase the dilution if needed. With Edwal 120, mix solution A and B and then dilute the working solution 1:1 or higher until you find a dilution that works for you.

It's not the paper, but the developer that makes a lith print. Start by heavily overexposing the paper; usually +2–3 stops are good starting points—Clayton Harley recommends as much as 5 stops, see Chapter 9. Developing times are usually from 5 to 9 minutes. As long as the paper is completely submerged and not floating on the surface, you can use minimal agitation. Closely watch the print in the developer and pull it before it appears to be completely developed—keep careful note of the development time so you can repeat your result.

BATCH DEVELOPING MULTIPLE PAPERS

To state the obvious, there are two sides to photo printing paper: the white base and the emulsion side. Two wet emulsions will not adhere to each other, but the white base will adhere to whatever it comes into contact with: the base of another print or the emulsion. We are only concerned with the emulsion side—we don't want it to adhere to the base or development will not evenly occur. You may, however, develop, stop, and fix as many prints in one tray as you can handle if you have sufficient volume of solution to keep them all submerged and make certain that one back always faces another back and one emulsion faces another emulsion. I call this "back-to-back and face-to-face."

Lith Print. Donna at Meteor Crater, 1994. © Steve Anchell. All rights reserved. Unfortunately, the *DCB* is only printed in black-and-white so you can't see the beautiful brown tone on this portrait.

Photograms

Kimberly Schneider

Many photographers would love to print from home but don't have proper darkrooms, so give up on the idea. However, what they don't realize is that there are quite a few ways to make handmade photographs, both with or without the use of a camera and without a proper darkroom.

Some photographers may wonder how an image made without a camera can be considered a photograph. However, the definition of photography essentially translates to drawing with light, which doesn't necessarily require a camera to achieve.

Just What Is a Photogram?

For those not classically trained in photography, the notion of a cameraless photograph may seem confusing. To clarify, a photogram is a photograph that you essentially build yourself. Rather than exposing film, you place materials directly on top of a light-sensitive surface and expose it to light. You then process the resulting print as you would a film-based enlargement.

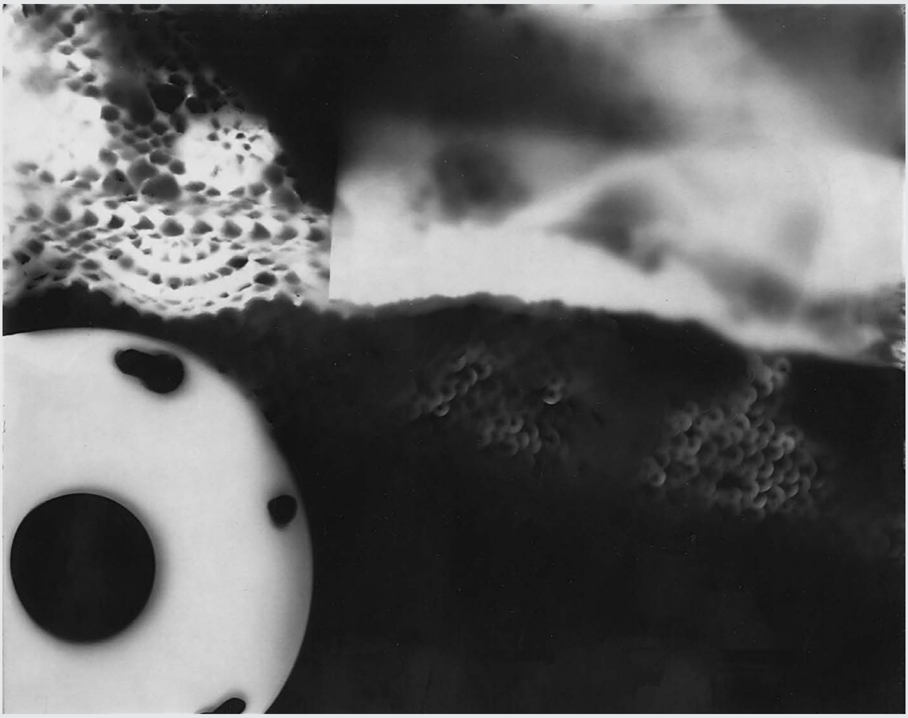
Unlike traditional enlargements, photograms are one-of-a-kind prints; once you make a photogram, that's it, it's done. The process cannot be duplicated, though the original can be copied for reproduction. However, you'll learn from both your successful photograms and your mistake prints—and many of your mistakes will turn out to be some of your strongest images.

It takes time, patience, and an open mind to learn how to consistently make strong photograms. However, it's a really fun process once you get used to the freedom of this type of printing. Before I explain how you can make your photograms, I want to make sure you understand that with each new variable, there is a new learning curve. Thus, it's best to start simple.

Creating a Workspace

Let's start with light sources. Don't have an enlarger? Not a problem. Those who wish to make more traditional-style photograms may wish to take inspiration from one of the masters; Edward Weston made his contact prints with a lightbulb that was fixed to the ceiling. You could hang a bulb from the ceiling with a drop cord, or you could find a fixed light source around your habitat that works for you. For example, set up a printing table so that the ceiling light is unobstructed and use the light switch on the wall.

Those who wish to get a bit more experimental have a myriad of options for light sources, anything from a flashlight to sparklers. The challenge will be learning to improvise as needed in order to make your



Untitled, 2020. © Kimberly Schneider. All rights reserved. One of my first photograms was made with lace, a sequin belt, flowers, and a lens board exposed via flashlight. From the "Ashes" (series), printed June 2020, 8 × 10 inches. Courtesy of Susan Herzig & Paul Hertzmann Collection, San Francisco.

light source work in a way that won't overexpose or underexpose your materials.

While you won't need an enlarger to make photograms, you will need to work out a makeshift wet side to develop your prints. It can be in a bathroom, spare room, garage, shed, anywhere you can make lighttight and have space to work. Running water would be ideal, but you can wing it if you need to wash your prints in another room.

As far as making the room lighttight, blackout plastic, like the black bags your photo paper comes in or black garbage bags should suffice. There are other tricks for light leaks, such as sticking a towel under the door.

If you want to see what you're doing, you're going to need a safelight, but it doesn't have to be anything fancy; there are many perfectly serviceable safelights available, and don't forget eBay. Just be sure to use an amber-colored safelight—not red—and don't have it too close to your light-sensitive material. You'll need to test, but depending on the wattage, 5–10 feet should be about right, see Photo 10.5.

Photo 10.5 Amber Safelight. An inexpensive amber safelight that can be wall-mounted or placed on top of a cabinet near your workspace will allow you to see what you're doing. The Arista Darkroom Safelight, available from Freestyle Photo, is suitable for tabletop or wall mount use. Use an amber/orange safelight for standard black-and-white photographic papers.

You will also want a clock with hands or a timer that you can see in the dark near the area where you'll be printing. An alternative is to use a mechanical metronome, Photo 10.6, and count the ticks. This is a very Zen thing to do.

Materials

Your materials are entirely up to you. Given the learning curve, I suggest you start out with two objects and add more as you feel more confident with their exposures. There are two kinds of objects you can use: those that are transparent, such as glass (colored or clear), and those that aren't, a rock or perhaps a sprinkling of glitter. While you can start with things found at home, in your backyard, or perhaps the local grocery store, finding the right materials that translate your vision takes trial and error.

Further, as you progress, you might find new ways of working with your materials. This can be done before, during, or even after the print has been made. For example, some photographers use textured or rather

Photo 10.6 Mechanical Metronome. This is available online for less than $25 USD. Use it instead of a timer to time your prints.

messy materials that they can literally "work" with their hands, others may opt to adhere materials to the print itself, after it's been made, or even while preparing the print for presentation.

It can take some time for "straight photographers" to get used to the idea that there are essentially no rules when it comes to making photograms; the only limitations beyond the self-imposed and safety concerns are those you place on yourself. The only rule that *almost* all photographers agree upon is don't open the back of your camera before rewinding your film.

Developers

I recommend print developers that can be tweaked with different dilutions as needed. You will also have to pay close attention during development, as some photograms need more time to fully process, while others need considerably less.

With safelight on, place a sheet of the photo paper you will be using, emulsion side up, in an easel, or tape it to the top of your dining room table (or any other convenient flat surface). Then do a step test by exposing the entire paper to 1 second of light, then covering about 1 inch using a piece of lightproof cardboard and exposing for 1 more second. Continue until you have moved the cardboard across the paper in 1-second increments.

Develop the paper. When dry determine where the paper is as black as it will get. That will become your starting time for your initial prints. As you become familiar with your materials and process you will become more intuitive in your approach. Often, photograms that aren't exposed for maximum black become some of your best images, once you become accustomed to recognizing your cameraless prints as unique works of art.

This is Where the Magic Begins

Photograms are the most liberating and purely creative photographic process. There are two methods for making photograms and they can be combined. The first is physical and the second is chemical.

The Dry Method (Physical)

To create a dry method photogram, you place objects on top of the paper and expose them for your basic time. You can use either the left or right brain method. The left brain method (logical) is to carefully arrange each object precisely where you want them. The right brain method (serendipity) is to throw them in the air and see where they land. (Hint: don't use the right brain method for heavy objects that might put a dent in your table.)

Once the objects are in position, expose the paper for the time determined earlier to achieve maximum black (Dmax) and then develop the paper. From that point on, it's all one great creative experiment and having fun.

The Wet Method (Chemical)

With the wet method, place the paper in a large developing tray. Pour, dribble, dab, or developer, bleach, fixer, or toner[3] on the paper. You can let it flow naturally, lift it to drain, or pour more on; there is no limit. Once finished, you can develop the paper or go right to the fixer.

The two methods can be combined by placing objects on the paper, then dripping and dabbling around them with chemicals, flashing with a pen light or sparklers, crumple the paper if you like.[4] There are no rules.

The magic of photograms is that once you gain a basic understanding of how your materials and light sources respond to the paper and the chemistry, the possibilities for how you choose to make your cameraless photographs are nearly endless.

So now you have a way to create without a darkroom or enlarger. I hope that this will give you a way to return to—or perhaps discover the joy of—silver gelatin printing, as well as get you to start thinking about your art in a way that transcends the realm of straight photography.

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[3] Let the toner sit for a minute or more to get the full effect.

[4] See Amanda Means in Appendix 4.

After the Rain (aka Heart in Your Hands) 2022. © Kimberly Schneider. All rights reserved. Mixed process photogram made with ice, spinach, sand, flowers, and more. Triple exposed via LED. “Winds of Change” (series), printed late 2022; begun as a demo print, the series commenced in early 2023, 11 × 14 inches. Courtesy of the Scott Nichols Gallery.

Printing Techniques of Master Printers

> *"The best photographers in the world will be the best printers. But the best printers are not always the best photographers."*
>
> —Ansel Adams

There is more than one way to achieve a fine print, and not all fine printers agree on how it should be done. In the following sections you will find several methods practiced and taught by master printers. Choose the one you like best or combine them to create your own method.

BRUCE BARNBAUM

An Efficient Way to Get to The Final Print

Step #1 Make good contact proofs of all negatives. Make them at very low contrast to get as much information as possible about what is on the negative. Look for relatively flat, low-contrast proofs that are neither too light nor too dark. Be sure you make all contact proofs at exactly the same low-contrast level. Using variable-contrast paper and a dichroic enlarger, I dial in 60 units of yellow filtration, which would be roughly equivalent to the 1½ filter on a Saunders VCCE head.

If negatives vary in density, give more or less exposure to each one in order to get good, readable information. If you are using 2¼ or larger film, the original contact proof should be sufficient. If you are using 35mm, I'd recommend selecting the best ones and making enlarged proofs for better evaluation, perhaps about 3½ × 5 inches.

Step #2 Evaluate the contact proofs carefully. First, note how the contrast level of the contact proof looks to you. If it looks good, then start your enlargements at about that same contrast level. If the proof looks slightly low in contrast, increase the contrast a small amount from that of the proof print. If it looks quite low in contrast, increase the contrast a significant amount. If it looks really dull and muddy, start printing at the maximum contrast level you can on your enlarger. Conversely, if the contact proof looks too high in contrast, lower your contrast accordingly.

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I find that I rarely lower the contrast level from that of the contact proof, but once in a while it happens, so I am prepared for that possibility. Of course, I try to develop each of my negatives so that the print will be printed at no filtration, or white light, on my dichroic head enlarger—equivalent to about a 2½ filter.

Second, look at the contact proof to see if an area is too light or too dark, recognizing that you may have to burn or dodge that area in the final print. Of course, if you plan to raise the contrast level from that of the contact proof in printing, you will have to burn or dodge even more.

Third, see if various parts of the image need different levels of contrast. You may be able to tell that one portion of the photograph will need a relatively high level of contrast, while another portion may need lower contrast.

At this point you've adequately evaluated the contact proof and developed a basic plan about how you want to print the negative.

Step #3 Make a three-part test print. This is not just a tiny strip of the image, but the entire print. Here's how you go about doing this. First, focus the negative at maximum aperture for the size image you want to print. I would recommend starting at 8 × 10 inches even if you want your final print to be 16 × 20 inches. Set your filtration for the contrast level you previously determined in Step #2. Then stop down the aperture to a "logical" level of light.

What do I mean by a "logical" level of light? Well, unless the negative is super-dense, your experience will tell you that the image on the easel at full aperture is too bright, and your exposure will be too short to allow any consistent dodging during the exposure. On the other hand, the minimum aperture is probably too dim for you to see the image. Somewhere between these two extremes is a light level that is not too bright that the exposure is too short but bright enough for you to easily see the image on the easel.

Now guess at the length of exposure you think will be correct. When you are first learning to print, this is a wild guess, but that's okay. Set your timer for exactly half of your guess—if you guess 18 seconds, set your timer for 9 seconds. Then place a full 8 × 10-inch sheet of enlarging paper in your easel and make three exposures of 9 seconds, first exposing about one-third of the print, then two-thirds of the print, then the full print. So now you have an exposure where one part received 50% of your 18-second guess which would be 9 seconds, and the final part received three 9-second exposures—50% more than your guess.

Be sure to get representative parts of the print into each section. Sometimes the three parts should be horizontal sections, sometimes vertical sections, and sometimes diagonal sections. Vary as necessary for best evaluation. Then develop the test print.

Most likely one of the three exposures will be fairly good. If, however, all three are either too light or too dark, close down the aperture or open it up and/or guess a much longer or shorter time for your exposure and try again. Once you get your first decent guess, you will have a good idea of the true "logical" amount of light to look for on your easel. Then for all subsequent negatives look for that same level of light on the easel. For denser negatives, stop down less; for thinner negatives, stop down more, but always get approximately that same logical light level.

If you follow the procedures for this full-size three-part test print, you will soon recognize the logical level of light so quickly that you can dispense with the test print and go directly to the first full print—with burning and dodging.

Step #4 Looking at the best of the three sections of the test print that you made, make another evaluation of the overall contrast level and readjust if necessary. Now go ahead with your first full print, dodging during the basic exposure where you already saw that dodging might be necessary and then burning where it appeared necessary. Any of the burns could be at a higher or lower contrast level than the basic exposure. In fact, there could be two basic exposures: one for a portion of the print that requires higher contrast and another for the part of the print that requires lower contrast, where you dodge the edge of the two separate exposures to meld them together smoothly.

Now, you have made just one test proof and one print, but you probably have already gotten a good basic exposure and good overall contrast and are most of the way toward the proper dodging and burning needed for a final print. At this point make the necessary adjustments and refine the print to your satisfaction.

Keep in mind Ansel Adams's admonition: "Sometimes there is a very small difference between a print that's acceptable and one that's exceptional." Always strive for the exceptional print; never settle for the acceptable one. That final 1% difference could take several more refinements, but following this procedure you can often get to the exceptional print quickly.

Sequoias and Sunburst, 1976. © Bruce Barnbaum. All rights reserved. Courtesy of the artist.

ROD DRESSER

Exposure and Developing Technique for Photographic Printmaking

Most black-and-white photographers are familiar with the axiom for producing negatives—expose for the shadows and develop for the highlights. Why is it such a leap of faith that there is not a complementary process in printmaking? I submit there is, and it is equally valid.

Author's Note: The axiom for creating negatives is to expose for the shadows and develop for the highlights. The axiom for printmaking is expose for the highlights and use contrast control for the shadow areas–either VC filters or paper grade selection.

Here are the steps to accomplish the most efficient and best print results for printing on VC paper:

1. Examine your negative and make a fair judgment as to its contrast. If it appears to be high in contrast, use a low-contrast filter (1, 1½, 2), and if it appears to be lacking contrast, use a higher-grade filter (3, 3½, 4). If you are unsure, start with a 2½ filter.
2. Set up the negative in the carrier and adjust the enlarger to project the desired size on the easel.
3. With unexposed paper in the easel, run a test strip using 2- to 3-second intervals. It is only necessary to make the strips about 1 inch wide.
4. Develop, stop, and fix the test strip for your normal paper development time.
5. Rinse the test strip and examine it under a 75-watt flood lamp about 4 feet away—this approximates normal museum/gallery lighting.)
6. Very carefully select the test strip that indicates the highlights that appear as you want them in your final print, for example, clouds that have full detail but are brilliant. Be sure that you have enough exposures on your test strip so that one is too light and one is too dark on either side of your chosen strip. If not, run another strip, adjusting your exposure time so that your target highlight is between an exposure that is too light and one that is too dark.
7. Calculate the optimum time from the selected strip and make this your base exposure time. An example is if you chose the fifth strip, counting from the lightest strip, and the exposure times were 3 seconds for each strip, your base exposure time is 15 seconds.
8. Make a full print for the base exposure time.
9. Develop, stop, fix, and rinse the print.
10. Carefully examine the print under the inspection light and validate the highlights. If they are too light, increase the exposure time. If they are too dark, decrease the exposure time.
11. When you have achieved the correct exposure time, look at the shadow areas. If they are too dark, the contrast is too high. If they are flat (too gray), the contrast is too low.
12. Adjust the contrast by changing filters and reprint. You may have to adjust the exposure time due to the change in filter density. This may necessitate a number of prints to finalize the perfect exposure time and contrast.
13. When you determine the exposure and contrast combination, compensate for dry down before making your final print.
14. Just remember, make only one adjustment at a time. If you modify both time and contrast and you notice a change, you may not know which adjustment caused it to occur. Be very patient and don't be afraid to use a lot of paper and chemicals. The perfect print is worth it.

Four French Tulips, Carmel, California, 2001. © 2016 Rod Dresser. All rights reserved. Courtesy of the artist.

#2-5041, 1996. © Henry Gilpin. All rights reserved. Courtesy of the artist.

HENRY GILPIN

Changing Print Contrast

Here are several techniques to change the contrast of your prints:

1. Use contrast filters in front of the camera lens (e.g., 11 green, 12 deep yellow, 15 orange).
2. Use plus or minus development times for your negatives.
3. Change the head on your enlarger. Condenser light sources, using collimated light, create at least one grade more contrast than cold light and diffused tungsten.
4. Change your VC filter to a higher or lower number.
5. Change your graded paper to a higher or lower number.
6. Selenium tone your *negative* (1:2 for 3 minutes).
7. Selenium tone your prints—dilution varies depending on the paper used and tone desired.

LES MCLEAN

Pre- and Post-Flashing to Control Contrast

The initial exposure to white light will produce no tone on enlarging paper—it simply eliminates the paper's inertia to light. Therefore, when exposing the paper with a negative in the enlarger, a certain amount of the exposure is not producing tone and, more importantly, detail. Flashing is a method of controlling contrast by presensitizing the paper with an exposure to white light that overcomes the paper's inertia.

When flashing is employed, all units of image-forming exposure passed through the negative will produce tone; therefore less exposure is required. Consequently, because of the reduced image-forming exposure, the lower values are less likely to block up, resulting in better separation in the shadows. At the other end of the tonal scale, the highlight detail is improved because, in effect, the paper is getting more exposure to the image-forming light that produces tone and detail. Because the inertia is overcome by the white-light flashing exposure, all light transmitted through the negative is "working" to ensure that the detail on the negative is recorded on the paper, hence the lowering of overall contrast and the improvement of detail throughout.

I use two terms to describe the light: white light and image-forming light. White light is any source of light that can be used for flashing, for example, an enlarger with no negative in the carrier. However, it is important that you can accurately control the time of the exposure and that the light source will provide consistent illumination. Image-forming light is the light projected on to the baseboard by the enlarger with the negative in place.

A second light source is required, preferably attached to an accurate timer to make the flashing exposure. A second enlarger will do, but I prefer the RH Designs Paper Flasher, which can easily be attached to the enlarger.

Another method is to leave the negative in the carrier and place a piece of diffusing material, such as Opal Perspex under the lens, similar to the procedure used when employing a color analyzer in color printing. However, this method will make the flashing exposures quite lengthy.

Making the Pre-flash Test Strip You can use a full 8 × 10-inch sheet of enlarging paper to make your pre-flash test strip or save paper by cutting a piece into 1 × 10-inch strips. With the paper held flat in an easel, use a black card to cover a 1-inch section of the test strip—this strip will receive no exposure and remain paper-base white.

With a pencil put indicator marks at about 1-inch intervals along the edge of the test strip; 8–10 should be sufficient. Expose the test strip to white light in the same way as you would when making a normal test strip; I use 1- or 2-second intervals. Move the card in sequence through each of the remaining indicator marks, exposing for the chosen time at each one. Process the test strip in your normal way, and after a short wash, dry in either a microwave oven or with a hair dryer. The maximum pre-flash exposure is the one before the step that shows tone. All further exposure tests, as well as the final print, should be pre-flashed prior to the image-forming light exposure.

Controlled Fogging When faced with a particularly difficult high-contrast negative, where the highlights appear to be completely burned out, I use controlled fogging to help print in the detail. Fogging actually puts tone on the paper, whereas flashing simply eliminates the inertia. A correctly pre- or post-flashed and developed sheet of photographic paper will show no trace of tone, but a pre-fogged sheet will clearly have an even gray tone. How then can we fog paper and retain delicate highlight detail and not end up with a degraded, flat image?

How to Calculate the Fogging Exposure To determine the post-fog exposure, I first make the image-forming exposure on a test strip-size piece of photographic paper, ensuring that the paper is placed across the area that requires post-fogging. Next, I cover part of the highlight area with a piece of card to ensure that it receives no fogging exposure—this is used as a reference area after the test is developed. Using my paper flasher, I then expose the test strip to white light in increments of say 3 seconds—you will need to experiment with different times depending on the size print you are making. Develop the test strip, examine it to determine the post-fog step that provides the information you require in the image, then compare with the adjacent area not flashed to see the full effect of the fogging. Having worked out the required exposures using test strips, it is essential that the final print is made in exactly the same sequence.

White Sand Dunes, New Mexico, 1998. © Les McLean. All rights reserved. Courtesy of the artist.

SAÏD NUSEIBEH

Rescuing Thin Shadows

I learned this simple trick from Ruth Bernhard while printing her negative *Rockport Nude*. The figure in Ruth's negative has wonderful midtone and highlight contrast but is very flat in the shadows. It is difficult to retain the contours of the model's exquisitely muscular physique as they recede into shadow.

Ruth suggested I make a series of nonimage, stepped exposures on black-and-white film using the enlarger. These become a group of neutral-density films that, when sandwiched with the original negative, raise important shadow areas off the toe of the paper's responsiveness to light. As the shadow exposure moves into the straight-line portion of the Hurter and Driffield (H&D) curve, the contrast increases, thereby giving more separation to this area than is otherwise possible.

To make the neutral density (ND) films I used a small right-angled jig made from black poster board taped to the baseboard. This allowed me to slip the film repeatedly into the same position under the lens. I did not use a contact printing frame or glass because that would merely provide another opportunity for dust to compromise the result. I also placed a piece of matte black paper under the film during exposure to make sure there were no reflections or stray light striking the film. I made each ND film using 4 × 5-inch Plus-X, emulsion side up, and developed in HC-110 with a weaker dilution than normal. If I were to do this today, I would use T-Max or any other fine-grain, continuous-tone film.

Film requires much less exposure than one is accustomed to in the darkroom. I raised the enlarger to the maximum height and stopped the lens down to its smallest aperture. Ultimately, I was forced to add ND filters to the light path as well. While my timer will make exposure distinctions in the tenths of seconds, I prefer to work in the tens of seconds because I have found that the results are more repeatable.

If you decide to make your own ND films, the problem to watch out for, next to dust, is that the illumination might not be even at the position of exposure. Clean the enlarging lens and carefully scrutinize the results on film in order to identify any irregularities or fall-off in tone. Of course, it is more common to obtain irregular densities via uneven development than from uneven illumination.

Double-check that there is no stray light in the darkroom. This includes light-emitting diodes (LEDs) on timers and temperature control units. Then go through dry runs of the operation because you will be working in complete darkness. You will need to be able to adjust your exposure time for at least a 4-stop range in half-stop increments. I adjusted my setup to enable exposures—in seconds—of 4, 6, 8, 12, 16, 23, 30, 45, and 60.

Test to determine the proper exposure and development to give the first discernible or meaningful density above "film base 1 fog." This can be done with a densitometer or by developing a single sheet of unexposed film with which to compare against. I tested using ND filters under the lens to achieve this density at 4 seconds. Once you have this benchmark, make approximately nine exposures, doubling the time every other exposure. Develop all the films together. Wash, dry, and examine for errors. You should have a nice sequence of ND films with increasing density. Number them 1–9 on the edge of the film so as to have a reference standard to which you can refer. File each film individually in a protective page and keep them next to your enlarger.

To Use

Given a negative thin in the shadows, place an ND film on top of the negative in the carrier. The film should be emulsion side down, as base-to-base would increase the likelihood of Newton rings. Increase the original print exposure slightly to compensate for the increased density.

The lighter films are most appropriate for minor compensations or adjustments, and the heavier densities are useful for moving the weak densities progressively farther off the toe and up onto the straight-line section of the curve. Until you become used to this technique, I recommend starting with a film about three-quarters of the way up the scale.

Photographic detail of carved 7th-century tie beam woodwork in the Masjid al-Aqsa, Haram al-Sharif, Jerusalem. © Saïd Nuseibeh. All rights reserved. Courtesy of the artist.

JOHN SEXTON

Enhancing the Surface Characteristics of Silver Gelatin Prints

This process is the application of steam to the emulsion of air-dried, silver gelatin, fiber-based photographic prints. This procedure has helped me solve countless technical and aesthetic photographic problems over the years.

The gelatin surface of a black-and-white print is amazingly complex and durable, but nonetheless fragile. For most of my own photography, I prefer a glossy surface paper, which I then air dry to a semi-gloss finish. When all goes according to plan, I find this surface to be the most appealing for a majority of the photographs I make. However, for a variety of reasons, this surface can be problematic. The application of steam to the emulsion of the print can help solve many of these surface problems.

In some photographic emulsions, I have encountered great batch-to-batch variations in the surface characteristics of the paper. Though labeled double-weight glossy on all the boxes, when air dried, the surfaces have ranged from a pleasant sheen to a dull matte surface. By applying steam to virtually any smooth surface paper after air drying, the surface gloss can be enhanced or intensified. With some papers, this increase in gloss is not desirable because of the already high surface sheen characteristic of that particular paper. However, when one unexpectedly encounters a box of paper that has a duller surface than usual, this can nearly always be restored to its expected sheen by a brief application of steam. Along with the increase in surface gloss comes a measurable increase in the maximum black, or DMax, of the print.

Please note that you cannot take a matte surface paper and make it glossy by applying steam. That being said, the change in gloss level on some air-dried glossy emulsions can be dramatic. Each type of paper, and indeed each individual emulsion batch, can behave differently.

In addition, when spotting prints—or more correctly unspotting—telltale residue from retouching dyes can sometimes be visible when looking at the print at an oblique angle. Steaming, which micro-swells the upper layer of the gelatin, will allow the print dyes to be absorbed within the surface of the print, thus minimizing or sometimes completely eliminating any surface evidence of the dye's application. Be cautioned, however, that once the dyes are steamed into the surface of the print, they are NOT easily removed.

Steaming does not involve sophisticated equipment. I use a standard tea kettle, with the water brought to a boil. The print is suspended, emulsion side down, 8–10 inches above the steaming spout and moved back and forth for 5–15 seconds, ensuring that all areas of the print are exposed to steam.

***Caution*:** Steam can easily cause severe burns to the skin.

Generally, I make two separate applications of steam over the tea kettle a minute or so apart to help ensure the entire print surface is evenly covered with steam. Normally, I steam prints prior to dry mounting. If this is the case, you will notice that the print will curl vigorously toward the emulsion side during the steaming process and while drying. Turning the print over and giving a brief application of steam to the base side of the print will minimize this tendency toward curling.

Occasionally, I need to steam a dry-mounted print. There is a tendency in the steaming process for the edge of a mounted print to “lift” from the mat board. I find this raised edge mechanically and aesthetically undesirable. If I need to steam a mounted print for some reason, I cut a hole in heavy slipsheet paper the appropriate size of the area that I want to steam. I then cover the entire mount with the slipsheet mask and apply steam only to the area that needs treatment. This will immediately regenerate the surface gloss of the print without exposing the edges of the mounted print to steam.

I understand that fabric steamers, which are used for taking the wrinkles out of draperies and garments, can be used as well, though I have no firsthand experience with them.

Remember: As is the case with any new procedure, be sure to test-print steaming on unimportant prints before trying to enhance one of your “masterpieces”.

Black Oak, Fallen Branches, Yosemite Valley, California. © John Sexton. All rights reserved. Courtesy of the artist.

MICHAEL A. SMITH

On Printing and Why There is No Such Thing as a Difficult Negative to Print

Author's Note: This is an expanded version of the article that originally appeared in the May/June 1998 issue of *View Camera* magazine.

Atchafalaya Basin, Louisiana, 1985. © Paula Chamlee. All rights reserved. Courtesy of Paula Chamlee/Lodima Press.

In the best of all possible worlds, all exposures would be perfect—neither over nor under exposed, and all negatives would be developed for the right amount of time. All negatives would then print on a normal grade of paper, require a standard amount of exposure, and require no dodging or burning-in. Perhaps I don't know the right people, but I have yet to meet a photographer who lives in that perfect world. Even those who have done seemingly interminable testing and refining of exposure and development techniques often have negatives that require extensive dodging and burning-in.

Although I only make contact prints on azo and develop them in amidol, and although some of the things I do while printing are specific to the materials I use, it will be easy for those who make enlargements to adapt my approach to their materials. Outside of making perfect negatives every time, there are two main ways to ensure that all your negatives will be relatively easy to print. One is to use a metronome to time exposures. The other is to use the method I call "outflanking the print." Both are explained here in detail.

Michael A. Smith, 1992. © Paula Chamlee. All rights reserved. Courtesy of Paula Chamlee/Lodima Press.

On Metronomes and Why Using One to Time Print Exposures is Absolutely Essential

In 1970 I was printing my first portfolio and trying to make 25 identical prints from each of 12 negatives. One print, even though it was a straight print that required no dodging or burning-in, would not print the same way twice in a row. Consistently, some prints were lighter and some were darker. At that time, I was using a Gra Lab timer to control the exposure for my prints—a timer that shut the light off automatically. Since I had a voltage regulator connected to the light source, I couldn't figure out what the problem was. At some point, I thought the only possible cause had to be that the timer was not shutting the light off at the same instant each time. I had previously read that Ansel Adams recommended using a metronome to time print exposures, but I had thought that the ticking would drive me nuts, so I never bothered to try one. But now, in my frustration with this print, on a Sunday night I drove 50 miles to a friend's house, borrowed an electric metronome, drove home, and went back into the darkroom.

I covered the print with a card, turned the light on, and then pulled the card away to begin the exposure. When the time was up, I quickly placed the card between the light and the paper. To my relief, the prints started coming out exactly alike. Every print I have made since that night has been timed with a metronome. It was, however, not until I printed some seemingly difficult negatives, ones that required significant amounts of dodging and burning-in, that the real value of using a metronome became apparent.

When using a metronome to time prints, the light is turned on before the exposure begins and is left on throughout the entire exposure. It is important that the light not turn off automatically so that its intensity is always at its peak. An opaque semi-stiff card is used to cover the paper and to begin and end the exposure and to interrupt it when dodging and burning-in. I use "shirt-type" cardboard; it is opaque, stiff enough to lie flat, and flexible enough to bend for use when dodging and burning-in. With the light left on throughout the entire exposure, one's eyes can remain constantly focused on the print. One is not distracted by the need to look away to reset a timer, and one needn't get reoriented to the print as is required when timers shut the light off, even if it is then turned back on automatically. Because one's eyes stay constantly focused on the print, one can concentrate more intensely. When timing a print with a metronome, one can easily do quite extensive and much more precisely timed dodging and burning-in. For example, with the light on for the entire time and the metronome ticking, it is possible to dodge a print for 2 seconds here, 4.5 seconds there, 7 seconds over there, and then to burn-in the same print for a half-second here, 4 seconds there, 9 seconds on the edge, 14.5 seconds in the sky, and so on. Simply by moving the dodging tool or burning-in card, one can easily dodge or burn any area for any multiple of seconds. I have a few prints where I have even dodged and burned-in over 20 places.

This would be almost impossible to do if, after many of the dodges and burns, the timer and the light went off and I had to reset it and then reorient myself and relocate the right spot on the print from which to continue. With a metronome ticking and one's eyes focused on the print, dodging and burning-in goes so smoothly that one seemingly glides from area to area of the print with rarely a pause or a missed beat. There are no wasted seconds.

Shore Acres, Oregon, 1979. © Paula Chamlee. All rights reserved. Courtesy of Paula Chamlee/Lodima Press.

Although most of my prints need relatively little dodging and burning-in, it is still only an occasional print that needs absolutely none, and from time to time some do require a great deal. I have also found that because using a metronome allows for such precise control of dodging and burning-in, bleaching of prints is seldom necessary. I found bleaching necessary on only two occasions, and those well over 20 years ago.

To my surprise, I found that the ticking of the metronome was not a distraction at all. I'm not sure why this is, but my best guess is that because one's eyes never leave the print, a rhythm gets established; the printing experience becomes much more intense, focused, and efficient; and therefore the ticking simply becomes unobtrusive.

Although there are audible electronic timers made for the photography market, metronomes are generally far less expensive. There are two types that should be available in any music store. There is the tall wind-up manual type where one locks the pendulum behind a catch to stop the beat, and there is the electric type that one turns on and off with a switch at the back. It doesn't matter which type you use. I use the electric type. I still have the Gra Lab timer, but now I use it only for timing development and the rest of the print finishing processes.

Outflanking the Print

I never make a test strip and I strongly advise others never to make one. I think that making test strips is simply a waste of time since they do not provide enough information. If one is making contact prints or enlargements that are of a constant size or a couple of constant sizes, one quickly learns the approximate amount of light needed. If one makes test strips, one learns what the correct exposure is, but one doesn't learn how much dodging and burning-in might be necessary. Usually, one goes through more paper figuring that out than if one took the approach I call "outflanking." To use outflanking, look at a negative and based on experience, take a guess at the proper printing exposure. Try to guess it exactly, but hope you are wrong—at least by a little. I have used far more paper when I have guessed the exposure seemingly correctly than when I was off, whether by a little or by a lot. Why this is so I will get to later. If you are wrong in your guess and the print is either too light or too dark, you are off to a good start. Now make a second print so that you are exactly the same distance on the other side of what you think the correct exposure will be. After this, the correct exposure will usually become immediately evident. Ideally, it will fall somewhere near the middle of the two previous exposures.

Here's how this works in practice

Let's say you look at a negative and estimate that it needs a 12-second exposure. You expose it for 12 seconds, but it is too light, and you now think the proper exposure should be 15 seconds. Do not make the next exposure for 15 seconds; make it for 18 seconds—outflanking the print. Now you will have one print that is too light and, hopefully, one print that is too dark. Next, step back and evaluate the two prints. Based on your evaluation of the light and dark prints, make what you think is the proper exposure. At this point do not dodge and burn, even if you know you will need to—the only exception to this is when in the lighter print there are still some areas that are too dark and in the darker print there are still some areas that are too light. Let us say you expose this third print for 15 seconds. Now evaluate this newest print. Because now you also have a lighter and a darker print as well as one that is at least very close to properly exposed, you should be able to easily see if the overall print is a little too light or a little too dark. Perhaps the exposure should have been 15.5, or 16 seconds, or perhaps it should have been 14 or 14.5 seconds. If the exposure should have been 16 seconds, make another print for that amount of time, again without dodging or burning-in. By working in this way, you can readily come to the exact basic exposure.

It is the lighter and darker prints that give you the understanding of exactly how much dodging and burning-in will probably be needed, and it is with the print following the one that has the correct basic exposure, usually the fourth or fifth print, that you begin to dodge and burn-in. By referring to the light print and to the dark print, you can now see exactly where and how much to dodge and burn-in. Had dodging and burning-in been done sooner, it would have been impossible to tell exactly what results were due to the dodging and burning-in and what results were due to the basic exposure—so make sure not to dodge or burn-in until the correct basic exposure has been determined. Working in this manner, ultimately you will save time and paper. Often you will have a finished print by the fourth or fifth sheet of paper—the first one that was dodged and burned-in.

If on the first print you guessed what appears to be the correct basic exposure, almost invariably you are in for trouble. First of all, you get no information as to exactly how much dodging and burning-in may be necessary, and then, you have what you think is the right exposure, but there is often the nagging suspicion that maybe it needs an additional second or a half-second, or on occasion, an additional quarter-second—easy to time with a metronome. And so, you make another print, let's say for a second more. And lo, it is better, a bit richer perhaps. Now, what would happen if yet another half-second were added? If you try that, you may end up thinking that an additional second is what it really needed, not an additional half-second. And conversely, if you add an additional second, sure enough you will think it only needed an additional half-second after all. Had you outflanked the print in the first place, usually you will not have to go through all of that and ultimately you will use less paper rather than more.

Since using a metronome and the outflanking method, I have concluded that there are no difficult negatives to print. Sure, some prints do need more dodging and burning-in than others, but by timing them with a metronome, that part is always easy. It is rare indeed that I cannot make five prints from a new negative within an hour, and usually it takes less time than that. And it is not because my negatives are always perfectly exposed and developed.

Processing Procedures

To anticipate questions about the rest of the printing process, here are my procedures for processing archival prints.

Developer: I use amidol, which I sometimes use in conjunction with a water bath and recommend it for printing with nearly all papers. See Table 11.1 for my amidol formula.

Stop bath: I use 28% acetic acid that I dilute from 99% glacial acetic acid. Glacial acetic acid is potent stuff. I do not dilute it in the darkroom. I go outside. Even then it is wise to use a respirator or safety mask of some kind. **For use:** For 8 × 10-inch prints I use 100 mL of 28% solution in a half-gallon of water in an 11 × 14-inch tray. For larger prints in larger trays, I use 200 mL in 1 gallon of water. The prints need not be in the stop bath for longer than 10–15 seconds. That is sufficient time to neutralize the alkaline residue carried over from the developer so that the fixer will not be neutralized too quickly.

Fixer: I use a fixer without hardener—straight sodium thiosulfate prismatic rice crystals mixed 32 ounces by volume to 1 gallon of water. I mix 10 gallons at a time as a stock solution. For 8 × 10-inch prints I use a half-gallon in an 11 × 14-inch tray. For 8 × 20 or 18 × 22, I use 1 gallon in larger trays. I use two fixing baths. In the first fixer tray I add 25 grams of sodium bisulfite to each half-gallon of fixer. Sodium bisulfite is acidic and buffers the sodium thiosulfate, keeping it from getting cloudy. The fixer in the first tray is the same as the one that was in the second tray from the previous printing session, but now with the sodium bisulfite added. In the first fixer, I fix for a total of 4 minutes. But after the first 30 seconds I turn on the viewing lights and evaluate the print. A gallon of fixer in a tray easily lasts for an entire printing session, well over 40 finished 8 × 20 prints, which means, on average, about 70–100 sheets of paper.

Table 11.1

Michael A. Smith's Amidol Paper Developer

	8 × 10	*8 × 10*	*16 × 20*	*20 × 24*
Water	1000 mL	1500 mL	3000 mL	4000 mL
Sodium Sulfite	30 g	45 g	90 g	120 g
Citric Acid	3 g	4.5 g	9 g	12 g
Potassium Bromide 10% Solution	2–3 mL	4–6 mL	8–12 mL	11–15 mL
Amidol	8 g	11 g	20 g	24 g

Holding bath: After prints are fixed, they go into a holding bath—a large tray with water circulating through a Kodak tray siphon.

Second fixer: At the end of the printing session, the prints are finished in batches of up to 15 prints. One gallon of fixer is always used to provide enough depth of solution. The prints are shuffled in the second fixer, which is plain sodium thiosulfate—no sodium bisulfite is added. The time for this is also 4 minutes.

Why a second fixer is necessary: In the first fixing bath, the unexposed and undeveloped silver halide molecules are removed from the surface of the print and become free in the fixing solution. As they build up in the solution, they get reabsorbed by the paper fibers. These reabsorbed silver halide molecules are extremely insoluble in water and so they must be removed by using a second fixer. I have always thought that fixer was misnamed and that it should have been called "remover" to describe more accurately what it does.

Toner for archival permanence: The prints go directly from the second fix to the toner, which consists of Kodak Rapid Selenium Toner® (RST) diluted in a gallon of working hypo clearing aid (HCA). The prints are shuffled in this bath for 3 minutes. For Azo, I use only 1 ounce of RST to a gallon of water.

First wash: After all the prints have been toned, I begin timing the first wash. The prints are washed for 30 minutes, followed by a treatment in HCA. But wait a second, wasn't there HCA in the toner? Yes there was, but one of the constituents of RST is sodium thiosulfate, and I want to make sure it is out of the prints as much as possible before the final wash. HCA changes the thiosulfates, which are relatively insoluble in water, to sulfates, which are much more readily soluble in water. Again, the prints are shuffled in batches of at least 15 but occasionally more for 5 minutes.

Final wash: I wash prints for 1 hour in an archival print washer that keeps the prints upright and separated. The prints are then squeegeed on both sides and placed face down on nylon drying screens.[1]

A Note About My Approach to Making a Print

The feeling one has while photographing is determined by myriad factors. The physical reality before you—the very real three-dimensional space, the light, the colors, the sounds, the smells, the weather—are all major factors. Of the others, some are more or less stable, such as one's worldview and the general state of one's psyche and health. Other factors are more fleeting, such as the time you have available—it is hard to be calm and contemplative when rushed, whether by quickly changing light or the need to be somewhere else—the other people who may be present, your dreams from the night before, or a conversation you may have just had. All these factors contribute to determining your mood, which in turn may affect how you feel about what is before you.

Realizing the absolute impossibility of trying to create for others and to re-create for myself, in a two-dimensional black-and-white photograph, the

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[1] A 16 × 20-inch or 20 × 24-inch piece of ¼-inch white Plexiglas is ideal for squeegeeing prints on.

feeling of the multifaceted experience of having been at the scene photographed, my goal when making prints is simply to try to make the best print I can and thereby to provide, both for myself and for the viewer, a new experience—one of the photograph itself.

As an artist, I am responsible for every square millimeter of the print, in the same way that a composer is responsible for every note, or a poet is responsible for every word. I try to make my prints so that all parts are of equal importance, and I do not feel they are successful if the viewer's eyes are not somehow involuntarily compelled to navigate to every part. Therefore, the dodging and burning-in I do is not to make elements stand out, but to have them cohere into a unity.

Part 4

After Processes

12

Stop Baths and Fixers

> *"I don't think there's any such thing as teaching people photography, other than influencing them a little. People have to be their own learners."*
>
> —Imogene Cunningham

Author's Note: For an in-depth study of stop baths, fixers, and fixing refer to Chapters 12, 13, and 14 of *The Film Development Cookbook*, second edition.

STOP BATHS

It is important to provide a buffer between the developer and the fixer. If the fixer is contaminated with the developer, it will rapidly exhaust. Maintaining the fixer's activity is of utmost importance to the longevity of negatives and prints.

The reasons for using an acid stop bath are to stop development as quickly as possible and to prepare the film or paper for immersion in an acid fixer. Conventional unbuffered stop baths can take anywhere from 30 seconds to 1 minute to completely arrest development. To completely stop development in less than 30 seconds with modern films, it is necessary to use a buffered stop bath see the Formulary: TS-7 Buffered Stop Bath.

A buffered stop bath will also minimize emulsion swelling and eliminate the possibility of pinholes in the emulsion. Pinholes occur when sodium carbonate, one of the most used alkalis in film developers, comes into contact with acid. This causes the release of carbon dioxide gas, which can cause blistering in the emulsion of the negative. The problem appears as a pinhole, usually in dense areas of silver deposits such as the sky.

Most of the problems associated with stop baths have to do with film development, even though they can also affect paper. This is because they are not as apparent with paper and because paper can be visually monitored and pulled when the desired density is reached. For example, pinholes occur in paper as well as in film, but cannot be seen.

With the exception of TS-7 buffered stop bath, all of the stop baths given in the Formulary are unbuffered.

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Citric acid stop baths have increased in popularity, largely because they do not smell as strongly as acid baths. Their effectiveness is about the same as a conventional unbuffered stop bath, meaning that when fresh, development will be arrested between 30 seconds and 1 minute.

With the exception of processes such as wet plates that require rapid cessation, there is no reason to use acid stop baths with modern emulsions. Instead, substitute a 1-minute running water bath between the developer and fixer, for both film and paper. If running water is not available fill the tray or tank with fresh water, agitate for 20–30 seconds, dump, and repeat three times before moving to the fixing bath.

A running water bath does not stop development in the same way as an acid stop bath—it will just slow it down to the point where the amount of residual development is insignificant. It does this by diluting the developer so that it rapidly exhausts in the highlights but continues to develop in the shadows.

A water bath always maintains the same pH—it never exhausts like a stop bath, so the time it takes to fully arrest development will always be constant, whereas as acid stop bath ages, the time it takes to completely stop development increases and cannot accurately be monitored, even with an indicator dye. Using a water bath means that testing your film for development time will result in slightly shorter and more accurate development times.

If you still prefer to use an acid stop bath, the most widely used formulas call for acetic acid in a 1–2% working solution. Other chemicals that have been used to make stop baths are boric acid, citric acid, and sodium bisulfite. As noted, citric and boric acid don't arrest development faster than a water bath, and sodium bisulfite is virtually useless with modern emulsions.

Chrome alum and potassium salts, such as potassium metabisulfite or potassium sulfite, should not be used. Both can cause green stains on some enlarging papers. In addition, the introduction of potassium salts into a fixing bath can convert the bath to potassium thiosulfate, which is nearly inactive as a fixing agent.

Prior to WWII, German companies formulated many stop baths using potassium salts, as they were less expensive than sodium—Germany was in a depression, as was the rest of the world. Subsequent research revealed the problems associated with potassium salts in stop baths, and its use was discontinued. Unfortunately, there are still some old pre-WWII formulas floating around.

FIXERS

The fixing process for paper and film is similar, but film and paper have their own unique characteristics and requirements. In brief, the fixing process is the removal, after exposure and development, of unused silver halides, such as silver bromide, from the paper or film. This is necessary because unused silver bromide particles will eventually ruin the image. For this reason, proper fixation is as important to the print-making process as proper development. Proper fixing can make the difference between an image of lasting value and an image that doesn't last.

The fixing process involves a series of chemical reactions in which the silver bromide is converted into complex argentothiosulfates, which are then dissolved by contact with fresh fixer and finally washed out of the film or paper. Upon immersing an emulsion—film or paper unless otherwise noted—into fixer, the first reaction is the conversion of unused silver bromide into an insoluble but not very stable compound. This compound can be seen by looking at negatives—not prints—after only a few seconds in the fix. The emulsion side will appear milky in appearance. If fixation is not continued and the compound not completely dissolved, the negatives will rapidly degenerate.

As fixing progresses, the complex compound reacts with fresh hypo to form a soluble compound of *sodium* argentothiosulfate that can be removed by washing. In other words, fixing creates by-products; more fixing eliminates them. The actual rate of fixation is relatively fast. It is the breaking down of by-products—complex argentothiosulfates to soluble sodium argentothiosulfate—that takes time.

Until the 1970s, the primary agent used for fixing was sodium thiosulfate (hypo). Other fixing agents, though not as commonly used, include ammonium thiosulfate, alkali thiocyanate, thiosinamine, cyanide, sodium sulfite, ammonia, thiourea, and concentrated solution of potassium iodide. Except for special purposes—for example, ammonium thiocyanate can be used to achieve fixing times of a few seconds, see Formulary: Fixers: Defender 9-F Rapid Thiocyanate Fixer—only two fixing agents are of interest to the general darkroom worker today: sodium thiosulfate and ammonium thiosulfate.

There are two differences between the two thiosulfates. The first is fixing time. According to Pierre Glafkides, in *Photographic Chemistry*, vol. 1, ammonium thiosulfate is 4 times faster than sodium thiosulfate, although this may be overly optimistic, as other sources suggest 2–3 times. For this reason, fixers based on ammonium thiosulfate are generally known as rapid fixers.

The second difference is that the buildup of iodide precipitating out of the emulsion increases the time it takes sodium thiosulfate to fix the emulsion. Ammonium thiosulfate is far less sensitive to iodide. Whenever possible, it is recommended to use ammonium thiosulfate fixers. This does not apply to alternative processes, as it has been found that with older processes and hand-coated emulsions, sodium thiosulfate hardening fixers should be used. Kodak F-5 is recommended with increased washing times due to the use of potassium alum.

At some point, ammonium thiosulfate wrongly gained a reputation for producing less-than-permanent images. It was also difficult to obtain. For that reason, many photographers added ammonium chloride to their sodium thiosulfate bath, approximately 50 grams per liter. This had the benefit of making the fixing bath 2 times faster. This is still viable should you have difficulty obtaining rapid fixer.

Today, ammonium thiosulfate is readily available as a 60% solution. There is a powdered form available, but it is rarely used, as it is not considered to be stable and is expensive. Avoid using ammonium thiosulfate anhydrous, as it will absorb water; only use the monohydrate form.

Types of Fixers

There are three general types of fixing baths: plain (or neutral), acid, and alkaline. A plain fixing bath is one consisting of sodium thiosulfate in water only. A plain bath can be easily mixed by adding 2 pounds of sodium thiosulfate crystals to 1 gallon/4 L of water. When using the crystalline form of sodium thiosulfate, begin with water of at least 90°F/32°C, as the temperature will drop considerably.

Plain Hypo Bath A plain hypo bath is often used prior to toning and sometimes as the second bath in a two-bath system. It has a short tray life and is not efficient at neutralizing alkali brought over from the developer. Used as the first bath with paper, see Fixing Paper in this chapter, or as the primary bath for film, a plain hypo bath may cause stains and other problems. For these reasons, it is not considered suitable for general applications or as a first bath.

Acid Fixers Until relatively recently in the history of darkroom practice, most fixers were of the acid type. Acid fixers are made by adding acid to a plain hypo bath. Not just any acid can be used as many would decompose the hypo and precipitate sulfur into the bath. Weak organic acids, like acetic acid, can be used, but only in combination with sodium sulfite to produce sulfurous acid in solution. Sulfurous acids can be used, but they are not stable in solution; sodium metabisulfite is more stable. Bisulfites can also be used and are more reliable.

Alkaline Fixers Alkaline fixers, especially those compounded with ammonium thiosulfate, are the most efficient and effective with modern emulsions, both film and paper. Although they have been used for scientific purposes since at least the 1930s, at the time of publication of *The Film Developing Cookbook* in 1998, the only commercially available formula was Photographers' Formulary TF-4. The formula for TF-3, a fixer with similar properties, is given in the Formulary.

There are numerous advantages to using alkaline fixers:

- Shorter washing times. Paper fibers are akin to the fibers found in clothing; the reason most soaps are alkaline is that they wash out more readily from clothing fibers. Likewise, alkaline fixers wash out more readily from paper.
- No hypo-clearing agent (HCA) is required when using an alkaline fixer.

- No acid stop bath is required when using an alkaline fixer. In order to preserve the alkalinity of the fixer, an acid stop bath should not be used.
- Greater working capacity than acid fixers.
- Both sodium thiosulfate and ammonium thiosulfate are more stable in an alkaline solution.

In addition to these advantages, keeping the process alkaline or neutral from developer to fixer will improve the permanence of the material, as the thiosulfate will not mordant to the silver image or base.

Hardener for Film Film hardener serves several useful purposes. For one, it helps adhere the gelatin emulsion to the film base. It also helps to keep the emulsion from swelling during development. Another is it prevents reticulation from occurring when there are more than a few degrees of temperature variation between solutions during development. Another is that it protects wet film from scratching, especially when it is removed to be hung for drying.

Older-style films, such as discontinued Ilford HP3, contained minimal hardener in their emulsion. They were easily abraded, and reticulation was common. Modern technology has improved hardeners, and modern films are often overhardened so that they can withstand high-temperature machine processing.

Alkaline fixers do not require hardener, and none should be used. Adding hardener to an acid fixer is usually a good idea if it doesn't already have one. This is because acid, unlike alkaline fixers, cause the emulsion to swell and the print or negative is more easily damaged. Even so, hardener in the fixer doesn't help where most of the scratches occur: the developing bath when tray-developing sheet films.

Scratches on Film Both acid stop baths and fixers can increase swelling of film and paper emulsions, making them more susceptible to scratching. Using a neutral running-water stop bath and an alkaline fixer will help prevent this.

Avoid using a squeegee that runs down both sides of a wet roll of film at the same time, such as the popular sponge squeegees. Instead, agitate the film in a wetting agent for 1 minute by gently sloshing it around in the tank or tray. After hanging the film to dry, run a soft-bladed single-sided squeegee dipped in wetting agent down one side of the film, then down the other applying little or no pressure. Wetting agents are surfactants that work like highly viscous soap, facilitating the rapid removal of water before it can dry, leaving spots on the negative. Do this one time only on each side of the film to minimize contact with the emulsion, which is still in a delicate state, until it is dry.

If you are still experiencing scratches on film or paper, it may be a result of minerals in your tap water. Try mixing your developer and fixer, either acid or alkaline, with distilled water to further minimize swelling and to avoid minerals in the water.

No Scratch

One of the most effective methods for making scratches on negatives disappear is nose grease. Rub both sides of the negative across the tip of your nose—this will eliminate all but the worst scratches. I have never had much luck with commercially available anti-scratch solutions. Nose grease works better.

Hardener for Paper It is not necessary to add hardener to fixer for paper unless you habitually experience scratches on the print emulsion; even then, adding hardener to the fixer only protects the print in the fixer. Careful handling of wet paper will help avoid scratching.

If being careful doesn't work, you can try adding hardener to the fixer starting with one-third of the manufacturer's recommended amount and increase in one-third increments until the problem is eliminated. For example, if the directions call for 45 mL of hardener, start with 15 mL; if the problem persists, add another 15 mL. Don't exceed the manufacturers maximum recommendation.

Author's Note: Hardener should only be added to acid ammonium thiosulfate rapid fixers. Sodium thiosulfate fixers are either formulated with hardener or they are not, and if not, there is a reason, and it should not be added.

The reason *not* to add hardener to photo paper is that it makes it more difficult for fresh fixer to penetrate the surface of the paper emulsion. The two most noticeable results are that fixing time is extended, hardener inhibits toning, and some toners, such as selenium toner, will have an adverse reaction to hardener, resulting in stains or uneven toning. And while hardener can be added after fixing, it serves no useful purpose of which I am aware.

If hardener has been added it will need to be removed before toning. This can be done through extended washing (not very effective), refixing in plain hypo for 3–5 minutes, or using a dehardener formula, see the Formulary: Miscellaneous: Dehardener. With that said, there is disagreement as to whether dehardener is effective. The only way to find out is to test it with a print hardened in fixer that has been dehardened and toned. If no stains appear and the toning is even across the paper, then the dehardener is working.

Fixing Negatives

A rule of thumb for fixing negatives is to allow at least twice the time required for the clearing of all traces of milkiness from the film. When the initial clearing time has doubled, as determined by periodic testing, it is time to mix a fresh fixing bath, see Determining Fixer Capacity in this chapter.

Fixing Paper

The time-honored method for fixing fiber-based paper, established by Kodak, is the two-bath method. In the two-bath method, two fresh fixing baths are placed side by side. Paper is immersed in the first bath for a predetermined time, drained, and moved to the second bath. If the first bath is fresh, the paper is completely fixed and only trace amounts of fixing by-products are carried into the second bath. There the action of fresh fixer breaks down any residual by-products, which are easily removed during washing. As the first fixer begins to age, increasing amounts of by-product are carried over to the second bath and eliminated there.

The final step is the changing of the baths. After the first bath is exhausted, which is determined by one of the methods described in the Determining Fixer Capacity, it is discarded, and the second bath replaces the first. A fresh bath is mixed to replace the second. According to Kodak, after the third rotation, both baths should be discarded and two fresh baths made. Agitation with this method should be at least 30 seconds every minute.

This method is meant for fiber-based FB papers. Resin-coated (RC) papers should be fixed in one ammonium thiosulfate rapid fixing bath. If the bath is acid, fixing time should be 3 minutes with agitation for 30 seconds every minute. If the bath is alkaline, fixing time should be 1 minute with constant agitation.

The Kodak two-bath method should only be used with ammonium thiosulfate fixers, either acid or alkaline, though neutral to alkaline baths are preferred. This has not always been the case, but the high amount of iodide layered on the top surface of modern FB paper emulsions does not respond as well to sodium thiosulfate. In addition, modern hardeners used for fiber-based papers are more difficult for sodium thiosulfate to penetrate. This translates into longer fixing times in both baths and can lead to by-products being trapped in the paper fibers.

I use the Kodak method with two trays of alkaline fixer. The paper is immersed in the first tray for 1 minute with continuous agitation, drained for 10 seconds and immersed in the second tray for 1 minute with continuous agitation, and then moved to an archival washer for 10 minutes.

Agitation for Film and Paper

Agitation during fixation is critical for both film and paper. It is necessary for the complex argentothiosulfates to come into contact with fresh fixer to break them down. For both film and paper, agitation should be at least 30 seconds every minute.

After one-quarter of the total fixing time has been reached, the film or paper can be exposed to light for examination. For example, if the total fixing time is 3 minutes, the lights can be safely turned on any time after 45 seconds. Even so, with sodium thiosulfate fixers, I prefer to wait a *minimum* of 2 minutes before turning on the lights, and 1 minute with ammonium thiosulfate fixers.

Determining Fixer Capacity

Changing the fixer *before* it reaches exhaustion is critical for the longevity of photographic materials. Ammonium thiosulfate fixers will smell like ammonia when they are fresh, and sodium thiosulfate fixers should hardly smell at all. As a fixer reaches its useful capacity it will begin to smell like sulfur. When the smell becomes noticeable, it is reaching its capacity.

Working dilutions of fixer should not be kept more than 2 months—less if the ambient temperature is over 85°F/29°C. Any fixer, whether stock or working dilution, should be discarded if it turns yellow or a white precipitate appears. This means that sulfur is precipitating out of the solution.

For Both Film and Paper Two methods can be used for testing either film or paper, and a third method can be used with film. Use whichever works best for you.

1. Every manufacturer publishes the capacity of its fixer, which usually errs on the conservative side. Keep count of how many 80^2 inches of film or paper have been fixed. When the manufacturer's recommended limit has been reached, the fixer should be discarded. If the capacity is not known, a safe rule to follow would be 20 rolls of film or 8 × 10-inch sheets of paper per liter/quart (80 per 4 liters/1 gallon) with acid fixer and 25 with alkaline fixer (100 per 4 liters/1 gallon).[1]
2. Using a liquid hypo check is a reliable means to test fixer exhaustion, but *only if you are accurate in your measurements and testing procedure*. The potassium iodide *must* be 10 mL of a 4–5% solution, and the amount of hypo tested should be exactly 100 mL. To create a precipitate, the combined solutions must be shaken; otherwise, the test is prone to errors, see the Formulary: Miscellaneous: Fixer Test Solution.

For Film Only An alternative method for testing fixer for film is to gently agitate a fully exposed undeveloped piece of 35mm or 120 roll of film in fresh fixer and time how long it takes to clear (become transparent). This should be done in normal room light. This will tell you two things: the minimum fixing time and if the fixer is exhausted.

With ammonium thiosulfate fixers, the *minimum* fixing time is 2 times the time it takes the film to clear in fresh fixer. With sodium thiosulfate fixers, the *minimum* fixing time is 3 times what it takes the film to clear in fresh fixer.

With some concentrated formulas such as Ilford Rapid Fixer or Photographers' Formulary TF-4, the film may be clear in 15–20 seconds. Even so, I recommend a minimum fixing time of 3 minutes for all films and fixers, acid or alkaline, except for extremely rapid fixing, such as negatives fixed in Defender 9-F Thiocyanate Fixer. This is not a "scientific" recommendation—it is my recommendation. With alkaline fixers, one extra minute or two of fixing time will not adversely affect the film, and it will help ensure complete fixation as the fixer ages. However, acid fixers will begin to dissolve image-bearing silver

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[1] Most fixers will last considerably longer than this recommendation. However, if not certain, it is better to err on the side of caution.

if the film or paper is left in the bath too long. This undesirable effect does not occur with alkaline fixers.

It is a good idea to test a leader from each *type* of film you will be fixing, as the clearing time will vary for different film types, with faster film taking longer to clear.

By periodically testing the fixer, ideally before each fixing session, the exhaustion rate of the fixer can be determined. When the initial clearing time in fresh fixer has doubled (alkaline fixer) or tripled (acid fixer), it is time to mix a fresh fixing bath.

13

Toning Prints

> *"Surely, it is the result that counts, no matter how it is achieved. A photographer can even become a prisoner of his own rules. Unless he invents new ones, he will soon copy himself, and his work will become sterile and repetitive."*
>
> —Bill Brandt

There are two reasons to tone prints: one is to change the color of the image; the other is for longevity. While some formulas both change the color and protect the image, this is not always the case. For example, prints treated with iron toners, while attaining a rich blue color, often will not last more than a few years.

There is a difference between toning paper and tinting. A toner affects the silver in the print; a tint stains the paper base without affecting the silver. For example, a warm tint can be achieved on many papers by using your morning coffee. After fixing with a nonhardening fixing bath and a brief rinse in running water, immerse the print in cold or warm coffee until the desired brown tone is reached. Finish by washing the print in the usual manner.

Not all papers tone equally well, and color effects can be harder to achieve with some paper/toner combinations than with others. Others may respond well to one toner and not another. The color of a toned print depends on the formula of the toner and its dilution, the paper type, surface, paper base tint, and processing method. This last includes not only the print developer used but also the choice of fixer.

***Caution*:** Toning involves some of the most toxic chemicals used in the darkroom. Please follow standard laboratory safety procedures and use adequate safety precautions, see Appendix 1: Safety in Handling Photographic Chemicals.

POINTS TO REMEMBER FOR ALL TONING PROCESSES

The following points apply to all toning processes:

- Don't exceed your developer's capacity when making prints. A contaminated or exhausted developer can cause image-color variations.
- Do not use an exhausted or overconcentrated stop bath. Stop bath left in the tray overnight will evaporate and become concentrated. This can cause mottling in the base of a toned print. Replace the stop bath frequently.
- Improper fixing is the major cause of stains in toned prints. An exhausted fixing bath contains insoluble silver compounds that will be retained by prints and

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cannot be completely removed by washing. When these residual silver compounds come into contact with a toner, they form a yellow stain that is noticeable in the highlights and borders.

- Prolonged fixing times with *acid* fixers is almost as bad. Prolonged fixing expands the paper and allows the solution to penetrate the base and become trapped. Acid fixer is difficult to wash out and may cause prints toned in selenium or sulfide to turn yellow. Alkaline fixers do not exhibit this characteristic.
- Purple stains can occur in both selenium and sepia toners when prints have stuck together in the fixer. Always keep multiple prints facing back-to-back and emulsion-to-emulsion in all solutions.
- Avoid the use of hardening fixers. Hardening fixers prevent toners from penetrating the emulsion and doing what they are supposed to do. Use plain hypo; Looten's Acid Hypo; Kodak F-24, TF-2, TF-3, or ATF-1 nonhardening rapid fixer; or commercial formulas such as Photographers' Formulary TF-4 or Ilford Rapid Fixer.
- Insufficient agitation of prints, especially during an acid stop bath, can also cause mottling. The mottling will not be evident until the print is toned with a selenium or sulfide toner.
- Thorough washing before toning is especially important, unless otherwise indicated by the formula or process. Residual silver salts and traces of hypo in the paper may cause stains, uneven tones, and fading. Hypo clearing agent (HCA) may be used to conserve water without adverse effect.
- HCA should be used after selenium toning and before the final wash. HCA is unnecessary after most toners unless refixing is indicated—for example, Nelson Gold Toner; partial redevelopment/toning, etc.
- While it is perfectly acceptable to tone wet prints that have just been fixed and washed, the most consistent results are obtained from toning *dry* prints that have been rewet for 5 minutes. This is because the emulsion of a freshly processed print is still in a state of flux. This instability may cause minor variations between prints, even within the same batch. If the prints are to be stored for extended periods *prior to toning*, use proper storage techniques, as you would for any fine print. Prints that have been stored in or around materials that off-gas may exhibit staining.
- It is difficult to wash out toner embedded in the edges of a print. Therefore, when toning resin-coated (RC) paper, keep toning times to a minimum to prevent the solution from penetrating the edges of the paper. If toning times longer than 5 minutes are anticipated with RC paper, use white salon borders of at least 1 inch around the image. The same is true for fiber-based prints meant to be toned for 10 minutes or longer.
- Toned prints should be dried face up on clean drying racks, as many toners will transfer to the screen when placed face down.
- Drying racks should be cleaned often with a solution of household bleach diluted 1:4 with water—wear gloves and use proper ventilation when using bleach.
- If you must dry toned prints with heat, use the lowest and coolest setting. Heat drying may cause a cool color shift in toned prints. You can often compensate by using a more dilute solution of toner and/or toning the prints to a warmer color.
- Use trays made of nonmetallic material such as glass, inert plastic, or hard rubber. The exception would be stainless steel trays.

TONER TEST STRIPS

Each toner/variation responds differently to different paper and developer combinations. For that reason, it is a good idea to make a swatch book for your toning experiments. This can be done using reject prints cut into strips and then toned. Ideally the rejected print should be one that almost succeeded or perhaps a perfect print that has been damaged at some point. In any event, they should be neither too dark nor too light and contain a full range of tones. Fix and wash these prints as you would any other and save them to make toner test strips.

To Make Toner Test Strips

Cut the print into strips. The strips can be horizontal or vertical sections, whichever direction contains the most information.

Place one untoned strip aside for reference.

The second strip is toned for 15 seconds, the third for 30 seconds, the fourth for 1 minute, the fifth for 2 minutes, the sixth for 4 minutes, the seventh for eight minutes, and the last for 16 minutes. If the published formula for the toner calls for a longer initial time than 16 minutes, adjust the test accordingly.

Write on the back of each strip the toner and the time. Keep them in a swatch book for reference.

It is not necessary to make test strips with toners that are meant to tone to completion, such as bleach and redevelop toners—for example, hypo-alum, sepia, etc.—as partial toning will result in an unstable final print.

TONING METHODS

There are two common methods for toning prints. The first is by direct toning without the use of bleach and the second is by bleach-and-redeveloping.

Direct Toners

There are four categories of direct toners:

1. Those which bond an inorganic compound directly to the silver in the image, in effect coating it. These include Kodak GP-1 and GP-2 and Kodak T-8 Nelson Gold Toner.
2. Those that convert the silver image into silver selenide, such as Dassonville T-55 Direct Selenium Toner.
3. Those that replace the silver with another metal. The compounds produced are usually either ferricyanide, as in Dassonville T-5 Copper Toner, or iron, as in Ansco 241. These are also known as replacement toners.
4. Organic dye toners, which penetrate the emulsion and tint the white portions of the paper as well.

Bleach-and-Redevelopment Toners

Bleach-and-redevelopment (B&R) toners bleach the silver to a pale color and then redevelop it to a new color. Most two-bath B&R toners are of the warm-tone sepia/sulfide type, such as Ansco 221. In some formulas, a copper bleach may be used, but this should not be confused with direct copper toners, see Direct Toners in this chapter.

The B&R process converts the black metallic silver in a print into clear silver halide. Once the silver has been reconverted to a halide, the print is *redeveloped* with a toner, a toning developer, or any number of solutions that will cause the transparent halide to reappear, usually exhibiting a warm tone.

Stopping the bleach process when some of the metallic silver is still visible will often create a deeper color than bleaching to completion. However, it is less controllable because the precise moment to pull the print may not be repeatable. Partial bleaching may also create a split-toned effect that may, or may not, be desirable.

The most common bleaching agents are copper sulfate, potassium permanganate, potassium ferricyanide, and potassium or ammonium dichromate. Most B&R toners require a darker print than usual, as there is often a loss of density. However, this is not always the case, as copper bleaches will intensify the print.

Caution: Sodium sulfide in solution smells like rotten eggs. The smell has been known to cause some people to have headaches. Use in a well-ventilated area; outdoors works just fine, as toning does not need to be done in a darkened room. Also, sulfide can damage undeveloped sensitized materials such as films and papers stored in your darkroom. This is another good reason to use sepia toners outdoors.

COLD AND WARM TONES

Cold Tones

One of the best methods to achieve blue-black tones is to use gold chloride. Not only does the gold chloride tone the print to various shades of blue, but it also serves to protect the silver from degenerating.

Gold chloride works in a direct ratio to the amount of silver in the print. In areas where there is no metallic silver in the print, such as clear highlights, the gold chloride will have no effect on the paper.

The following are suggestions for gold toning:

- The most brilliant blue tones will be secured on glossy papers.
- Papers of the slow chlorobromide variety, usually classic-style graded papers, will be more successful for blue toning than fast chlorobromide, usually variable-contrast (VC) papers or bromide papers.
- The paper developer affects the results. Any developer that produces a brownish color by direct development is good for gold toning for cold tones. Dassonville D-3 is a good choice.
- If a fixer with hardener has been used, refix in plain hypo or use dehardener.
- After toning, if the emulsion feels soft to the touch, either reharden the print before drying or be extra careful that the surface does not stick to anything.
- The temperature of the solution can affect the color. Normally the temperature should be around 70°F/21°C, but if the action of the toner appears sluggish, it might help to heat the formula to 75°F/24°C or even as high as 95°F/35°C.
- The higher the contrast of graded paper, the harder it is to achieve a blue tone.
- Wash thoroughly before gold toning. Any appreciable hypo left in the print will create a yellow-brown stain, or the toning will take a long time and not be very good.
- The concentration of the gold chloride affects the brilliance of the blue. Make the formula stronger by using less water or more gold chloride to increase the effect.

Iron Blue Toners Besides the use of gold chloride, blue tones can be achieved using various iron-based toners. These toners often use some combination of ferric ammonium citrate—green is preferred—and potassium ferricyanide (*ferric-* and *ferri-* both denote iron). Iron toners can produce a variety of pleasing blue tones. However, they do nothing to enhance image stability. In fact, some may even lead to early degradation.

A dry, untoned print that looks perfect might be too dark after iron blue-toning because of the intensification effect. If in doubt, make a slightly lighter print with clear highlights.

Warm Tones

At one time, every portrait studio had its own signature warm-tone formula. Many times, the tone was achieved by using more than one toner in a multiple-toning sequence. Often the formula and technique were a proprietary secret of the owner, who disproved the adage, “you can’t take it with you,” as many of them most certainly did.

The easiest method to achieve warm tones is to choose a paper that is susceptible through direct development. These include Ilford Multigrade FB Warmtone, Kentmere Kentona Warm Tone, and Fotokemika Emaks. Though there used to be many more papers of this variety, manufacturers have moved away from making them in favor of neutral-tone papers. While this is a loss to fine-art photographers, warm tones can still be achieved through the use of toners.

One of the reasons there are fewer warm-tone papers today is the ban on the use of cadmium in 1992 due to its environmental concerns. Without cadmium, it is not as easy to formulate a warm-tone paper. It is easier for manufacturers to tint the paper base.

Other Colors and Tones

Copper Toners Many colors and tones can be produced with copper toners, both alone and in combination with other toners. A good one to try is Dassonville T-5 Copper Toner. It can be used for a variety of tones from purple-brown to chalk-red. Another toner, GT-15, uses copper sulfate to produce reddish tones and can also be used in combination with other toning formulas.

Purplish- to Reddish-Brown Tones Purplish to reddish browns are usually the result of using some form of selenium or copper. Ilford-Harman Selenium Toner is commercially available.

The advantage to mixing your own selenium toner is that it is possible to obtain colors not possible with commercial products. The disadvantage is that selenium in powder form is highly toxic, and all three formulas in *The Cookbook* require heating to dissolve the selenium powder, which poses the further risk of inhaling fumes.

For those who wish to mix their own selenium toner, I have included Dassonville T-55 Direct Selenium Toner, Dassonville T-56 Bleach and Redevelop Selenium Toner, and T-7 Flemish Toner.

Warning: Only mix selenium toner in a well-ventilated area or outdoors, and wear gloves and a face mask rated for hazardous chemicals.

Red Tones Red tones can be achieved using a direct toner, such as GT-15, or by combining toners. Try a combination of Ansco 221 Sepia Toner and Blue Gold Toner. Follow the directions published with Ansco 251 Green Toner for washing between processes.

Another combination is to use any sepia or polysulfide toner, followed by toning in Kodak T-26 Blue Toner. Wash the print thoroughly after using sepia or polysulfide toner, then use T-26 as per the directions. The red tone should appear after approximately 15–30 minutes in this solution at 90°F/32°C. This technique usually produces a density loss in the shadows. Start with a print that has higher-than-normal contrast. Cold-tone papers will produce a truer red; warm-tone papers will produce an orange hue.

PROTECTIVE TONING

Even a properly fixed and washed print will form silver sulfide as a result of atmospheric pollutants, such as sulfur dioxide. Unless controlled, these sulfide compounds will occur in a haphazard manner that will eventually degrade or destroy the print.

Two methods can help prevent this from occurring. The first is to convert the metallic silver to either silver sulfide or selenide completely and uniformly across the entire print. Once this is done, further deterioration is no longer possible. In other words, converting the silver to silver sulfide all at one time will protect the image, while allowing the silver to convert haphazardly over time in a random manner will destroy it.

Two types of toners can be used to completely convert metallic silver. The first are sulfide/hypo alum toners. The second are selenium toners such as Dassonville T-55. The sepia/sulfide/hypo alum toners are the most stable, as the selenium toners will only protect the shadow areas, not the highlights, unless toning is taken to completion, in which case the entire print will take on a color/tone that will depend on the paper used.

The second method is to protect the silver by coating it—as opposed to converting it—with another metal, such as gold. There is controversy as to the effectiveness of this second method.

Sulfide/Hypo-Alum Toners

When a print is improperly fixed or the fixer has reached or is near exhaustion, areas of the dry print will convert from metallic silver to silver sulfide, leaving random brown stains. This conversion may take place in a matter of weeks or years.

However, by using a single-solution, sulfur-reacting toner such as Kodak T-1a or polysulfide toner, it is possible to convert the entire print at once. When this is done, the print cannot degenerate any further, and instead of a ruined print the result is an archival print.

With most sulfide/hypo-alum toners, the color will be sepia to deep brown depending on the toner, paper, and developer used. However, polysulfide toner at dilutions of 1:100 has been found to protect most papers with little or no color shift.

Sulfide/hypo-alum toners are reusable and often improve with age. They usually contain a milky-white deposit, the result of sulfurization, which should *not* be filtered but stirred well before use.

The following are suggestions for sulfide/hypo-alum toning:

- While the toned print is still in water, wipe it with cotton to remove any surface scum.
- Use temperatures of around 110°F/43°C to reduce toning times. At this temperature, prints will still take from 15 to 45 minutes to tone. However, RC papers should not be toned at this temperature or for extended time.
- While chrome alum can be used in hypo-alum toners, it is more hazardous to the environment and so potassium alum is preferred.

Warning: Toners are toxic. Wear gloves and a face mask rated for hazardous chemicals.

Selenium Toning

Selenium toner converts silver bromide in the emulsion to selenide. Selenide is impervious to most environmental pollutants. Not only that, but selenide has a deeper maximum black than metallic silver, enhancing the richness of the shadows.

Selenium begins by converting the densest areas of the print, then the midtones, and finally the areas of least density, the highlights. Dilution ratios can vary from 1:9 to 1:39, depending on the toner and paper combination. To determine the correct dilution, make five identical prints. One should be left untoned. The others should be toned for 5 minutes in different dilutions of selenium toner, 1:9, 1:19, 1:29, and 1:39. After washing check the four toned prints against the untoned print to determine the lowest dilution that can be used without a color shift.

Selenium toning should be done after fixing and bleaching. If a nonhardening fixer or plain hypo has been used, the prints may be moved directly to the toner. If not, then the prints will need to be refixed in a nonhardening fixer, such as F-24 or plain hypo. Immerse the prints for 5 minutes, with agitation. After toning, soak the prints in a second bath of HCA, then wash for the recommended time.

Unfortunately, recent tests indicate that selenium is a less-than-perfect archival toner, because in order to be fully effective, the print must be toned to completion, which means lower dilutions (1:9 or less) that will often result in an undesirable color shift over the entire image. In addition, where there is little or no silver on the paper, the paper base is susceptible to environmental pollutants. For more on selenium toning and intensification see Appendix 3, Archival Print Procedure.

Gold-Toning for Protection

The classic formula for gold protective toning is Kodak GP-1 Gold Protective Solution. With some papers, GP-1 will cause a slight color shift. What shift there may be is toward a slight blue-black. With some papers, GP-1 will also improve separation in the highlights.

More recently it has been found that Kodak GP-2 offers more protection than GP-1. Studies by the Image Permanence Institute (IPI) at the Rochester Institute of Technology (RIT) indicate that it may be the thiocyanate present in GP-2, not the gold, which protects the image. The IPI tests also brought into question whether gold toning was effective at protecting photographic materials. Notably these tests were performed in 1988 and only on microfilm, not on paper prints. More recent tests indicate that the IPI tests may not be valid for paper and that the classic GP-2 formula does provide archival protection.

For further discussion on toning for archival quality see Appendix 5: Archival Print Procedure.

OTHER TONERS AND METHODS

Organic Dye Toners

Organic dye toners come in two types: mordant and straight. As carbon-based (organic) dyes do not normally combine with inorganic compounds such as metallic silver, mordant dye toners use a special bleach to convert metallic silver to either silver iodide or silver ferrocyanide that will adhere to inorganic compounds. The dye is deposited in direct proportion to the density of the mordant image. In other words, the more silver that is mordanted, the stronger the final color, see the Formulary: Toners: Two-Solution Dye Toner.

With straight dye toners, the silver is not converted and the dye affects all areas equally. Although straight toning can produce vivid colors, the lack of difference in toner intensity between the highlight and shadow areas tends to create a flat color effect. This can either unify an image or make it visually dull. However, by masking off certain areas of the image, selected areas can be toned using a straight dye toner, while others remain unaffected, see Multiple Toning in this chapter.

Dupont 6-T Toning System

The 6-T system consists of three separate bleaches, three separate toners, a sodium chloride solution, and a gold-tone modifier. By mixing and matching the various bleaches and toners and throwing in the chloride bath and/or the modifier, a large variety of tones can be achieved, from purple-brown to a bright sepia. This system works best with old-style soft emulsion papers.

Multiple Toning

It is possible to selectively tone areas of a print with different toners. The trick is to cover areas *not* to be toned with either rubber cement or a frisket material, such as Grumbacher Miskit.

To use Miskit, dilute it 1:1 with rubber cement thinner. Using an appropriately sized soft brush that forms a good point and does not lose its bristles. On a dry print apply two or three thin coats to the areas to be masked. Smooth out each coat, then coat another area or wait a few minutes before applying the next coat.

After you have applied the mask, soak the print in water: fiber-based prints for 5 minutes; RC papers for no more than 2 minutes. Then immerse the print in the toning solution. The print might buckle or curl, but keep it immersed as much as possible. If the toner bleeds under the mask, try skipping the presoak.

After the print has been washed according to the toner's instructions, you can remove the mask by carefully rubbing your fingers across the print surface while it is in the final stages of the wash. After the print is dry, any previously toned area may be masked and an entirely different area toned with a different color toner. There is no limit to the number of colors that can be applied or the areas that can be toned.

Toning: Workflow, Pitfalls, Choices, and Preferences

Tim Rudman

There really is nothing inherently difficult about toning. *But* there are many different toners out there, and as most can be used either singly or in a number of permutations with a range of papers, which in turn can react to toners differently, there is considerable potential for confusion or catastrophe. So, it pays to keep things simple and become thoroughly familiar with a few basic combinations, adding more as experience grows.

The pre-toning workflow is vitally important, for it is a fact that many of the toning blotches, splashes, streaks, fingerprints, and other unwelcome surprises that can appear out of nowhere in the toning bath are caused before you ever reach for the toner, and although you may get away with overworked chemicals and sloppy technique for untoned black-and-white prints, these indulgences will come back to haunt you at many of the toning stages. With a little care and diligence, these pitfalls are easily avoided.

Fresh chemicals; full, even, and timed development; no fingering or poking in the image area; full—but not excessive—fresh fixing without hardener must be the order of the day, avoiding cross contamination, chemical splashes, and ensuring prints do not lie overlapping in any of the solutions—I am no longer surprised at workshops when I see people leaving orphaned prints half-forgotten stacked up stewing in the fixer. It's a shame to see them ruined at the toning stage after all the work to get them there! Toning processes that involve a bleaching action are especially likely to unmask poor processing technique, so remember, "Cleanliness is definitely next to (toner) godliness."

Of the various ways of classifying toners, archival versus nonarchival, is a useful and simple starting point. Of the archival toners, polysulfide (smelly!), sepia (smelly or nonsmelly varieties), gold, and selenium are the most common. They are all available in commercial kit form and are very easy to use. Apart from those using a bleach stage, when used alone, they give more restrained color changes with many papers than do their nonarchival counterparts, which can produce strong and even vivid colors. Iron blue and copper red or brown are the most widely available of these.

Toning combinations too many to mention are possible with most toners, regardless of classification, although particular "rules of engagement" may apply with some combinations. My own favorite choices depend on (1) the purpose of the print—for sale or collection, (2) the printing process—lith prints may tone idiosyncratically or more colorfully with the archival toners, (3) the nature of the image—or the other works in that set—and (4) my mood at the time. So, describing my "favorite" is like being asked which one record I would take to a desert island.

When using archival toners, I most commonly use sequential combination toning rather than a single toner, especially selenium + gold, selenium + sepia, and selenium + sepia + gold.[1] This latter combination can yield either very colorful images or extremely subtle nuances to influence the viewer's response.

Successful multiple toning with these toners relies on two facts.

First, each of these three toners works successively through the tonal values of the print, rather than toning all the tonal values at the same time and the same rate. Selenium works "bottom up"; in other words, it starts toning the darkest areas of the print first, works on up through the middle values, and reaches the highlight tones last. Sepia bleach starts in the highlights and works "top down" to reach the shadows last, and the sepia toner, which follows the bleach stage, tones only the silver that has been bleached. Gold toner also works "top down"—this is more relevant when duo-toning gold with selenium at opposite ends of the tonal scale but is

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[1] This description refers to the widely available single-bath "off the shelf" toners, not necessarily to the formulas described in this book.

less relevant when gold toning after sepia to change the sepia color, see later in this chapter.

Second, with one main exception, the silver that has been toned by one of these archival toners is stable and is left unaffected by almost any chemical used subsequently. The one main exception is that when immersed in gold toner, sepia-toned silver does change color towards salmon/orange/red, depending on the paper emulsion and the way the sepia toner is made up.

The significance of these two facts is that a print can be "split toned"[2] with one toner—toning just part of the image tonal scale. In the case of selenium, this might be just the darkest tones or dark and midtones. In the case of sepia, it could be just the lightest of highlights for a very subtle effect or down to the midtones for obvious impact. In either case, this leaves the print part-toned with the untoned silver still being "up for grabs" by a second toner. Selenium + gold will, with warm-tone and lith prints, give an attractive brown/blue duotone. Selenium + sepia will give either two shades of brown with warm-tone papers or one of the many sepia hues on top of contrasting eggplant purplish-brown shadow tones with a neutral/cold-tone paper. If gold toner is then used as a third stage, the sepia tones will begin to shift, not toward blue but toward the red/orange/salmon range, and the degree of this shift is dependent on toning time, so great control is possible to give hues from just a hint of sunshine to strong color. If the midtones are left as untoned silver, beautiful tri-tone effects are obtained.[3]

Author's Note: Prints should be well washed between toning baths, and in particular acidic prints (e.g., from direct gold toner, acid stop baths, etc.) can stain if transferred straight to selenium without being well washed or first put through alkaline HCA.

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[2] Some workers use the term "split toning" as I have here, using a single toner, but also use it to indicate that two or more toners have been used. To avoid confusion, I prefer to refer to the latter as duo-toning or multiple toning, rather than split toning. Be aware that more than one interpretation is in use.

[3] Examples of these and many other color effects are found in *The Photographer's Toning Book*; see the Bibliography.

Rock in the Merced River. © Tim Rudman. All rights reserved. Courtesy of the artist.

Ryuijie Douglas

Split Toning with Polytoner

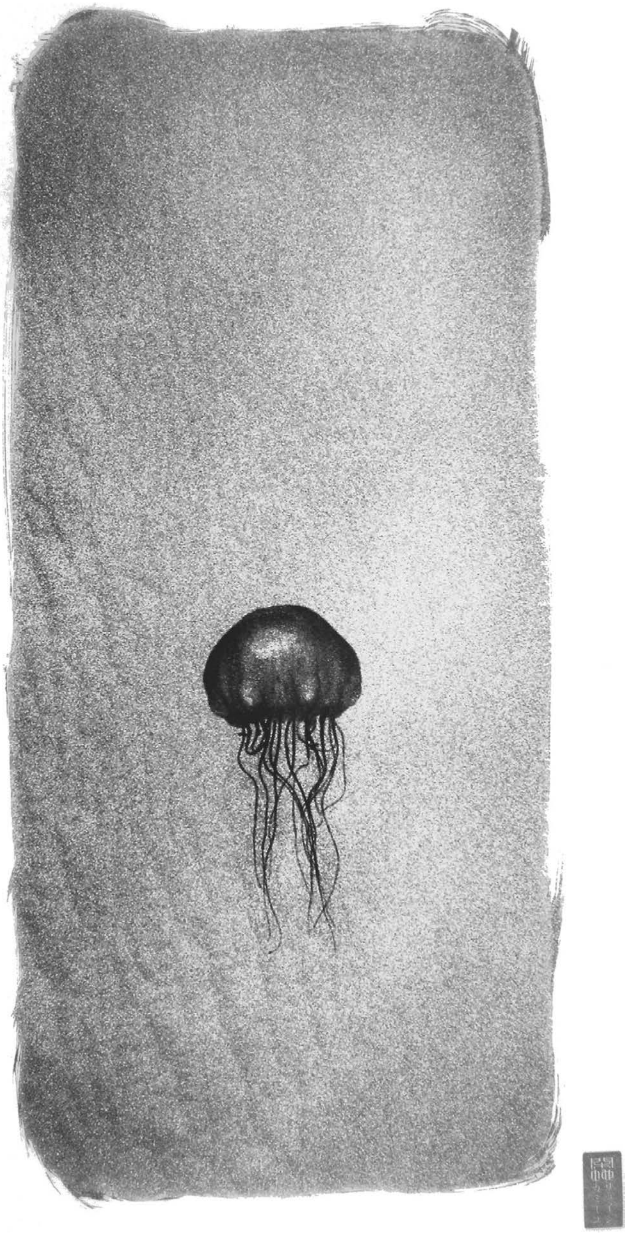
I use Ilford Multigrade fiber-based paper and Kodak Polytoner to split-tone my ice form photographs. As Polytoner is no longer available, here is a substitute:

Polytoner substitute
Distilled water, 500.0 mL
Sodium carbonate, monohydrate, 160.0 g
Kodak Brown Toner, 320.0 mL
Kodak Rapid Selenium Toner, 80.0 mL[4]
Water to make 1.0 L

Toning Procedure

After processing the print, give it a short wash. Place the print in the polytoner 1:30 for about 30 seconds. Move the print to a water bath and let it sit without any agitation. Toning comes up slowly. When the print reaches the desired color, remove it from the water bath and wash normally.

[4] You can substitute any brown toner and/or selenium toner for the Kodak product to create your own polytoner.



K49 Jellyfish, 2008. © Ryuijie Douglas. All rights reserved. Courtesy of the artist.

Reduction and Intensification

"Photography is 90% sheer, brutal drudgery! The other 10% is inspiration!!"
—Brett Weston

Most photographers have, at one time or another, created masterpieces of over- or underexposure, over- or underdevelopment, and sometimes both! Not all negatives can be saved, but the techniques of reduction and intensification may prove to be just the tonic to reclaim what undoubtedly would have been the best photograph ever created. Even if the negative is printable, reduction and intensification techniques can often improve slight miscalculations in exposure or development.

NEGATIVE REDUCTION

Negative reducers are used to subtract density from film that has been overexposed or overdeveloped. Reduction is not a controlled process and requires experience to achieve the correct negative densities. Nor is it a one-time, all-or-nothing process. Thus, a negative can be reduced slightly, dried, a print made, and then the negative further reduced if necessary. Therefore, always err on the side of not enough reduction.

Reducers are classified into three general types:

1. Cutting reducers, also known as subtractive or sub-proportional, remove equal amounts of silver from all densities, producing a less dense negative with no change in contrast. They are most often used for clearing film fog. Kodak R-4a Farmer's Cutting Reducer for Overexposed Negatives is the most used and easiest to control.
2. Proportional reducers decrease the image density throughout the film in proportion to the amount of silver already deposited. The effect is similar to giving the film less development to lower the contrast of the negative. Kodak R-4b Farmer's Proportional Reducer for Overdeveloped Negatives is the one most used.
3. Super-proportional reducers have a considerable effect on highlight areas but a negligible effect on shadow densities. They are the most unpredictable and should be used with caution. Super-proportional reducers are used when a greater reduction in contrast is desired than can be achieved with cutting reducers. Kodak R-15 for Extreme Overdevelopment is an example of a super-proportional reducer.

Cutting and Proportional Reducers

While there are about a dozen or so formulas available, the most widely used is Howard Farmer's formula, which dates to 1883. The ingredients are easy to

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obtain in almost any part of the world, the process is almost foolproof from the chemical angle, and the results are permanent.

There are dozens of published formulas claiming to be Farmer's Reducer. The actual makeup is flexible, with the two main ingredients being potassium ferricyanide and sodium thiosulfate (hypo). The quantity of ferricyanide used determines the strength of the solution.

Farmer's Reducer may be used as a single- or two-solution formula. The single solution gives cutting reduction, that is, it reduces the shadows first, then the highlights; this method corrects for overexposure.

The two-solution method is proportional, giving reduction in the highlights and shadows in proportion to the amount of metallic silver that has been formed during development, correcting for overdevelopment.

Before attempting to reduce any negative, you should fix and wash it thoroughly. If an acid fixer is used, it should include hardener; this applies only to negatives, not prints. Also, reduce only one negative or strip of negatives at a time to avoid damage. Following reduction, the negative should always be washed thoroughly and handled carefully before drying.

Super-Proportional Reducers

Super-proportional reducers have the property of reducing the denser parts of the negative (highlights) in preference to the middle tones and shadows. Ammonium persulfate can do this particularly well. However, ammonium persulfate is notably subject to deterioration and is easily affected by other substances. Therefore, the use of potassium persulfate, as in Kodak R-15, is recommended.

PRINT REDUCTION (BLEACHING)

Print reduction is a technique that should be known to all photographers. Among photographers, print reduction is commonly known as bleaching. However, it should not be confused with true bleaching, also known as rehalogenation or rebromination, by which a developed silver image is converted back to silver bromide, see the Formulary: Print Reducers: Print Rehalogenating Bleach.

There are three methods for bleaching prints: overall, local, and spot.

Overall: The print is completely immersed in the reducing solution. This is for brightening the print and increasing overall contrast.

Local: This is the method for working on comparatively large areas but not the entire print. Local bleaching is done with a small wad of cotton or a brush.

Local reduction can brighten specific areas, put luminosity into shadows, or drastically alter tonal values.

Spot: This is the way to eliminate black spots, place catch lights in eyes, or when precise control of a small area is necessary. The bleach is applied with a spotting brush, toothpick, or similar pointed tool.

Prints that have been selenium-toned should only be reduced by the overall method, as the color of the print will change in the area that is bleached. Gold-chloride blue-toned prints should not be bleached at all, as the color will usually change to green blue. For these reasons, it is better to reduce prints intended for these processes before toning.

Cutting vs. Proportional Print Reduction

Like the technique of dodging and burning during exposure, bleaching can brighten the highlights, open the shadows, and increase contrast.

Cutting print reduction removes the same number of silver grains from a prints highlights as from the shadows. As an example, suppose that after developing and fixing the print the highlights contain 100 silver grains and the shadows, being denser, contain 1,000 silver grains. Let's say the cutting reducer removes 20 grains of silver from the highlights and 20 from the shadows. You would now have 80 silver grains in the highlights and 980 in the shadows. With 20 grains less silver the highlights would be whiter, but the shadows would have hardly changed, effectively increasing the overall contrast. This is the opposite effect as using a cutting reducer on a negative.

A proportional print reducer would remove a proportionate amount of silver from the lightest and densest area. In this example let's suppose that the proportionate reducer removed 20% of the silver from both the shadows and highlights. That would leave 80 grains of silver in the highlights and 800 in the shadows. Because the ratio of highlights to shadows remains the same proportional reduction would open the shadows and brighten the highlights while maintaining the same overall contrast.

The effect of bleaching largely depends on the paper. Some papers readily take to bleaching, whereas others are highly resistant.

Overall Reduction for Prints

For overall reduction of prints you can use either Farmer's Reducer Kodak R-4a or Ammonium Thiosulfate Reducer. As in negative reduction, the easiest and most versatile is still Farmer's.

Author's Note: If the reducer is too potent, the lighter areas may be wiped out and the print ruined. Therefore, a highly dilute solution of Farmer's is recommended.

To create delicately separated shadows with more pronounced highlights, make a print about ⅓ stop darker in the highlights and a half-grade lower to keep the shadows open.

Another technique that creates a unique effect with pronounced tonal separation is to overexpose the print by 1 to 1.5 stops using one full grade less contrast, then bleach using Farmer's Reducer. Although the prebleached print will look dark, holding it up against a light will reveal the detail waiting to become visible. This method accentuates the graininess of the image.

General Instructions for Overall Bleaching

- For overall proportional reduction of the highlights, midtones, and shadows, start with a wet print.
- For cutting reduction to clear the high values only, start with a dry print.

With either method, wet or dry, the print should be thoroughly washed after fixing and not toned. Always use a *nonhardening fixer* for any after-process *for prints* such as reduction, intensification, toning, etc.

Have a tray of standing or running water ready to stop the action of the reducer. Slide the print face up quickly and completely into the bleach. Do not agitate, as this will cause bleaching to proceed faster on the edges than in the center.

The print should remain in the solution for 5–10 seconds. Pull the print from the solution and submerge it face down under the fresh water. Do not try to judge the print until it has been soaked for a minute in water. If standing water is used, use constant agitation and change it often.

After all traces of reducer have been removed and the action stopped, remove the print from the water and carefully examine its condition. A good practice is to have an unreduced wet print available for visual comparison. If the reduction is not enough, repeat the process for 5 seconds, but be careful. It is easy to eliminate all detail and texture from the highlight areas. When you are satisfied with the results, rinse the print well and refix in a fresh, nonhardening fixer, followed by HCA and an additional wash to remove the fixer.

Local Reduction

Local reduction is a technique for centralizing the interest, brightening certain areas—for example, the sky, windows, etc.—adding contrast, and giving the image a three-dimensional effect. Knowing that reduction increases contrast in an area, you may want to refrain from dodging and rely on local reduction to lighten and increase local contrast.

Under full-room light, place a freshly washed print on a flat surface, such as the back of a large tray or a piece of quarter-inch white Plexiglas. Stand the working surface up in your darkroom sink. Wipe the surface of the print dry with a sponge or squeegee. If available, hold a sink hose with running water directly beneath the area to be reduced. Slowly move the hose or sponge from side to side so that any bleach that runs down the print will be diluted and washed away.

There are several ways in which to apply the bleach. One is to dip a piece of cotton into the bleach and squeeze until it is almost dry. Beginning at the top, so the bleach will run down over the area to be reduced, lightly wipe the cotton over the area for 2 or 3 seconds. Do not use friction, which could abrade the wet print. Instead, let the chemical action do the work. You do not want reduction to happen too fast or all of a sudden. If you have the correct dilution of bleach, it should take several applications to achieve the results you want. However, if the print is exceptionally dense in the area being worked on, you can strengthen the working solution by adding more ferricyanide, though I recommend against this until you are highly experienced.

Instead of a cotton ball, you can use a #10 Winsor & Newton watercolor brush for large open areas. Jay Dusard—also known as Captain Ferricyanide—uses a Japanese calligraphy brush, also available from art supply outlets.

To halt the bleach process, use the hose directly on the area being bleached. If a hose is not available, use a sponge saturated with clean, fresh water. After the bleach has been thoroughly rinsed with water, immerse the print in fixer for a few seconds to completely neutralize the bleach. You may repeat the bleaching process as many times as necessary. When the process is complete fix in a fresh, nonhardening fixer and wash the print thoroughly.

Spot Bleaching

Spot reduction is a basic form of print retouching. Spot reduction is useful for the removal of small pinhole spots or other small areas that need to be lightened. The spot method allows the photographer to add pleasing catch lights to eyes and to remove an occasional unwanted element from the image.

I was taught spot reduction by photographer Boyd Wetlauffer of Canada in 1974. Boyd taught me using a wet print. I prefer to use a dry print, as I have found spotting a wet print hard to control. Try both methods and see which works best for you.

You will need spotting brushes and blotters. Be certain that you *only* use these brushes for bleaching. For small areas, use brushes as small as #000 or a toothpick; for larger areas, try a #3 brush. Pec-Pad Photowipes and Kimtech Kimwipes make good blotters.

Start with a strong viewing light, at least 75 watts, and either a wet or dry print. The published method calls for a strong solution of Farmer's R-4a: 1 part A to 2 parts of B, without adding water. Boyd dispensed with solution B altogether. Instead, he would add ferricyanide to 30 mL of distilled water at 125°F/52°C with stirring until it stopped dissolving. When no more ferricyanide would go into solution, he filtered the solution through a chemically untreated coffee filter.

Place a blotter on one side of the print and hold a second in your opposite hand. Dip the brush into the reducer and wipe it on the blotter next to the print, drawing it across and turning it to a fine point several times. Hold the brush 90 degrees to the print and carefully touch the area to be reduced with the tip. As with local reduction, *do not use pressure*; let the chemical action do the work. If you get a bit careless, use the blotter in your hand to stop the action.

Having deposited a very small amount of ferricyanide on the area to be reduced, watch it for a few seconds. The spot will slowly become lighter. The action will automatically cease because the small amount of reducer will become exhausted. Repeat the procedure as needed. If you are using the traditional A/B solution instead of Boyd's single solution and feel the action is too slow, add more solution A. If you inadvertently carry the action too far, you can darken it with spotting dye such as Marshall's Retouching Dye.

When all black spots have been removed, catch lights added to the eyes, and satisfaction achieved, rinse, fix, and wash. This final step must be done for even the smallest spot; otherwise, the color of the print will eventually change.

An alternative to Farmer's Reducer for spot reduction is medicinal iodine tincture diluted 1 + 2 to 1 + 4. Use as you would Farmer's for removing dark or black spots. It can be applied with a toothpick and can reduce the intensity of a dark spot without going all the way to white, depending on the dilution with water. Fogging along the border of prints can also be removed by carefully applying diluted iodine tincture, making sure that it does not touch the image itself. This can be done using a friskit along the edge or a steady hand. Remove the resulting silver iodide by immersing the print in hypo, just as you would with Farmer's. Fix and wash normally.

Fixer and the Bleaching Process

Fixer acts as a bleach neutralizer, halting the bleaching action. How quickly it stops the bleach from working depends on how much ferricyanide is in the solution. However, the fixer also acts as a catalyst to speed up bleaching *even while it is neutralizing the bleach*. This means that if the print looks perfect on the board, it will probably be too light after it is placed in the fixer. This is another reason it is important to work up slowly to the density you want.

Fixer that has been partially exhausted will cause bleached prints to stain more easily. At the same time, ferricyanide bleach rapidly destroys fixer. Use fresh fixer and discard after the bleaching session. Before discarding the fixer, neutralize it by dumping the remaining bleach solution into it. Because it is easy and inexpensive to make, plain hypo is a good choice for arresting the bleach process.

When bleaching is complete, rinse the print thoroughly for 5–10 minutes in running water and then refix with a fresh nonhardening fixer. After fixing, the print must be thoroughly washed. If an acid fixer is used, use HCA before the final wash to ensure against residual staining. If toning is desired, it could be done at this time, or later starting with a dry print.

INTENSIFICATION

Negative Intensification

Negative intensification is a technique to increase the density of underexposed or underdeveloped negatives. It can also be used to both decrease and increase contrast.

Cutting or subtractive intensifiers mostly affect the shadow areas and have little effect on the highlights, thereby reducing contrast.

Proportional intensifiers affect both the highlights and shadows but not equally. The highlights receive more intensification than the shadows.

Super-proportional intensifiers mostly affect the highlights, thereby increasing contrast.

Author's Note:

- Work with one negative or strip of negatives at a time.
- Use a white tray to better judge density increases. Experience will enable you to accurately judge increases.
- Both 35mm and 120 negatives, either singly or in strips, can be placed on reels to minimize possible damage while wet. However, visual inspection will be more difficult.
- Intensification may take place in room light.
- Negatives should be well washed and wet. If they have been dried, soak them for 5 minutes before intensifying.
- Some intensifiers can cause a color change to the negative, which may affect printing with VC papers.

Chromium Intensification Chromium intensifier is a proportional intensifier; the amount of intensification is proportional to the amount of silver present in the negative. Therefore, denser areas of the negative are affected more than thin areas. Chromium intensification is useful for increasing contrast since it has little effect on thin, shadow areas. Chromium intensification must often be repeated several times.

Caution: The two main ingredients in chromium intensifier—potassium dichromate and hydrochloric acid—are both hazardous chemicals. Handle chromium intensifier with chemical-proof gloves and use a respirator, observing all safety precautions, see Appendix 1: Safety in Handling Photographic Chemicals.

Ilford In-3 is the most useful negative intensifier, as it has two working dilutions. Solution A is stronger than solution B. The bichromate stock solution will last indefinitely. All you need to do is carefully and slowly add the hydrochloric acid, see Pharmacopeia for safety precautions using hydrochloric acid.

Negatives to be intensified with chromium should first be hardened either during fixing or after fixing in a hardening bath. Failure to do so may cause the gelatin to reticulate and ruin the negative.

Immerse the negatives in the bath until completely bleached; this converts the silver image into a combination of chloride and chromium compounds. The negative is then washed until completely free of yellow stain, about 5 minutes, and redeveloped until the image has blackened completely. Good developers to use for redevelopment are Kodak D-72 1:3 or Ilford ID-36. An alternative to either D-72 or ID-36 would be Pyrocat to obtain the benefit of image stain to increase the density.

After redevelopment, fix the negative for 3–5 minutes and then wash thoroughly and dry. One advantage of using chromium is that if sufficient intensification is not achieved, the process may be repeated.

Sepia Intensification Bleach-and-redevelop sepia toners, such as Ansco 221 Sepia Toner or Kodak T-7a Sulfide Sepia Toner, are more effective than chromium intensifiers and will provide maximum archival protection for your negatives. This is because the silver is converted to silver sulfide, which is highly resistant to environmental pollutants, making the image as permanent as it possibly can be.

These instructions can be used with any bleach-and-redevelop sepia toner. The entire process requires the negative to be wet for a considerable time. This will make the negative more susceptible to damage. Handle with care.

1. Refix the negatives in an alkaline fixer for 1 minute. This will reduce wet time.
2. Wash the negatives for 30 seconds to 1 minute.
3. Move to the bleach bath and agitate for 30 seconds every minute for 5 minutes.
4. Rewash the negatives until they are completely clear of the yellow bleach.

Author's Note: The negative will appear clear as if the silver has been removed. Don't panic! The silver has been reconverted to a clear silver halide. It will turn black again in the next step.

5. Move to the B bath. The negatives should be fully toned in 2 minutes.
6. Rinse the negatives for 1 minute, then immerse in HCA for 1 minute, with agitation to neutralize the sulfide.
7. Wash for 3 minutes.
8. Rinse in wetting agent for 1 minute, then hang to dry.

Caution: Sodium sulfide in solution smells like rotten eggs. The smell has been known to cause some people to have headaches. Use in a well-ventilated area; outdoors works just fine—redevelopment can be done in open shade. Also, sulfide can damage undeveloped sensitized materials such as films and papers in a darkroom. This is another good reason to use sepia toners outdoors or at least away from the darkroom.

Selenium Intensification Ansel Adams used intensification to expand roll-film negatives by at least one paper grade, or in Zone System parlance, N + 1. The intensifier he used was selenium toner diluted with water 1:2. His technique was to first refix the negative in plain hypo and then soak the negative in selenium toner 1 + 2 for 3–5 minutes.

The purpose of refixing the negative in plain hypo before selenium intensification is to ensure that there is no residual hardener. Hardener will cause staining in both negatives and paper when it comes into contact with selenium. If you are confident that your negatives have been thoroughly washed, or if you use fixer without hardener, then refixing should not be necessary. But when in doubt, refix.

Kodak IN-5 Silver Intensifier Silver intensification has a noticeable effect on low values, which is where thin, underexposed negatives usually need help. The formula given, Kodak IN-5, is meant to be used with slow-speed, fine-grain films. It should not be used with films higher than EI 100 without testing first.

Silver nitrate has the unfortunate habit of staining everything black. Wear gloves and try not to get it on your hands or clothes, but if you accidentally stain yourself, try using the developer stain remover for hands.

Instructions for silver intensification will be found in the Formulary: Negative Intensifiers: Kodak IN-5 Silver Intensifier.

Kodak IN-6 Negative Intensifier When used with high-speed negative materials, this intensifier produces the greatest degree of intensification. The intensified image is a brownish hue and is not permanent. However, the negative will remain in satisfactory condition for several years if stored properly.

The intensified image is destroyed by acid hypo; under no circumstances should the intensified negatives be placed either in an acid fixing bath or in wash water contaminated with an acid fixing bath. Kodak IN-6 Intensifier is not suitable for fine-grain materials or when only moderate intensification is desired.

Instructions for silver intensification will be found in the Formulary chapter: Negative Intensifiers: Kodak IN-6 Silver Negative Intensifier.

Print Intensification

Intensifying a print has two advantages:

1. If the print is weak, it will exhibit greater density and contrast.
2. In almost all instances the tonal quality will be improved. The resulting image will exhibit either a rich, warm brown or a finer black than was originally obtained during development. The degree to which this effect is achieved depends on the type of developer, the strength of the intensifier, and the paper used.
3. Intensification is also a good technique for paper negatives, as it will strengthen the paper transparency or paper negative for contact printing on enlarging papers.

Chromium Intensification The technique is to bleach the print and then redevelop it in a nonstaining developer, just as you would for a negative. Slow chlorobromide and chloride papers respond best to this technique. Cold-toned and bromide papers don't respond as well to chromium intensification, but changes will occur. If in doubt, give them a try using a discarded print.

Selenium Intensification Selenium toning causes a slight increase in print density, a form of intensification that gives most prints a richer appearance. The increased density is more noticeable in the shadow areas. For more on Selenium Intensification and toning see Appendix 4, Archival Print Procedure.

Print Bleaching

Jay Dusard

I prefer to bleach on prints that have been fixed, washed—at least superficially—and fully dried. This way I have an accurate handle on the general appearance of the prints when mounted. For applying bleach, I use bamboo-handle calligraphy brushes, one small and one large.

Arrange the following in the darkroom sink:

- Tray of water for presoaking prints.
- Bleach container—close to running water, leaving ample working room.
- Tray of neutralizing fixer—save the final fix from a previous print finishing session.
- Large tray of water for holding prints that have been bleached.

Bleach Mixture

Pour a small pile of potassium ferricyanide crystals—approximately the size of a dime—into a small white plastic container. Add about 90 mL of water and then a splash of plain hypo. The splash will vary based on the desired contrast of the mixture. The hypo acts as a catalyst, but ultimately neutralizes the bleach. A solution strong in ferricyanide and low in hypo is fairly contrasty. One lower in ferricyanide and higher in hypo is lower in contrast and slower acting. With experience, you will be able to judge bleach strength by its color saturation.

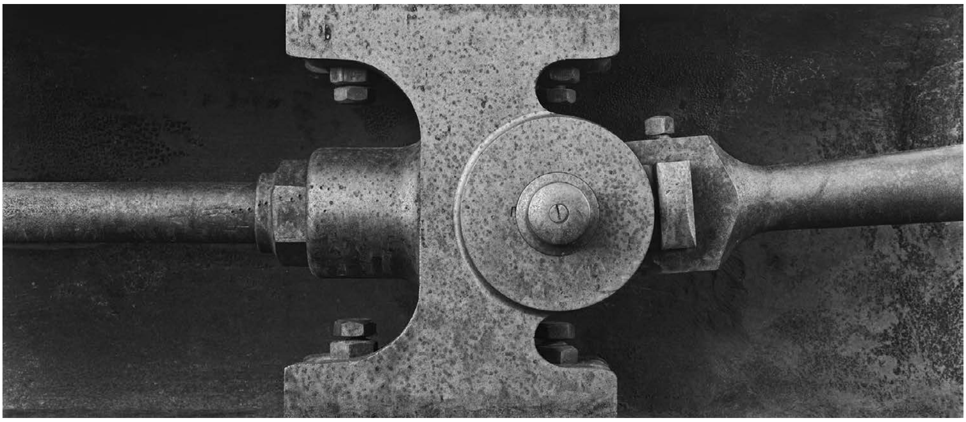
I like to hand-hold prints 11 × 14 inches and smaller on slightly larger sheets of Plexiglas. Place a thoroughly soaked print on a support panel—this is a good time to note that the rewetted print is lighter in value than it was when dry.

With a supply of water running into the sink, work with the print panel in one hand and a brush in the other. Apply bleach to an area of the print that needs work, then flush it off by placing the print under the stream of water. Inspect the print and apply more bleach if needed; usually it is. Keep working in this manner, a little at a time. If the surface of the print is wet, the applied bleach will spread in all directions. Tipping the print will control the direction that the bleach runs off; use gravity to keep the runoff away from critical areas.

If you want precise placement with no spreading or runoff, the surface water must be removed from the print. This may be done quickly by blowing it off a small area. A small squeegee may be used for larger areas. Using the smaller brush, place the bleach carefully, then flush it off, inspect, etc. It's a good idea to keep monitoring the entire print to be sure there is not a stray drop of bleach lurking somewhere uninvited—keep the print rinsed off.

When you are finished, rinse the print surface well, then place the print into a tray of neutralizing fixer for 1.5–2 minutes with some agitation. Rinse the print again and place it into the holding tray. At this point you can dry your prints for further evaluation and possible additional bleaching or proceed to final fixing and archival finishing.

For prints larger than 11 × 14 inches, work on a support panel standing up in the sink and tilted away from you, and use a hose to control bleach placement and rinsing-off.



■■■■
Pitman Arm, 2000. © Jay Dusard. All rights reserved. Courtesy of the artist.

15

Enlarged Digital Negatives

> *"You get no points for making the image the hard way. You only get points for stopping people in their tracks with great images."*
>
> —Dan Burkholder

Enlarged negatives are used to make contact prints with silver gelatin paper or with an alternative process, such as platinum/palladium (plt/pld), gum printing, salted paper, cyanotype, etc. Making enlarged negatives is one of the most tedious and time-consuming procedures you can do in the darkroom. For many years I enlarged 120mm and 4 × 5-inch film negatives to 11 × 14-inch negatives to make plt/pld contact prints. If I am grateful to digital imaging for anything, it is the ease with which one can make an enlarged negative for contact printing.

Along with scanning, enlarged digital negatives are the bridge between photography and digital imaging. They create a hybrid medium that has helped revive alternative process printing. If you still wish to make enlarged film negatives rather than digital, you will find the procedure in previous editions of *The Darkroom Cookbook*.

Making a digital negative from a film negative is not difficult—it is really only a matter of having the correct settings for your printer. While the process for making a digital negative from a digital original is more or less the same, I will only refer to film negatives to keep things simple.

WHAT YOU WILL NEED

1. A photo-quality printer such as an Epson or Canon. Both Epson and Canon inks are generally superior for photographic reproduction, higher fade resistance, and higher black Dmax (maximum density). Epson inks have a marginally higher Dmax than Canon, but not much. At a recent large format and enlarged digital negative workshop at the Photographers' Formulary Workshops in Montana, I had the opportunity to compare the Dmax of Pictorico OHP using both an Epson P700 and a Canon P-1000 printer. The Epson P700 produced a Dmax of 1.3 and the Canon P-1000 a Dmax of 1.2, hardly enough to make a difference in the finished print.

   While Dmax is probably the most important consideration when choosing a printer, the printer dialog interface is also important. The more robust the interface, the more control you will have over the process. Currently, the Epson printer dialog has the most options. The example I give for making enlarged digital negatives will be based on the Epson 3880. If your printer does not have all of the controls shown, simply skip them and use the controls that are most similar to the 3880.

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2. Overhead projection film (OHP), either Pictorico OHP Transparency Film or Fixxons Inkjet Negative Film, see Material Sources. Not all OHP is suitable for creating negatives. An example of this would be Epson Inkjet Transparencies OHP, which is meant for overhead projections for presentations and meetings.
3. A 300-ppi scan of the original negative you wish to enlarge. Use the highest-quality scan your scanner or lab can make.
4. You do not have to use a scanner. A copy stand, light table, and high-quality camera will allow you to create digital negatives that can be enlarged using the procedures in this chapter.
5. A software editing program. This chapter will only deal with Photoshop.
6. Tone curve coordinates for the alternative process you intend to use. This is because some alternative processes require more contrast than others. If you own a densitometer and know how to plot curves, you can create your own. Otherwise, there are various sources for tone curves. One of them is Christina Z. Anderson's book, *Cyanotype: The Blueprint in Contemporary Practice*, published by Routledge. In *Cyanotype*, Anderson lists tone curve coordinates for several alt processes including Classic Cyanotype, New Cyanotype, and plt/pld.
7. See Table 15.1 for curve coordinates. If you want to create your own curves, get the eBook, *Calibration for Alternative Photographic Processes* by Calvin Grier, available on the Alternative Photography.com website.
8. *Photoshop Actions* by Clay Harmon: clayharmonblog.com/downloads.html. Download these actions, extract them from the folder they are in, and install them in Photoshop Actions.

CREATING A TONE CURVE

You only need to create a tone curve once for a specific alt process. Once created, save it as a preset so it can be applied to all future negatives intended for that process.

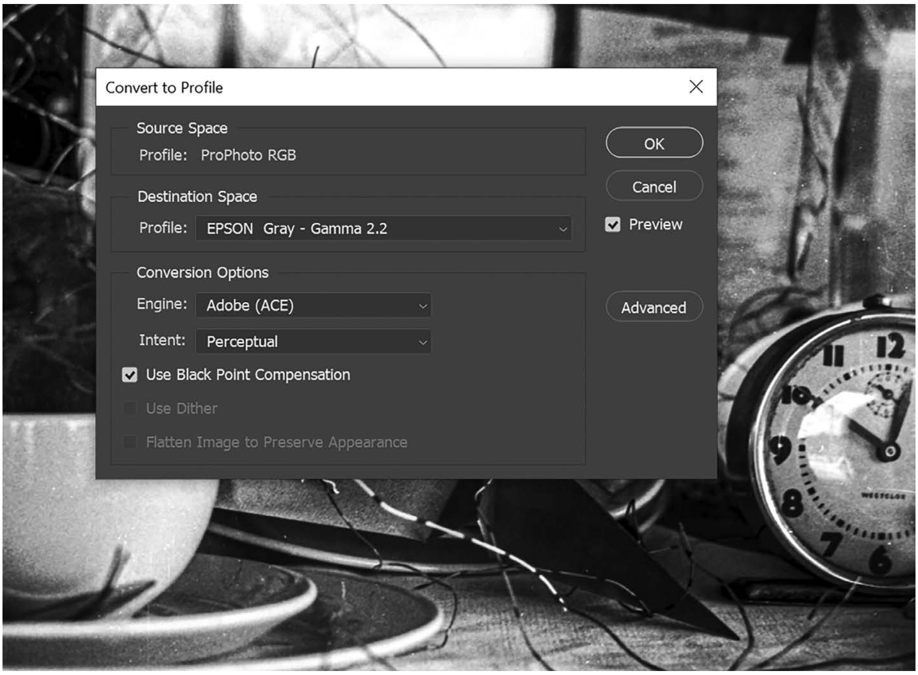
1. Open an image in Photoshop and convert it to Gray Gamma 2.2: **Edit > Convert to Profile > Gray Gamma 2.2**, see Figures 15.1 and 15.2.
2. Add a curve layer: **Layer > New Adjustment Layer > Curves**. Change the name from Curves 1 to the name of the printing process you will be using, in this example, New Cyanotype, Figure 15.3.
3. In the **Curves Panel** go to the dropdown menu at the top-right corner and select **Curve Display Options**. Check that **Pigment/Ink %** is selected, Figures 15.4 and 15.5.
4. It's time to enter your curve coordinates in the empty Curve dialog box. The curve creation process for all negatives is the same: plugging in a set of coordinates in the Photoshop Curve dialog panel. The only difference is in the actual coordinate numbers.

Different photographers publish different curve coordinates for the same process. If you come across a major difference, you will need to try more than one set of coordinates to see which works best for your process and preferences. The alternative is to create your own, as mentioned earlier.

On the curve, click anywhere on the diagonal line at the bottom left. This will set a point on the curve, see Figure 15.6.

Under the curve you should see Input and Output. If you do not see these, use your cursor to pull down the bottom of the Curves dialog box and

Figure 15.1 Open an image in Photoshop.

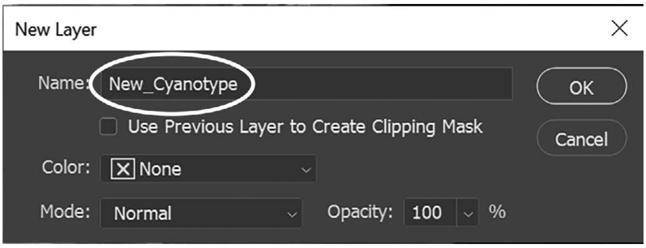

Convert to Profile

Source Space
Profile: ProPhoto RGB

Destination Space
Profile: EPSON Gray - Gamma 2.2

Conversion Options
Engine: Adobe (ACE)
Intent: Perceptual
☑ Use Black Point Compensation
☐ Use Dither
☐ Flatten Image to Preserve Appearance

Figure 15.2 Gray Gamma 2.2. Convert the image to Gray Gamma 2.2. If you are using an Epson printer, select Epson Gray – Gray Gamma 2.2.



New Layer

Name: New_Cyanotype

☐ Use Previous Layer to Create Clipping Mask

Color: ☒ None

Mode: Normal

Opacity: 100 %

Figure 15.3 Curve Layer. Change the name from Curves 1 to the name of the printing process you will be using, in this example, New Cyanotype.

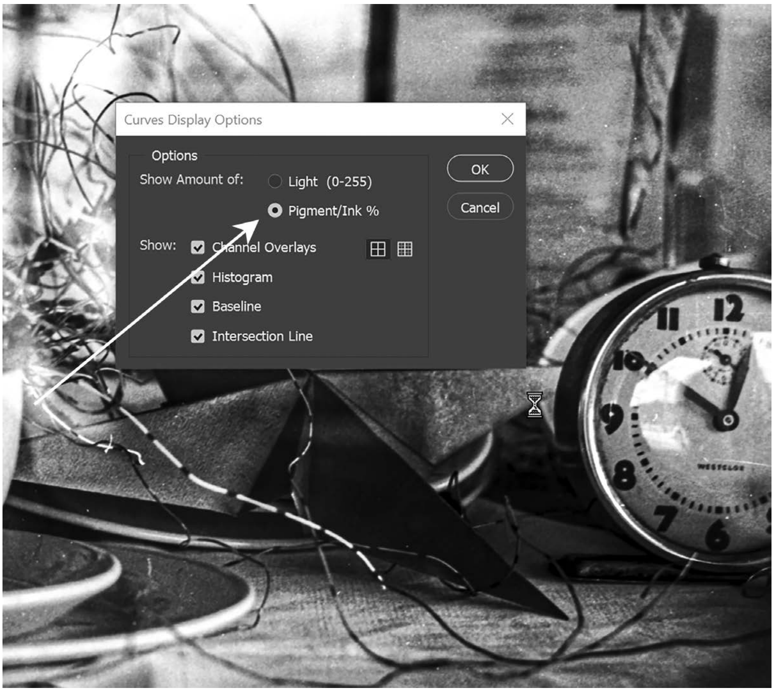
Properties

Curves

Preset: Default

RGB

Figure 15.4 Dropdown Menu. The Curves drop-down menu can be found by clicking on the four horizontal bars in the upper right corner of the Properties panel. Select Curves Display Options.



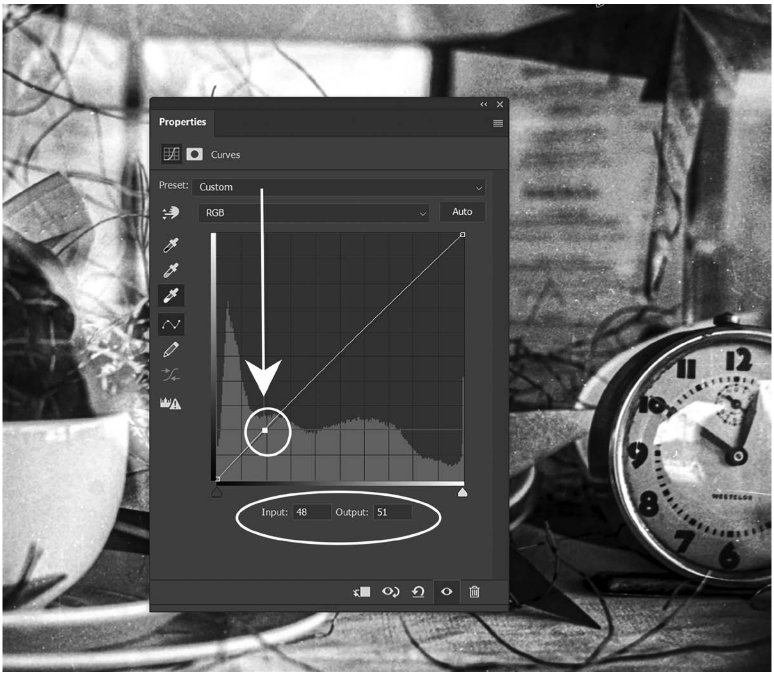
Curves Display Options

Options

Show Amount of: ○ Light (0-255) ● Pigment/Ink %

Show: ☑ Channel Overlays ☑ Histogram ☑ Baseline ☑ Intersection Line

Figure 15.5 Pigment Ink. In the Curves dropdown menu check that Pigment/Ink % is selected.



Properties

Curves

Preset: Custom

RGB

Input: 48 Output: 51

Figure 15.6 Setting curve coordinates. Click on the lower portion of the diagonal line to set a point.

Table 15.1

Alternative Process Curve Coordinates								
BW Paper Neutral Tone CZ Anderson	*BW Paper Warmtone CZ Anderson*	*Classic Cyanotype CZ Anderson*	*New Cyanotype CZ Anderson*	*Gum Print D. Hatton*	*Platinum C. Grier*	*Salted Paper CZ Anderson*	*Salted Paper F. Gorga*	*Van Dyke J. Read*
X/10	2/10	5/10	5/10	2/32	12/65	4/10	13/15	0/23
X/20	4/20	10/20	8/20	6/67	25/102	7/20	27/21	20/61
2/20	5/30	14/30	10/30	10/75	40/131	11/30	38/24	44/90
4/40	8/40	18/40	12/40	14/76	50/149	15/40	51/29	90/121
7/50	12/50	22/50	15/50	25/83	63/165	20/50	64/33	120/138
11/60	16/60	29/60	24/60	47/90	77/179	29/60	89/40	156/162
18/70	23/70	47/70	43/70	72/99	88/188	44/70	115/48	190/190
29/80	38/80	76/80	66/80	101/107	103/200	64/80	140/61	225/222
64/90	70/90	92/90	88/90	127/116	116/208	90/90	166/81	255/255
-	-	-	-	152/126	127/214	-	191/110	-
-	-	-	-	177/136	138/219	-	207/132	-
-	-	-	-	200/150	151/225	-	229/204	-
-	-	-	-	219/168	172/233	-	242/230	-
-	-	-	-	233/188	204/244	-	-	-
-	-	-	-	245/224	-	-	-	-

Alternative Process Curve Coordinates. The first coordinate is always 0/0 and the last is always 255/255; you do not have to enter the first and last coordinate as they are already entered by default in the Curve dialog box.

An “X” indicates where a point can’t be entered because the Curves Panel doesn’t accept points closer than a certain range so ignore those and move on to the next.

they should appear. You will only be able to enter values if a point has been selected. The selected point will appear as a white box on the curves line; the remaining points will appear as open boxes.

For this version of New Cyanotype, there are nine points to set. The curve coordinates can be found in Table 15.1.

Type in the Input/Output coordinates for the first point. The point will move to that position. Click anywhere above the first point and repeat for the remaining eight points.

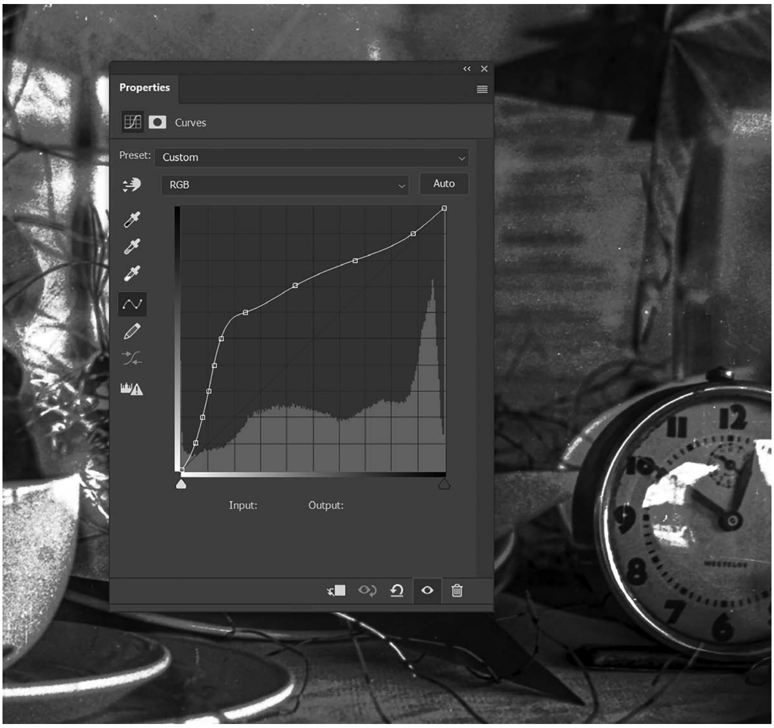
Recheck each point to make certain that you entered them correctly. Using the + or – key will cycle the cursor through each point.

Author's Note: There should be nine horizontal and nine vertical gridlines showing in the Curves panel. If there are fewer than nine Alt/Opt click inside the panel and it will toggle to nine.

When you are satisfied that all nine points are correctly set, open the drop-down menu again and select Save Curves Preset. Name the curve for the alt process you will use it with.

Figure 15.7 shows the finished input/output curve for New Cyanotype.

That's all there is to it. Your curve has been saved and you can apply the preset on all future images intended for the New Cyanotype process.



Preset: Custom

Figure 15.7 Finished curve for New Cyanotype.

DIGITAL ENLARGED NEGATIVE WORKFLOW

Scan your original negative as a positive. Edit the image in either Lightroom or Photoshop––or any program of your choice; from this point on only Lightroom and Photoshop will be mentioned. Use **Soft Proofing** to adjust the positive image scan. Except for Clarity, Texture, and Dehaze, do not sharpen in Lightroom; save this step for Photoshop.

When your edits are complete, use either Ctrl or Cmd + E to open your image in Photoshop. Choose Edit a Copy with Lightroom Adjustments.

Before proceeding do the following in Photoshop:

1. Save the image with a new name such as Coffee Time-New Cyanotype.
2. Select **Image > Mode** and select **16 Bit**. It is not necessary to select Grayscale. Doing so may cause you to lose access to color controls in the printer dialog, such as adding yellow to increase density.
3. Select **Image > Image Size**. Select the size you want to print using 300 ppi.
4. Select **Edit > Convert to Profile**. Choose **Gray Gamma 2.2**.
5. Apply the following four **Actions** created by Clay Harmon (clayharmonblog.com > Downloads > Photoshop Actions), in the following order, see Figure 15.8.

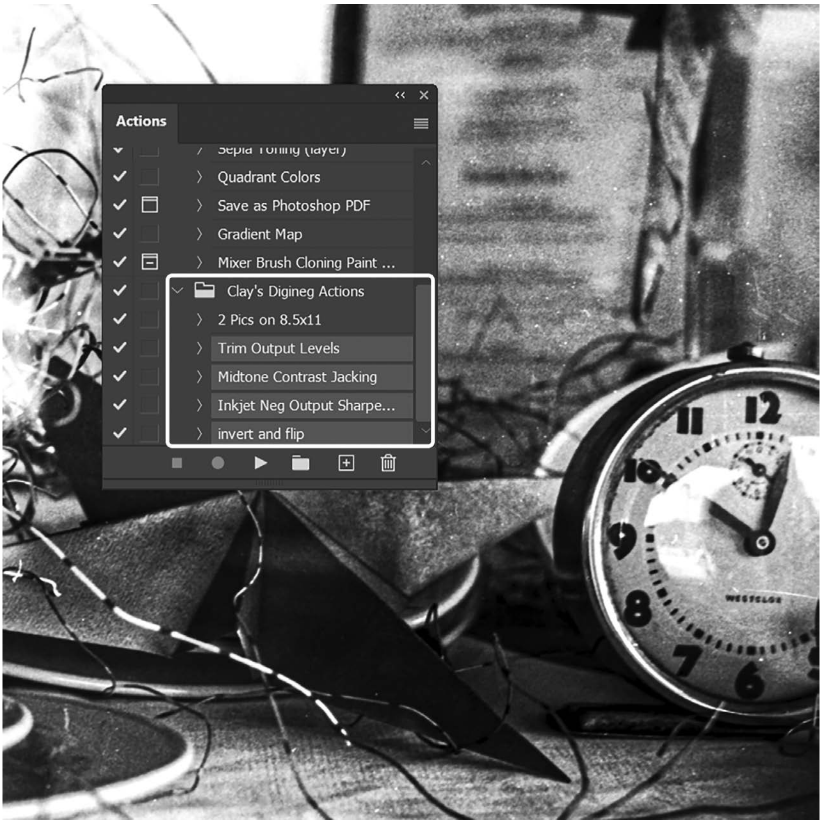


Figure 15.8 Apply Clay Harmon's Actions in the order shown. Do not include 2 Pics on 8.5x11 unless you intend to print 2 negative on one sheet of OHP.

Figure 15.9 Coffee_Time-Flipped. Your image should be negative and reversed, or letters and numbers will be reversed when you make a contact print.

(Do not apply 2 Pics on 8.5 × 11, unless you intend to print two images on one sheet of OHP.):
Trim Output Levels
Midtone Contrast Jacking
Inkjet Neg Output Sharpening at 360 dpi
Invert and Flip

Your image should now appear as it does in Figure 15.9. The image should be negative and reversed, or letters and numbers will be reversed when you make a contact print.

The final step is to load the New_Cyanotype curve preset you created earlier. Go to **Layer > New Adjustment Layer > Curves**. Click the dropdown menu as in Figure 15.4 and select **Load Curves Preset**. Choose the preset you made for your alt process.

Save the image (Ctrl/Cmd + S). Do not flatten the two layers. This will allow you to choose a different curve preset for printing in another process.

PRINTING THE NEGATIVE

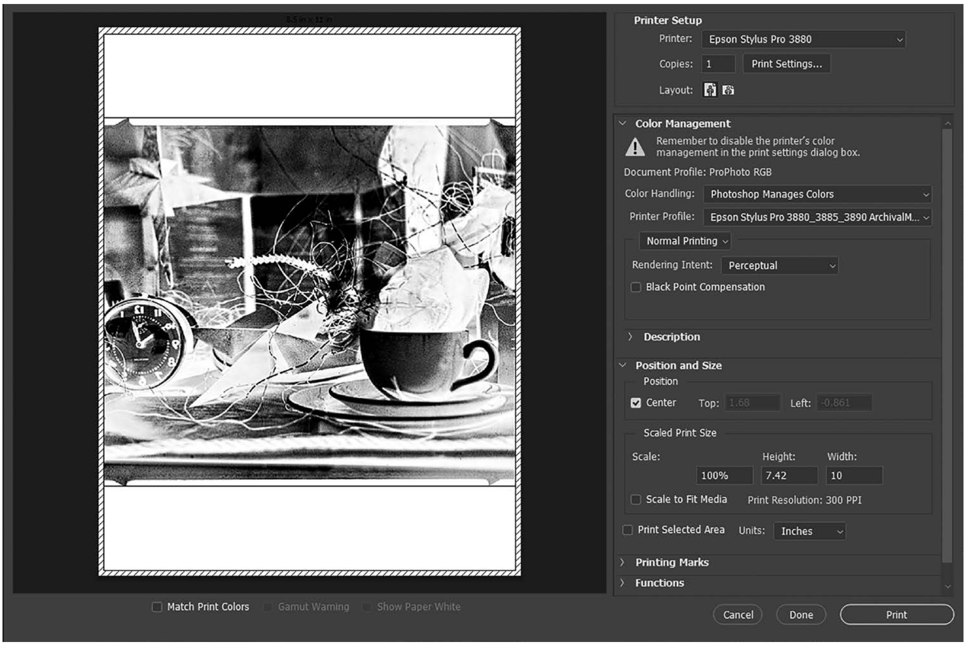
Photo-quality printers, even from the same manufacturer, will often have different drivers with different options. However, many options will appear across different drivers, especially when the driver is to be used with a program such as Photoshop. Follow the suggestions provided in this chapter, and if an option does not appear for your printer make and model, simply skip it and choose from the options that are available.

Printing the negative is nothing more than having the correct settings for the driver. The following settings are for an Epson 3880. Most of these will be found on newer Epson printer drivers, such as the driver for the P700, and on Canon printer drivers.

Printer Setup Panel

From the top as seen in Figure 15.10.

1. Go to **File > Print**.
2. Check to make certain the printer you are using is selected.
3. The default orientation is **Portrait**. Choose **Landscape** if appropriate.
4. Choose **Photoshop Manages Colors**.
5. The Printer Profile does not matter, as Photoshop will be managing the colors. But if you choose anything make it **Epson StylusPro3880_3885PremiumGlossy PhotoPaper**.
6. Choose **Normal Printing**.
7. For Rendering Input, choose **Perceptual**.
8. Uncheck **Black Point Compensation**.
9. Scale the negative to the size to be printed.
10. Return to the top and select **Print Settings**.



Printer: Epson Stylus Pro 3880
Copies: 1
Remember to disable the printer's color management in the print settings dialog box.
Document Profile: ProPhoto RGB
Color Handling: Photoshop Manages Colors
Printer Profile: Epson Stylus Pro 3880_3885_3890 ArchivalM...
Normal Printing
Rendering Intent: Perceptual
☐ Black Point Compensation
☑ Center Top: 1.68 Left: -0.861
Scale: 100% Height: 7.42 Width: 10
☐ Scale to Fit Media Print Resolution: 300 PPI
☐ Print Selected Area Units: Inches
☐ Match Print Colors ☐ Gamut Warning ☐ Show Paper White

Figure 15.10 The Printer Setup panel for the Epson Stylus Pro 3880.

Printer Properties Panel

From the top seen in Figure 15.11.

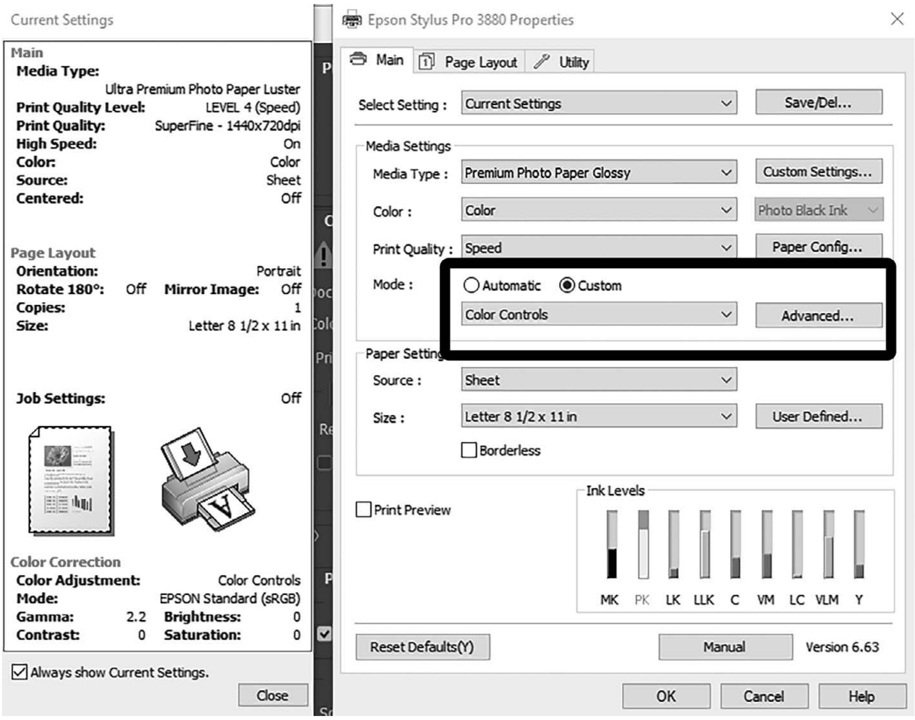
1. In the Printer Properties window select **Main Tab**.
2. For Media Type select **Photo Paper > Premium Photo Paper Glossy**.
3. For Color, select **Color**.
4. For Print Quality, select **Quality Options**.
   Move the Speed vs. Quality slider to the right to either **4** or **5**.
   Uncheck **High Speed**, **Edge Smoothing**, **Finest Detail**, and anything else that appears here.
5. For Mode, choose **Custom > Color Controls**.
6. Choose **Save and Print**.

Always print with the emulsion side toward you. Pictorico has one corner cut. Hold the transparency sheet with the cut corner in your right hand at the top, and the emulsion side will be facing you.

With Fixxons or any transparency film that does not have a notched corner, lick a finger, touch it to a corner, and see which side of the transparency it sticks to; that will be the emulsion side—this is an old darkroom trick used to determine the emulsion side of matte paper.

Allow the negative to dry face up for at least an hour before printing. You can speed up the drying process with a hair dryer.

Follow your normal procedure for making prints using your intended process.



Current Settings

Main
Media Type: Ultra Premium Photo Paper Luster
Print Quality Level: LEVEL 4 (Speed)
Print Quality: SuperFine - 1440x720dpi
High Speed: On
Color: Color
Source: Sheet
Centered: Off

Page Layout
Orientation: Portrait
Rotate 180°: Off Mirror Image: Off
Copies: 1
Size: Letter 8 1/2 x 11 in

Job Settings: Off

Color Correction
Color Adjustment: Color Controls
Mode: EPSON Standard (sRGB)
Gamma: 2.2 Brightness: 0
Contrast: 0 Saturation: 0

☑ Always show Current Settings.

Epson Stylus Pro 3880 Properties

Select Setting : Current Settings

Media Settings
Media Type : Premium Photo Paper Glossy
Color : Color
Print Quality : Speed
Mode : ○ Automatic ● Custom
Color Controls

Paper Settings
Source : Sheet
Size : Letter 8 1/2 x 11 in
☐ Borderless

☐ Print Preview

Version 6.63

Figure 15.11 The Printer Properties panel for the Epson Stylus Pro 3880.

Adjusting the Print

The tone curve you created and applied to your image should be seen as a jumping-off point. Its purpose is to help produce a negative with the appropriate degree of contrast for the process you are using. The print may still be too light or too dark.

After you have made an initial print, you may find that adjustments must still be made. As with the traditional darkroom, it is rare to make a first print that is spot-on. As in the darkroom, it often takes several for an experienced printer to be satisfied with the results.

There is more than one way to change the negative to improve the final print.

1. Reopen the image in your editing program and make adjustments on the screen as needed.
2. Some printers, especially Epson, have an Advanced Settings option, located to the right of Mode in Print Settings. This is only available if you choose **Mode: Custom > Color Controls**, see Figure 15.12.

   In Advanced Settings you can do things such as change brightness, contrast, or saturation. Should you need more density, you can add yellow using the color wheel. These are global changes across the entire negative. If you need local changes, use Option 1, and make changes in your editing program.


Color Controls

Printer Color Adjustment

Mode : Adobe RGB

Gamma : 2.2

Color Adjustment Method
● Color Circle ○ Slide Bar

Horizontal: 0

Vertical: 0

Brightness: + 0

Contrast: + 0

Saturation: + 0

Cyan: + 0

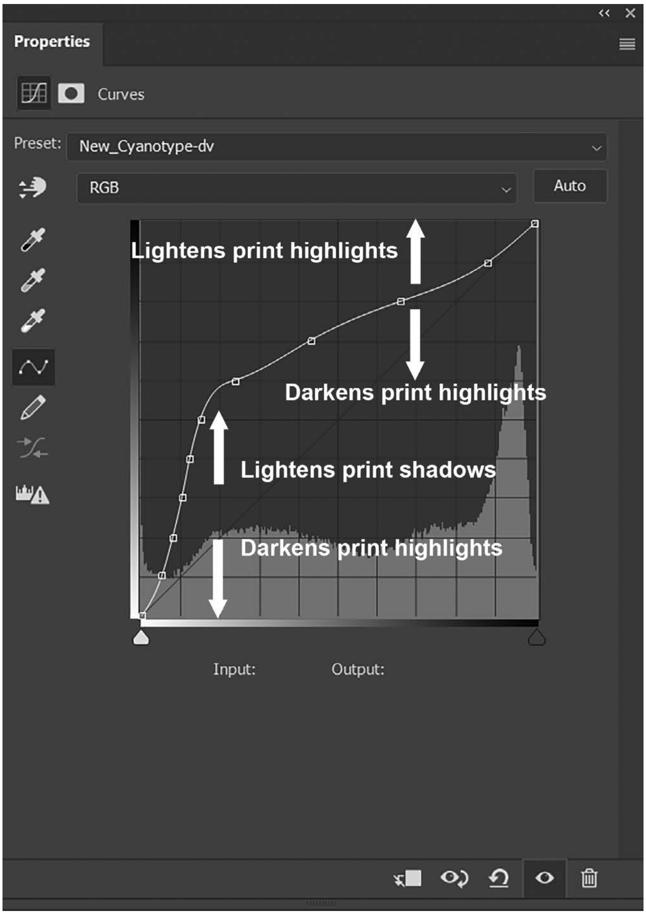
Magenta: + 0

Yellow: + 0

Figure 15.12 An Advanced Settings panel is available on Epson printers. This allows you to do things such as change brightness, contrast, or saturation or increase density by adding yellow.

3. Open any image in Photoshop, and open the Curve Preset for the process you are making the negative for. Make changes directly on the preset curve by dragging the points straight up or down. Dragging the points up on the tone curve lightens the image, dragging them down darkens the image.

   The curve coordinates can be customized for specific images by moving the coordinate point up or down on the Curves dialog in Photoshop, see Figure 15.13. Begin with the coordinates found on the Curves Coordinates Chart, see Table 15.1, and move the line up or down to lighten or darken the highlights or shadows.



Preset: New_Cyanotype-dv

Figure 15.13 Adjusting Curve Coordinates. The curve can be customized for specific images using the Curves dialog in Photoshop.

Printing Out Processes

> *"You must always believe that there is fertile soil for your ideas. If you lose hope, then you will miss opportunities to plant a seed."*
>
> —Ruth Bernhard

The use of P.O.P. is a time-honored method for making inexpensive prints without a darkroom.

The term "printing out paper" and the associated initials P.O.P. were introduced in 1891 by the Ilford Company for their gelatin-chloride papers. The name has come to be applied to salted paper and similar processes.

The P.O.P. process is probably the best introduction to hand-coating paper and alternative processes. If you are new to alternative processes, the easiest to use and learn are salted paper and cyanotype.

The basic printing technique is simple: The coated paper is contact printed with a negative, using the sun for a light source to make a visible image without development—a UV lamp, available from grocery and hardware stores, can also be used.

***Caution*:** Do not look directly at a UV light source as it can damage your eyes. It is recommended that you wear good quality polarized sunglasses anytime you are exposed to UV light.

There are several different types of P.O.P.: salted paper, cyanotype, albumen, gelatino-chloride, and collodio-chloride, differing in the medium used to suspend the light-sensitive substance and whether the sensitizer is applied in the salting solution—as in an emulsion—or as a second step. In the traditional salted paper process, the silver is held by the fibers of the paper, while albumen papers use egg whites as the binder. Gelatino-chloride papers suspend the silver in a gelatin layer, and collodio-chloride uses a binder of cellulose nitrate.

The basic light-sensitive substance used in all these papers is silver chloride with an excess of silver nitrate. Once the image has been printed and toned, it is fixed, washed, dried in much the same way as a silver print. Because the silver particles of printed-out images are a much finer size than those of developed-out prints, they are often more susceptible to deterioration. But with proper processing, they will stand the test of time as well as any process. Indeed, collodio-chloride is the most stable silver printing process because the nitrocellulose binder hermetically seals the silver from the harmful atmosphere that fades all silver-based photographic prints.

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Printing out papers rely on a technique called self-masking. This means that thin areas of the negative allow the light to quickly darken the surface of the paper and block light from reaching the lower layers of the sensitive surface. The result is that the shadow areas are held back, allowing the highlights of the picture to print. Achieving a good print with these processes requires a dense negative with good shadow detail and clear base in the deepest shadows.

Printing out papers can only be contact printed. For this reason, a 4 × 5-inch or larger negative is usually preferred.

MAKING A SALTED PRINT

Paper Selection

Making a simple silver-chloride salt print begins with the selection and preparation of the paper. Arches Hot Press Watercolor, Hahnemühle Platinum Rag, and Crane's Kid Finish AS8111 are good choices, but you can experiment with any good-quality 100% cotton paper.

Before proceeding, identify the front of the paper. This is important, as fine art papers are made to be printed only on one side. Once the paper has been prepared, it is often harder to identify the front. If the paper is in a tablet or pad, the top side is the front. If it is purchased as an individual sheet, the easiest way to identify the front is to hold it up to the light and look for the watermark. If the watermark reads correctly, left to right, you are looking at the front.

If there is no watermark, the front surface is often smoother and brighter. Finally, a factory-deckled edge always bevels up to the front surface. Having identified the front, place a light tick mark on the back with a pencil.

Many experienced printers like to use paper larger than the negative. For example, with an 8 × 10-inch negative, they may use a 9 × 12- or 11 × 14-inch piece of paper.

Salting the Paper

The next step is to coat the paper with a gelatin or starch salting emulsion, a process known as "sizing." The salting formula not only prepares the paper to receive the silver nitrate but also creates a finish that keeps the image from forming deep into the fibers of the paper. Salt prints are made with either sodium chloride or ammonium chloride. The choice of a particular salt is one of the creative controls you have over the look and feel of your final image.

Salting formulas using gelatin will produce cooler prints than those using starch. The paper may be floated upon or immersed in the salting solution for 2–3 minutes, or it may be coated by means of a brush then hung to dry. The floating and immersion methods use more solution, but it is easier to obtain an even coat. Brush-coated papers can be dried with a hairdryer; floated or immersed papers are usually dried by hanging on a line using plastic clothespins.

Floating the Paper

Salting the paper by floating was commonly used in the nineteenth century. The salting solution is poured into a glass tray larger than the paper to be coated.

For prints 8 × 10 inches (20 × 25 cm) and smaller, Pyrex baking dishes work well. Plastic trays with flat bottoms are good, but they are more difficult to clean thoroughly.

There are two ways to prepare the paper for floating: folding two opposite corners to create small tabs or folding a ¾-inch (19 mm) flap along two opposite ends of the paper.

Holding the paper by the corners or the end flaps allows the front of the paper to sag in the middle. The middle is lowered until it makes contact with the solution, and then the sides are lowered until the entire piece of paper floats. Keep the solutions from flowing to the back of the paper. If the paper starts to curl, hold the flaps with your fingertips and breathe onto the back of the paper. Increasing the humidity with your breath will relax the paper. Float the paper on the salt solution for 1–2 minutes. Hang on a line using plastic clothespins to dry before sensitizing.

Sensitizing the Paper

After the paper is salted and dried, you will need to sensitize it before printing. Sensitizing may be done by tungsten light, though a Kodak OC safelight filter is preferable. The paper should be coated with a brush then hung to dry. While it is okay to salt the paper by floating or immersion, the light sensitive coating should be brushed on as you do not want to sensitize the back of the print.

The paper, having been coated, is now light-sensitive. It can be dried with a hair dryer on the cool setting under a safelight or left to dry in a dark room. If you live in a humid area, the paper should be used immediately after the silver coating is dry to prevent it from discoloring. Adding a few drops of glacial acetic acid to the silver solution to lower the pH to around 3.5 will slow down the tendency of the paper to discolor.

***Caution*:** Silver nitrate stains skin and clothing. Wear rubber gloves. Should staining result, try removal with one of the stain removers listed in the "Formulary" chapter: Miscellaneous.

Author's Note: Formulas for salting and sensitizing paper can be found in the Formulary under Salted Paper.

Coating the Paper with a Brush

Cover a large, flat board with a sheet of blotting paper. An oversized piece of white Plexiglass or a good quality ¾-inch plywood or an old breadboard is perfect for this. Tape the perimeter of the blotting paper onto the edges of the board. To make the process of brush coating easier, buy an inexpensive plastic Lazy Susan to place under the coating board. This will allow the paper to be turned at right angles quickly and easily to brush the solutions onto the paper from different orientations.

Brushing on the solutions is a critical part of the process and the one that gives printers the most difficulty. The problem is compounded because the sizing and sensitizer are both clear and can't be seen while they're being applied. Be sure to use two separate brushes: one for the sizing and one for the sensitizer.

The Tape or pin the corners of the paper to be coated onto the coating board. Make tick marks with a pencil at the corners where the negative will be positioned.

Pour the sensitizing solution onto the center of the paper or begin to pour it at one end of the paper and drag the container—usually a small beaker—in a straight line down the center. Then coat the solution in overlapping rows using a good-quality artist brush[1] until the area inside the tick marks appears to be evenly covered. After coating the paper, turn the coating board 90 degrees and brush the paper again. Turn the board one more time and brush again. The second and third brushing will aid in distributing the solution evenly on the surface of the paper.

PRINTING WITH P.O.P.

Printing out papers are printed using a wooden contact-printing frame with a hinged back or between a piece of glass and a flat plywood board before sensitizing. If the paper is not thoroughly dry, it can cause stains on the negative. If you're concerned about damage to your negative or are using an irreplaceable historic negative, place a thin piece of clear acetate, available at art stores, between it and the paper.

When exposed to a light source—UV printer, sunlamp, or sunlight—the paper will darken quickly at first and then slow down. When using a contact-printing frame, you can check the progress of the print under subdued light by unhinging the short side of the back and peeling the print back to inspect the progress. Be careful not to fog the paper by exposure to bright light or to move the registration. The highlights should be darker than the tone desired in the final print, and the shadows may even have a metallic sheen called bronzing. With practice, you'll learn to judge when the print has reached the proper density.

Contrast Control

Chemical Control of Contrast Fuming the paper with ammonia changes the pH of the silver halide to an alkaline state. The paper will print faster and have more contrast. This technique was used in the nineteenth century with all printing out papers.

To fume paper use a large plastic storage box with the bottom lined with cotton wool. Tape the sensitized paper by four corners to the underside of the lid, emulsion side facing out. Drizzle 3 ounces of household ammonia evenly over the cotton and replace the lid with the paper taped in place. Fume for 1–3 minutes. Remove the paper and allow it to outgas for about 2 minutes before placing it in the printing frame.

***Caution*:** Do not breathe the fumes when opening the lid.

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[1] An inexpensive foam brush works well but soaks up more solution.

Controlling Contrast with Light The greater the amount of UV light, the faster the printing time and the lower the contrast. Sunlamps and direct sunlight both contain relatively high amounts of UV and create the lowest contrast.

Another method is to place one or more sheets of tracing paper or a sheet of frosted glass over the printing frame. Exposure time will be increased, butcontrast will also be increased dramatically. Placing the printing frame on the shaded side of a building or under a shady tree on a sunny day will have a similar effect.

Processing the Print

The print should first be washed to remove any free silver nitrate. Free silver nitrate will precipitate gold from the toning bath and interfere with fixing. This step is done using tap water that contains chlorine to precipitate the excess silver. If you are not sure if your tap water contains chlorine, add a pinch of table salt to the wash water. Wash by periodically rocking the tray and changing the water every few minutes. until all milkiness in the water has been removed. Using a dark tray or placing a sheet of black Plexiglas in the bottom of the tray makes seeing this precipitate easier. At this point, the paper has lost most of its sensitivity, but it is still sensitive until fixed.

Toning

Toning is optional and is to be done *after* the first washing step and *before* the fixing bath. Without toning, the final print will tend toward a warm brown color. By toning with gold, you can create a variety of colors ranging from reddish-brown to purple to blue-gray. Toning also increases the permanence of the print, not unlike silver-gelatin papers.

As a rule, acid toners, such as Borax Toning Bath, act slowly and tend to be warm; alkaline toners, such as Thiocyanate Toning Bath, act more quickly and tend to be cool or blue. If gold toning is intended, trim the darkened edges from around the print so that you don't waste gold solution.

It is difficult to judge the final tone of these papers, as the color gets cooler as they dry. It is a good idea to print out several step tablets and place them in the toner at 3-minute intervals. Carefully mark each one and keep them for reference.

Fixing

After toning, fix the print in fixer without hardener for about 5 minutes. If an acid stop bath has been used, then after fixing, immerse the print in HCA and wash as you would any double-weight, fiber-based paper.

OTHER PROCESSES

That's all there is to making simple salted paper prints. The processing of salt prints is similar to other printing out papers, so if you learn one method you will have a basic understanding of all the processes. Alternative printing processes can be rewarding avenues of creativity. The level of difficulty is minimal when measured against the great control and freedom of expression available through manipulation of the process.

Gold Toning

Scully & Osterman

This bicarbonate-type toner gives warm red-brown, to cool brown, to purple-brown tonality depending on the depth of printing and depth of toning. It can be used immediately after mixing.

Percent solutions were rarely used in the nineteenth century. Toning formulas were based on adding gold by the grain to the toning solution. The standard for making and using a gold chloride toning solution begins with dissolving 1 gram of gold chloride into a given quantity of water, which is equal to 15.4 grains.

Gold Chloride Stock Solution

Gold chloride, 1.0 g
Distilled water, 154.0 mL

Based on the earlier example, every 10 mL will give you 1 grain of pure gold. So, when a formula calls for *x* quantity of water and so many grains of gold, it's easy. The pH is adjusted by test papers.

Gold-Bicarbonate Toning Formula for Albumen, Salt, and Collodion Paper

Gold, 2.0 grains (20.0 mL of the stock solution)
Distilled water, 700.0 mL
Add: Bicarbonate of soda to test pH 8

If needed, more water or gold can be added to make the bath more controllable. For toning salt prints—which tone much faster—start with 1 gram of gold and tweak as needed.

Sel d'Or (Gold with Hypo) One-Step Fix/Tone for Salt and Albumen

This was the very first toning approach for photographic prints and was taken directly from the technique used to gild daguerreotypes, except that in that technique, heat was applied to the underside of the plate during the process.

Most people usually mix this formula "to taste," but essentially, it's about 4–6 grains of gold stock solution added to a 1000-mL mixture of 150 grams hypo and a pinch of bicarbonate. The print will initially lighten up when first applied but then darken gradually as gold replaces the silver.

Like all gold toners, the *action is more effective if performed slowly*. Adjust the gold or water content to require between 5 and 10 minutes at room temperature for complete toning.

Sleepless, 2004. © France Scully Osterman. All rights reserved. Courtesy of the Tilt Gallery. Waxed salt print from collodion negative.

Collodio-Chloride Printing Out Paper also known as Collodion Aristotype Paper

Mark Osterman

The collodio-chloride printing out process was first introduced by Auguste Gaudin in 1861 but never realized commercial success or general acceptance until the 1880s when clay-coated paper stock was adopted for photography. In 1884, Paul Liesegang introduced a collodion chloride emulsion for paper that he called Aristotype. It was related to the wet plate collodion process, used to make negatives, ambrotypes, and ferrotypes, but relies on emulsion technology.

The Aristotype Company in Jamestown, New York, introduced the most popular collodion papers in two different finishes: glossy and matte. The formula shown later is for making a glossy finish paper. Glossy papers were typically toned to a purple brown using gold chloride. Matte papers were toned with platinum *and* gold and look very much like a platinum print. Regardless of the finish or toning approach, collodion papers were the most archival of all silver halide photographic papers and are easily identified today because they are usually found in excellent condition.

Collodio-Chloride Emulsion

Formulas and Emulsion Mixing Directions

The alcohol listed in this formula is ethyl alcohol—also known as ethanol or grain alcohol. The strength should be as strong as possible since water will be used to dissolve some of the solid chemicals. Some water is necessary in collodion formulas, but too much will cause chambered markings in the film called “crepe lines.” The following can be done under common household light.

Solution A

Strontium chloride, 1.0 g
Alcohol, 4.0 mL
Glycerin, 4.0 mL
Distilled water, 5.0 mL

Add the strontium chloride to distilled water and dissolve by gentle heat and agitation using a glass rod. Add to this the alcohol and glycerin and mix well.

Solution B

Collodion USP, 250.0 mL
Alcohol, 85.0 mL

Add the alcohol to the collodion and mix until dissolved. Add chloride Solution A to the collodion Solution B and mix well. This is now called "salted collodion."

Solution C

Citric acid, 1.8 g
Alcohol, 2.0 mL

Add the citric acid to the alcohol and mix until dissolved. Add this to the salted collodion solution.

Solution D

Silver nitrate, 6.0 g
Distilled water, 7.0 mL
Alcohol, 20.0 mL

Add the silver nitrate to some of the distilled water and dissolve. The less water you use to dissolve the silver, the better. Add the alcohol to the silver solution and mix until dissolved. You will now have two distinct solutions: the salted collodion and the silver nitrate. The emulsion is made by carefully combining these two solutions.

Making the Emulsion

A mechanical magnetic stirrer is great for making emulsion. In lieu of that, you may stir the solution with a glass rod in one hand while adding the silver solution with the other. The following should be performed under safelight conditions, using either amber or red light. Making the emulsion involves adding silver nitrate solution to the halide solution with constant agitation. The silver may be added by using a plastic hypodermic syringe with a fine opening. In collodion emulsions, the silver may be added in a thin, continuous spray while the collodion solution is being stirred. As the silver is added, the collodion will change from a clear liquid to an opalescent color.

Once the silver is added, pour the emulsion into a very dark brown glass bottle or, better yet, search your local antique shop for the less common black glass bottle. Cork the bottle and shake it vigorously for a couple of minutes. Set the bottle aside, undisturbed, for at least a day. Never allow the emulsion to be shaken again, as this will stir up any precipitates and produce millions of fine bubbles, both of which will make it impossible to make an even coating. The mixed emulsion has a remarkable shelf life if kept in a cool, dark place.

Coating Paper with Collodio-Chloride Emulsion

Because collodio-chloride emulsions are alcohol/ether-based, paper for coating must be either heavily sized with hardened gelatin or coated with a baryta layer. The baryta layer—as used in all commercial gelatin-based photographic papers—contains an inert white solid suspended in hardened gelatin. Baryta-coated papers are becoming more difficult to find, as traditional silver-based photographic papers have fallen out of the marketplace. *If uncoated papers are used, the solvents in the collodion emulsion will flow right through the paper fibers.*

Cut a sheet of glass an inch larger on all sides than the paper you wish to coat. Desharpen all the edges with a sharpening stone to prevent accidental cuts. Fold up a ½-inch margin on all the edges of your paper and carefully secure the paper onto the glass sheet using small pieces of graphic arts tape.

If you are familiar with the wet collodion process, the following technique is the same for coating plates. Holding the glass supporting the paper in one hand, pour the collodion emulsion onto the center of the paper. Tilt the paper so that the emulsion flows to all the corners covering the entire sheet. Pour off the excess emulsion from one corner back into the bottle. This draining step may result in diagonal lines forming in the surface of the coating. To prevent these, rock the plate from side to side during the draining step. Keep the corner from which the collodion was drained lower than the rest until the collodion starts to set to a firm gel.

Once the collodion has set, carefully detach the paper and hang it by one corner to dry in a darkened room. Because collodion emulsions are solvent-based, the emulsion will dry to a hard film in minutes. Once coated, it can be printed immediately or preserved for days in a light-tight box. Collodion printing out paper is toned and processed using the same technique as described for salt, albumen, or gelatin-chloride papers.

The only difference between collodion-coated papers and all the others is that during processing, the paper may curl slightly. This is because the collodion side will not easily absorb the processing solutions. This effect can be corrected by using solutions slightly warmed or a smaller quantity of solutions in each tray.

***Caution*:** Collodion, the binder for this emulsion, is a clear, viscous solution made by dissolving nitrated cellulose in ether and alcohol. It is flammable, and you should take care not to coat papers or expose open containers of collodion to sparks or flames. Purchase collodion USP for this process.

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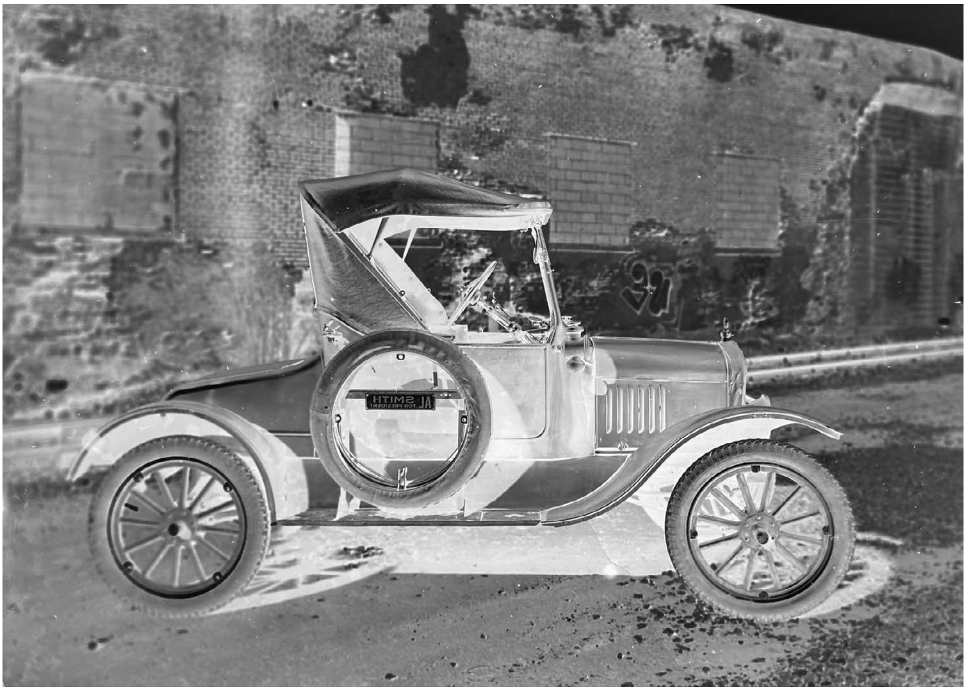

8 × 10-inch dry collodion glass negative. Developed by inspection with pyro and pull processed. © Mark Osterman. All rights reserved.

Model T Ford, 2024 © Mark Osterman. All rights reserved. Courtesy of the artist.

The Bleach-Etch Process, aka Mordançage

Christina Z. Anderson

Excerpted from *The Experimental Photography Workbook*, 2012

Mordançage

The bleach-etch/mordançage process uses an acidified copper bleaching solution to simultaneously bleach and etch a gelatin silver print. The dissolving occurs proportionately to the darks—the darker the area, the more dissolution. This process has been around since 1898 under other names—etch-bleach, bleach-etch, gelatin relief, reverse relief, etc.—but today it is best known as Jean Pierre Sudre's mordançage process because he essentially resurrected it. The formula I use is Jack Coote's from *Ilford Monochrome Darkroom Practice*, Focal Press, 2000.

Warning: Use this process at your own risk, and do not breathe the fumes.

- This process requires excellent ventilation, so do it outside.
- Always protect eyes from splashing; eye goggles are highly recommended.
- Wear old clothes or an apron.
- Wearing gloves is an absolute must.
- Remember: Always add acid to water, never water to acid.
- The mordançage solution will eat through stainless steel, so do not use metal.

Solution A

Water, 750.0 mL
Copper chloride, 10.0–30.0 g (1–2 tablespoons)
Glacial acetic acid, 90.0 mL (6 tablespoons)
Water to make 1.0 L

Add copper chloride slowly to the water and stir. Add acetic acid slowly to this mixture and stir. Add water to make 1 L.

Store this solution, correctly labeled POISON, in a plastic, 1-liter container—never metal. This solution is usable indefinitely.

Solution B

10–20 volume hydrogen peroxide.
Use in equal proportion to Solution A at time of use.

Regular-strength drugstore peroxide will work adequately as well, but 20v from a beauty supply store works great. No need for a higher volume.

The Process

1. Mix Solutions A and B together in equal parts to produce the amount of working solution needed. A total of 500 mL of combined solution will bleach-etch many prints.
2. Once A is mixed with B, this working solution will last several days and can be "reactivated" with 20v hydrogen peroxide for at least a year.
3. Set up trays, from left to right, in this order: mordançage solution, plain water, working-strength or weak developer, plain water, and a final tray of plain water for rinsing.
4. Bleach a wet print in the mordançage solution for 1–5 minutes, depending on the print, paper, strength of hydrogen peroxide, and amount of copper chloride.
5. Nudge a dark area of the print to see if it is lifting off and bubbly. Ilford MGIV usually only takes 1 minute to complete the bleach-etch. Jace Becker's tip: Mordançage the print for just a minute, and then place it to rinse in a tray of warm or hot water. It will immediately speed the process along, keep the print cleaner, and minimize chemical contamination of all solutions and the print.
6. Rinse well, especially with fiber paper. Be cautious with the veils that float around, and never touch the surface of the print with tongs. If the veils are too delicate, it may be that rinsing well is not possible should one desire to leave veils attached.
7. Should one desire to remove veils, rub off the disintegrating emulsion carefully with cotton balls. Do this either underwater or with the print flat on a piece of Plexiglas. If the trays are not flat-bottomed, place a piece of Plexiglas at the bottom of each tray so the tray ribs will not affect the print or the rubbing.
8. Redevelop the print in a dilute paper developer or Part B of a sepia or thiocarbamide toner, or expose the print to direct and strong sunlight for as much time as it takes for an image to appear fully. This will give warm tones such as pinks, magentas, and red browns.
9. Rinse carefully, but sometimes this is not at all possible if the veils are in perfect place.
10. Dry. Don't use a normal drying cabinet for this because the prints may contaminate the screens. Once dry, press between two dedicated pieces of mat board in a dry mount press so as not to contaminate the press. A great aid is a Teflon sheet. With this placed on top of the print in the dry mount press, the softened gelatin will not stick to the press or the mat board.
11. Spray the print with Krylon Crystal Clear nonyellowing acrylic varnish to preserve the print.

Hooker Oak V, 2019. Mordançage process. © 2024 Christina Z. Anderson. All rights reserved. Courtesy of the artist.

17

Print Solarization

ED BUFFALOE

> *"Don't be repressed in your work, dare to experiment, consider any urge, if in a new direction all the better."*
>
> —Edward Weston

THE SABATIER EFFECT

The Sabatier effect, named for French scientist Armand Sabatier, has been popularly referred to as "print solarization." And though this is technically not correct, I find it easier to speak in terms of "solarizing" a print than of "Sabatiering" it.

Solarizing means portions of a photographic paper's emulsion receive differing amounts of exposure, corresponding to various density values in the negative. Some areas receive no exposure or virtually none (high values in the print), other areas receive moderate amounts of exposure (middle values in the print), while yet others receive very large amounts of exposure (low or shadow values in the print). *Each of these areas responds differently to the secondary solarization exposure*, see Diagram 17.1.

The so-called *Sabatier edge effects*, which appear as white lines between areas of distinctly different densities, were proven by Stevens and Norrish in 1937 to be the result of diffusion halation.

There is likewise a *fogging effect* that takes place in areas of low initial exposure that is controllable by varying the length and intensity of the second exposure. This fogging is not strictly the Sabatier effect, which involves desensitization of the emulsion, but is nevertheless a phenomenon associated with what I refer to as "print solarization."

Print solarization includes the Sabatier effect, reversal due to release of bromides, edge effects, and fogging. This definition includes the important steps in making a solarized print, i.e., initial exposure, first development, second exposure, and second development. Through manipulation and control of these steps, a variety of effects can be produced, from mere traces of tone in print highlights to posterization-like reversals.

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The Three Times (Past, Present, & Future) Cuetzálan, July 29, 1994. © Ed Buffaloe. All rights reserved. Courtesy of the artist.

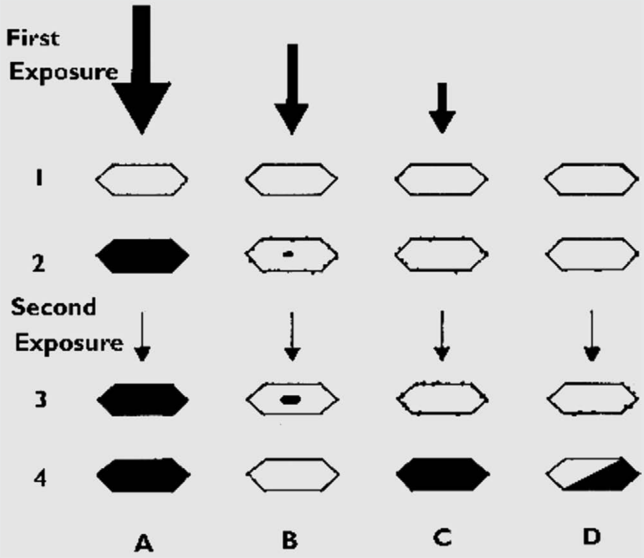


Diagram 17.1 Solarization Exposure. This diagram represents grains of silver halide (1) after the first exposure, (2) after the first development, (3) after the second exposure, and (4) after the second development.

Column A shows that grains receiving large amounts of initial exposure are completely developed during the first development and are not affected by the second exposure and development.

Column B shows that grains receiving a moderate amount of initial exposure may form an internal latent sub-image speck, which attracts electrons and silver ions to the center of the grain. The second exposure only serves to create an internal latent image speck, which is not reducible by a brief second development.

Column C shows grains that receive a small amount of initial exposure. During the first development, these grains form surface—but not internal—latent sub-image specks, which during the second exposure become surface latent image specks, allowing the entire grain to be reduced to silver during the second development.

Column D shows grains that receive no initial exposure. They remain unaffected by the first development. During the second exposure, these grains form surface latent sub-image specks or latent image specks, depending on whether they receive a very weak second exposure or a very strong one, respectively. If the second exposure is weak, these grains will not be reduced to silver. However, if the second exposure is strong, these grains will be reduced. EB

Tree Transformation, 1993. © Ed Buffaloe. All rights reserved. Brovira grade 5, solarized in Ansco 120 1:3.

CONTROLLING THE VARIABLES

Critical variables to be considered in print solarization include paper; developer; developer temperature; initial exposure time; development time prior to second, or solarization, exposure; duration of second exposure; and final developing time. Secondary variables include paper contrast, bromide level in the developer, developer dilution, and intensity of the light source used for the solarization exposure.

Paper

Ideally the paper should be a contrasty bromide emulsion. The most contrasty grades 4 or 5 are typically used for very dramatic posterization-like effects, whereas grade 3 and, in rare instances, grade 2, are used to achieve more subtle results. There are some mixed-emulsion chlorobromide papers that solarize well. At the time of this writing, Bergger Prestige CB Art grades 2, 3, and 4 solarize well.

Developer

The developer should be a metol or phenidone formula, such as Selectol Soft undiluted or 1:1; Ansco 120 1+1, 1+2, or 1+3; R77; Jolly's Solarizing Developer; or a similar formula with low sulfite content and *no hydroquinone*. It is not recommended to keep old solutions for more than a single use, see Table 17.1.

Certain solarization effects may be obtained with metol-hydroquinone formulas, such as Dektol, but the results pale by comparison with the formulas listed earlier. This may be due to the reaction products that are formed when hydroquinone is present.

THE METHOD

First Exposure

The initial exposure is usually one-quarter to one-half stop less than necessary to produce a deep black when developed for half the normal time. This first

Table 17.1

Solarizing Developers

	Ansco 120	*Jolly's Solarizing Developer*	*R77*	*R77M*
Metol	12.3 g	12.0 g	-	5.0 g
Sodium sulfite, anhy.	36.0 g	37.5 g	15.2 g	15.2 g
Pyrocatechin	-	-	3.4 g	3.4 g
Sodium carbonate, mono.	36.0 g	41.0 g	12.0 g	12.0 g
Phenidone	-	-	0.5 g	-
Potassium bromide	1.8 g	-	1.6 g	1.6 g
Sodium Bromide	-	4.8 g	-	-

Water to make 1.0 L

exposure determines the level of original low values that will appear as black in the final print, as well as which portion of the image will reverse. If the first exposure is increased too much, there will be no Sabatier reversal. In this case, the second exposure merely serves to reduce overall paper contrast. If the initial exposure is considerably reduced, the image may be completely reversed during solarization, with the high values fogging and the low values reversing and becoming white.

First Development

Development time prior to solarization should be about half normal, in the 30- to 90-second range. Start with 50 seconds. If the low values do not develop out enough, this time may be extended, but reversal effects with some papers will diminish—it is usually more effective to increase initial exposure to strengthen low values. However, interesting effects may be obtained when the initial exposure is decreased slightly and development time prior to solarization is extended. This reduces overall print contrast and may give a subtle solarization effect that is often mistaken for a normal rendering.

Second Exposure

The light source is generally a frosted incandescent light bulb placed 3 or 4 feet above the developer tray, preferably in some sort of reflector that will evenly illuminate the tray. A switch for the light is necessary. An electronic timer with a footswitch would be ideal but is not essential. I keep an array of different incandescent bulbs for solarization, from 7.5 watts up to 250 watts.

I try to keep the second exposure in the 1- to 10-second range, but exposure time may be extended to several minutes if the light source is weak. The least exposure will produce only a very slight density increase in the high values, where it may illuminate detail that might otherwise be lost. Lengthy exposures will produce deep gray or black in what would otherwise have been highlights and, up to a point, may increase the reversal effect in certain middle print values. With a brighter light source, less exposure is required. I find it is helpful to lift the print out of the developer and float it on the surface just before making the solarization exposure.

Second Development

The second and final development time should be 60–90 seconds but may be extended with highly dilute developers. In most cases, total developing time approximates the normal time used for a typical paper/developer combination. Removing the print early may reduce the reversal effects, which can be desirable under certain circumstances. Agitation should be continuous throughout both development phases, except for the second development in a very high-bromide developer solution, where agitation can cause bromide streaks.

More Variables

The contrast grade of the paper is an important consideration for interpretive reasons. Hard, contrasty papers are typically used when very dramatic high-contrast effects are desired. Softer grades are progressively more subtle and can be used to make prints that may not even look solarized. For example, a low-contrast negative may have excellent shadow detail, but the high values might be degraded and print as shades of gray. A very light solarization exposure on a grade 3 paper may cause these gray values to reverse, in many cases without affecting any other portion of the print, giving the appearance of a normally exposed and developed print. The lower the contrast grade of the paper, the less light is required to solarize it.

The bromide level in the developer may be adjusted to affect both paper contrast and the warmth of the resulting image. The addition of bromide has a warming effect, which is particularly noticeable after toning in selenium or Kodak Polytoner. Typical metol developers contain a gram or two of potassium bromide per liter—enough to cut fog but leave the print with a relatively neutral black tone. As the bromide level is increased, papers develop out progressively warmer, become progressively slower (i.e., require more exposure), and demonstrate progressively less contrast. If a warm tone effect is desired, up to 70 grams of bromide per liter of working solution may be added. Or, if you are out of grade 3 but a lower effective contrast is desired, a high-bromide-content developer may be used to reduce the contrast of a grade 4 paper while imparting considerable warmth to the image.

Increasing the bromide concentration may require adjusting the initial exposure time, the initial developing time, the intensity of the second exposure, the length of the second exposure, or the length of final development, any of which may require further adjustments.

Image warmth may also be controlled to some extent by changing developer dilution. The greater the dilution, the greater the warmth of the resulting image.

The intensity of the light source, as well as the length of the second exposure, affects how dark the fogging effect in the high values will be: The brighter the light source, the darker the resulting tone. They also affect how much reversal will take place. A less intense light source may not produce as clean a reversal effect as a bright source. However, too bright a source will fog the entire paper. If developer dilution is increased or bromide content is increased, a brighter light source is often required. When using very high-bromide developers, it may be necessary to use a 200- to 250-watt light bulb in order to get good reversal effects. An ideal situation would be a very bright bulb attached to a rheostat, so that the desired illumination level could be chosen as required. Different paper brands, as well as different paper grades and different developers, often require different light intensities for optimal solarization.

Practical Procedures

Choose an appropriate aperture and make test exposures at approximate quarter-stop intervals. Under 20 seconds, use 3-second intervals: 9, 12, 15, 18, and 21 seconds. If these exposure times do not produce the desired effect, change the lens aperture and test again. When the correct aperture is determined, each exposure will show the area of reversal shifted to a different tonal value. Sometimes there is no doubt one exposure gives the perfect result, but for the best results, you may find it necessary to make three or more prints at quarter-stop intervals so you can see the entire print at each exposure. Exposure information should be carefully recorded on the back of each print.

With experience and care, one can achieve reasonable consistency. To begin with, change one variable at a time. Choose a developer with a couple of grams of bromide per liter and make a working solution. Use a single light source, such as a 60-watt bulb, at about 4 feet from the developer tray and use a set time for the solarization exposure—start with 5 seconds. Adjust the initial exposure for the ratio of low values to reversed areas and the solarization exposure for the amount of fogging you wish to take place in what would otherwise be high values in the print. If you don't get good blacks, increase the initial exposure. If you don't get enough reversal, increase the length or intensity of the second exposure and be sure to develop fully. If you don't get any reversal at all and the print looks normal or overexposed, reduce the initial exposure by a full f/stop and repeat your test.

Print controls such as dodging and burning are still available in conjunction with the Sabatier effect, but there are times when the photographic artist must adopt a counterintuitive approach. If a print area does not reverse, it may not have received enough initial exposure, and the area will require burning in. Similarly, a print area might require dodging during the initial exposure to keep it from reversing when solarized. If the exposure is long enough, you may also dodge and burn areas of the print in the developing tray during the second exposure.

A number of significant variations on the solarization exposure have been recorded—such as making the second exposure through the enlarger with a negative in it. The same negative may be used as for the first exposure, producing interesting edge effects, or another negative may be used to introduce a different image into areas of the print not developed out prior to solarization. If the same negative is used for the second exposure, print alignment becomes a factor. In either case, you will find it necessary to remove the print from the developer and squeegee it for the solarization exposure.

Another variation is to presoak the paper for several minutes in a concentrated developer solution, then squeegee and place under the enlarger—after the first exposure you can watch the print develop out, and after the second exposure you can watch it solarize. You may re-expose if the second exposure was insufficient to induce solarization.

Duotone Effects

One of the most interesting and little-explored possibilities in print solarization is that of duotone effects. To achieve a duotone effect, you must utilize two developers, one for use prior to the solarization exposure and one for use during and afterward. The first developer should have a very low bromide content—only 1 or 2 grams per liter—while the second developer should have a very high bromide content in the vicinity of 30–70 grams per liter of working solution, depending on the paper. The print is exposed and developed for 30–60 seconds in the first developer, then is transferred to the second developer, where it is solarized and developed to completion. The "fog" that is deposited into what would have been the high values of the normal print will be of a distinctly warmer tone than the darker values developed out in the first development prior to solarization.

When utilizing a high bromide developer, it is necessary to use a much brighter light source for the solarization exposure, since bromide tends to reduce emulsion speed. Remember that better results are often obtained with brighter light sources rather than longer exposures.

Bromide streaks are common due to the intense development after the second exposure: To eliminate these, remove from the first developer and soak in a tray of running water for 30 seconds before placing the print in the second developer tray. Allow the print to settle and the developer to become completely still before solarizing, then allow development to finish without agitation. The print may need to stay in the second developer for as long as 2 or 3 minutes.

With the R77 developer, you should make the solarization exposure in the first developer tray, then transfer immediately to the second developer and agitate throughout development. For the second developer tray, try adding 70 grams of potassium bromide to R77.

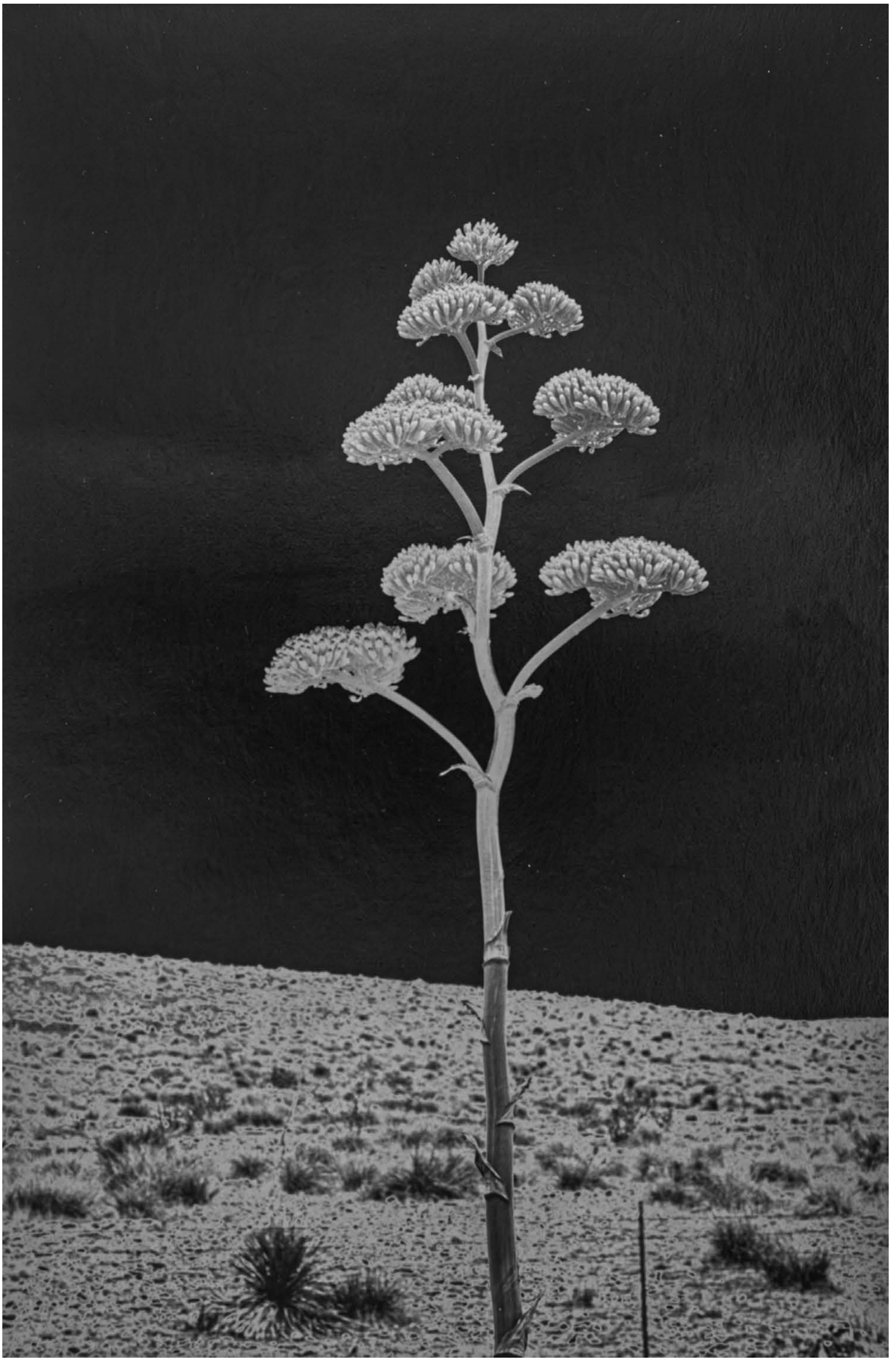
The more variables one introduces into the process, the greater the number of failures one is liable to generate and the greater is the potential for unexpected results. By the same token, you are also increasing the possibility that you will obtain a unique effect.

Bleaching

The high values of solarized prints may become somewhat degraded during the reversal process and may be reduced in a highly diluted ferricyanide reducer. Use the formula for prints—you may wish to dilute it more than normal. Beware of overbleaching, but also consider the fact that prints will dry down considerably—they must be reduced to the point of "apparent" overbleaching, or you may well be disappointed when they dry. Once the prints have been toned, they should not be reduced again, but it is perfectly feasible to let a print dry to see how the high values look before toning. After reduction, the print should be agitated in rapid fixer for 30 seconds before toning. Iodine bleach may also be used for a minute or two at a dilution of 1 + 99. Be sure to fix thoroughly, as silver iodide is difficult to remove.

Toning

The print may be toned in selenium 1:15 or stronger or in a thiocyanate-based gold toner for blue tones. I find that a long toning time tends to reduce duotone separation. Toner dilution may be decreased to enable shorter toning times with some papers.



Alien Broccoli, June 10, 1990. © Ed Buffaloe. All rights reserved. Courtesy of the artist.

Making a Simple Silver Bromide Gelatin Emulsion

MARK OSTERMAN

> *"There is no such thing as taking too much time, because your soul is in that picture."*
>
> —Ruth Bernhard

The following instructions, updated from previous publications, are a starting point for learning how to make your own black-and-white photographic emulsion. The emphasis is for making gelatin dry plates on glass, but the same emulsion is also suitable for coating onto flexible films and paper. Mind you, these are the very basics, but if you follow the directions, it's possible to make your own dry-plate glass negatives capable of extraordinary resolution and with wide transition tones.

I acknowledge my good luck to have had a gifted student and then colleague like Nick Brandreth and my senior mentor, the late Ron Mowrey, for advice and support.

Mark Osterman
February 2023

SOME HISTORY

By the late 1870s, there were three additional variants of the wet-plate collodion process: preserved moist collodion, preserved dry collodion, and collodion emulsion. Unlike the former two, collodion emulsion relied on adding silver nitrate to the halides in the collodion binder before it was applied to the plate or paper. The basic concept that evolved from making collodion-based emulsions was the basis of emulsion photographic technology that continues today.

Like the daguerreotype, albumen on glass, and collodion processes that preceded them, all gelatin emulsions begin as sensitive only to blue and violet light. However, depending on the procedure, early gelatin emulsion plates could be made two to ten times more sensitive than the typical collodion negative. The sensitivity of many of these early gelatin plates was even expressed numerically by how many times faster they were compared to a wet plate.

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Making gelatin emulsions in the early 1880s was not particularly difficult once the basic concepts were understood. Hand-coating these early plates was also easy since the emulsion could be applied to glass plates under red light. Today an individual can, without expensive equipment, make a similar emulsion that is perfectly suited for hand-coating plates for negatives and positive transparencies.

Gelatin of consistent quality was impossible to find in the mid-nineteenth century, which made it difficult to produce reliable emulsions from batch to batch. As the speed and spectral sensitivity of emulsions increased, the purity of gelatin became more of an issue and photographic-grade gelatin was improved. Photographic-grade gelatin was, and still is, purer than the food-grade variant. Even if commercial chemical-based photography is phased out, better grades of gelatin will still be available because they are used in other industries.

UNDERSTANDING GELATIN

There are good reasons why gelatin replaced collodion as a photographic binder. When gelatin is placed in cold water, it swells as much as ten times its volume. Gelatin melts in hot water but sets to a firm jelly when chilled. Silver halides can easily be suspended in hot gelatin, and they remain in suspension after the gelatin dries and returns to its original volume. Gelatin emulsions can be hardened to resist melting in warm solutions, making it possible to produce plates, films, and papers that can be processed in solutions of a wide range of temperature. Finally, gelatin acts as a sensitizer, allowing the possibility of higher sensitivity than ever possible with collodion-based emulsions.

If possible, start by making your first emulsions with photographic-grade gelatin and once you can make clean working plates, try other sources. When using food-grade gelatin, it's possible that you will need to add more than the formula requires to achieve the same setting characteristics as the photographic grade. This is not a problem, as more gelatin can be added at any time as required to set into a firm jelly at room temperature.

Gelatins are occasionally assigned a "bloom rating," which is important for knowing the setting potential of your emulsion. In the nineteenth century, gelatins were simply offered as soft or hard. It was common to use softer bloom gelatins for the first melt and harder samples for the reserve gelatin added after ripening. This small percentage of softer gelatin in an emulsion allowed the film to be penetrated by the chemicals more easily. Different bloom gelatins in photographic grade are available from the German company ADOX, but it's not necessary to use more than one type in a basic emulsion, see Material Sources: Europe: ADOX.

SENSITIVITY OF GELATIN EMULSIONS

The speed with which you combine the silver solution with the gelatin bromide solution—called the **precipitation step** or the **addition**—has much to do with the sensitivity and resolution potential of the final emulsion. There are several ways to control this variable. These include:

- The quantity and bloom of gelatin in the gelatin bromide solution.
- Speed of agitation when combining the silver with the gelatin bromide.
- Where the silver is added, under the surface or on the surface.
- The opening of the orifice on your syringe and how quickly the silver streams or drips from the orifice. *The slower the silver is introduced, the larger the silver halide grain size and the more sensitive the emulsion.* The reverse is also true; the faster you introduce the silver, the smaller the silver halide and the less sensitive the emulsion.

When making your first gelatin emulsions, sensitivity is much less important than making a clean, fog-free plate with a good range of tones. An incredibly slow, fine-grained emulsion is made by literally pouring the silver solution from a beaker into the gelatin halide solution in a continuous stream while stirring. A much more sensitive emulsion is made by adding the silver, little by little, over a longer time.

RIPENING AND DIGESTION: ITS EFFECT ON GELATIN EMULSIONS

Once the silver solution has been added to the gelatin halide solution, the sensitivity of a simple gelatin emulsion can also be increased by a process called **ripening**. The hot emulsion is kept at a constant temperature to promote the growth of larger silver halide particles on the nucleus of already established silver halide grains. These larger grains are more sensitive to light than the initial smaller particles formed when first adding silver. The hotter the temperature of the emulsion and the longer the ripening period, the larger the silver halide grains will become. It is possible to overripen, a cause of fogging, so follow the suggested heat and time requirements.

After ripening, **reserve gelatin** is added to the emulsion. Once the reserve gelatin is added and integrated into the emulsion, it will also be subjected to a second heat ripening treatment called **chemical digestion**.

Chemical digestion evolved from simply more heat ripening to be a chemical treatment with ammonia, sulfur, gold, or other additives. The basic emulsion described here does not include chemical digestion. It is ripening, however, which continues to increase the sensitivity *every time a gelatin emulsion is reheated.* If an emulsion is reheated too many times or at too high a temperature, it will eventually break down the gelatin to release compounds that produce nonimage fogging. Reheating the emulsion also causes the gelatin to lose its setting characteristics, which are *absolutely crucial for successful coating* and subsequent processing. This is why the reader should never melt the entire stock of emulsion when planning to only use a small portion. Always scoop out only what you need to melt for a coating session and return the bulk container of emulsion to the refrigerator.

"WASHED" EMULSIONS

When silver nitrate is mixed with a bromide and iodide, silver nitrate reacts with the halides, creating a new compound of light-sensitive silver bromo-iodide. In a process called **double decomposition**, a by-product of water-soluble potassium nitrate is also formed. Generally, the iodide reference is dropped in discussion since bromide is the dominant halide. So, this expression of double decomposition is expressed as:

Silver nitrate + Potassium bromide = Silver bromide + Potassium nitrate

When making developed-out silver bromide emulsions, the resulting water-soluble potassium nitrate should be washed away with water, or it will crystallize on the surface of your coated plates. These nitrates are not a problem when coating printing paper, however, because the paper base absorbs them. But washing is an absolute necessity when coating plates or film with emulsion. You can coat with an unwashed emulsion and then wash the plates, but it is more effective and easier to wash the entire emulsion. The first step in washing away this unwanted nitrate in the emulsion is called **noodling**.

CHILLING AND NOODLING

Potassium nitrate is washed out of the emulsion by first allowing the hot emulsion to chill to a still jelly in a refrigerator. Once chilled to a firm jelly, the emulsion is put into a noodle press and extruded into gelatin noodles. In the nineteenth century this was originally done by cutting the emulsion into shreds with a silver fork or squeezing it through the small openings of a cloth mesh, like those used for making hooked rugs. These thin noodles give the emulsion a greater surface area, which aids in releasing the water-soluble potassium nitrate when they are washed in very cold water. The diameter of the noodle dictates the washing time. After washing the chilled emulsion noodles, they are drained of excess water and remelted, leaving behind only light-sensitive silver bromo-iodide in a gelatin binder.

The choice of water for washing the noodles is important. The best choice for initial experiments is either distilled or deionized water. Distilled water can have differences in pH depending on the original source but is usually fine. Tap water is variable. It could be fine; on the other hand, city water with additives or well water with unknown minerals can cause fogging. Worse are the particulates and iron compounds from old iron pipes. Again, start with distilled or deionized water for your first emulsions, and once you make a fog-free emulsion, you can try other sources of water for washing the noodles.

BASIC THEORIES OF EMULSION MAKING

Though it's technically a **suspension**, the end product of this technique has become known as an **emulsion**. The goal is to produce a liquid that suspends the precipitated silver halide particles and keeps the mixed compound from falling to the bottom of the beaker.

The ten basic steps of making a simple washed silver bromide emulsion are as follows:

1. Mix a dilute solution of gelatin dissolved in hot water.
2. Add bromide and iodide to the hot gelatin solution, see Author's Note 1.
3. Mix a silver nitrate solution.
4. Add silver nitrate solution to the gelatin/bromide solution to make an emulsion.
5. Ripen the emulsion by heat.
6. Add more reserve gelatin to the emulsion and reheat to digest.
7. Chill the emulsion.
8. Noodle the chilled emulsion.
9. Wash and drain the noodled emulsion.
10. Remelt and add finals as needed.

Author's Note 1: The presence of a small amount of potassium iodide, along with a higher amount of bromide, in the formula promotes the processing of negatives with a stronger contrast and cleaner minimum density areas in the developed image. This is particularly so if processed with a more active developer. For negatives with "normal" density for enlarging onto silver gelatin developing-out papers or for scanning, the potassium iodide may be omitted. It is best, however, if you make your first batches of this emulsion with potassium iodide.

RELATIONSHIP OF SILVER TO HALIDES

The emulsion described here is a silver bromo-iodide variety. The bromide in this type of emulsion is always in excess to the iodide, and the total halides must always be in excess to the silver. This is also why the silver nitrate solution is always added to the gelatin bromide rather than the other way around. Excess bromide-to-silver ratio is important when adding silver, as it prevents potential fogging during development of the finished emulsion. The emulsion would be more sensitive to light if the silver was in excess, but serious nonimage fogging would be the result. So, the restraining action of a slight excess of bromide is considered beneficial even if it produces a less sensitive basic emulsion. The addition of a small amount of potassium iodide in the formula initially makes the emulsion less sensitive. It acts as a restrainer that promotes cleaner nonexposed areas, giving the final image more contrast. This restraining action of the iodide will also allow the emulsion to be heat ripened longer, promoting larger silver halide grain growth and, as a result, more sensitivity.

MAKING FORMULA MO-1880 SILVER BROMIDE EMULSION

The following instructions are based on typical emulsion technology from the 1880s. The formula will make around 300 mL of a slow gelatin bromo-iodide emulsion for landscape or well-lit portrait work. Naturally you can make a larger batch, but it's best to start out small. You can also make this emulsion more sensitive by adding the silver solution slower combined with ripening and digesting the emulsion longer, but it's better for the novice to start with slow, clean working emulsions. Walk before you run.

EQUIPMENT AND MATERIALS NEEDED

Equipment

Much of this equipment can be used for other historical photographic processes. The hot plate/stirrer, for example, is one of those pieces of equipment that is a great help for mixing all sorts of things. Pyrex glass beakers in assorted sizes are essential in every historical process darkroom. The crock pot and potato ricer or noodle press are specific, however, to gelatin emulsion making, an activity very similar to cooking.

- Safety glasses or goggles
- Latex gloves
- Accurate gram scale (0.01–25 grams)
- Pyrex glass beakers: two 300 mL and one 100 mL
- 100-mL Pyrex glass graduated cylinder (for fine measuring of solutions)
- 1½-quart Pyrex "tempered glass" loaf baking dish for chilling
- Laboratory combination hot plate/stirrer with magnet. see Author's Note 2
- Glass or digital thermometer (digital thermometers are cheap and perfect for making emulsion, particularly when they have a built-in alarm)
- Spring-type clothespin or small piece of cardboard to support the thermometer
- Three-quart (about 3 liters) glazed ceramic or stainless steel mixing bowl
- Stainless steel wire mesh drainer big enough to rest in the opening of the aforesaid mixing bowl
- Small brown ceramic cheese crock with wire-locking ceramic lid or an old 35mm stainless steel developing tank
- One square foot of black plastic sheeting (must be opaque)
- One-gallon bag made of black plastic sheeting (must be opaque)
- 60-mL plastic syringe with long removable stainless 18.gauge needle
- Heavy-duty stainless-steel potato ricer or compression noodler, see Author's Note 3
- Refrigerator (a small dormitory type is perfect) and ice cube tray
- Electric crock pot with at least two temperature settings
- 25-inch square piece of sheer white nylon or polyester cloth (for washing and draining noodles)
- Piece of strong cotton string
- Stainless steel spoon
- Glass stirring rod
- Deep red safe light of known effectiveness
- Darkroom timer with sweep second hand
- Paper towels

Author's Note 2: You can use a saucepan half-filled with water on a hot plate or a crock pot for precipitating and ripening the emulsion, but a laboratory combination hot plate with magnetic stirrer is perfect for making emulsion and well worth the expense. You can purchase them secondhand on the internet from online auctions.

Author's Note 3: For years we used a heavy-duty stainless steel potato ricer available through gourmet cooking stores. We tried a screw-type noodler from China but discovered it had parts that were *not* stainless steel. Contact of the emulsion with *ordinary* steel can cause fogging. Most recently, we found a ratcheting plastic cookie press with plastic dies that is the best option as of this writing.

Materials

The quantities listed here are for making one batch of approximately 250 mL emulsion. Naturally it is a better plan to buy larger amounts any time you buy these materials, as they are generally less expensive when purchased in quantity. When you can make a good clean emulsion, you may choose to make bigger batches by proportionately increasing the quantities.

Distilled or deionized water, 250.0 mL
Potassium bromide, 10.5 g
Potassium iodide, 0.4 g (this may be omitted for lower-density negatives)
Silver nitrate crystals, 12.0 g
Gelatin, 21.0 g (start with photographic grade)
Chrome alum, 5.0 g (only added as needed)
Thymol crystals, see the Finals section
95% grain alcohol, see the Finals section

***Caution*:** Safety goggles and latex gloves should always be worn when handling silver nitrate to prevent possible eye injury and indelible stains on skin.

THE PROCEDURE

Very Important: Take the time to read and visualize the following steps before you attempt to make the emulsion. Have everything set up before you start, and be sure all your glassware is clean and rinsed with distilled water. Failures in making emulsions are usually the result of substituting materials, taking shortcuts, or not fully understanding the directions. You may want to practice step 6 with plain water to feel comfortable with the technique. Try to spray 40 mL from the syringe in a continuous stream within 1 minute. Preparing all the materials and equipment prior to working under safelight conditions always makes the procedure much easier to perform. Now is a good time to put on latex gloves and safety goggles or glasses.

In Daylight

Place 3 grams photographic-grade gelatin into a 300-mL Pyrex glass beaker with 85 mL distilled water. Allow at least 15 minutes for the gelatin to become fully swollen and easily flattened—or squished—between the fingers. This is called the “first melt” gelatin.

Put 18 grams of photo-grade gelatin into a second 300-mL beaker with about 80 mL *cold* distilled water, or enough to just cover the gelatin. Allow this gelatin to absorb enough water to make it soft as tested between the fingers. This is called the “reserve” gelatin, which will be drained of any excess water and then added to the emulsion after the first melt.[1]

Dissolve the swollen first-melt gelatin by placing the beaker on a hotplate stirrer. Place the magnet spinner in the solution and turn the speed to

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[1] Often, there is no excess water.

moderately slow. Install the probe of a thermometer deep in the solution but not in the way of the spinning magnet. The thermometer can be held in place by poking a small hole in a piece of cardboard that covers half of the opening of the beaker. Allow room for the syringe to be inserted. Alternatively, the probe may also be secured to the edge of the beaker with a spring-type clothespin. Turn the heat dial to a low temperature and slowly increase the heat. If you start with the hot plate set too high, it will take a long time to return to the proper lower temperature. In either case, keep the gelatin solution moving so that you see a slight vortex in the middle of the solution. Using a thermometer, try to maintain the temperature of the gelatin solution around 120°F/49°C.

Once the gelatin is completely dissolved, add 10.5 grams of potassium bromide and 0.4 grams of potassium iodide—the iodide may be omitted, as stated previously—to the first-melt gelatin.

Prepare the silver solution by placing 12 grams of silver nitrate in a 100-mL Pyrex glass beaker with 85 mL distilled water. Heat this silver solution to around 120°F/49°C and draw half of this solution, 42.5 mL, by putting the tip of the syringe in the solution.

After this point, every operation should be done under a medium dark-red safe light that is known to be "safe."

Precipitation: Slowly squirt the heated silver solution at a rate of 42.5 mL per minute in a continuous stream *with the tip below the surface of the gelatin halide solution* while the gelatin bromide solution is stirred continuously. This is where a hot-plate stirrer comes in handy. The speed of stirring should be moderate, and you should keep track of how fast on the dial of the hot-plate stirrer so you can always do it at the same rate. Refill the syringe—this should take about 20–30 seconds—and continue until all the silver solution has been added to the gelatin-halide solution. As you combine the clear silver with the clear gelatin-halide solution, you will immediately see the two clear liquids change into a milky-looking silver bromo-iodide emulsion. Clean up any drops of silver on your workspace with a paper towel, see Photo 18.1.

Tip: When making more sensitive emulsions that require slower additions, you can be more accurate if you use a musician's metronome to keep you on track as you gently and continuously push the plunger of the syringe. You can set your own rhythm on the shaft of the metronome to as slow as you want.

First Ripening: After all the silver has been added, heat-ripen the emulsion by maintaining the temperature at around 120°F/49°C for 15 minutes with constant but slightly slower stirring. During this first ripening the initially established silver bromide crystals will grow larger. Remember that being accurate with time and temperature will produce more consistent results. At this point you should have around 200 mL emulsion.

Adding Reserve Gelatin and Second Ripening aka Digestion: While the emulsion is ripening, begin draining any excess water from the reserve gelatin you mixed earlier. Too much water in the reserve gelatin can cause weak, thin images. The gelatin usually takes up nearly all the water.

When ripening is complete, add all the reserve gelatin to the emulsion while stirring. When you first add the reserve gelatin, the temperature of the emulsion

Photo 18.1 Precipitation of the silver solution into the promo-iodized gelatin solution.

may fall a little. It might take a few minutes to bring the temperature of the emulsion back to 120°F/49°C. Gentle stirring is maintained throughout this operation. Once the emulsion has once again reached 120°F/49°C, maintain this temperature for about 5 minutes with gentle agitation to further "digest" the silver halide. During this time the silver bromide crystals continue to grow on the original crystals. The larger the crystal, the more sensitive the resulting emulsion.

After you make and test your first batch of successful emulsion, experiment with extending this second ripening for added speed. After adding the reserve gelatin, you should now have around 250 mL emulsion.

Chilling: Pour the hot emulsion into the shallow glass Pyrex loaf dish and carefully slide this into the light-tight black plastic bag. Secure the opening of the bag so that no light can fog the emulsion. Place the bagged emulsion in a refrigerator for about 2 hours or until completely set to a stiff jelly. The reason a shallow dish is used for chilling the emulsion is so that it will set the gelatin to a stiff jelly faster and more evenly than if left in the beaker. You can speed up the process by prechilling the Pyrex dish with some ice water for a few minutes. Wipe it with a paper towel before adding the emulsion.

In the following steps it is advisable to continue to wear latex gloves, not because of potential silver stains but to prevent contamination of the emulsion from your hands.

Under red safe light remove the emulsion from the refrigerator and pull the dish from the bag. The emulsion will look white under the safe light—it is actually light yellow. Scoop out some of the firm jelled emulsion with the stainless steel spoon and put into the "noodler."

Noodling and Washing: Place the 25-inch-square sheer white nylon fabric in the stainless steel wire drainer and lay the drainer in the mixing bowl. Squeeze the noodler to extrude emulsion noodles that will fall into the center of the fabric. When the emulsion is completely noodled into the fabric, gather the edges of the cloth and secure the bag of noodles with cotton string. Pour around 1.5 liters distilled or deionized water into the mixing bowl. Add a few ice cubes made with the same water and gently move the noodle-filled fabric under the water with your hands for about 5 minutes. Occasionally squeeze the bag with the fingertips to be sure the emulsion noodles are separated. Let the bag of noodles soak for 5 more minutes without agitation and then replace the water. Change the water two more times and wash the noodles as previously described, see Photo 18.2.

Photo 18.2 Noodling. Squeeze the noodler to extrude emulsion noodles that will fall into the center of the fabric.

The quantity of water doesn't have to be exact but should be near this volume. It should, however, be around 44°F/7°C. Failure to wash the noodles as directed will produce a less sensitive emulsion because this step can also remove some beneficial excess potassium bromide, which acts as a restrainer.

Remelt and Finals: Empty the water from the wash bowl and place the strainer in the top of the bowl. Twist and squeeze the bag to drain the washed emulsion noodles. Place the bag in the strainer, untie the string, and open the bag to expose the noodles. Allow the noodles to continue draining for 15–30 minutes; longer draining is even better. Move the noodles around from time to time with a stainless steel spoon. It is important to remove as much excess water as possible because too much water will dilute the emulsion causing weak, thin images.

Carefully scrape up all the noodles with the stainless steel spoon and place them in a clean 500-mL Pyrex beaker. Remelt the emulsion using the electric crock pot or a small saucepan of hot water at around 120°F/49°C. The emulsion will usually be around 80°F/26°C to 100°F/37°C when melting with a crock pot. Once the emulsion is melted, completely add the "finals." The finals are 5 mL 95% alcohol to aid in coating and three drops 10% thymol to prevent bacteria growth. Remember that gelatin is the perfect medium for growing bacteria. **Thymol** is only really needed if you plan to store the emulsion in a refrigerator for more than a few weeks, though it's best practice to always include thymol. With thymol, emulsions will keep for many months.

Dmin Dmax Test: To determine if you have made the emulsion correctly.

Before adding any finals, storing your emulsion in the refrigerator, or coating plates, it is instructive to test the minimum and maximum density potential of your emulsion. This is easy. All you need is an eye dropper and two 4 × 5-inch sheets of clean 100% cotton blotting paper. Place several drops of hot emulsion on each blotter and let them dry in a dark place. Expose one set of drops to daylight but not the other. After the emulsion drops have dried completely, process both test sheets in the same developer, using stop and fixing solutions for the same times as you would your plates, see the section on processing in this chapter. You should see clear dots in the unexposed sheet (Dmin) and very black dots in the exposed sheet (Dmax) if you made the emulsion correctly.

Finals

- 95% grain alcohol
- 10% solution of thymol solution (10 grams thymol dissolved in 100 mL 95% grain alcohol)

Add finals into the emulsion and stir with a glass rod. When fully incorporated, pour the entire contents into a brown ceramic cheese crock, see Photo 18.3, carefully cover the opening with a piece of black opaque plastic, and secure the ceramic lid with the wire spring. Another storage option is an old stainless steel 35mm developing tank. Developing tanks can be covered with the same opaque black plastic material and secured with a rubber band. Place the emulsion in the refrigerator for future use. Remove only what's needed when coating a batch

Photo 18.3 Cheese-Crock. When fully incorporated, pour the entire contents into a brown ceramic cheese crock.

of plates by scooping out the chilled emulsion with a stainless steel spoon. The stock emulsion will last many months if thymol is added and it's kept cool and protected from white light.

"Doctors"

Doctors are additives introduced into small batches of the emulsion just prior to coating plates, film, or papers. The only doctor that *might be needed* in this emulsion is **chrome alum**. If you are developing plates in a hot climate, where your processing solutions are warmer than 68°F/20°C, you should consider using chrome alum as a hardener. Unhardened emulsions will soften and eventually dissolve in chemicals that are 75°F/24°C and warmer.

Most of the early emulsion formulas *do not* include chrome alum, and if you work in a temperate climate or in an air-conditioned workspace, you may not need a hardener in your emulsion. It's best to make your first emulsion without any chrome alum hardener if possible.

If you do choose to use chrome alum, add the solution drop by drop while stirring the emulsion or the emulsion will instantly seize into a solid lump.

Too strong a chrome alum doctor will prevent the dried gelatin emulsion from absorbing the processing chemicals, resulting in thin images and prolonged developing times.

The hardening effect of chrome alum also continues long after the emulsion has dried on the surface of the plate, so it's best to use the plates within a week or so to keep development time short. There is no way to include the absolute correct amount because the characteristics of each source of gelatin are going to be different. The quantity of chrome alum may need to be decreased or increased as needed. *Make only as much chrome alum solution as you will need, as it goes bad quickly.*

Chrome alum Doctor: Add 0.6 mL of a 5% chrome alum solution—1.25 grams chrome alum into 25 mL distilled water—for every 100 mL emulsion just prior to coating your plates.

Coating Glass Plates with Gelatin Emulsions

Coating glass plates with gelatin emulsions is a little different than working with a solvent-based binder such as collodion, which relies on evaporation for the coating to set to a firm film. Gelatin emulsions must be heated to a liquid form and, once applied to the glass support, be able to set back into a firm jelly at an average room temperature. This so-called "**set time**" or "**setting time**" is governed by the ambient temperature of the room, the bloom and percentage of gelatin, and the quantity of chrome alum added to the emulsion.

Shortening the setting time was almost always done by quickly lowering the temperature of the emulsion. The most common approach was to level a piece of polished marble or thick glass and place the warm coated plates upon the surface until the emulsion cooled and became firm. The setting of gelatin emulsions on paper supports was generally accomplished by chilled air.

The earliest commercially made gelatin dry plates were coated by pouring the emulsion by hand. An 1884 account of the coating operation at the Cramer Dry Plate Works in St. Louis was described as "eight busy men, with pitchers of emulsion on one side, a pile of glass on the other. . . and in front of them, a peculiar leveling stand" (*Philadelphia Photographer*, Jan 1884, p. 11).

The following instructions are based on the techniques of the early 1880s, before the invention of cascade or slit coating and continuous belt chilling chambers. This system of hand coating with a pouring cup and chilling table is not difficult to master and enables one person to make dozens of plates in one sitting. The only real limitation is the capacity of the drying box and supply of cleaned plates.

EQUIPMENT AND MATERIALS NEEDED

- Equipment
- Glass cutter
- Cork backed straightedge
- Small sharpening (whet) stone
- 2-inch-wide natural-bristle paint brush
- Soft natural-hair makeup brush

- Two wood plate racks
- Clear liquid dish detergent
- Two 300-mL Pyrex glass beakers
- 30-mL Pyrex glass beaker with 15-mL mark
- Electric crock pot with at least two temperature settings
- Gold-plated metallic mesh coffee filter
- Electric laboratory hot plate
- Deep red safe light
- Paper towels
- Two 1 × 1-inch marble tiles or ¼-inch-thick glass plates
- Small spirit level
- Two wood leveling stands
- Drying box

CUTTING AND CLEANING GLASS PLATES

Framing glass is usually good enough for hand-coated photographic plates. Make sure you purchase these from a framing supply house in unopened boxes. The plates should be interleaved with paper to prevent surface scratches. Never buy your glass cut by someone else. If you have never cut glass before, pay a visit to a stained glass shop, purchase the best glass cutter you can afford, and ask for a demonstration.

Cut the glass to the desired size, and never lay the plate surface down on anything or it will become scratched. Place the plate upright against a wall or in a wood rack. It is extremely important to remove the razor-sharp burr on all the edges on both sides with a small hand sharpening stone. Dust off the powdered glass dust with a stiff natural brush. This is also a good time to check if the plates fit your holders *before you coat them with emulsion.*

Apply a few drops of clear dishwashing detergent to a plastic wash tub of warm water. Dunk a plate into the sudsy water and rub both sides of the glass surface thoroughly with your fingers. Wash the plate completely under warm running water. Be sure to rinse your hands carefully along with the glass plate. Keep washing in running warm water until the water sheets off evenly. Only handle the washed plate by the tips of the corners and place the plate upright in a rack to dry.

HEATING AND POURING THE EMULSION (UNDER RED SAFE LIGHT)

The directions are based on coating a standard 4 × 5-inch plate. The whole coating procedure requires very little time—less than 10 seconds for this size plate from the initial pour to placing the plate on the chilling table. It is similar to coating collodion plates, though not exactly. *Naturally all of the following is performed under red safe light conditions.* Before you turn off the white lights, level your chilling tables using the spirit level.

1. Remove the emulsion from the refrigerator. Scoop out enough cold gelatin emulsion for several plates and place this in a clean 300-mL glass beaker. Put the beaker containing the emulsion in a heated crock pot and with enough water to

keep the emulsion warm without having the container float or flip over. Heat the emulsion to between 95°F/35°C and 105°F/40°C.

2. When the emulsion is thoroughly liquefied, pour it through a gold-plated metallic coffee filter into a second 300-mL beaker. Allow some time for the emulsion to settle so that the bubbles rise to the top and pop. Pour 25 mL emulsion into the 30-mL beaker from the heated stock beaker. If bubbles are a problem, add a drop of alcohol to the emulsion just before pouring. This will break the surface tension and pop the bubbles.
3. Slightly heat the plate of glass by placing it momentarily on the surface of a warm laboratory hot plate or food warming tray covered with two layers of paper towels. The plates should be a little warm, but not too hot to handle. While the plate is still warm hold it in the left hand with the fingertips supporting the back of the plate. Give the plate a quick dusting with the makeup brush. Note: As you become better at coating, you can omit preheating the plate.
4. Holding the 30-mL beaker with emulsion in the right hand, pour all of the 25 mL emulsion onto the center on the plate. Keep the plate level so that the creamy emulsion forms a perfect circle and allow it to spread across the plate, see Photos 18.4–18.5.
5. Very gently tilt the plate if needed so that the emulsion flows progressively to all four corners *without going over to the back side*. Once the plate is completely covered, slightly tip the plate to let some of the emulsion flow off one corner and back into the pouring cup, see Photo 18.6.
6. Immediately after draining the excess emulsion, give the plate a slight rocking motion for a second or two so that the emulsion redistributes evenly on the entire surface and then quickly place the plate on the leveled chilling slab, leaving

Photo 18.4 Pour the 25 mL emulsion onto the center on the plate.

Photo 18.5 Distributing the emulsion across the surface of the plate.

Photo 18.6 Slightly tip the plate to let some of the emulsion flow off one corner and back into the pouring cup.

a slight lip to hang over the edge of the slab for subsequent removal, see the Appendix at the end of the chapter for images of the chilling slab and leveling table. The emulsion should still be warm and still fluid enough to level itself on the surface of the plate before it begins to set to a firm even coating. If you wait too long, the coating will start to set too soon and cause ridges.

7. As the gelatin begins to set up, you may see some dimples on the surface. Move the plate to a new section of the chilling table until the emulsion is firm enough to place upright on a rack in the drying box. You can test the firmness of the emulsion by touching one corner with your finger, though with experience you'll eventually have a sense of when they're ready to be removed from the slab without touching the surface.

The slower gelatin plates are dried, the better. Fast drying can cause concentric ridges in the surface of the emulsion. Make sure the drying box is absolutely light-tight but fitted with adequate ventilation. Collect the dry coated plates the next day and place them in a light-proof slotted box or interleaved with clean paper until needed.

This emulsion is slow by modern standards and only sensitive to blue and violet light. Depending on the batch of gelatin, how careful you were when adding the silver, the duration of ripening, and washing, you may assume an ISO rating of between 1 and 4 based on this formula and procedure.

PROCESSING GELATIN EMULSION PLATES

A typical developer formula for processing gelatin emulsions has the following elements: the **reduction agent** (pyro or metol/hydroquinone), an alkaline **accelerator** (ammonia or sodium carbonate), a **restrainer** (usually potassium bromide), and a **preservative** such as sodium sulfite. By knowing the function of these components, a photographer could tweak the formula to suit specific needs and correct exposure problems to some degree.

Unlike twentieth- and twenty-first-century camera films, development is by a red safe light. This is an advantage because the effect of over- or underexposure can be seen during development. The knowledgeable photographer therefore can adjust the developer as needed to produce the best possible results. It was typical in the nineteenth and early twentieth century for the photographer to have small dropper bottles of accelerator (ammonia) and restrainer (potassium bromide) solutions at the ready near the processing sink to make adjustments as necessary.

Because these are only blue- and violet-sensitive plates, development is most easily done in a white tray so that the progress of development can be viewed by safe light. All other chemical operations can be done in any type of tray, though Pyrex glass is always the best choice, as it is easily cleaned.

Processing the Negative Under Red Safelight

The exposed plate is placed, emulsion side up, into a light-colored tray containing more than enough developer to cover the plate. The developer should be used at a temperature of around 65°F/18°C to 68°F/20°C. Cold developer will result in very low silver density. Hot developer will melt the emulsion. It is necessary to rock the tray during the entire development so that fresh developer is always in contact with the emulsion.

When developing by inspection, the most common mistake is to stop development too soon. The maximum density areas of a negative always look much darker when working under safelight. It will be necessary to lift the plate from the tray and inspect the progress by looking through the plate, illuminated from behind by the safe light. Also look at the back of the plate. Gelatin emulsions gain density from the surface downward, the opposite of wet collodion plates. Assigning a development time of around 10–12 minutes at 68°F/20°C is a good starting point for testing your plates. An average, properly exposed landscape negative develops gradually with the sky visible first, followed by architecture and eventually well-lighted foliage. Overexposure will result in the image coming up faster, including even the darkest areas of the subject. Development can be carried out longer, but this is usually a sign of underexposure and all you will achieve is high contrast or, worse, fog.

Once development is judged to be complete, stop the action of the developer by placing the plate in a dish of dilute acetic acid wash for at least a minute. You can use glacial acetic acid, commercial indicator stop bath, or even vinegar, but it should test around pH 4. Fix the negative in a tray of fresh sodium thiosulfate or commercial fixing agent for at least 5 minutes with occasional agitation. Wash the plate in several changes of fresh tap water or running water for at least 20 minutes and then place on a rack in a dust-free place to dry.

A finished test negative can be seen in Photo 18.7. Photo 18.1 contains a workflow chart.

TROUBLESHOOTING

Peeling problems: On occasion, you may have problems with an unhardened emulsion—without chrome alum—lifting from the edges of the plate, an effect called "**frilling**." This usually happens if water is used instead of an acid stop bath after development. The developer is alkaline and swells the emulsion to as much as 10 times its volume. Plain water will remove the developer, but the emulsion may swell even more and detach. Some people might like the effect for aesthetic reasons.

Assuming the glass support was properly cleaned, the temperature of the developer was not too hot, and an acid stop is used, this shouldn't happen. If you still have problems, a simple 2% alum hardening bath after development is usually enough to prevent frilling.

Image does not appear or takes too long to develop: The plate was either underexposed or the emulsion was too hard due to the addition of excessive chrome alum. A presoak in 70°F/21°C water for about 5 minutes will usually soften a hardened emulsion enough for development. You may also add a drop or two of glycerin to the presoak. Adding a few drops of ammonia to the developer will also help, though excessive ammonia will soften the gelatin too much, causing frilling and fog.

Photo 18.7 An exposure test negative on an MO-1880 gelatin dry plate. Developed by inspection with Dektol.

Fog: There will always be some degree of fog present in gelatin emulsions. Too much fog can be a problem. When made as described, this emulsion is generally very clear. The most common causes of fogging are:

- Poor-quality gelatin
- Heating the emulsion at too high a temperature and/or for too long
- Reheating an emulsion (take only what you need to reheat for a coating session)
- Pre-exposure of the emulsion or the coated plate to white light
- Faulty safe light
- Light leaks in the camera or plate holder
- Overexposure
- Too warm or active a developer

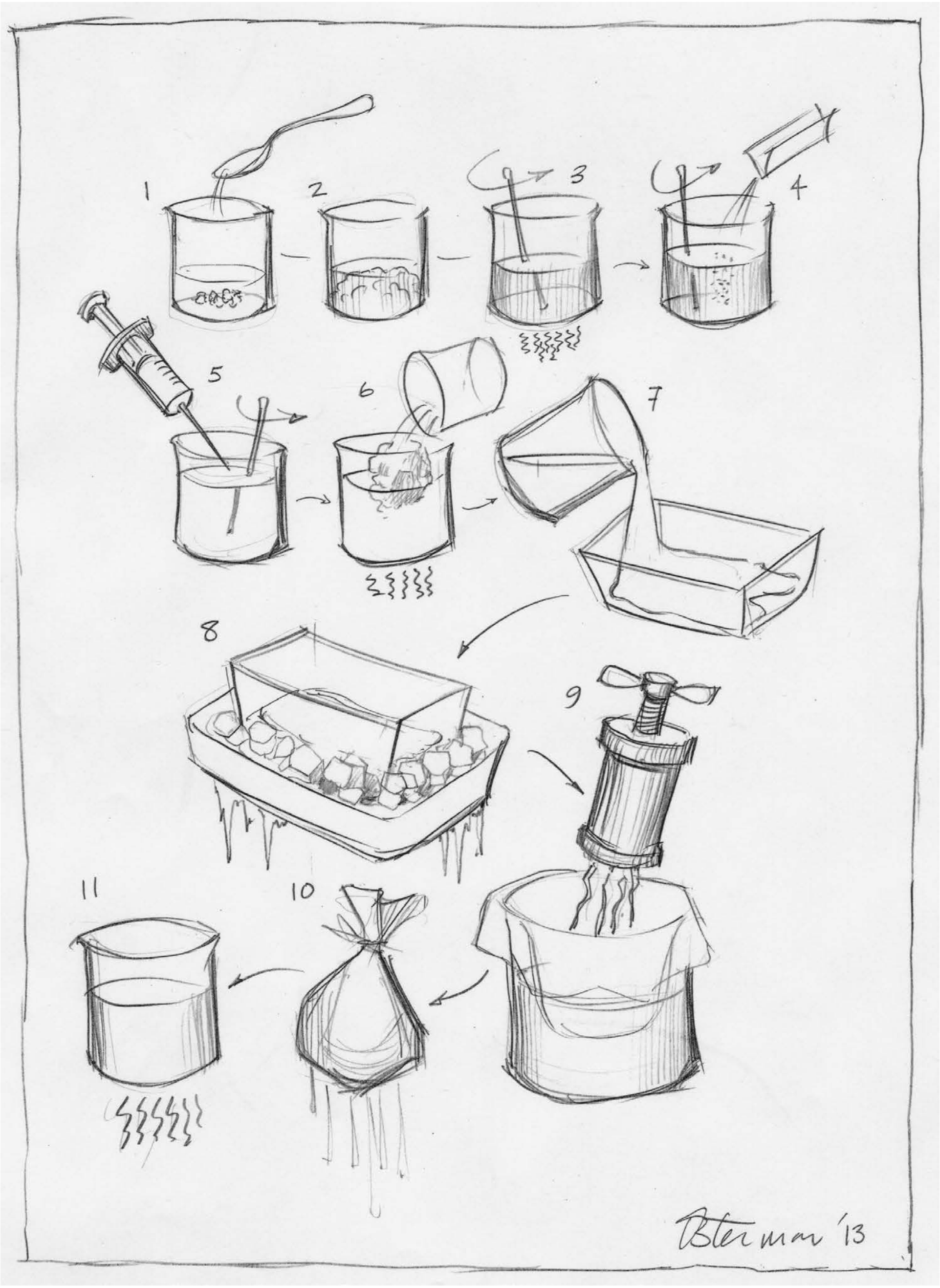


Figure 18.1 Hand-drawn diagram of the important steps for making a gelatin emulsion. © Mark Osterman, Scully & Osterman Studio, Rochester, NY.

If the shadows cast by the plate holder on the edges of the negative are clear, the problem is always overexposure in the camera.

Thin, flat negatives: These are negatives that display a proper amount of visual information in both shadow and highlight areas but have very little density. It is common for beginners to produce thin images. This is usually the result of not following the directions carefully or substituting materials when making the emulsion. Once an emulsion is properly made, the other common causes of thin images are overexposure combined with underdevelopment. Using cold or dilute developer, not developing long enough, or not developing with enough agitation will result in weak, thin images. Density is gained by proper exposure combined with prolonged processing with a strong developer and adequate agitation. Excess water in the emulsion from not draining the reserve gelatin or the washed noodles effectively is another common cause of weak, thin images.

Too much contrast: High contrast is the result of underexposure and overdevelopment. If there is no shadow detail despite prolonged development, it is a clear sign of underexposure.

Remember that visual information in a negative is governed by exposure, whereas density is based on development.

FORMULAS FOR PROCESSING PLATES

Editor's Note: The following formulas can be found in the Formulary.

You can use any print developer, such as Kodak D-72 or Agfa 130, for processing plates coated with this emulsion. Begin by using it undiluted. Dilute with water if you feel the maximum highlight density is too strong.

Kodak D-49 was originally formulated for processing bromide prints, though it can be used undiluted for negatives made with ordinary blue-sensitive emulsions. Kodak D-19 is a more active developer that is good for making stronger negatives for albumen printing or other printing out processes that require a negative with more silver density.

As with all MQ developers, metol and hydroquinone are the active developing agents. Potassium bromide is the restrainer. Sodium carbonate is the accelerator, and sodium sulfite the preservative. If you want more density than extended development will provide you, may raise the pH of your mixed developer, which will make the gelatin swell more.

A good starting point is about 2–4 drops of household ammonia in 100 mL of developer. Pour the developer from the developing tray into a glass beaker, add the ammonia to the developer solution, and then pour the developer back into the tray. Raising the pH with ammonia or sodium carbonate will make the gelatin soft and more permeable so that the developer can be more effective, though too much will cause the emulsion to fog, lift from the glass, and cause frilling.

Increasing the potassium bromide restrainer in the developer will also cause the developer to work slower and cleaner by restraining it more. Tweaking the developer formula as needed eventually becomes intuitive. In the old days dry-plate photographers had two dropper bottles on either side of the developing tray: one for bromide restrainer and the other for ammonia accelerator.

Working Solution for Sodium Thiosulfate Fixer

Water between 65°F/18°C and 75°F/24°C, 1 L
Sodium thiosulfate, 150.0 g

APPENDIX

You will need to construct three things before coating gelatin emulsion plates: a plate rack, a wood leveling stand for a chilling table, and a plate drying box.

Photographic Plate Racks

Vintage plate racks can be purchased at antique shops and on internet auctions, though availability is uncertain. You can make a nice rack by simply drilling pairs of holes into the top of a wooden board and fitting a series of wood dowels, see Photo 18.8. The size plate you wish to coat will dictate the size of the

Photo 18.8 Vintage plate racks can be purchased at antique shops and on internet auctions.

materials. New plate drying racks are now being made for glass plates and can be found by doing an internet search or following a specialty forum for alternative photography.

Leveling Stands for a Marble or Glass Chilling Slab

The chilling table is generally made from a smooth sheet of marble or glass resting on a leveling table. Marble tiles can be purchased at a home improvement or bath and tile shop. Larger marble tabletops can occasionally be found at flea markets or antique shops. In either case, you will need to make sure the chilling table is level before it is used for setting the emulsion on your plates. This is done with a leveling stand, which is essentially a short adjustable tripod with a wide, flat top. Making your own chilling table is easy; simply follow the directions that follow.

Materials

- Two 8 × 8-inch pieces of ¾-inch birch plywood
- Six 1½-inch × 5⁄16-inch bolts
- Six 5⁄16-inch nuts
- Six ¼-inch flat washers
- Six 5⁄16-inch coupler nuts

Drill three 5⁄16-inch holes through the plywood. Countersink the holes so that the heads of the bolts sit below the surface of the plywood when installed. Install the bolts and attach the washers and nuts to the bolts on the underside of the plywood, see Photo 18.9. Thread the coupler nuts on the end of each bolt. The coupler nuts allow adjustment of the leveling stand from below. A marble or glass chilling plate rests upon the leveling stand to complete the chilling table.

A spirit level is placed on the marble surface to establish a perfect level, see Photo 18.10.

Plate Drying Box

In time you may want to make a sturdy wood box with filtered ventilation, but for your first experiments, a cardboard drying box is easy to make and will do the job very well. In fact, the cardboard actually contributes to drying the emulsion. You will need a good-quality, corrugated cardboard box and a couple of extra sheets of the same weight cardboard for constructing the ventilated light trap. The size of the box is dictated by the size of the plates on a plate rack and the quantity you wish to coat in one session. While any tape will work, I have found that the old-fashioned water-soluble gummed paper-backed tape available at art supply stores works well.

Simply put, the box must allow adequate ventilation without exposure to white light. Holes must be cut into either end of the box and then fitted with a light trap. Make sure you have a good-fitting top to cover the box. You can test it for light leaks by putting a lamp in the box and turning off the room lights. Finally, it doesn't hurt to have a piece of black cloth to cover the box for extra protection.

Photo 18.9 Install the bolts and attach the washers and nuts to the bolts on the underside of the plywood.

Photo 18.10 The finished chilling table.

Rochester Plumbing Supply Co. 4 × 5-inch glass negative coated with MO-1880 emulsion. Developed by inspection with undiluted Kodak Dektol. © Mark Osterman. All rights reserved. Courtesy of the artist.

Liranal Direct Positive Developer

Lee Lira

The following developer and procedure are specifically formulated to make direct positive images on black-painted metal plates or glass coated with simple gelatin bromide emulsions. Like the earlier wet collodion ambrotype and tintype processes, silver forms the highlight of the finished image, and the darkest parts of the image are established by the dark material of the support.

Unlike their wet collodion counterparts, gelatin direct positive plates are dry when exposed in the camera. This made the process particularly good for street camera photography in tourist destinations, which was popular in the 1890s–1930s. Initially, the process was based on gelatin emulsions applied to black "japanned" metal plates but eventually evolved to the use of black varnished card stock.

Liranal developer works well with any basic blue-sensitive (colorblind) or orthographic-sensitized gelatin emulsion. The basic gelatin emulsion in this chapter is a good fit for the Liranal developer and procedure. As in the wet collodion process, the support material can be black aluminum "trophy" plates, dark glass, or clear glass. Regarding the use of clear glass, there is always a chance of halation caused by reflection from the back of the glass during exposure. Reducing the exposure will help reduce this effect, or it can be controlled by coating the back of the plate with orange-red tempera paint. Clear glass images will also require a black backing of paint, paper, or black velvet to allow viewing the final image as a positive.

LIRANAL DEVELOPER FORMULA

Mix the developer at 120°F/50°C in the order listed here. Make sure each chemical is fully dissolved before adding the next.

Developer Stock Solution

Distilled or deionized water, 375.0 mL
Metol, 1.0 g
Sodium sulfite, 35 grams
Hydroquinone, 2.0–4.0 g
Sodium carbonate, anhydrous, 22.0 g
Potassium bromide, 2.0 g
Water to make 500.0 mL

The quantity of hydroquinone can be adjusted between 2–4 grams for different emulsions. This will regulate the highlight density. The percentage of hydroquinone also controls the overall contrast and highlight density color from whiteish to yellow.

PROCESSING EXPOSED PLATES

The following is based on developing 4 × 5-inch plates in a 5 × 7-inch tray. The image is best developed at a temperature of 64°F/18°C–68°F/20°C.

1. Begin by diluting 125 mL stock developer with 125 m: distilled or deionized water. Add 6 grams ammonium thiocyanate to this working solution and dissolve.
2. Develop for 1.5–2 minutes only. Development is by time, so do not expect to see a visible image until the fixing stage.
3. Stop development in a conventional acid stop bath for 1 minute with gentle agitation.
4. Fix the image for 4–5 minutes in fresh 15% sodium thiosulfate or a conventional rapid fix film formula with gentle agitation.
5. Wash the plate in fresh running tap water or changes of water with gentle agitation for at least 10 minutes.
6. Place the plate in a tray of conventional wetting agent for a few seconds and stand to dry vertically on a rack.

After developing four plates, pour the developer into a storage bottle to let the sludge that forms settle to the bottom overnight. After the solids fall to the bottom, decant the clear solution to use again for four more plates. Wash the storage bottle carefully before storing the developer for the next time. This will prevent sludge from settling on the plate during development. The 1:1 dilution suggested earlier has been good for around six to eight plates with developer maintenance described earlier.

Assume correct exposure, as, like all reversal/positive processes, there is no development latitude. Development is merely mechanical and based on a set time.

Expect some dry-down color changes. Also, remember that the hue of the image silver highlight is based on the light temperature reflected off the surface of the plate. When exhibiting any direct positive images such as daguerreotypes, ambrotypes, and tintypes, the very fine particles of silver that establish the highlights of the image are essentially tiny reflectors; the more light shown on them, the brighter the visible image.

Disc Brake. Dry ambrotype on black glass. © Lee Lira. All rights reserved. Courtesy of the artist.

Garden Rose. © Lee Lira. All rights reserved. Courtesy of the artist.

Formulary

FILM DEVELOPERS

Development Time

During development a complete image is formed within 3 minutes. The problem is, there is no contrast, just an image. Everything after the first 3 minutes builds density and contrast. This is why it is important to have the correct development time.

It is not possible to give accurate development times online or in a book for two reasons. The first is that your camera and working methods are unique to you. The second, and even more important, is that development time is dependent on the method of agitation. Continuous agitation will result in a development time that is approximately 20% less than intermittent agitation. Not only that, but there are several variations on intermittent agitation, see Chapter 6. Rarely, if ever, will you find a published development time that specifies the agitation method. This is why you should always test a roll or two before committing important images to a new developer or method.

With that understood, the best source for finding a starting film development time is the Massive Development Chart (MDC) found on the Digital Truth website, see Material Sources. The times posted may not be accurate for your camera and working methods, but they will get you in the ballpark.

If your film and developer combination are not listed in the MDC, or perhaps you prefer to use the developing time range given with many of the film developing formulas in the *DCB*, use one of the three following guidelines based on the manufacturer's ISO rating. Unless otherwise stated, use 68°F/20°C as your standard temperature.

Method #1

- For films rated between ISO 100 and ISO 320, use a time in the middle of the range.
- For films rated from ISO 12 to ISO 80, decrease the development time from the midpoint by 25%.
- For films rated higher than ISO 320, increase the time from the midpoint by 25%.

Example: The formula recommends using between 10 and 14 minutes.

- With an ISO 100 film, start by developing a test roll for 12 minutes.
- With an ISO 50 film, develop for 25% less, or 9 minutes.
- With an ISO 400 film, increase by 25% to 15 minutes.

Method #2

Knowing that agitation affects development time, if you are planning to use continuous agitation, perhaps with a JOBO processor, choose the shorter time. If you plan to use intermittent agitation at 30-second intervals, choose a time in the middle of the range. If you plan to use 1-minute intervals, choose the longest time. Don't consider these conclusive; they are only meant to get you close enough to zero in on the correct time.

Method #3

If there is no time range given, or when in doubt:

For dilute developers (e.g., D-76 1+1, etc.) start with 9 minutes for slow films, 12 minutes for medium-speed films, and 15 minutes for fast films.

For undilute (full-strength) developers, use 6 minutes as a start time for slow films, 8 minutes for medium-speed films, and 10 minutes for fast films.

Ansel Adams, the co-creator of the Zone System, used to tell his students, "Test, test, test!"

Adjusting Developer Formulas

Developer formulas are not carved in stone. They can be adjusted to customize the results by making one or more of the following changes found in Table 1.

Table F.1 Adjusting Developer Formulas

Contrast	*Density*	*Modification*
Increase	Increase	Increase temperature (same developing time)
Increase	No change	Increase hydroquinone
Increase	Decrease	Increase restrainer
Decrease	Increase	Decrease restrainer Increase metol
Decrease	Decrease	Decrease temperature (same developing time) Decrease hydroquinone

To increase the activity of a developer, increase the amount of accelerator or use an accelerator of higher pH (e.g., substitute sodium carbonate for sodium metaborate or borax). The approximate relative pH of some commonly used alkalis, acids, and reducing agents can be found on the pH scale in Chapter 4.

Divided Developers

FORMULA #1

D2D Divided Developer, William E. Davis

SOLUTION A

Water at 110°F/45°C, 750.0 mL
Metol, 3.7 g
*Sodium sulfite, 67.5 g
Hydroquinone, 7.5 g
Water to make 1.0 L

SOLUTION B

Water at 110°F/45°C, 750.0 mL
Borax, 37.5 g
Sodium carbonate, anhydrous, 30.0 g
Potassium bromide, 0.5 g
Water to make 1.0 L

*Add a pinch of the total sulfite, dissolve the metol completely, and then add the remainder of the sulfite.

Solution A—4 minutes
Solution B—8 minutes (7 minutes with a rotary processor)

Agitate in both solutions for an initial 15–30 seconds, then for 5 seconds every 30 seconds thereafter.

After development the film should be rinsed in a stop bath or a plain running-water bath and then fixed and washed in the usual manner.

For softer negatives, use less carbonate in Solution B. For higher-contrast negatives, use more carbonate. Using this method, one could have one Solution A and several different B solutions to handle scenes of any brightness range.

Replenishment

Solution A: Use a fresh batch of Solution A to bring the working solution back to its original volume. If Solution A is not contaminated by Solution B, it should last indefinitely.

Solution B: As Solution A is carried over into Solution B, film will gradually become grainier and higher contrast. To prevent this use a fresh batch of Solution B each time or replenish with Solution B Replenisher, shown next. To replenish, discard ⅓ of the old Solution B and refill to the original level.

In time both Solution A and B will oxidize, form a precipitate, and turn brown and muddy. This is normal and will not affect the working properties of the formula.

Solution B Replenisher

Water at 110°F/43°C, 750.0 mL
Borax, 37.5 g
Sodium carbonate, 22.5 g
Potassium bromide, 0.5 g
Water to make 1.0 L

FORMULA #2

Modified D-23 Divided Developer

This is one of the best divided developer formulas for fine grain and full tonal scale. For the first bath use the modified version of D-23, given here.

FIRST BATH

Water at 125°F/52°C, 750.0 mL
Metol, 5.0 g
Sodium sulfite, 100.0 g
Water to make 1.0 L

SECOND BATH

For the second bath, use one of the following accelerators in 500.0 mL of water:

Borax, granular, 18.0 g
Sodium metaborate, 7.5 g
Sodium carbonate, anhyd., 4.5 g

Borax produces the finest grain with the least contrast, metaborate produces medium grain with low contrast, and sodium carbonate has the highest contrast and coarsest grain. For minus development, use borax in the second bath.

Development times should be from 2 to 3 minutes in the first bath, with continuous agitation, and 3 minutes in the second bath, with 5 seconds of agitation, each 30 seconds.

Author's Notes:

1. Bob Ingraham of British Columbia recommends one inversion every 20 seconds in the first bath and one inversion every 30 seconds in the second bath.
2. Extending time in the A bath will increase overall density. Increasing time in the B bath will not appreciably alter the results.

FORMULA #3

D-76H Divided Developer, David Vestal and Bill Troop

D-76H was first published in *The Film Development Cookbook*, first edition. This may well be the best of all two-bath developers and also may well be the best of all versions of D-76. It will develop with a wider range of tones than D-76 would be capable of, but it will preserve the fine grain and good speed.

SOLUTION A

Water at 110°F/4°5C, 750.0 mL
Metol, 3.0 g
Sodium sulfite, 50.0 g
Water to make, 1.0 L

SOLUTION B

Water at 110°F/45°C, 750.0 mL
Borax, 5.0 g
Sodium sulfite, 50.0 g
Water to make 1.0 L

Solution A—3 minutes
Solution B—3–5 minutes

Agitate continuously in Solution A for the first 60 seconds, then for 5 seconds every 30 seconds thereafter. Agitate continuously in Solution B. Alternatively, agitate continuously in both solutions. After development the film should be fixed and washed in the usual manner.

FORMULA #4

Ilford ID-3 Two-Solution Developer

SOLUTION A	**SOLUTION B**
Water at 110°F/43°C, 750.0 mL	Water at 110°F/43°C, 750.0 mL
Metol, 12.0 g	Sodium Carbonate, anhyd., 75.0 g
Sodium sulfite, 50.0 g	*Potassium bromide, 2.0 g
Water to make 1.0 L	Water to make 1.0 L

*Omitting the potassium bromide and diluting 1+1+8 will give a developer similar to Beutler's High-Definition Developer.

Mix 1 part A, 1 part B, and 6 parts water. Develop film approximately 9–12 minutes at 68°F/20°C.

FORMULA #5

Stoeckler's Fine-Grain Divided Developer, H. Stoeckler

This developer is a hybrid of Kodak D-23 and Kodak D-25. This formula is one of the best to use for Zone System contractions (N-1, N-2) and works well for expansions (N+1, N+2), even with modern emulsions.

SOLUTION A	**SOLUTION B**
Water at 110°F/43°C, 750.0 mL	Water at 110°F/43°C, 750.0 mL
Metol, 5.0 g	Borax, 10.0 g
*Sodium sulfite, 80.0 g	Water to make 1.0 L
Sodium bisulfite, 20.0 g	
Water to make 1.0 L	

*Stoeckler's formula has been published in two variations. The first variation uses 100 grams of sodium sulfite and *no bisulfite*. The second variation, given here, substitutes 20 grams of sodium bisulfite for 20 grams of sodium sulfite. The addition of bisulfite has two advantages: It delays development in Solution A, which is good, and increases the stability of Solution A, which is also good.

It has been suggested that Stoeckler's formula may work better with modern emulsions by substituting sodium metaborate for borax. Classic emulsions should work as intended with the formula as is.

The following table is a starting point for Zone System expansion and contractions. As the temperature gets higher, the times become shorter and more critical. Best results will be achieved close to 68°F/20°C.

Table F.2 Development times for modern emulsions at 68°F/20°C

ISO	*Solution A*	*Solution B*
Less than 80	3 minutes	3 minutes
100–320	4 minutes	3 minutes
Higher than 320	6 minutes	3 minutes

Table F.3 Zone System Times for Stoeckler Using Classic Emulsions

Temp	*Development Time, Solution A*					*Solution B*
	N-1	*N-2*	*N*	*N+1*	*N+2*	
65F/18C	4m 30s	5m 30s	6m 30s	8m	9m	4m
68F/20C	3m 30s	4m 15s	5m	6m	7m	3m
75F/24C	2m	2m 30s	3m	3m 30s	4m 30s	2m
80F/27C	1m 30s	1m 45s	2m	2m 20s	3m	1m 15s
85F/29C	1m 10s	1m 20s	1m 40s	2m	2m 30s	1m

Author's Notes:

1. The recommended normal development time with continuous agitation to give normal development is 5 minutes in A and 3 minutes in B at 68°F/20°C for Ilford Delta 400.
2. Different films will require different times in A to achieve normal development. Five minutes is used in the table provided as a starting point.

Extreme Compensating Developers

FORMULA #6

Catechol Compensating Developer, Maxim Muir

This developer is a modern version of the pioneering Windisch Compensating Developer. It is used to retain detail in extremely high values—in Zone System parlance, Zone IX and higher.

SOLUTION A

Water, 250.0 mL
Sodium metabisulfite, 10.0 g
Pyrocatechin, 40.0 g
Water to make 500.0 mL

SOLUTION B

Sodium hydroxide, 10.0 g
Cold water to make 100.0 mL

Mix 2 parts A, 1 part B, and 200 parts water. Presoak the film for 2–5 minutes in plain water.

Development time is approximately 6–8 minutes at 70°F/21°C, with slow-speed films. Intermittent agitation is recommended.

For further contractions (N-2, N-3), Maxim Muir recommends an alternative Solution B.

ALTERNATIVE SOLUTION B

Water, 375.0 mL
Sodium carbonate, mono., 50.0 g
Water to make 500.0 mL

For N-2 contractions, use 1 part A, 4 parts B, and 100 parts water. Develop for approximately 8 minutes at 70°F/21°C with slow-speed films.
For N-3 contractions, use 1 part A, 2 parts B, and 100 parts water. Develop for approximately 8 minutes at 70°F/21°C with slow-speed films.

Author's Note: N-2 and N-3 development will cause a loss of film speed and compress the midtones.

***Caution*:** Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #7

Kodak D-175 Tanning Developer

SOLUTION A

Pyrogallol, 4.0 g
Sodium sulfite, 10.0 g
Water to make 1.0 L

SOLUTION B

Sodium carbonate, anhyd., 28.0 g
Water to make 1.0 L

Mix 1 part Solution A with o1ne part B and dilute the stock solution with 8 parts water. Development time is between 5 and 8 minutes.

Author's Note: This is a variation of the original formula designed to work with modern emulsions.

FORMULA #8

Windisch Extreme Compensating Developer, Hans Windisch

This developer is primarily used to retain definition in negatives with extreme high values. Historically, this was the first extreme compensating developer.

Windisch published two dilutions for this formula, which can be made from the two-stock solutions shown. The first is for extreme compensating use; the second is for use as a general-purpose film developer. Both have a very short life once mixed as a working solution. Both dilutions work best with slow- and medium-speed films.

SOLUTION A

Distilled water at 125°F/52°C, 750.0 mL
Sodium sulfite, 12.5 g
Pyrocatechin, 80.0 g
Distilled water to make 1.0 L

SOLUTION B

Cold distilled water at 60°F/16°C, 750.0 mL
Sodium hydroxide, 100.0 g
Cold distilled water at 60°F/16°C to make 1.0 L

Caution**:** Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Dilution #1 (extreme compensating)

Solution A 25.0 mL
Solution B 15.0 mL
Water to make 1.0 L

Develop for 12–16 minutes at 68°F/20°C

Dilution #2 (General purpose)

Solution A 40.0 mL
Solution B 30.0 mL

Develop for 10–12 minutes at 68°F/20°C.

Fine-Grain Developers

FORMULA #9

FX 37 for Tabular-Grain Films, Geoffrey Crawley

This developer was formulated for tabular and crystal grain films. However, according to Crawley, it can be used for traditional films when “the finest grain is not the prime requirement.”

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 60.0 g
Hydroquinone, 5.0 g
Sodium carbonate, anhyd., 5.0 g
Phenidone, 0.5 g
Borax, 2.5 g
Potassium bromide, 0.5 g
Benzotriazole, 1% solution, 5.0 mL
Water to make 1.0 L

Dilute 1:3 to 1:5. The higher dilution will increase film speed. Developing times for 1:3 dilutions at 68°F/20°C.

Table F.4 FX 37 Developing Times

Film	*Minutes*
Iford Delta 100	7.5
Ilford Delta 400	8
Ilford FP4+	4.5
Ilford HP5+	6.5
KodakT-Max 100	8
Kodak T-Max 400	9
Kodak T-MaxP3200	8
Kodak Plus-X	5.5
Kodak Tri-X	6

FORMULA #10

Kodak D-76/Ilford ID-11, J. G. Capstaff

This developer is good for low contrast and maximum shadow detail. The commercial product, marketed by Kodak, is the world's best-selling black-and-white developer. It is also the standard most used to compare other films to.

Water at 125°F/52°C, 750.0 mL
Metol, 2.0 g
Sodium sulfite, 100.0 g
Hydroquinone, 5.0 g
Borax, 2.0 g
Water to make 1.0 L

Dilute 1+1.

D-76 may be used undiluted, but there is no advantage in doing so unless replenished. The negatives, while slightly finer grain, do not exhibit the same degree of sharpness or tonal scale.

Development times vary from 9 to 17 minutes. More accurate times are available from most film manufacturers.

FORMULA #11

Kodak D-76R, Replenisher for D-76 and ID-11

Water at 125°F/52°C, 750.0 mL
Metol, 3.0 g
Sodium sulfite, 100.0 g
Hydroquinone, 7.5 g
Borax, 20.0 g
Water to make 1.0 L

For every 80^2 inches of film processed add 30.0 mL of undiluted replenisher and pour off any excess to maintain the original volume. When the original volume of D-76 has been replaced by an equal volume of D-76R, the developer should be discarded. For example, 1 liter of D-76 should be discarded after it has been replenished with 1 liter of D-76R.

Replenisher is for undiluted D-76 only. Do not replenish D-76 that has been diluted 1+1 or higher. D-76 variations should not be replenished.

Table F.5 D–76 Variants

	Kodak D76	*Kodak D76R*	*Kodak D76d*	*Kodak D76H*
	750ml Water at 125°F/52°C			
Metol	2 g	3 g	2 g	2.5 g
Sodium Sulfite (anh)	100 g	100 g	100 g	100 g
Hydroquinone	5 g	7.5 g	5 g	–
Borax	2 g	20 g	8 g	2 g
Boric Acid cryst	–	–	8 g	–
Water to make	1.0 L	1.0 L	1.0 L	1.0 L

FORMULA #12

Kodak D-76b

D-76b is a softer-working (low-contrast) developer with the same grain structure as D-76.

Water at 125°F/52°C, 750.0 mL
Metol, 2.75 g
Sodium sulfite, 100.0 g
Hydroquinone, 2.75 g
Borax, 2.5 g
Water to make 1.0 L

Test using D-76 developing times.

FORMULA #13

D-76d

This variant has increased buffering, providing greater stability. overcoming the increase in contrast and development associated with the original D-76 formula. The results are indistinguishable from D-76

Water at 125°F/52°C, 750.0 mL
Metol, 2.0 g
Sodium sulfite, 100.0 g
Hydroquinone, 5.0 g
Borax, 8.0 g
Boric acid, cryst., 8.0 g
Water to make 1.0 L

Test using D-76 developing times.

FORMULA #14

D-76H, Grant Haist

Water at 125°F/52°C, 750.0 mL
Metol, 2.5 g
Sodium sulfite, 100.0 g
Borax, 2.0 g
Water to make 1.0 L

This formula works indistinguishably from Kodak D-76 and can be used in the same way, including the same development times. It has the advantage of costing less to make, being more "environmentally friendly," and being more stable to pH change than D-76. See *The Film Development Cookbook* for why D-76 changes pH and why this can cause unexpected problems.

Use as you would D-76.

Author's Note: Grant Haist said that either the metol or borax could be increased to 2.5 g to achieve the same results. Increasing the borax is less likely to have a pollutant effect and is less expensive.

The packaged D-76 Kodak formula contains several additional chemicals to avoid caking, extend the shelf life of the powder, and enable it to mix easily in all types of water. This allows the formula to be sold as a single package.

Ilford markets its version of D-76 in two packets, separating the metol from the sulfite, under the name ID-11. This helps to eliminate some of the extra chemicals found in the Kodak version. Even though ID-11 also contains additional chemicals, it is closer to the original D-76 formula.

Many photographers feel that the original formula, as given in the *Cookbook*, without the "extras" is superior to either commercial product.

FORMULA #15

Mytol, Paul Lewis

A film developer similar to Kodak XTOL. Like XTOL, this is a more "environmentally friendly" developer. Unlike XTOL, this formula uses readily available chemicals.

Water at 80°F/27°C, 750.0 mL
Sodium sulfite, 85.0 g
Sodium metaborate, 4.0 g
Sodium ascorbate, 12.0 g
*Phenidone, 0.15 g
Sodium metabisulfite, 3.0 g
Water to make 1.0 L

*Dissolve the Phenidone in 5 mL of methanol and then add to the solution. Or dispense with the alcohol and allow the Phenidone to dissolve in its own time.

Use as you would XTOL.

Author's Note: The Phenidone/ascorbate combination, properly formulated, makes for a superior developer. Unfortunately, most if not all, Phenidone/ascorbate formulas are prone to "sudden death." That is, they simply stop working for no apparent reason. You successfully develop a few rolls, come back a day later, and the next batch of film comes out blank, as if you had developed them in plain water.

The solution is to expose a piece of silver-gelatin paper to light, then immerse it in a small amount of the Phenidone/ascorbate developer. If it turns black, the developer is safe to use.

FORMULA #16

Windisch W—22 Fine-Grain Developer, Hans Windisch

Water at 125°F/52°C, 550.0 mL
Metol, 8.0 g
Sodium sulfite, 65.0 g
Potassium metabisulfite, 7.0 g
Water to make 1.0 L

Develop film for 8–15 minutes at 68°F/20°C.

High-Contrast Developers for Film

FORMULA #17

Ansco 47, High-Contrast Developer

This is a long-lived, clean-working formula. It is ideal for producing brilliant negatives in controlled lighting situations (i.e., studio) or for low-contrast landscapes.

Water at 125°F/52°C, 750.0 mL
Metol, 1.5 g
Sodium sulfite, 45.0 g
Sodium bisulfite, 1.0 g
Hydroquinone, 3.0 g
* Sodium carbonate, mono., 6.0 g
Potassium bromide, 0.8 g
Water to make 1.0 L

* Sodium carbonate, anhyd., 5.0 g

For tank development, dilute 1:1 with water and develop for 8–12 minutes at 68°F/20°C. For tray development, use undiluted for 5–8 minutes at 68°F/20°C.

FORMULA #18

Kodak D-19, High-Contrast Developer

This is a high-contrast developer with good keeping properties and high capacity. It is especially recommended for continuous-tone scientific and technical work that requires higher-than-normal contrast. This developer has special applications for reversal processing.

Water at 125°F/52°C, 750.0 mL
Metol, 2.0 g
Sodium sulfite, 90.0 g
Hydroquinone, 8.0 g
Sodium carbonate, anhyd., 45.0 g
Potassium bromide, 5.0 g
Water to make 1.0 L

Use undiluted. Develop 6 minutes in a tank or 5 minutes in a tray at 68°F/20°C.

FORMULA #19

Kodak D-19R, Replenisher for Kodak D-19

Water at 125°F/52°C, 750.0 mL
Metol, 4.5 g
Sodium sulfite, 90.0 g
Hydroquinone, 17.5 g
Sodium carbonate, anhyd., 45.0 g
Sodium hydroxide, 7.5 g
Cold water to make 1.0 L

Use this replenisher undiluted. After each 80^2 inches of film add 25.0 mL of replenisher. The total volume of replenisher added should not exceed the original volume of the developer.

***Caution*:** Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

High-Definition Developers

FORMULA #20

Beutler High-Definition Developer, Willi Beutler

This early high-definition developer works best with slow- to medium-speed films.

SOLUTION A

Water at 125°F/52°C, 750.0 mL
Metol, 10.0 g
Sodium sulfite, 50.0 g
Water to make 1.0 L

SOLUTION B

Water at 125°F/52°C, 750.0 mL
Sodium carbonate, anhyd., 50.0 g
Water to make 1.0 L

Mix 1 part A, 1 part B, and 10 parts water. Develop T-Max 100 for 8 minutes at 68°F/20°C.

Author's Notes:

1. To obtain the highest degree of sharpness with this developer, Beutler recommends intermittent agitation for 5 seconds (2 inversions) every minute.
2. Develop slow-speed films at 65°F/18°C for 7–10 minutes.
3. Medium-speed films require a lesser quantity of solution B. Test.

FORMULA #21

FX 1, Geoffrey Crawley

This is the Beutler high-definition developer optimized for "modern" films. Crawley did this by halving the amounts of metol and carbonate used by Beutler, which he found were already too high for the films of the early 1960s. It is probably the highest-acutance developer formula ever published.

This developer was formulated for maximum acutance with conventional medium- and slow-speed films. Initially, it was not recommended for fast films or for tabular grain films but can be used with them today.

Distilled water at 125°F/52°C, 500.0 mL
Metol, 0.5 g
Sodium sulfite, 5.0 g
Sodium carbonate, anhyd., 2.5 g
*Potassium iodide, 001% solution, 5.0 mL
Water to make 1.0 L

*To make a 001% potassium iodide solution, add 1 gram to 1.0 liter of water. Take 10.0 mL of this solution and dilute to 1.0 liter. Use 5.0 mL in the formula.

Use undiluted. Developing time is between 7 and 14 minutes at 68°F/20°C.

Author's Note: When using FX 1 with modern high-iodide films, the addition of potassium iodide cannot hurt, but probably will not help. However, it will increase sharpness and edge effects on classic and conventional films.

FORMULA #22

FX 2, Geoffrey Crawley

This developer not only has high acutance, it increases film speed and is a good choice for stand development.

Distilled water at 125°F/52°C, 500.0 mL
Metol, 0.25 g
Glycin, 0.75 g
Sodium sulfite, 3.5 g
*Potassium carbonate, cryst., 7.5 g
Pinacryptol Yellow, 3.5 mL
Water to make 1.0 L

*FX 2 requires potassium carbonate crystals, not anhydrous.

Developing times for Ilford FP4+ are 11 minutes at 68°F/20°C.

Author's Note: Pinacryptol Yellow should not be used with modern flat-grain films. TFX-2, available from Photographers' Formulary, is an improved version of FX 2 for use with conventional and modern films.

FORMULA #23

GSD-10, High-Definition Film Developer, Jay DeFehr

GSD-10 is formulated for slow fine-grain films like Kodak T-Max 100, Fuji Acros 100, and Ilford Delta 100 but can also be used with films ranging from slow document type and ortho films to IR.

This formula is especially suited for stand development and minimal agitation techniques, although normal intermittent agitation and rotary processing may be used.

Distilled water, 750.0 mL
Sodium sulfite, 50.0 g
Sodium carbonate, 75.0 g
Glycin, 10.0 g
Distilled water to make 1.0 L

For stand or minimal agitation (one inversion every 3 minutes), dilute 1:10 (100.0 mL of stock solution to 1.0 liter of water).

For rotary processing dilute 1:5 (200.0 mL of stock solution to 1.0 liter of water).

The following development times are at 70°F/21°C.

Table F.6 GSD-10 Developing Times

Film	*Time*	*Dilution*	*Agitation*
TMX (EI 200)	24 minutes	1:10	Continuous agitation for the first minute, then stand for the remainder of the time.
Acros (EI 200)	28 minutes	1:10	Continuous agitation for the first minute, then stand for the remainder of the time.
FP4+ (EI 160)	24 minutes	1:10	Continuous agitation for the first minute, then stand for the remainder of the time.
TMY (EI 800)	22 minutes	1:10	Continuous agitation for the first minute, then one inversion every 3 minutes.
Pan F+ (EI 50)	6:30 minutes	1:5	Continuous agitation for the first minute, then ten seconds every minute.

Author's Notes:

1. This formula is similar to the traditional glycin formulas used by late nineteenth- and early twentieth-century photographers in France, such as Atget. Compared to a glycin-metol formula such as FX 2, there will be a loss in speed of about 1 stop, but this can be tolerated to approach more nearly what the old photographers were doing.
2. This formula is related to Hubl paste but is less concentrated.

FORMULA #24

Ilford ID-60 Glycin Developer

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 20.0 g
Potassium carbonate, 60.0 g
Glycin, 30.0 g
Water to make 1.0 L

Dilute 1:7 and develop for about 12 minutes in a tray or 15 minutes in a tank at 68°F/20°C.

FORMULA #25

Rodinal-Type Developer, Circa 1880

This formula is similar to the original Agfa Rodinal, the oldest proprietary formula in use today, with the original formula dating to the 1880s. It is considered by some to be the finest all-around film developer even for modern T-grain films.

Because it is proprietary, the actual composition of the developer cannot be known. It is known that it has gone several variations since it was first introduced. The following formula is said to be one of these variations.

SOLUTION A

Water at 125°F/52°C, 750.0 mL
p-Aminophenol hydrochloride, 100.0 g
*Potassium metabisulfite, 300.0 g
Water to make 1.0 L

SOLUTION B

Cold water, 300.0 mL
Sodium hydroxide, 200.0 g
Cold water, 400.0 mL

*Although it is usually acceptable to substitute sodium metabisulfite for potassium metabisulfite, it is not suitable in this formula.

Mix Solution A and allow to cool before adding Solution B. A precipitate of *p*-aminophenol hydrochloride will form. Place Solution A in an iced water bath and, with continuous mixing, slowly add 280.0 mL of Solution B. Then very slowly add additional Solution B until a sudden darkening in color takes place. Finally, add Solution B drop by drop until only a few crystals remain. If this is done properly, the remaining crystals will dissolve in the working solution. In time, the developer will turn dark brown. However, the unused stock solution will last for several years.

This formula can be used at dilutions ranging from 1:25 to 1:100. Developing times published for Agfa Rodinal can be used as a starting point.

***Caution*:** Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, a mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Low-Contrast Developers for Document Films

FORMULA #26

POTA for Document Films, Marilyn Levy

This formula was originally designed by Marilyn Levy to record nuclear blasts on conventional films. It is capable of recording light over a 20-stop range. With modern films, the results are low in contrast. However, with films such as Kodak Technical Pan (discontinued), it produces a full gray tonal scale.

Water at 185°F/85°C, 750.0 mL
Sodium sulfite, 30.0 g
Phenidone, 1.5 g
Water to make 1.0 L

Use undiluted for 11½–15 minutes in a tank or 6½–8 minutes in a tray at 68°F/20°C. Use this formula as soon as possible, as the solution deteriorates quickly.

FORMULA #27

TDLC-103 for Document Films, Bill Troop

Water at 125°F/52°C, 750.0 mL
Metol, 0.25–1.0 g
Sodium or potassium sulfite, 5.0 g
Sodium or potassium bicarbonate, 10.0 g
Water to make 1.0 L

Use a trial EI of 12 with document films. Use undiluted with a trial development time of 10 minutes at 68°F/20°C. With conventional films there may be a speed increase of a half-stop or more. If you can obtain the potassium instead of the sodium forms of sulfite and bicarbonate, there may be a small increase in speed. See *The Film Developing Cookbook*, Chapter 10, for the research that revealed potassium salts may increase speed.

FORMULA #28

T/O XDR-4, Shepp and Kammerer

Water at 125°F/52°C, 750.0 mL
Metol, 1.0 g
*Potassium sulfite, 25.0 g
Hydroquinone, 1.0 g
+Potassium bicarbonate, 10.0 g
Water to make 1.0 L

*20 grams of sodium sulfite can be substituted for potassium sulfite, though there may be a slight decrease in film speed.
+10 grams of sodium bicarbonate (baking soda) can be substituted for potassium bicarbonate.

Use undiluted for 8–12 minutes at 68°F/20°C.

Author's Note: There may be a decrease in film speed if sodium salts are used.

Monobath Developers

FORMULA #29

FX 6a, Geoffrey Crawley

Water, 750.0 mL
Sodium sulfite, 50.0 g
Phenidone, 1.0 g
Hydroquinone, 12.0 g
Sodium thiosulfate, pentahydrate, 70.0–125.0 g
Sodium hydroxide, 10.0 g
Water to make 1.0 L

Add the Phenidone to the water; do not mix. Add a pinch of hydroquinone and place the rest aside. Add the remaining ingredients in the order given. Mix well to dissolve the Phenidone. Finally, add the remainder of the hydroquinone.

The amount of sodium thiosulfate is variable. In addition to controlling contrast, the amount of hypo can be tailored towards specific films. This is because slower, fine-grain films have a faster clearing time and require less thiosulfate. Faster films, including tabular-grain film, need the maximum amount. Try 3 minutes at 75°F/24°C as a starting point for development.

***Caution*:** Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #30

Keelan's Monobath, H.S. Keelan

Water, 500.0 mL
Sodium sulfite, 50.0 g
Phenidone, 10.0 g
Hydroquinone, 15.0 g
Sodium thiosulfate, pentahydrate, 110.0 g
Sodium hydroxide, 18.0 g
Potassium alum, 18.0 g
Water to make 1.0 L

Dissolve the alum separately and add to the solution after all the other ingredients are completely dissolved.

Add the Phenidone to the water; do not mix. Add a pinch of hydroquinone and place the rest aside. Add the remaining ingredients in the order given. Mix well to dissolve the Phenidone. Add the remainder of the hydroquinone and then the alum. Try 3 minutes at 75°F/24°C as a starting point for development.

***Caution*:** Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Pyro Developers

Unless otherwise specified, mixing and development with pyro formulas should be carried out between 65°F/18°C and 70°F/21°C.

FORMULA #31

510-Pyro, Jay DeFehr

Triethanolamine (TEA), 75.0 mL
Ascorbic acid, 5.0 g
Pyrogallol, 10.0 g
Phenidone, 0.38 g
TEA to make 100.0 mL

The standard dilution is 1:100 and can be increased to 1:500. Starting development time is 5–7 minutes at 70°F/21°C.

Author's Notes:

1. Can be diluted up to 1:500 for extended development and reduced agitation techniques and for increased edge effects. Use 1-minute initial agitation, followed by one inversion every 10–15 minutes for up to 1 hour.
2. TEA concentrates are easily measured with a measuring syringe. A 3-, 6-, or 25-mL syringe will cover a wide range of dilutions and working solutions. Small variations in dilution make no practical difference in the performance of the working solution.

FORMULA #32

Kodak D-1, ABC Pyro Circa 1890

This is the classic ABC formula using three *stock* solutions as it is traditionally published. You will find the dry mix working solution that I use for large format in Chapter 7.

STOCK SOLUTION A

Water between 65°F/18°C and 70°F/21°C, 750.0 mL
Sodium bisulfite, 9.8.0 g
Pyrogallic acid (pyro), 60.0 g
Potassium bromide, 1.1 g
Water to make 1.0 L

STOCK SOLUTION B

Water between 65°F/18°C and 70°F/21°C, 1.0 L
Sodium sulfite, 105.0 g

STOCK SOLUTION C

Water between 65°F/18°C and 70°F/2°1C, 1.0 L
Sodium carbonate, mono., 90.0 g

The standard ABC formula calls for a dilution of 1:1:1:7 for tray development. With modern emulsions, I recommend using 1:1:1:11, which is the dilution usually given for tank development. Develop between 6 and 10 minutes at 68°F/20°C.

The standard dilution for tank development is given as 1:1:1:11. I recommend 1:1:1:14. Use this dilution if you want the maximum amount of image stain. Develop between 8 and 12 minutes at 68F°/20°C.

For more information on using ABC Pyro see Chapter 7.

FORMULA #33

Kodak SD-1 Pyro Stain Developer

This formula is recommended for hand-coated glass plates, as the pyro hardening would be beneficial.

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 1.4 g
Pyro 2.8 g
Sodium carbonate, mono., 6.2 g
Water to make 1.0 L

Develop about 6 minutes at 68°F/20°C, rinse quickly with water, and fix in a plain hypo bath or alkali fixer.

Author's Notes:

1. This formula will give a good stain image with a minimum of general stain. If a negative is stained too strongly, the stain may be reduced by first removing it entirely by bleaching in Kodak S-6 Stain Remover and then redeveloping in a mildly staining pyro developer such as Kodak D-7. This will usually result in more general stain in proportion to the stain image than if the original emulsion had been developed properly in SD-1.

2. This formula may not work well with modern films, but it is a good choice for hand-coated glass plates and handmade gelatin emulsions such as found in Chapter 18, as the pyro hardening would be highly beneficial.

FORMULA #34

Kodak D-7 Metol-Pyro Developer

This is a mildly staining developer that is useful for redeveloping a negative that is stained too strongly, see Chapter 7. It has no other useful advantage over PMK or WD2H+.

SOLUTION A

Water at 125°F/52°C, 500.0 mL
Metol, 7.5 g
Sodium bisulfite, 7.5 g
Pyro, 30.0 g
Potassium bromide, 4.0 g
Cold Water to make 1.0 L

SOLUTION B

Water, 1.0 L
Sodium sulfite, 150.0 g

SOLUTION C

Water, 1.0 L
Sodium carbonate, mono., 90.0 g

For tray development (1:1:1:8) take 64.0 mL (2 oz) each of A, B, and C and add water to make 500.0 mL (16 oz). Develop about 7 minutes at 68°F/20°C.

For tank development (1:1:1:13) take 250 mL (8.0 oz) each of A, B, and C and add water to make 4 liters (1 gallon). Develop about 10 minutes at 68°F/20°C.

FORMULA #35

PMK, Gordon Hutchings

SOLUTION A

Water, 750.0 mL
Metol, 10.0 g
Sodium bisulfite, 20.0 g
Pyrogallol, 100.0 g
EDTA-disodium (optional), 5.0 g
Water to make 1.0 L

SOLUTION B

Water, 1400.0 mL
Sodium metaborate, 600.0 g
Water to make 2.0 L

Mix 1 part A to 2 parts B to 100 parts water (e.g., 10.0 mL of A to 20 mL of B to 1000 mL of water). Measure the water and then add the A and B solutions. Development times are between 9 and 15 minutes at 70°F/21°C.

Author's Notes:

1. To help preserve the developing agents in Solution A, measure out the sodium bisulfite first and add a "pinch" to the water before the metol. Set the remainder of the bisulfite aside and add it in proper sequence.
2. Sodium metaborate may be difficult to dissolve completely at room temperature, but any residual amount will dissolve by itself over a 24-hour period. The small amount of residual chemical is not enough to affect the solution activity even if it is used immediately.
3. The addition of a "pinch" of amidol (approximately 0.5 grams) immediately prior to development will increase the activity of the developer and create an apparent speed gain of ⅓ to ½ stop without altering development times. Gordon Hutchings calls this PMK1.
4. Unlike most other pyro developers, PMK can be used at temperatures between 65°F/18°C and 80°F/26°C.

FORMULA #36

Rollo Pyro (AB C+ Pyro), Harald Laban, 1997

This developer was formulated for use with a JOBO rotary drum processor.

SOLUTION A

Distilled water, 750.0 mL
Sodium bisulfite, 20.0 g
Metol, 20.0 g
Pyrogallic acid, 150.0 g
Ascorbic acid, 10.0 g
Potassium bromide, 1.5 g
EDTA tetrasodium, 2.0–5.0 g
Distilled water to make 1.0 L

SOLUTION B

Distilled water, 900.0 mL
Sodium metaborate, 300.0 g
EDTA tetrasodium, 5.0 g
Distilled water to make 1.0 L

Working solution for four 8 × 10-inch films

10.0 mL Part A
20.0 mL Part B
500.0 mL water

Table F.7 Normal developing times with continuous rotation in a JOBO Expert Drum at 68F/20C:

Film	*El*	*Time*
FP4+	100	6 minutes
HP5+	400	6.5 minutes
BPF 400	400	6 minutes
T-Max 100	100	6.5 minutes

FORMULA #37

WD2H+, Metol-Pyro Developer, John Wimberley

SOLUTION A

Distilled water, 750.0 mL
Metol, 6.0 g
Sodium bisulfite, 20.0 g
Pyrogallol, 60.0 g
EDTA tetrasodium salt, 5.0 g
Distilled water to make, 1 L

SOLUTION B

Distilled water, 750.0 mL
Sodium carbonate, mono., 110.0 g
Distilled water to make 1.0 L

Working Dilution for Normal and Reduced Contrast

Distilled water, 1600.0 mL
Stock Solution A, 25.0 mL
Stock Solution B, 25.0 mL

N-2: EI 32, develop 7 minutes
N: EI 64, develop 9.5 minutes

Working Dilution for Increased Contrast

Distilled water, 1600.0 mL
Stock Solution A, 25.0 mL
Stock Solution B, 50.0 mL

N + 2: EI 84, develop 6.5 minutes
N + 4: EI 100, develop 12 minutes

Developing times and ISO ratings are for Ilford FP4+, tray processed with continuous agitation at 68°F/20°C. These specifications should also apply with slight adjustment to other medium-speed films. For slower films, the developing times will need to be reduced by about 10%. For faster films, developing times will need to be increased by about the same amount.

Pyrocatechol Developers

FORMULA #38

Pyrocat-HD, Sandy King

This is the original Pyrocat-HD formula. A newer version of this formula, Pyrocat-HDC+Glycol, along with a table of development times can be found in Chapter 7.

SOLUTION A

Distilled water at 125°F/51°C, 750.0 mL
Sodium metabisulfite, 10.0 g
Pyrocatechin, 50.0 g
Phenidone, 2.0 g
Potassium bromide, 2.0 g
Distilled water to make 1.0 L

SOLUTION B

Distilled water, 700.0 mL
Potassium carbonate, 750.0 g
Distilled water to make 1.0 L

Mixing Directions for Solution B for All Pyrocat Variants

1. Start with 700 mL of distilled water.
2. Weigh out 750 g of potassium carbonate and add the chemical very slowly to the water, with constant and rapid stirring. If you add the carbonate too fast or don't stir enough, it will be impossible to dissolve all of it in the water. As you add the chemical, an exothermic reaction takes place and the solution will warm up appreciably.
3. Add distilled water to 1 liter.
4. For negatives intended for printing with silver gelatin papers, mix 1 part A with 1 part B with 100 parts water (1:1:100).

For printing with AZO and most alternative processes, including carbon, kallitype, pt/pd, Vandyke, POP, albumen, and salted paper, a 2:2:100 solution is recommended (2 parts Stock Solution A + 2 parts Stock Solution B + 100 parts water).

FORMULA #39

Two-Solution Pyrocatechin Developer

SOLUTION A

Water, 750.0 mL
Sodium sulfite, 40.0 g
Pyrocatechin, 20.0 g
Water to make 1.0 L

SOLUTION B

Water, 750.0 mL
Potassium carbonate, 120.0 g
Water to make 1.0 L

For use, take equal amounts of Solution A and B. Use a starting time of 7 minutes.

Speed-Increasing Developers

FORMULA #40

Diafine-Type Speed-Increasing Film Developer

This formula was said to give a one-stop speed increase on the conventional grain films of the 1960s and 1970s, with grain and sharpness equivalent to Kodak D-76. This developer was also said to be panthermic, meaning it could be used at any temperature between 68°F/20°C and 80°F/28°C without altering the time.

STOCK SOLUTION A	**STOCK SOLUTION B**
Water at 125°/F/52°C, 750.0 mL	Water at 125°/F/52°C, 750.0 mL
Sodium sulfite, 35.0 g	Sodium sulfite, anhd., 65.0 g
Hydroquinone, 6.0 g	Borax, 20.0 g
Phenidone, 0.2 g	Water to make 1.0 L
Sodium metabisulfite, 6.0 g	
Water to make 1.0 L	

1. Soak the film in the A bath for 3 minutes and then move to the B bath for 3 minutes without rinsing in between. Do not use a presoak.
2. Do not use an acid stop bath. Use a water rinse for 30 seconds to 1 minute. Use an alkaline fixer when available.

Table F.8 Speed Increasing Developers

	FX 11	*Ilford ID-68*	*Ilford ID-68R*
	Water at 125°/F/52°C, 750.0 ml		
Phenidone	0.50 g	0.13 g	0.22 g
Sodium Sulfite (anh)	125.0 g	85.0 g	85.0 g
Hydroquinone	5.0 g	5.0 g	8.0 g
Glycin	5.0 g	-	-
Borax	2.50.0 g	7.0 g	10.0 g
Boric Acid (cryst)	-	2.0 g	-
Potassium Bromide	0.5 g	1.0 g	-
Water to	1.0 liter	1.0 liter	1.0 liter
To Use	Full Strength	Full Strength	-
Development Times 68°F/20°C	7 to 14 min.	4½ to 6 min.	-

FORMULA #41

FX 11, Geoffrey Crawley

This formula produces at least a one-stop true speed increase with grain and sharpness similar to Kodak D-76.

Water at 125°F/52°C, 700.0 mL	Sodium sulfite, 125.0 g
Phenidone, 0.25 g	Borax, 2.5 g
Hydroquinone, 5.0 g	Potassium bromide, 0.5 g
Glycin, 1.5 g	Water to make 1.0 L

The development times at 68°F/20°C are as follows:

Table F.9 FX 11 Development Times

Film	*Time*
Plus-X	7 minutes
Tri-X 35 mm	7 minutes
Tri-X 120	8 minutes

Crawley intended FX 11 to be used with fast films such as HP5 and Tri-X. He also recommended that negatives be kept thin with this developer.

This developer can also be diluted from 1+1 to 1+3. Test for developing times.

FORMULA #42

Ilford ID-68 Microphen-Type Fine-Grain Developer

Microphen-type fine-grain PQ developer produces a ½ stop increase in film speed without a corresponding increase in graininess. It is included here because Ilford recommends it for push processing.

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 85.0 g
Hydroquinone, 5.0 g
Borax, granular, 7.0 g
Boric acid, granular, 2.0 g
Potassium bromide, 1.0 g
Phenidone, 0.13 g
Water to make 1.0 L

Microphen can also be diluted 1+1 (8–11 minutes) or 1+3 (14–21 minutes). The greater the dilution, the greater the acutance and tonal scale.

Microphen is especially good for developing T-Max 100 copy negatives of full-scale black-and-white prints for reproduction. Make initial tests using Microphen 1+2 with a development time of 6 minutes at 72°F/22°C.

FORMULA #43

ID-68R Replenisher

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 85.0 g
Hydroquinone, 8.0 g
Borax, granular, 10.0 g
Phenidone, 0.22 g
Water to make 1.0 L

Add the replenisher to the developer so as to maintain the level of solution. A quantity of replenisher equal to that of the original developer may be added before the solution is discarded.

Superfine-Grain Developers

When using superfine-grain developers it is important to note that many of these were formulated when the fastest films commercially available were ISO 160 or less. Before the wide-spread use of “miniature” formats such as

120 and 35 mm, fine grain was not an issue as photographers were using large-format sheet films. As miniature formats became increasingly popular, the quest for fine and superfine grain became the holy grail of film development. To this end, *p*-phenylenediamine and its derivatives were the most popular developing agents to obtain superfine grain.

Author's Note: Most superfine grain developers require a 2–4 times increase in exposure and extended developing times. The addition of metol, as in Edwal 12, will increase film speed and shorten development times. Test for the best EI before committing valuable negatives.

Each of the following developers will produce its own distinct fine-grain pattern. If fine grain is your goal, try them all. The best results are usually with slow films.

FORMULA #44

Edwal 12, Superfine Grain

At one time Edwal 12 was the most popular and widely used commercial fine-grain formula. It was considered one of the best developers containing the combination of *p*-Phenylenediamine-glycin-metol. Edwal 20 surpassed Edwal 12.

Water, 500.0 mL
**p*–Phenylenediamine, 10.4 g
Metol, 6.2 g
Sodium sulfite, 90.0 g
Glycin, 5.1 g
Water to make 1.0 L

**p*-Phenylenediamine should be dissolved in 250 mL of water between 160°F/71°C and 180°F/82°C. Add to the 500 mL of water at approximately 125°F/52°C. Add a pinch of sulfite. After the sulfite is completely dissolved, add the metol then the rest of the sulfite.

Use undiluted. Develop slow-speed films for 10–20 minutes at 68°F/20°C.

***Caution*:** *p*-Phenylenediamine stains everything and is a known allergen believed to be the source of chronic skin rashes. Always use gloves and a mask to mix or handle.

FORMULA #45

FX 5, Microdol-X Equivalent, Geoffrey Crawley

In this formula that closely resembles Microdol-X, Crawley has attempted to retain the maximum definition compatible with true fine grain.

Water at 125°F/52°C, 750.0 mL
Metol, 5.0 g

Sodium sulfite, anhdy., 125.0 g
Borax, 3.0 g
Boric acid, cryst., 1.5 g
Potassium bromide, 0.5 g
Water to make 1.0 L

Develop undiluted 10–15 minutes

Table F.10 Fine to Superfine-grain Metol–only Developers

Formula	*D-23*	*D-25*	*D-25R*
Water at 125°/F/52°C, 750 mL			
Metol	7.5 g	7.5 g	10.0 g
Sodium sulfite (anh)	100.0 g	100.0 g	100.0 g
Potassium bromide	-	-	20.0 g
*Sodium metabisulfite	-	15.0 g	-
Water to make 1.0 liter			

*If it is not essential to obtain minimum graininess, use half the quantity of sodium metabisulfite.

Author's Note: Expect a film speed loss of one stop.

FORMULA #46

Kodak D-23, Superfine-Grain Developer

Metric Formula	**Spoon Formula**
Water at 125°F/52°C, 750.0 mL	Water, 24.0 oz.
Metol, 7.5 g	Metol, 2 tsp
Sodium sulfite, anhyd. 100.0 g	Sodium sulfite, anhyd., 4 Tbs + 1 tsp
Water to make 1.0 L	Water to make 32.0 oz

D-23 is one of the most versatile developers ever formulated. Having only two ingredients, it is simple to mix and with various modifications can be used over a wide range of situations. This is a semi-compensating developer that produces fine shadow values while retaining a high emulsion speed. This developer produces negatives of speed and graininess comparable to Kodak D-76, without D-76's tendency to block highlights. Its low alkalinity and high salt content, as well as its low fogging propensity, make it suitable for use up to 85°F/29°C.

Develop full-strength for 12 minutes at 68°F/20°C.

Diluted 1+3 development results in full midtones and lower contrast. Try 1.5 times the time used for the full-strength developer, and use 3 times the developer volume for each 80^2 inches of film.

D-23 can also be used as a water bath to manage extreme contrast. Be certain to allow enough exposure to ensure good shadow detail—usually at least one additional stop.

The water bath method is as follows:

1 minute: D-23 with constant agitation
4 minutes: water without agitation
1 minute: D-23 with constant agitation
4 minutes: water without agitation
1 minute: D-23 with constant agitation
4 minutes: water without agitation

After the last immersion in water, transfer the film directly to fixer.

Author's Note: A white scum of calcium sulfite may occur on films processed in high-sulfite, low-alkalinity developers. This scum is soluble in acid stop baths and in fresh acid fixing baths, especially if the film is well agitated. It is slowly soluble in water and may also be wiped or sponged off wet film, although light deposits may not be noticed until the film is dry. Kodak SB-5 Non-swelling Acid Rinse Bath is recommended for its removal.

FORMULA #47

Kodak D-25

This is a fine-grain developer with medium to low contrast. The grain is softer than that produced by Kodak D-23. As with most fine-grain developers, it will cause a loss of emulsion speed of at least one stop. It is important to test D-25 before using with modern emulsions.

Water 125°F/52°C, 750.0 mL
Metol, 7.5 g
Sodium sulfite, 100.0 g
*Sodium bisulfite, 15.0 g
Water to make 1.0 L

*If it is not essential to obtain minimum graininess, use half the quantity of sodium bisulfite.

Develop for 20 minutes at 68°F/20°C.

This formula can also be used as a divided developer. To use as a two-solution developer, try 4 minutes at 68°F/20°C followed by 3 minutes in a 2% borax solution. Use intermittent agitation in the first solution and gentle but continuous agitation in the second solution. This will prevent uneven development, especially with 120 roll film. For higher-contrast lighting, increase exposure and shorten the time in the first solution.

FORMULA #48

Kodak D25 Replenisher for D-23 and D-25

Water at 125°F/52°C, 750.0 mL
Metol, 10.0 g
Sodium sulfite, 100.0 g
Balanced alkali, 20.0 g
Water to make 1.0 L

For Kodak D-23 add 22 mL for each 80^2 inches of film, discarding some developer if necessary to keep the original volume.

For Kodak D-25, 45 mL of replenisher should be added for each 80^2 inches of film, for the first 12 rolls per liter. For the next 12 rolls per liter, add only 22 mL per roll. Discard the developer after 20 rolls have been processed.

FORMULA #49

MCM 100

This fine-grain developer has unusually high speed and extremely fine grain due to the combination of *p*-Phenylenediamine and pyrocatechin.

Water at 125°F/52°C, 500.0 mL
p-Phenylenediamine, 7.0 g
*Sodium sulfite, 88.0 g
Pyrocatechin, 9.0 g
Borax, 2.3 g
+Trisodium phosphate, crystalline, 6.9 g
Potassium bromide, 10% solution, 2.0 mL
Cold water to make 1.0 L

**p*-Phenylenediamine should be dissolved in 250.0 mL of water between 160°F/71°C and 180°F/82°C. Add to the 500.0 mL of water at approximately 125°F/52°C. Add a pinch of sulfite. After the sulfite is completely dissolved, add the pyrocatechin and then the rest of the sulfite.
+Do not use the mono. of trisodium phosphate.

Use either a citric acid stop bath or running water and an alkaline fixer. It is essential not to use an acid hardening fixer with any developer containing sodium phosphate.

Development times at 68°F/20°C:

Table F.11 MCM 100 Development Times

Film	*Time*
Up to ISO 80	10–12 minutes
Between ISO 100 to 320	13–15 minutes
ISO 400+	18–20 minutes

Author's Notes:

1. A characteristic of this developer is that the emulsion side will have a high sheen, making it difficult to distinguish from the base side.
2. This formula is currently available from the Photographers' Formulary.

Caution: *p*-Phenylenediamine stains everything and is a known allergen believed to be the source of chronic skin rashes. Always use gloves and a mask to mix or handle.

UNIVERSAL DEVELOPERS

FORMULA #50

Ilford ID-62, Neutral Tone Developer

STOCK SOLUTION

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, anhyd., 50.0 g
Hydroquinone, 12.0 g
Sodium carbonate, anhyd., 60.0 g
Phenidone, 0.5 g
Potassium bromide, 2.0 g
Benzotriazole, 1% solution. 20.0 mL
Cold water to make 1.0 L

For use with contact papers, dilute 1:1 and develop 45–60 seconds.
For use with enlarging papers, dilute 1:3 and develop 1½–2 minutes.
For try development of film and plates, dilute 1:3 and develop 2–4 minutes.
For tank development, dilute 1:7 and develop for 4–8 minutes.

Author's Note: ID–62 does not have a long shelf life.

FORMULA #51

Kodak D-72 Dektol-type Developer

D-72 can be used to develop either film or paper. It is also a good choice for redevelopment of film after intensification, rehalogenation, or other after processes that bleach the silver. Press photographers often used this formula to develop film when quality was not as important as meeting a press deadline. However, for the creative photographer the results can be interesting.

Water at 125°F/52°C, 750.0 mL
Metol, 3.0 g
Sodium sulfite, 45.0 g
Hydroquinone, 12.0 g
Sodium carbonate, mono., 80.0 g
Potassium bromide, 2.0 g
Water to make 1.0 L

For Paper

- Dilution may vary from 1:1 to 1:4 depending upon the contrast and image tone desired. Normal dilution with chlorobromide papers is 1:2.
- For warmer tones, dilute 1:3 or 1:4 and add approximately 8 mL of 10% potassium bromide per liter.
- For higher contrast with bromide papers, dilute 1:1 and add 1 mL of 10% bromide per liter.
- Development times are from 1½–3 minutes.

For Film

- For tray development dilute 1+3 and develop for 3–5 minutes at 68°F/20°C.
- For tank development dilute 1+7 and develop at 68°F/20°C for 6–10 minutes at 68°F/20°C.

FORMULA #52

Kodak DK-93

This formula can be used to develop film and paper. The use of this developer is especially recommended for people subject to skin irritation.

Water at 125°F/52°C, 500.0 mL
p-Aminophenol hydrochloride, 5.0 g
Sodium sulfite, 30.0 g
Hydroquinone, 2.5 g
Sodium metaborate, 20.0 g
Potassium bromide, 0.5 g
Water to make 1.0 L

FILM: Use without dilution. Develop roll film about 9 minutes in a tank of fresh developer at 68°F/20°C. Develop sheet film for about 6 minutes at 68°F/20°C. More or less contrast may be obtained by developing longer or shorter than specified.

PAPER: For warm tones on papers, use without dilution and develop for about 2 minutes at 68°F/20°C. For colder tones, double the quantity of sodium metaborate; use without dilution and develop 1–2 minutes.

In either case, the tones produced by this developer are slightly warmer than the tones produced by Kodak D-52 and Kodak D-72.

PRINT DEVELOPERS

Author's Note: To find out the true potential of a paper for manipulation through toning or development, try using a paper that is not super coated or iodide rich such as David Lewis Bromoil or Lodima Fine Art Silver Chloride paper for testing.

Amidol Paper Developer

Author's Notes:

1. Amidol works without an accelerator (alkali).
2. Use a 3-minute standard development time for amidol developers with chloride and bromide papers.
3. Varying the amount of sodium sulfite affects the keeping qualities of the solution.
4. The amount of bromide may be adjusted to ensure clear highlights without fogging.
5. Amidol powder works best when it is fresh. Fresh amidol has a slight green cast. Old, oxidized amidol is gray or black and looks like sand. Oxidized amidol will often be usable, but the results will be different from those obtained with a fresh batch, including longer development times. Oxidized amidol also tends to stain prints.
6. The pH of an amidol developer should be between 7 and 8; most developers are between pH 10 and 12. Benzotriazole should not be used with amidol as it is essentially inactive at this pH level.
7. To prevent staining of the borders and highlights of prints, use Kodak SB-8 citric acid stop bath or a plain running water bath. Citric acid stop bath exhausts quickly, so discard after about ten to twelve 8 × 10–inch prints.
8. When mixing amidol formulas, use a mask, as the fine powder is easy to inhale.

Safety Handling Toxic Chemicals

Brett Weston was one of the top ten selling photographers in the world when he died from a stroke in 1993 at the age of 81. He began his career at the age of 16 under the tutelage of his famous father, Edward, who used both amidol and pyro for most of his career, as did Brett.

Brett never wore gloves; he stuck his hands directly into the tray of amidol developer without protection, and did the same when tray developing large-format negatives using pyro. Was his stroke caused by years of toxic exposure to amidol and pyro? Would he have lived to be 101? We'll never know.

What we do know is this: Should you use chemistry that is toxic, protect yourself. Wear chemical-proof neoprene gloves, masks, and eye protection when mixing powders. Make certain your darkroom has good ventilation. Read Appendix 1. Take your health as seriously as you take your art.

FORMULA #53

Amidol Black Developer, J. Ghislain Looten

Water at room temperature, 750.0 mL
Sodium sulfite, 24.5 g
Citric acid, 0.6 g

Amidol, 8.1 g
Potassium bromide, 0.6 g
*Potassium thiocyanate, 0.3 g
Water to make 1.0 L

*Potassium thiocyanate is optional in this formula but recommended for truer black tones. If the potassium salt is not available, the sodium salt may be substituted.

Use at full strength. Develop for 1½–4 minutes.

***Caution*:** Thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.

FORMULA #54

Amidol Teaspoon Formula

This famous "teaspoon" formula first appeared in *Practical Photography* No. 5 in 1935. It is a good developer for bromide papers and is often recommended for bromide enlargements that are intended for the Bromoil process.

Water at room temperature, 500.0 mL
Sodium sulfite, 1 tablespoon
Amidol, 1 teaspoon
*Potassium bromide, 1/8 teaspoon

*Use more potassium bromide as needed.

Use undiluted or 1:1.

Author's Note: The sulfite and bromide can be mixed as a stock solution and the amidol added just before use.

FORMULA #55

Amidol Water Bath Developer, A. Knapp

Amidol, 5.0 g
Sodium sulfite, 20.0 g
Water to make 1.0 L

Experiment with times and/or use a different amidol formula. The basic method is as follows.

Use the next higher grade of paper or filter than the desired final contrast. For example, if the desired contrast is between grade 1 and grade 2, use grade 2 paper.

Immerse the print emulsion side up, in a tray of developer for 40 seconds without agitation.

Quickly slide the print, without draining, into a fresh tray of water.

Allow the print to lie in the water, fully immersed, for 2 minutes without agitation.

Quickly move the negative back to the developer and let it sit without agitation for 50 seconds before moving it back to the water bath for 90 seconds.

You can move the print back to the developer for additional highlight development, or rinse and fix.

As with two-tray development, the time in each developer can be varied, though the *minimum* time in the amidol is about 1 minute. However, too long in the water bath could result in streaking. A good starting point would be to develop the print for 90 seconds in amidol and 30 seconds in the water bath then adjust accordingly.

FORMULA #56

Ansco 113, Amidol Paper Developer

Water at room temperature, 750.0 mL
Sodium sulfite, 44.0 g
Amidol, 6.6 g
Potassium bromide, 10% solution, 5.5 mL
Water to make 1.0 L

Do not dilute. Develop for 1½–7 minutes.

Author's Note: The sulfite and bromide can be mixed as a stock solution and the amidol added just before use.

FORMULA #57

Below's Amidol Paper Developer

Metol, 1.0 g
Sodium sulfite, 30.0 g
Amidol, 6.0 g
Potassium bromide, 0.4 g
Water to make 1.0 L

Dilute as needed to manipulate contrast. Develop for 2–4 minutes.

Author's Note: The sulfite and bromide can be mixed as a stock solution and the amidol added just before use.

Weston Amidol Developers

All three of the famous Westons—Edward, Brett, and Cole—used amidol paper developer formulas. Each had his own variation. All four of the following formulas are used undiluted and should be followed by running water or a citric acid stop bath.

The Westons were famous for their black-and-white print quality. Notice that all of their formulas use significantly more amidol than the previous textbook formulas. Brett once told me that if he had trouble achieving the black he wanted, he simply threw in a handful more amidol.

Before you start shoveling amidol into your print developer, remember that amidol's special property is that it begins developing from the base of the print and works toward the surface. This allows it to reduce exposed silver halides that other developers don't reach, creating a visual appearance of depth. Test your paper to make certain that it is not supercoated or overhardened, preventing the amidol from penetrating to the paper base. If it is supercoated or overhardened, you are just wasting amidol as you will get similar results with D-72 (Dektol).

FORMULA #58

Edward Weston's Amidol Paper Developer

Water at room temperature 1200.0 mL
Sodium sulfite, 35.0 g
Amidol, 11.0 g
Potassium bromide, 10% solution, 7.4 mL

FORMULA #59

Brett Weston's Amidol Paper Developers

Circa 1971

Sodium sulfite, 60.0 g
Amidol, 26.0 g
Potassium bromide, 10% solution, 3.7 mL
Water, 1.0 L

Circa 1982

Water at room temperature, 3.5 L
Sodium sulfite, 90.0 g
Amidol, 40.0 g
*Citric acid
Potassium bromide, 10% solution, 4.0 mL

*Brett's formula calls for "a pinch" of citric acid. Brett believed the citric acid acted similarly to an organic antifoggant like benzotriazole. Actually, what it does is lower the pH of the developer, and by so doing, reduces the activity. The citric acid may act similarly to an antifoggant in this particular developer, but in the sense that it depresses development. It is a valuable practical technique when working with amidol.

FORMULA #60

Cole Weston's Amidol Paper Developer

Water at room temperature, 2.0 L
Sodium sulfite, 54.0 g
Amidol, 16.0 g
Potassium bromide, 10% solution, 12.0 mL
Citric acid, 10% solution, 12.0 mL

FORMULA #61

DuPont BB Formula

BB solution was a proprietary liquid restrainer marketed by DuPont, once a leader in the manufacture of film and paper. When added to a developer it created cooler tones on enlarging paper. It was reputedly used by Edward Weston in his amidol formula. According to Dody Thompson, Edward's former assistant and Brett's second wife, Edward may have tried it at one time but did not use it, as he preferred warm-tone images. Brett, on the other hand, may well have used BB while it was available.

DuPont ceased marketing photographic materials in the early 1970s. This formula is said to be a viable alternative, if not the exact formula.

Sodium sulfite, 85.0 g
Benzotriazole, 7.5 g
Water to make 1.0 L

Add BB solution 10.0–15.0 mL at a time to neutral or cold-tone print developers until the desired tone is achieved.

Author's Note: Sodium sulfite may cause BZT to lose its activity rather than retain it. An alternative to the above formula would be to make a 1.5% solution of benzotriazole dissolved in isopropyl alcohol and use as suggested. This alternative solution should last many years.

See also Benzotriazole Restrainer.

Bromide Paper Developer

FORMULA #62

Kodak D-49 for Blue-Sensitive Emulsions

Kodak D-49 is one of two developers recommended by Mark Osterman for developing gelatin emulsions, such as the one in Chapter 18. The other is Kodak D-19 for higher-contrast results.

D-49 may also be used for developing bromide paper emulsions such as David Lewis's Bromoil paper.

Distilled water at 120°F/49°C, 500.0 mL
Metol, 3.1 g
Sodium sulfite, 45.0 g
Hydroquinone, 11.0 g
Sodium carbonate, 45.0 g
Potassium bromide, 2.1 g
Distilled water to make 1.0 L

Development of gelatin plates is traditionally done using a red safelight. The photographer must learn to judge when the plate is fully developed, see Chapter 18.

Cold-Tone Paper Developers

FORMULA #63

Ansco 103 Modified Cold-Tone Paper Developer

Water at 125°F/52°C, 750.0 mL
Metol, 3.5 g
Sodium sulfite, anhydrous, 45.0 g
Hydroquinone, 11.5 g
Sodium carbonate, mono., 78.0 g
Potassium bromide, 10% solution, 6.0 mL
Benzotriazole, 1% solution, 25.0 mL
Water to make 1.0 L

Use diluted 1:2.

FORMULA #64

W130B, John Wimberley

By changing the restrainer used in Ansco 130 from potassium bromide to benzotriazole, W130B achieves cooler tones. The quantity of benzotriazole given in this formula is higher than the minimum needed to prevent fog, preventing density shifts in the first few prints and slightly increasing tonal separation in highlights.

Water at 125°F/52°C, 750.0 mL
Metol, 2.2 g
Sodium sulfite, anhyd., 50.0 g
Hydroquinone, 11.0 g

Sodium carbonate, mono., 78.0 g
Benzotriazole, 0.2 g
Glycin, 11.0 g
Water to make 1.0 L

The recommended standard dilution is 1:1. Use full strength for maximum contrast or diluted up to 1:3 for less contrast. Development times are between 3 and 6 minutes, with 5 minutes recommended as standard.

High-Contrast Developers for Paper

FORMULA #65

Agfa 108, Hard Paper Developer

Water at 125°F/52°C, 500.0 mL
Metol, 5.0 g
Sodium sulfite, 40.0 g
Hydroquinone, 6.0 g
Sodium carbonate, mono., 40.0 g
Potassium bromide, 2.0 g
Water to make 1.0 L

Use undiluted with a normal development time of 2 minutes. Longer development will increase the contrast even more.

Author's Note: In this formula, potassium bromide may cause a slight green cast with some papers. Add 20 mL of a 1–1.5% solution of benzotriazole dissolved in isopropyl alcohol, see BB Solution.

FORMULA #66

Edwal 120, High-Contrast Developer

SOLUTION A

Water at 125°F/52°C, 500.0 mL
Pyrocatechol, 20.0 g
Sodium sulfite, 40.0 g
Water to make 1.0 L

SOLUTION B

Water at 125°F/52°C, 750.0 mL
*Potassium carbonate, anhyd., 120.0 g
+Potassium bromide, 1.0 to 3.0 g
Water to make 1.0 L

*134.0 grams of sodium carbonate mono. can be substituted for a less warm tone.
+ Adding the minimum amount of potassium bromide will yield a print of neutral tone; adding more will create an increasingly colder tone.

Mix 1 part of Solution A and 2 parts of Solution B with 1 part water.

Lith Paper Developer

FORMULA #67

Defender 15-D for Printing

SOLUTION A

Water at 125°F/52°C, 750.0 mL
Hydroquinone, 45.0 g
Sodium sulfite, anhydrous, 30.0 g
Sulfuric acid, concentrate, 4.0 mL
Water to make 1.0 L

SOLUTION B

Water at 125°F/52°C, 500.0 mL
*Sodium carbonate, anhydrous, 30.0 g
Potassium carbonate, 90.0 g
Potassium bromide, 8.3 g
Sodium sulfite, anhydrous, 90.0 g
Water to make 1.0 L

*If monohydrate carbonate is used, the quantity given must be increased to 35.1 g.

Dilute 1:1 for use. Developing times for lith film can vary from 4 to 5 minutes.

For lith paper development, dilute the A+B working solution from 1:1 to 1:4 with water. Testing for development time will be required for your materials and working methods.

Caution: When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, always add the acid to the solution, otherwise the solution may spatter causing serious burns to the hands or face.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #68

Kodak D-85 Kodalith Developer

Water not over 90°F/32°C, 500.0 mL
Sodium sulfite, anhyd., 30.0 g
Paraformaldehyde, 7.5 g
Sodium bisulfite, 2.2 g
*Boric acid, granular, 7.5 g
Hydroquinone, 22.5 g
Potassium bromide, 1.6 g
Cold water to make 1.0 L

*Use granular boric acid, as powdered boric acid dissolves with great difficulty.

Use a 1-gallon narrow-mouthed bottle for mixing the developer. Check the volume of the bottle and mark it to indicate the exact level of 1 gallon of solution. Fill the bottle half full of water at about 90°F/32°C. After adding each chemical in the order given, seal the bottle and agitate. When all the chemicals have been dissolved, add cold water until the solution comes up to the 1-gallon mark. Insert the stopper tightly to exclude as much air as possible. Allow to stand for 2 hours after mixing. Cool to 68°F/20°C for use. For lith printing dilute 1:2 or higher.

Author's Note: Store any unused solution in a smaller bottle or use an amber bottle. If only a portion of the developer is to be used, save the balance in smaller bottles to keep as much air out as possible.

Low-Contrast (Soft-Working) Paper Developers

FORMULA #69

Agfa 105 Soft-Working Paper Developer

Water at 125°F/52°C, 750.0 mL
Metol, 3.0 g
Sodium sulfite, 15.0 g
Potassium carbonate, 15.0 g
Potassium bromide, 0.4 g
Water to make 1.0 L

Use undiluted with a normal development time of 1½ minutes.

FORMULA #70

Ansco 120, Soft-Working Paper Developer

This is a good formula for use in two-tray development where the first tray is a soft developer and the second is either normal or high-contrast. For this application dilute as much as 1:4.

Ansco 120 can also be used for print solarization, see Chapter 17.

Water at 125°F/52°C, 750.0 mL
Metol, 12.3 g
Sodium sulfite, 36.0 g
Sodium carbonate, mono., 36.0 g
Potassium bromide, 1.8 g
Water to make 1.0 L

Table F.12 Agfa 120 Dilution, Exposure, and Development Time

Tone Desired	*Exposure Time*	*Dilution*	*Development Time at 68F/20C*
Warm-black	Normal	1:5	4–5 minutes
Brown-black	1½ × longer than normal	1:4	3 minutes

Author's Note: This is one of the few metol-only paper developers. It may not have the desired effect on papers that have developer incorporated into their emulsion, including all resin-coated (RC) papers.

FORMULA #71

Defender 59-D, Soft-Working Developer

This developer is for prints from high-contrast negatives.

Water at 125°F/52°C, 500.0 mL
Metol, 3.0 g
Sodium sulfite, 36.0 g
Sodium carbonate, mono., 21.0 g
Potassium bromide, 4.0 g
Water to make 1.0 L

Dilute 1:3. Develop for 3–4 minutes at 68°F/20°C.

FORMULA #72

Gevaert G.253 Soft-Portrait Paper Developer

Water at 125°F/52°C, 750.0 mL
Metol, 3.0 g
Sodium sulfite, 20.0 g
Sodium carbonate, mono., 23.0 g
*Potassium bromide, 1.0 g
Water to make 1.0 L

*Warmer tones may be obtained with the addition of up to 4 grams of potassium bromide.

Use undiluted or 1:1 and use developing times from 1 to 3 minutes.

Author's Note: This is a good formula for use in two-tray development where the first tray is a soft developer and the second is either normal or high-contrast. For this application dilute as much as 1:4.

Neutral-Tone Developers

FORMULA #73

Agfa 125

Water, 500.0 mL
Metol, 3.0 g
Sodium sulfite, 44.0 g
Hydroquinone, 12.0 g
Sodium carbonate, mono., 65.0 g
Potassium bromide, 2.0 g
Water to make 1.0 L

Use full strength or diluted 1:2. Develop prints for 2 minutes.

FORMULA #74

Ansco 130

This is a versatile developer that is capable of beautiful gradation. The tone will vary, depending on the paper and adjustments made to the chemistry.

Water at 125°F/52°C, 750.0 mL
Metol, 2.2 g
Sodium sulfite, 50.0 g
Hydroquinone, 11.0 g
Sodium carbonate, mono., 78.0 g
Potassium bromide, 5.5 g
Glycin, 11.0 g
Water to make 1.0 L

Normal dilution is 1:1 with water. For high contrast, use full strength; for low contrast, use 1:2 with water. The useful development range with bromide papers is 2–6 minutes. With chlorobromide papers it is 1½–3 minutes.

Author's Note: The prepared stock solution is clear but slightly colored. The coloration does not indicate the developer has deteriorated.

FORMULA #75

Ansco 130, Ansel Adams's Variation

Ansel Adams created his own version of Ansco 130 by eliminating the hydroquinone and bromide and reducing the amount of sulfite. He added bromide as needed to prevent fog. If the contrast was too low, he added, as required, a solution of hydroquinone (given here). In addition to increasing the contrast, the hydroquinone would cause a cooling of the image tone. If an even cooler image is desired, try adding a small amount of benzotriazole instead of, or in addition to, the bromide.

STOCK SOLUTION

Water at 125°F/52°C, 750.0 mL
Metol, 2.2 g
Sodium sulfite, 35.0 g
Sodium carbonate, mono., 78.0 g
Glycin, 11.0 g
Water to make 1.0 L

Hydroquinone Solution

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 25.0 g
Hydroquinone, 10.0 g
Water to make 1.0 L

Add the hydroquinone solution as needed to the stock solution.

Author's Note: Maxim Muir recommends adding 5 grams of sodium bisulfite to buffer the hydroquinone solution.

FORMULA #76

E-72 Neutral-Tone Paper Developer, Chris Patton

Water at 125°F/52°C, 750.0 mL
*Phenidone, 0.3 g
Sodium sulfite, anhyd., 45.0 g
Ascorbic acid, 19.0 g
Sodium carbonate, mono., 90.0 g
Potassium bromide, 1.9 g
Water to make 1.0 L

Dilute 1:1 with water for high-contrast prints, 1:2 for less contrast, or 1:3 for normal contrast. 1:4 will give a low-contrast print.

Solarizing Developers

See Chapter 17

FORMULA #77

R77, Solarizing Developer, Clarence Rainwater

Water at room temperature, 750.0 mL
Sodium sulfite, anhyd., 15.2 g
Pyrocatechin, 3.4 g
Sodium carbonate, mono., 12.0 g
Phenidone, 0.5 g
Potassium bromide, 1.6 g
Water to make 1.0 L

The developer's temperature should be kept between 65°F/18°C and 75°F/24°C or unwanted fog will result.

FORMULA #78

R77M, Solarizing Developer with Metol, Clarence Rainwater

Water at room temperature, 750.0 mL
Metol, 5.0 g
Sodium sulfite, anhyd., 15.2 g
Pyrocatechin, 3.4 g
Sodium sulphite, mono., 12.0 g
Potassium bromide, 1.6 g
Water to make 1.0 L

R77M is a superb solarizing formula. It is R77 with metol substituted for Phenidone in 10 times quantities by weight.

The temperature of the developer must not be much above 65°F/18°C to 75°F/24°C or unwanted fog will result.

FORMULA #79

Solarizing Developer, William Jolly

Water at 125°F/52°C, 750.0 mL
Metol, 12.0 g
Sodium sulfite, 37.5 g
Sodium carbonate, mono., 41.0 g
Sodium bromide, 4.8 g
Water to make 1.0 L

See Chapter 17 for using this developer.

Variable-Contrast Developer

FORMULA #80

Beers' Variable Contrast Developer, Dr. Roland F. Beers

SOLUTION A

Water at 125°F/52°C, 750.0 mL
Metol, 8.0 g
Sodium sulfite, 23.0 g
*Potassium carbonate, 21.0 g
Potassium bromide, 10% sol., 11.0 mL
Water to make 1.0 L

SOLUTION B

Water at 125°F/52°C, 750.0 mL
Hydroquinone, 8.0 g
Sodium sulfite, 23.0 g
*Potassium carbonate, 28.4 g
Potassium bromide, 10% sol., 22.0 mL
Water to make 1.0 L

*Substituting sodium carbonate will give a more neutral print tone and more pleasing color with some papers. Use 23.4 and 31.5 grams, respectively, of mono. in place of the potassium salt.

Mix the stock solutions in the following proportions to give a progressive range of contrasts:

Table F.13 Dilution Table for Beers' Two-Solution Variable Contrast Developer

Contrast Solution No.	*Low*		*Normal*			*High*	
Grade	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Parts of A	8	7	6	5	4	3	2
Parts of B	0	1	2	3	4	5	14
Parts water	8	8	8	8	8	8	0

The lower-contrast solutions can be diluted with water for even softer contrast. Use normal development times of 2–3 minutes but with less agitation.

Author's Notes:

1. Mix 1 liter of Solution A and Solution B and keep them in tightly stoppered bottles for when you may need them. While they will not last indefinitely, this is a paper developer. If it loses its volatility sitting on your shelf, you will know on the first print. Mix a new batch.
2. You can use Beers' Solution B to increase the contrast in any developer, though it may change the image tone, see Chapter 10: Chemical Manipulation: Variable Contrast Print Developers.

Warm-Tone Developers

FORMULA #81

Ansco 110, Direct Brown-Black Paper Developer

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 57.0 g
Hydroquinone, 22.5 g
Sodium carbonate, mono., 75.0 g
Potassium bromide, 2.75 g
Water to make 1.0 L

Dilute 1:5. Give 3–4 times normal exposure and develop for 5–7 minutes at 68°F/20°C.

FORMULA #82

Catechol Copper-Tone Developer

Water at 110°F/43°C, 750.0 mL
Pyrocatechin, 50.0 g
Sodium sulfite, 20.0 g
Potassium carbonate, 45.0 g
Potassium bromide, 0.7 g
Water to make 1.0 L

Use 1:1 and develop between 1 and 2 minutes at 70°F/21°C. The shorter the development time, the warmer the tone, see Chapter 8.

FORMULA #83

Dassonville D-3/Ansco 115/Edwal 106 Auto-toning Developer

Water at 125°F/52°C, 500.0 mL
Sodium sulfite, 82.5 g
Sodium carbonate, mono., 138.0 g
Glycin, 26.5 g

Hydroquinone, 8.5 g
Potassium bromide, 3.7 g
Water to make 1.0 L

For warm black tones with bromide papers, dilute 1:3.

For brown blacks, dilute 1:7 and develop for 2–3 minutes and 4–6 minutes with slow chlorobromide papers.

At a dilution of 1:15, Dassonville D-3 produces tones known as “gravure brown.” At this dilution, develop for 3–5 minutes. The image should not begin to show for at least 1½ minutes.

With slow chlorobromide papers D-3 produces tones that vary from greenish brown to sepia and are useful in high-key work where the predominant tones are lighter than middle gray. With fast chlorobromide papers, it produces delicate tones that are also exceptional for high-key images.

FORMULA #84

Defender 55-D Professional Portrait Developer

Defender 55-D is a good choice for producing subtle, warm blacks. It also creates a beautiful tonal scale with gentle gradations.

Water at 125°F/52°C, 500.0 mL
Metol, 2.5 g
Sodium sulfite, 37.5 g
Hydroquinone, 10.0 g
*Sodium carbonate, anhyd., 37.5 g
+Potassium bromide, 5.0 g
Water to make 1.0 L
*Sodium carbonate, mono., 45.0 g

Dilute 1:2. Exposure should be adjusted to produce the desired contrast and tone when developed from 1½ to 2 minutes at 68°F/20°C.

FORMULA #85

DuPont 51-D Warm-Tone Developer

For warm black tones on slow chlorobromide and chloride papers and neutral tones on bromide papers.

Water at 125°F/52°C, 500.0 mL
Metol, 1.5 g
Sodium sulfite, 22.5 g
Hydroquinone, 6.3 g
*Sodium carbonate, mono., 17.5 g
Potassium bromide, 1.5 g
Water to make 1.0 L

*Sodium carbonate, anhyd., 15.0 g

Dilute 1:1. For normal use, exposure should be adjusted to produce the desired contrast and tone when developed from 1½ to 2 minutes at 68°F/20°C.

FORMULA #86

Gevaert G.261 Brown-Black Paper Developer

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 40.0 g
Glycin, 6.0 g
Hydroquinone, 6.0 g
Sodium carbonate, mono., 35.0 g
Potassium bromide, 2.0 g
Water to make 1.0 L

Without dilution this developer will produce brown-black tones on papers in about 2 minutes. Diluted 1:2, this developer produces brown tones in 4–8 minutes. Diluting 1:4 and developing 8–15 minutes, produces a red-brown tone. Diluting 1:6 and developing from 15 to 25 minutes will produce a red tone. For still warmer tones, add 10 grams of sodium bicarbonate to each liter of the diluted developer.

FORMULA #87

Gevaert G.262 Special Warm-Tone Paper Developer

This is a special warm-color paper developer. The image color tends toward red as the dilution is increased or as development time is extended.

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 70.0 g
Hydroquinone, 25.0 g
*Potassium carbonate, 90.0 g
Potassium bromide, 2.0 g
Water to make 1.0 L

*For slightly less warm tones, 81 grams of sodium carbonate, mono., can be substituted for the potassium salt.

Development times are between 1½ and 6 minutes. The relationship between image color and solution strength is as follows:

- Undiluted, the image will be brown-black.
- Diluted 1:2, the image will be brown.
- Diluted 1:4, the image will be brown red.
- Diluted 1:6, the image will be red.

Author's Note: Some papers will react in unusual and inconsistent ways to this developer.

FORMULA #88

Ilford ID-78 PQ Warm-Tone Developer

ID-78 is a modern PQ warm-tone developer that is very close in its formula to Ilford Neutol WA. It works extremely well with modern papers.

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 50.0 g
Hydroquinone 12.0 g
Phenidone, 0.5 g
Sodium carbonate, 62.0 g
Potassium bromide, 4.5 g
Water to make 1.0 L

Dilute 1:1 or 1:3.

Author's Notes:

1. This formula is often incorrectly published showing only 0.4 grams of potassium bromide. The correct formula was published by Ilford when it was introduced in 1960, and in 1966 by L.F.A. Mason, the head of research at Ilford, in *Photographic Processing Chemistry*, Focal Press.
2. If a stock solution is made up with no bromide or benzotriazole, it can vary from a cold/blue-black developer to a warm-tone developer with the addition of benzotriazole or bromide.

FORMULA #89

Kodak D-52 Selectol-Type Developer

This formula is similar to the proprietary formula Kodak Selectol.

Water at 125°F/52°C, 500.0 mL
Metol, 1.5 g
Sodium sulfite, 22.5 g
Hydroquinone, 6.0 g
Sodium carbonate, mono., 17.0 g
Potassium bromide, 1.5 g
Water to make 1.0 L

Dilute 1:1 and develop for about 2 minutes. More bromide may be added if warmer tones are desired. For a softer print, dilute 1:3. To increase the warmth, add bromide up to double the amount in the formula (this may cause a slight green cast with some papers).

FORMULA #90

Kodak D-155 Warm-Tone Developer

For brown-black to red-brown image tones.

Water at 125°F/52°C, 750.0 mL
Metol, 0.4 g
Sodium sulfite, 22.0 g
Hydroquinone, 4.0 g
Sodium carbonate, anhyd., 18.0 g
Potassium bromide, 4.0 g
Glycin, 2.6 g
Water to make 1.0 L

Dilute 1:1 to 1:4 for use.

FORMULA #91

Kodak D-166 Red-Brown Paper Developer

Water at 125°F/52°C, 750.0 mL
Metol, 0.6 g
Sodium sulfite, 12.5 g
Hydroquinone, 4.2 g
Sodium carbonate, anhyd., 12.5 g
Potassium bromide, 6.2 g
Water to make 1.0 L

Dilute 1:1 for use. Develop until the desired image tone is reached.

FORMULA #92

Pyro Warm-Tone Developer

Water at room temperature, 300.0 mL
Potassium metabisulfite, 1.5 g
Sodium sulfite, 30.0 g
Pyro, 4.4 g
Sodium carbonate, mono., 30.0 g
Potassium bromide, 4.4 g
Water to make 750.0 mL

Use full strength. Develop paper for not less than 1½ minutes. Warmer tones are possible with longer exposure and shorter development. This developer oxidizes rapidly and has a short tray life.

FORMULA #93

SA Warm-Tone Paper Developer, Steve Anchell

SA Warm-Tone is a versatile warm-tone paper developer.

Water at 125°F/52°C, 750.0 mL
Metol, 1.5 g
Sodium sulfite, anhyd., 22.5 g
Hydroquinone, 6.3 g
Potassium carbonate, mono., 15.3 g
*Potassium bromide, 1.0–4.0 g
Cold water to make 1.0 L

*The normal bromide content for this developer is 1½ grams. To increase the warm image tone, add up to 4 grams of bromide. If this developer is used in a two-bath arrangement or mixed with another developer, use only 1 gram of bromide.

Normal dilution is 1+1 with developing times between 1½ minutes. SA Warm-Tone can be used at a dilution of 1+3 to decrease contrast while maintaining a warm tone. At this dilution, it can also be mixed in varying proportions with neutral-tone developers to lower contrast without altering the neutral image color.

Author's Note: This is a good formula to use with two-tray development, where the first tray is a soft developer (SA Warm-Tone) and the second is either a normal or high-contrast developer. For this application use the 1+3 dilution.

FORMULA #94

Sepia-Tone Paper Developer, Jim Carbone

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 60.0 g
Sodium carbonate, mono., 90.0 g
Glycin, 25.0 g
Hydroquinone, 8.0 g
Potassium bromide, 2.0 g
Water to make 1.0 L

Dilute 1 part stock to 2 parts of water. Develop for a full 2 minutes. For warmer tones, increase the dilution.

STOP AND HARDENING BATHS

FORMULA #95

Indicator for Stop Baths, Grant Haist

Bromocresol green, 0.5% solution
Distilled water to make 250.0 mL

Add a few drops of indicator to any amount of fresh acid stop bath. If the dye is yellow, the pH of the bath is 4 or below. When the dye appears green, the bath is just above 4 but still good. When the bath turns blue, discard it and use a fresh bath.

FORMULA #96

Kodak SB-1 Nonhardening Stop Bath

Water, 1.0 L
*Acetic acid, 28% solution, 48.0 mL

*To make 28% acetic acid from glacial acetic acid, dilute 3 parts of glacial acetic acid with 8 parts of water.

Rinse prints for at least 15 seconds. Capacity is approximately twenty 8 × 100 prints per liter.

FORMULA #97

Kodak SB-5, Non-Swelling Acid Rinse Bath

Water, 500.0 mL
Acetic acid, 28% solution, 32.0 mL
Sodium sulfate, anhyd., 45.0 mL
Water to make 1.0 L

This bath is satisfactory up to 80°F/27°C. It should be replaced after processing about 12 rolls per liter. The bath should not be revived with acid.

When working at temperatures below 75°F/24°C, the life of the acid rinse bath may be extended by giving films a few seconds to rinse in running water prior to immersion in the acid rinse.

FORMULA #98

TH-5 Prehardener, Bill Troop

Water, 750.0 mL
Glutaraldehyde, 25%, 30.0 mL
Sodium sulfite, 20.0 g
Sodium metaborate, 2.0 g
Water to make 1.0 L

Use TH-5 as a pre-bath for 2 minutes before development. A less preferred alternative is to add 30 mL of 25% glutaraldehyde to virtually any one-shot developer. TH-5 should not be kept for more than a week.

FORMULA #99

Kodak SB-7, Citric Acid Odorless Stop Bath

John Wimberley: For decades the standard ingredient of stop baths has been acetic acid, which has one serious problem; its odor is strong and corrosive to mucous membranes, making long-term exposure in the darkroom problematical. Citric acid is a much healthier alternative because it is essentially odorless.

Water, 750.0 mL
Citric acid, 15.0 g
Water to make 1.0 L

FORMULA #100

TS-7 Buffered Stop Bath, Bill Troop

Water at 125°F/52°C, 500.0 mL
Acetic acid 28%, 120.0 mL
Sodium acetate, 80.0 g
Cold water to make 1.0 L

FIXERS

- Crystalline hypo (sodium thiosulfate), when mixed with water, produces a noticeable lowering of temperature. Always begin with water of at least 90°F/32°C when mixing the crystalline form.
- Use 64% of the anhydrous salt as a substitute for the crystalline form. With either crystalline or anhydrous, mix the hypo first then add the remaining ingredients.
- When a mixture of sodium sulfite and acetic acid is used, dissolve the acid ingredients separately (e.g., boric acid) in a small volume of hot water.
- Removing the hardener from fixer will improve the gloss on fiber-based glossy paper (e.g., leave the potassium alum out of Kodak F-5 and don't add the hardener solution, Kodak F-5a).
- As a *very* general guideline, most fixing baths, rapid or standard, have a capacity of twenty 8 × 10–inch prints or films per liter. If no capacity is specified, use this as your guide for archival processing of film and paper. Err on the side of replacing the fixing bath before it is exhausted.
- Excessive fixing times with acid fixers will promote retention of the fixer complexes in gelatin emulsion and on the fibers of the paper's base. In addition, excessive fixing can bleach image-bearing silver, especially those on paper prints. Warm-tone images are particularly at risk. Alkaline fixers *do not* dissolve or bleach image-bearing silver even with extended fixing times.

Fixing Times for Film and Paper with All Fixers

Unless otherwise directed to do otherwise, use the following for all films and papers.

FILM: Fix for three times the clearing time for each film type.

PAPER: Use the two-bath method. Determine the clearing time for each paper and fix for that time in both the first and second bath. If one bath is to be used, fix for three times the clearing time.

FORMULA #101

Acid Hypo Fixer, J. Ghislain Looten

Water at 125°F/52°C, 2.0 L
Sodium thiosulfate, 480.0 g
Sodium bisulfite, 45.0 g

Use undiluted. Unlike plain hypo, this fixer can be saved and reused, though it should be tested for potency as with all fixers, see Chapter 12. It allows easy toning with direct toners, such as selenium.

FORMULA #102

Agfa 304 Rapid Fixer

This fixer makes use of sodium thiosulfate and ammonium chloride to form ammonium thiosulfate in solution.

Water at 125°F/52°C, 750.0 mL
Sodium thiosulfate, 200.0 g
Ammonium chloride, 50.0 g
Potassium metabisulfite, 20.0 g
Water to make 1.0 L

FORMULA #103

ATF-1 Nonhardening Rapid Fixer, Donald B. Alnutt

Use this formula for film or paper to reduce fixing times. The hardener is optional.

STOCK SOLUTION

Ammonium thiosulfate, 60% solution, 750.0 mL
Sodium sulfite, 48.0 g
Acetic acid, glacial, 36.0 mL
Boric acid, granular, 30.0 g
Water to make 1.0 L

Add the acetic acid slowly while stirring. Dissolve the boric acid separately in a little hot water and add this last.

Optional Hardener

Aluminium chloride, hexahydrate, 50.0 g
Water to make 100.0 mL

FORMULA #104

ATF-5, Acid Hardening Rapid Fixer, Donald B. Alnutt

Use this formula for film or paper when hardening is desired to reduce fixing times.

Water at 125°F/52°C, 600.0 mL
*Ammonium thiosulfate, mono., 60% solution, 333.0 mL
Sodium sulfite, 15.0 g
Acetic acid, 28% solution, 55.0 mL
Potassium alum, 15.0 g
+Boric acid, granular, 7.5 g
Add water to make 1.0 L

*200 grams of ammonium thiosulfate, crystalline can be used.
+Dissolve the boric acid separately in a little hot water and add this last.

FORMULA #105

Chapman Alkaline Fixer

From *English Amateur Photographer*; volume VII, 1903

Water, 750.0 mL
Sodium thiosulfate, 113.0 g
Sodium carbonate, 1.29–1.94 g
Sodium sulfite, 7.0 g
Water to make 1.0 L

FORMULA #106

Defender 9-F Rapid Thiocyanate Fixer

Use this fixer when fixing has to be completed in a matter of seconds or when fixing must take place in very low temperatures.

Water at 125°F/52°C, 600.0 mL
Potassium thiocyanate, 100.0 g
Potassium alum, 50.0 g
Add water to make 1.0 L

When this is thoroughly dissolved, add:

Acetic acid, glacial, 25.0–35.0 mL

Use 25.0 mL of acetic acid for rapid fixing and 35.0 mL for low temperatures.

***Caution*:** Thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.

FORMULA #107

Kodak F-1a, Acid Hardener

Water at 125°F/52°C, 425.0 mL
Sodium sulfite, 60.0 g
Acetic acid, 28% solution, 190.0 mL
Potassium alum, 60.0 g
Water to make 1.0 L

The sodium sulfite should be dissolved completely before adding the acetic acid. After the sulfite-acid solution has been mixed thoroughly, add the potassium alum with constant stirring.

To make an acid hardening fixing bath, add 250 mL of hardener to 1 liter of plain hypo solution (240 g/liter of sodium thiosulfate to water). If the hypo is not thoroughly dissolved before adding the hardener, a precipitate of sulfur is likely to form.

Harden film or paper for 1 minute prior to fixing.

To make a prehardening bath (prior to development), dilute 250 mL of the stock hardener solution in 1 liter of water.

Author's Note: Do not add hardener to a fixing bath if you intend to tone the paper.

FORMULA #108

Kodak F-5, Acid Hardening Fixer

F-5 is the standard sodium-thiosulfate-based formula. Many commercially marketed fixers are essentially unaltered versions of this formula. Use this formula for film and paper when hardening is desired.

Water at 125°F/52°C, 600.0 mL
Sodium thiosulfate, 240.0 g
Sodium sulfite, 15.0 g
Acetic acid, 28% solution, 48.0 mL
Boric acid, crystalline, 7.5 g
Potassium alum, dodecahydrate, 15.0 g
Water to make 1.0 L

FORMULA #109

Kodak F-5a Hardener

Water at 125°F/52°C, 500.0 mL
Sodium sulfite, 75.0 g
Acetic acid, 28% solution, 235.0 mL
Boric acid, crystals, 37.5 g
Potassium alum, dodecahydrate, 75.0 g
Water to make 1.0 L

The sodium sulfite should be dissolved completely before adding the acetic acid. After the sulfite-acid solution has been mixed thoroughly, add the potassium alum with constant stirring.

To make an acid hardening fixing bath, add 250 mL of hardener to 1 liter of cool hypo solution. If the hypo is not thoroughly dissolved before adding the hardener, a precipitate of sulfur is likely to form.

To make a prehardening bath, dilute 250 mL of the stock hardener solution in 1 liter of water. Harden film or paper for 1 minute prior to fixing.

FORMULA #110

Kodak F-6, Odorless Hardening Fixer

Most fixers have strong odors caused by sulfur dioxide. Substituting sodium metaborate for boric acid in the F-6 formula eliminates the odor almost entirely.

Water at 125°F/52°C, 600.0 mL
Sodium thiosulfate, 240.0 g
Sodium sulfite, 15.0 g
Acetic acid, 28% solution, 48.0 mL
Sodium metaborate, 15.0 g
Potassium alum, 15.0 g
Water to make 1.0 L

Mix the alum separately in a small amount of hot water to prevent sulfurization. Add this solution with rapid stirring.

FILM: Fix for three times the clearing time.

PAPER: Use the two-bath method. Determine the clearing time and fix it for that time in both the first and second baths.

Do not use this fixer for the second bath if you intend to tone the print. Use Kodak F-24 Nonhardening Acid Fixer instead.

FORMULA #111

Kodak F-24, Nonhardening Acid Fixer

Fixer without hardener is preferred for prints that are to be toned. Prints without hardener are also easier to wash and retouch with spotting fluid.

F-24 works well with pyro negatives, although care must be taken to avoid scratching while wet. The reason F-24 is a good choice for pyro is that it is less acidic, using sodium bisulfite instead of the stronger 28% glacial acetic acid found in many formulas. Fixers that are too acid tend to remove desirable pyro stain. Hardener is not necessary with pyro since the developer creates its own hardening effect.

Water at 125°F/52°C, 500.0 mL
Sodium thiosulfate, 240.0 g
Sodium sulfite, 10.0 g
Sodium bisulfite, 25.0 g
Water to make 1.0 L

FILM: Film shouold be clear in 5 minutes and fully fixed in 10. Discard when the clearing time is close to 10 minutes.

PAPER: Use the Kodak two-bath method, 5 minutes in each bath. Do not use this fixer for the second bath if you intend to tone the print.

FORMULA #112

Plain Hypo Bath

Use a plain hypo bath for the second fixing bath immediately before toning. Also, as it contains no sulfite, it will allow the maximum image stain to form on pyro negatives.

A plain hypo bath can fix a print in 30 seconds. However, it has poor keeping qualities and must be used with an acid stop bath, or staining will occur. Do not keep a used plain hypo bath overnight.

Water at 125°F/52°C, 2.0 L
Sodium thiosulfate, 480.0 g

Use fresh and undiluted.

FORMULA #113

TF-2 Alkaline Fixer, Bill Troop

Due to its alkalinity, this fixer will wash out of a negative and print materials more rapidly than an acid fixer. It should be odorless.

Water, 750.0 mL
Sodium thiosulfate, 250.0 g

Sodium sulfite, 15.0 g
Sodium metaborate, 10.0 g
Water to make 1.0 L

Use undiluted for either film or paper. Follow development by a 60-second plain water rinse or a minimum of five full changes of water. Fix films for three times the clearing time, or a minimum of 5 minutes, agitating for a full 30 seconds during each minute. Fix paper for twice the clearing time with occasional agitation.

The capacity of TF-2 is twenty 80^2-inches of prints or films per liter.

FORMULA #114

TF-3 Alkaline Rapid Fixer, Bill Troop

As with TF-2, this fixer will wash out of negative and print materials more rapidly than will an acid fixer. It has the added advantage of fixing films and papers in less than half the time of the TF-2 alkaline fixer.

Ammonium thiosulfate, 57–60% solution, 800.0 mL
Sodium sulfite, 60.0 g
Sodium metaborate, 5.0 g
Water to make 1.0 L

Use undiluted for either film or paper. Follow development by a 60-second plain water rinse or a minimum of five full changes of water. Fix films for three times the clearing time, or a minimum of 5 minutes, agitating for a full 30 seconds during each minute. Fix paper for twice the clearing time with occasional agitation.

TONERS

- Different papers, even different paper grades of the same paper, react differently to toners. Paper developers also affect a toner's color. Test each paper/developer/toner combination before committing valuable work to the process. Keep a book of the results.
- Be certain the print is completely and correctly fixed. Incorrectly fixed prints will often stain. Papers intended for toning should be more thoroughly washed than average prints.
- Use a nonhardening fixer. If a print has been previously hardened, use a dehardener.
- Unless otherwise specified, a print should be washed after toning and air-dried, as heat-drying can produce noticeable color shifts.

Safety Precautions

The chemicals used for toning are among the most toxic in photography. If proper safety procedures are adhered to there should be no more danger than in any other process, see Appendix 1. Here are some additional precautions:

- Be sure to use gloves for all toning processes.
- Be certain there is adequate ventilation and that ventilator fans are turned on. Toning takes place under normal working light, so there is no reason not to open the door.
- Sulfide toning should not be carried on in a room where film or paper is stored, as the fumes of the sulfide can cause fogging of sensitized materials. When in doubt, have no other photographic materials in the toning area.
- It is also wise to use the sulfide bath in a well-ventilated room since the fumes will cause headaches and illness if too much is inhaled.

Blue Toners

FORMULA #115

Ansco 241 Iron Blue Toner

This formula is suitable for bromide and fast chlorobromide papers.

Ferric ammonium citrate, 8.0 g
Potassium ferricyanide, 8.0 g
Acetic acid, 28% solution, 265.0 mL
Distilled water to make 1.0 L

Prints for toning should be fixed in plain, nonhardening hypo at a temperature of 68°F/20°C or less to prevent excessive swelling. When prints have been fully toned, they will be greenish in color, but they will change to clear blue when placed in running water.

The depth of the blue toning will vary with the quality of the prints toned. Some intensification of the print usually occurs in toning; consequently, prints should be slightly lighter than the density desired in the final toned print.

Wash water should be acidified slightly with acetic acid, since the blue tone is quite soluble in alkaline solutions and is considerably weakened when the wash water is alkaline. Pleasing variations in the tone can be obtained by bathing the washed prints in a 0.5% solution (5 g/L) of borax, which produces softer, blue-gray tones, the extent of which depends on the length of treatment.

Author's Note: The solution should be prepared with distilled water. If enameled iron trays are used, no chips or cracks should be present, or spots and streaks may appear in the print.

FORMULA #116

Blue-Gold Toner

This formula is one of the fastest and easiest to use. It is capable of creating a deep blue color on warm tone chlorobromide papers.

Distilled water at 125°F/52°C, 750.0 mL
*Ammonium thiocyanate, 105.0 g
Gold chloride, 1% solution, 60.0 mL
Water to make 1.0 L

*110 grams of sodium thiocyanate or 135 grams of potassium thiocyanate may be substituted.

After fixing and thoroughly washing, tone the prints for 10–20 minutes with occasional agitation. The prints should then be washed and dried.

***Caution*:** Thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.

FORMULA #117

Dassonville T-6 for Gray-Blue Tones

SOLUTION A

Thiourea, 16.0 g
Water to make 1.0 L

SOLUTION B

Gold chloride, 4.0 g
Distilled water, 1.0 L

For use, take:

Water, 360.0 mL
Solution A: 90.0 mL
Solution B: 90.0 mL

Add 16 drops of concentrated sulfuric acid *slowly* with constant stirring to the *cold* A + B.

Use the bath at 75°F/24°C. Prints should be toned two at a time, back to back and well covered with the toning solution. Agitate occasionally. Toning will take from 5 to 20 minutes. The bath may be used until exhausted. The stock solutions will keep indefinitely, but the mixed toner will not keep for more than a few days. The toned print is permanent and will not fade or change color.

If a lighter shade of blue is desired, remove the prints from the toning bath before the maximum effect is reached. After toning, treat the prints in a washing aid and wash for ½ hour; dry as usual.

Prints to be blue-toned should be developed in Dassonville D-3 Autotoning Developer. (Other warm-toned developers can be used, but they will probably not give as deep a blue tone. A warm-toned print will give a deeper blue than a cool-toned print; D-3 will give very warm-toned results and correspondingly deep blues.)

Prints should be slightly softer and lighter than normal and should be developed for 5 minutes. This long development is important. If the print is too dark, decrease exposure; do not reduce development time.

After development, the prints should be fixed in a nonhardening fixer and thoroughly washed. Two-bath fixing is recommended, the second being a plain hypo bath without a hardener.

Author's Notes:

1. Stains are caused by incomplete washing between fixing and toning.
2. The surface of the print will be quite soft after washing since no hardener is used in the fixing bath. It is recommended that the prints be dried between washing and toning. This will tend to harden the emulsion slightly and help to prevent frilling in later baths (frilling separates the emulsion from the paper; this also can occur when solutions or wash water are excessively hot). Care should also be used in handling the prints after toning.
3. The stock solutions will keep indefinitely, but the mixed toner will not keep for more than a few days.

Caution: When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, always add the acid to the solution, otherwise the solution may spatter causing serious burns to the hands or face.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #118

Gold Chloride Blue Toner

This gives a soft, grayish purple rather than a vivid blue. A green-blue tone will appear on some chlorobromide papers.

SOLUTION A

Water, 250.0 mL
*Thiourea, 3.5 g

SOLUTION B

Water, 250.0 mL
Citric acid, 3.5 g

SOLUTION C

Water, 250.0 mL
Gold chloride, 1.0 g

*If potassium or sodium thiocyanate is substituted for thiourea, more purplish tones will appear.

Take 30 mL of each stock solution and add 300 mL of water. Fix the print in a plain hypo bath and wash for 10–30 minutes. Agitate the prints during toning. The average print will be toned in about 15 minutes. Dark prints take longer. After toning, treat with a washing aid and wash for about 1 hour.

Author's Note: Slight intensification will take place with some papers, particularly chloride and chlorobromide emulsions.

This quantity of toner can be used for two to four 11 × 14-inch prints. The mixed solution will keep for several hours.

***Caution*:** Thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.

FORMULA #119

Kodak T-12, Iron-Toning Bath

Ferric ammonium citrate, green, 4.0 g
Oxalic acid, crystals, 4.0 g
Potassium ferricyanide, 4.0 g
Water to make 1.0 L

Using the Toner: Immerse the well-washed print in the toning bath for 10–15 minutes until the desired tone is obtained. Then wash until the highlights are clear.

Author's Note: Dissolve each chemical separately and filter before mixing together.

FORMULA #120

Kodak T-26, Blue Toner

Blue toner for solid deep blue tones on warm-tone papers and soft blue-black tones on neutral-tone papers.

Water at 125°F/52°C, 937.0 mL

Add:

Gold chloride, 1% solution, 40.0 mL

With stirring add:

Thiourea, 1.0 g
Tartaric acid, 1.0 g
Sodium sulfate, anhyd., 15.0 g

Continue to stir until all the chemicals are dissolved.

The range of toning times is 8–45 minutes at 68°F/20°C. Increasing the temperature to between 100°F/38°C and 105°F/40°C decreases the toning time from 2 to 15 minutes. Since toning is slow, only occasional agitation is needed to avoid streaking.

***Capacity*:** T-26 exhausts rapidly. It has a capacity of only five to fifteen 8 × 100 prints per liter.

Author's Note: T-26 increases the contrast and density of the print. Compensate by reducing the normal exposure time (start with 10% less). Toning starts in the highlights and slowly moves into the shadows. Careful observation is necessary to avoid a partially toned print with blue highlights and untoned shadows.

Brown Toners

FORMULA #121

Ansco 221, Sepia Toner for Warm-Brown Tones

Bleach:

Water at 125°F/52°C, 750.0 mL
Potassium ferricyanide, 50.0 g
Potassium bromide, 10.0 g
Sodium carbonate, mono., 20.0 g
Water to make 1.0 L

Redeveloper:

Water, 300.0 mL
*Sodium sulfide, anhyd., 45.0 g
Water to make 500.0 mL

*Be sure to use sodium sulfide, not sodium sulfite.

Using the Toner: Dilute 1 part of Solution A with 8 parts water. Prints should be washed thoroughly and then bleached in Solution A until the black image is converted to a very light brown color, about 1 minute. Prints should then be washed for 10–15 minutes and redeveloped.

With continuous agitation, redevelopment should be complete in about 1 minute. After redevelopment the prints should be washed for about 30 minutes and then dried. If the toner leaves sediment, immerse the print for a few seconds in a 3% solution of acetic acid, after which a 10-minute washing is necessary.

Author's Notes:

1. This solution should be stored in the dark, as ferricyanide solutions are light sensitive. Should the solution turn blue, the bleach should be discarded.
2. Use plastic trays, especially with the bleaching bath. Otherwise, blue spots may form on the print.

FORMULA #122

Ansco 222 Hypo-Alum Toner for Reddish-Brown Tones

SOLUTION A

Water, 2350.0 mL
Sodium thiosulfate, 450.0 g

SOLUTION B

Water, 30.0 mL
Silver nitrate, 1.3 g

SOLUTION C

Water, 30.0 mL
Potassium iodide, 2.7 g

Add Solution B to Solution A, then Solution C. Finally, add 105 grams of potassium alum and heat the bath to the boiling point or until sulfurization takes place (indicated by a milky appearance of the solution). Tone prints 20–60 minutes at 110°F/43°C to 125°F/52°C. Agitate prints occasionally until toning is complete.

Author's Note: Care should be taken to see that the blacks are fully converted before removing the prints from the toning bath. Otherwise, double tones may result.

FORMULA #123

Brown Toner, Alexandra Opie

Water, 750.0 mL
Potassium polysulfide, 228.0 g
Sodium carbonate, 98.0 g
Sodium hydroxide 13.0 g
Water to make 1.0 L

Caution: Slowly add the sodium hydroxide to the water, do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #124

Formulary Thiourea Toner, William M. Wilson

This formula is similar to Ansco 221 Sepia Toner, but without the rotten egg smell associated with sulfide toners.

Bleach

Water at 125°F/52°C, 750.0 mL
Potassium ferricyanide, 50.0 g
Potassium bromide, 10.0 g
Sodium carbonate, mono., 20.0 g
Water to make 1.0 L

This solution should be stored in the dark, as ferricyanide solutions are light sensitive. Should the solution turn blue, the bleach should be discarded.

Redeveloper

SOLUTION A	**SOLUTION B**
Sodium hydroxide, 10.0 g	Thiourea, 5.0 g
Cold water to make 100.0 mL	Water, 100.0 mL

Add the thiourea to the water and stir until the entire solid goes into solution. Pour into a container for storage.

Using the Redeveloper: Mix 1 part A and 1 part B with 16 parts water.

Table F.14

To make:	250.0 mL	500.0 mL	1000.0 mL
Solution A	14.0 mL	28.0 mL	56.0 mL
Solution B	14.0 mL	28.0 mL	56.0 mL
Water to make	250.0 mL	500.0 mL	1.0 L

Once mixed, the redeveloper is good for a working session, but cannot be saved. Dispose of the spent solution down the drain using excess amounts of water.

Using the Toner: Use plastic trays, especially with the bleaching bath. Otherwise, blue spots may form on the print.

Prints should be washed thoroughly and then bleached while wet (if they have previously been dried, rewet before bleaching). Bleach until the black image is converted to a very light brown color, about 1 minute. Wash the bleached prints for 10–15 minutes in running water. The bleach can be reused.

Immerse the well-washed, bleached prints in the redeveloper. Redevelopment should be complete in about 1 minute, with constant agitation. After redevelopment the prints should be washed for about 30 minutes and then dried. If the toner leaves sediment, immerse the print for a few seconds in a 3% solution of acetic acid, after which a 10-minute washing is necessary.

***Caution*:** Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #125

Ilford IT-2 Hypo-Alum Sepia Toner

This is a versatile toner that generally produces purplish-sepia tones. Adding a solution of potassium iodide can cause it to yield warmer tones.

Toner

Water at 125°F/52°C, 750.0 mL
Sodium thiosulfate, pentahydrate, 150.0 g

Place the hot water in a mixing bowl and add the hypo. Stir until the solid goes into solution. Then add a little at a time:

Potassium alum, 25.0 g

Ripening the Toner

A solution containing only thiosulfate and alum will bleach a print by removal of the silver. When the silver concentration in the bath is high enough, the solution will act as a toner. In order to convert a fresh hypo-alum solution to a toning bath, silver must be added. This can be done by adding silver nitrate and then immersing spoiled prints in the bath until the desired toning result is reached. If silver nitrate is not available, the bath can be ripened by immersing a series of spoiled prints alone.

Chemical Ripener

Water, 5.0 mL
Silver nitrate, 0.12 g

Add the water to the silver nitrate and mix well. Add the nitrate solution to the toner. Ignore any precipitate. Stir the solution to ensure it is homogeneous.

IT-2 tends to give cold tones. If warmer tones are desired add the following solution.

Iodide Warming Solution

Water at 68°F/20°C, 50.0 mL
Potassium iodide, 1.0 g

Pour the iodide solution into the toner. It is normal for a precipitate to form. Once the toner is mixed, the ripening solution added, and the optional warming solution created, add cold water to bring the total volume to 1 liter.

Prints to be toned should be developed more than usual. RC papers will tend to appear gray due to the loss of their brighteners in this bath. The bath should be used undiluted at 120°F/50°C to minimize the toning time. Rock the tray to keep precipitate off the surface of the print, and tone for approximately 10 minutes. After toning wash the print for 10–20 minutes and use a wet cotton ball to wipe any scum off the print surface.

FORMULA #126

IT-8 Ilford Pyrocatechin Toner for Olive-Black Tones

Thanks to Ian Grant

SOLUTION A

*Potassium bichromate, 50.0 g
Water to make 1.0 L

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in the Pharmacopoeia.

SOLUTION B

Hydrochloric acid, concentrate, 100.0 mL
Water to make 1.0 L

Make up bleach from 2 parts A and 10 parts B with 40 parts water.

***Caution*:** Always add the hydrochloric acid to the water slowly, stirring constantly. Never add water to the acid.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Using the Toner: Expose and process the print as normal and wash well. Bleach the print, wash until all the yellow from the bichromate has been removed from the highlights, and redevelop in the following developer.

IT-8 Developer

Pyrocatechin, 1.75 g
Sodium carbonate, anhyd., 15.0 g
Water to make 1.0 L

Develop to completion.

Author's Note: The developer should be fresh and discarded once it turns green.

FORMULA #127

Kodak T-1a, Hypo-Alum Toner

For sepia tones on warm-tone papers.

This formula is particularly suitable for warm-toned slow chlorobromide and chloride papers. Prepare this formula carefully following these instructions:

Distilled water, 2800.0 mL
Sodium thiosulfate, 480.0 g

Dissolve thoroughly and add the following solution:

Distilled water at 160°F/70°C, 640.0 mL
Potassium alum, 120.0 g

Then add the following solution (including precipitate) slowly to the hypo-alum solution while stirring the latter rapidly:

Distilled water, 64.0 mL
*Silver nitrate, crystals, 4.0 g
Sodium chloride, 4.0 g

After combining the solutions, continue as follows:

Add water to make 4.0 L

*The silver nitrate should be dissolved completely before adding the sodium chloride; immediately afterward, add the solution containing the milky white precipitate to the hypo-alum solution. The formation of a black precipitate in no way impairs the toning action of the bath if adequate agitation is used.

Using the Toner: Pour into a tray supported by a water bath heated to 120°F/50°C. Bring the toner to this temperature. At this temperature prints will tone in 12–15 minutes, depending on the type of paper. Never use the solution above 120°F/50°C because blisters and stains may result. Toning should not be continued longer than 20 minutes at 120°F/50°C.

Toning may be sped up by placing the prints in a bath of 10% sulfuric acid for 1 minute and then transferring them directly to the toning bath.

In order to produce good sepia tones, the prints should be exposed so that the print is slightly darker than normal when developed normally (1½–2 minutes).

The prints to be toned should be fixed thoroughly and washed for a few minutes before being placed in the toning bath. Dry prints should be soaked for 5 minutes in water. To ensure even toning, the prints should be immersed completely and occasionally separated, especially during the first few minutes.

After the prints are toned, they should be wiped with a soft sponge and warm water to remove any sediment then washed for 1 hour in running water.

Author's Note: When the toner is first mixed, it has too great a reducing action. This can be avoided by toning a few waste prints before the toner is used on good prints.

When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, always add the acid to the solution, otherwise the solution may spatter causing serious burns to the hands or face.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #128

Kodak T-7a, Sulfide Sepia Toner for Cold-Tone Papers

STOCK BLEACHING SOLUTION A

Potassium ferricyanide, 75.0 g
Potassium bromide, 75.0 g
Potassium oxalate, 195.0 g
Acetic acid, 40.0 mL
Water to make 2.0 L

STOCK TONING SOLUTION B

*Sodium sulfide, 45.0 g
Water to make 500.0 mL

*Be sure to use sodium sulfide, not sodium sulfite.

Prepare the bleaching bath as follows:

Stock solution A, 500.0 mL
Water, 500.0 mL

Prepare the toner as follows:

Stock solution B, 125.0 mL
Water, 1.0 L

Use plastic trays, especially with the bleaching bath. Otherwise, blue spots may form on the print.

The print should be washed thoroughly. Place it in the bleach until only faint traces of the midtones are left and the black of the shadows has disappeared. This will take about 1 minute.

Rinse thoroughly in clean cold water. Place in the toner until original detail returns—about 30 seconds. Give the print an immediate and thorough water rinse; then immerse it for 2–5 minutes in a hardening bath composed of 1 part of hardener (Kodak F-5a Hardener) and 13 parts of water. Wash the prints for 4 minutes in running water at 65°F/18°C to 75°F/24°C.

FORMULA #129

Kodak T-8, Nelson Gold Toner

Using Nelson Gold Toner, three-dimensional brown tones can be obtained that vary from a hint of warmth to rich brown sepia browns. The depth of tone depends upon the duration of time the print remains in the toning bath, from 5 to 20 minutes.

Author's Note: Most gold chloride toners create a cold tone print. Nelson's Gold Toner is an exception.

SOLUTION A, PART 1

Distilled water at 125°F/52°C, 750.0 mL
Sodium thiosulfate, 240.0 g
Ammonium persulfate, 30.0 g
Water to make 1.0 L

Dissolve the hypo completely and then add the persulfate while stirring vigorously. If the solution does not turn milky, increase the temperature until it does. Then add the cold water.

SOLUTION A, PART 2

Distilled water at room temperature, 15.0 mL
Silver nitrate, 1.3 g
Sodium chloride, 1.3 g

Part 2 should be mixed in a container that is different from that of Part 1; the two solutions will be mixed in a subsequent step. The silver nitrate should be thoroughly dissolved before adding the sodium chloride; otherwise, the nitrate will be trapped in the solid that forms. A white precipitate will form; stir vigorously.

Combining Part 1 and Part 2: Both solutions must be at room temperature before they are combined to make Stock Solution A. Stir Part 2 vigorously to disperse the solid throughout the solution, then pour all of Part 2 into Part 1. Stir the combined solution to ensure thorough mixing. A precipitate may be present in the final solution. Transfer the combined solution along with any precipitate to the storage container.

SOLUTION B

*Gold chloride, 1% solution, 52.0 mL

*To make a 1% solution, mix 1.0 gram of gold chloride with 100.0 mL of distilled water. Gold chloride is deliquescent and rapidly absorbs atmospheric moisture. The solid may have liquefied by the time you wish to use it. Since you will be transferring it to a water solution, prior liquefaction is not detrimental. However, when gold chloride liquefies, some of the liquid clings to the container cap. Because of the small amount used, it is important that all of the residual gold chloride is salvaged.

Mixing the Working Solution: Add one half of Stock Solution B to Stock Solution A (the balance of Stock Solution B will be used to replenish the bath). Stir the mixture to ensure that it is homogeneous. The bath should not be used until after it has cooled and formed sediment, preferably overnight.

Using the Toner: Prints for toning should be wet. They should be fully fixed, but only a brief washing is necessary. Very carefully pour off the clear liquid, being careful to avoid the sediment.

Heat the toner to about 110°F/43°C for use. Maintain the temperature between 100°F/38°C and 110°F/43°C while toning. If necessary, place a smaller tray containing the toner inside a larger tray of running water at 110°F/43°C.

Toning takes from 5 to 20 minutes depending on the desired hue. After all the prints have been toned, refix for 5 minutes then wash for 1 hour in running water.

The bath should be revived at intervals by the addition of further quantities of Solution B. The quantity to be added will depend on the number of prints toned and the time of toning. For example, when toning to a warm brown, add 4.0 mL of gold solution after each fifty 8 × 10-inch prints or their equivalent have been toned.

Author's Note: Due to the cost of gold chloride, the best method for obtaining a 1% solution is to purchase it premixed from Photographers' Formulary.

FORMULA #130

Polysulfide Toner for Sepia Tones

This toner creates slightly darker brown tones than Kodak T-7a on warm-tone papers. It has a further advantage over hypo-alum formulas of not requiring heating, although raising the temperature to 100°F/38°C will reduce the toning time.

Water, 750.0 mL
Potassium polysulfide, 7.5 g
Sodium carbonate, mono., 2.5 g
Water to make 1.0 L

Immerse the well-washed print in the bath and agitate for 15–20 minutes at 68°F/20°C or for 3 or 4 minutes at 100°F/38°C.

After toning, rinse the print for a few seconds in running water and place for about 1 minute in a sodium bisulfite solution containing 30.0 grams per liter of water. Then, immerse the print for about 2 minutes in a hardening bath prepared by adding 2 parts of Kodak F-5a Hardener to 16 parts of water.

If any sediment appears on the print, the surface should be wiped with a soft sponge. The print should be treated in a washing aid then washed for at least 30 minutes.

The approximate life of the toning bath is thirty-five 8 × 10-inch prints per liter.

For archival toning, dilute the stock solution 1:100 with water and tone for 3–5 minutes at 70°F/21°C.

FORMULA #131

Polytoner, Ryuije Douglas

Distilled water, 500.0 mL
Sodium carbonate, mono., 160.0 g
Kodak Brown Toner, 320.0 mL
Rapid selenium toner, 8.0 mL
Water to make 1.0 L

Toning Procedure: After processing the print, give it a short wash. Place the print in the polytoner 1:30 for about 30 seconds. Move the print to a water bath and let it sit without any agitation. Toning comes up slowly. When the print reaches the desired color, remove it from the water bath and wash normally.

Author's Note: You can substitute any brown toner and/or selenium toner for the Kodak product to create your own polytoner.

Copper Toners

FORMULA #132

Dassonville T-5 Copper Toner for Purple-Brown to Chalk-Red Tones

SOLUTION A	**SOLUTION B**
Copper sulfate, 6.5 g	Potassium ferricyanide, 5.5 g
Potassium citrate, neutral, 24.8 g	Potassium citrate, neutral, 24.8 g
Water to make 1.0 L	Water to make 1.0 L

Take equal parts of A and B. Tone the thoroughly washed prints one at a time until the desired color is reached. The prints will progress from black to deep brown and finally to red-chalk. Toning may be stopped by removing the print and washing well. A washed and dried print may be returned to the toner at any time. As it is important to remove prints at the exact moment that the desired color is obtained, a guide print should be toned first.

Wash prints for ½ hour after toning. If pinkish tints appear, add more potassium citrate to Solution B.

For maximum permanence, prints should be toned as deeply as possible, given a bath in weak hypo, treated with a washing aid, and washed. However, any print toned to less than red chalk should not be treated with hypo.

The mixed solution will not keep well and should be discarded after use. Prints that appear weak after toning can be strengthened by immersing in a bath composed of the following:

Copper sulfate, 48.0 g
Potassium bromide, 24.0 g
Acetic acid, 28% solution, 50.0 mL
Water to make 1.0 L

Prints should be washed for another ½ hour after using this solution. Fresh solution should always be used.

FORMULA #133

GT-15 Copper Red Toner

SOLUTION A	**SOLUTION B**
Potassium citrate, neutral, 100.0 g	Copper sulfate, 7.5 g
Water at 68°F/20°C, 500.0 mL	Water to make 250.0 mL

SOLUTION C

Potassium ferricyanide, 6.5 g
Water to make 250.0 mL

Mix Solution B with Solution A. While stirring, slowly add stock Solution C.

Author's Note: GT-15 bleaches the print. Compensate by extending the printing time as much as 50%.

Dupont Toning System

FORMULA #134

DuPont 6-T Toning System

This system of bleaches and toners can be mixed and matched to provide a variety of tones from purplish sepia to brilliant yellow, see Chapter 13.

Toning bleach 6B-1

Water, 750.0 mL
Potassium ferricyanide, 22.0 g
Potassium bromide, 25.0 g
Water to make 1.0 L

Toning bleach 6B-2

Water, 750.0 mL
Potassium ferricyanide, 22.0 g
Potassium iodide, 10.0 g
Water to make 1.0 L

Toning bleach 6B-3

Water, 750.0 mL
Potassium ferricyanide, 22.0 g
Sodium chloride, 35.0 g
Nitric acid, 15.0 mL
Water to make 1.0 L

Prints should be developed for 1½ minutes and fixed in a nonhardening fixing bath. Thoroughly wash the prints, then bleach in one of the previous bleaching baths for twice the time necessary to completely convert the black image. Then wash again until the image is free from the yellow bleach color.

The bleached print is placed in one of the following toning baths and left until toning is complete.

Toner 6T-1

Water, 750.0 mL
Thiourea, 3.0 g
Sodium hydroxide, 6.0 g
Water to make 1.0 L

Toner 6T-2

Water, 750.0 mL
Thiourea, 3.0 g
Sodium carbonate, 45.0 g
Water to make 1.0 L

Toner 6T-3

Water, 750.0 mL
Thiourea, 3.0 g
Potassium carbonate, 48.0 g
Water to make 1.0 L

Caution: Slowly add the sodium hydroxide to the water, do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Various combinations of bleach and toner will give different tones as shown by the following table:

Table F.15 DuPont Toning System

Bleach	*Tone*	*Resulting Tone*
6B-3	6T-1	Deep brown, slight purplish tint.
6B-1	6T-1	Deep brown tint.
6B-2	*6T-3	Increasing warmth with a golden tinge until a bright sunlit sepia is produced with these three combinations.
6B-1	*6T-3	
6B-3	*6T-3	

*6T-2 can be used instead of 6T-3 for a cooler color.

Gold Tone Modifier

Gold chloride, 1.0 g
Potassium thiocyanate, 6.0 g
Water to make 1.0 L

This bath can be used directly on a print to produce a blue-black tone. It may also be used on prints that have been toned in any of the preceding methods. The toned print is first immersed in a 3% sodium chloride solution.

Sodium Chloride Solution

Water, 750.0 mL
Sodium chloride, 30.0 g
Water to make 1.0 L

After treatment in the chloride bath, briefly rinse the prints and place them in the gold solution. This bath replaces the golden tint with a reddish one. Toning may be continued for 2–16 minutes, with the color becoming more purple as the toning proceeds. A short wash should be done before drying.

If a slight yellowish stain appears on the gold-toned print, it may be cleared with a second treatment in any nonhardening fixing bath. Thorough washing should follow.

The following table indicates the effect obtained by gold modification after toning in the various bleach-toner combinations.

Table F.16 DuPont Toning System Gold Modification

Bleach	*Tone*	*Tone Resulting after Gold Modification*
6B-1	6T-1	From purplish-brown to rich purple colors.
6B-2	6T-1	More crimson-like tone.
6B-1	6T-3	Rich-reddish brown.
6B-3	6T-3	Brilliant light reddish-brown, darkening as toning progresses.

When modified, the 6T-3 toners produce fewer purple colors than the 6T-1 toners. All gold-tone modified prints change color somewhat on drying, and this cannot be avoided. The color descriptions given earlier apply to the dried prints.

***Cautions*:**

1. Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, a mask, and eye protection when dissolving hydroxide. See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.
2. Thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.

Dye Toners

FORMULA #135

Single-Solution Dye Toner

Wood (methyl) alcohol, 100.0 mL
Potassium ferricyanide, 1.0 g
*Glacial acetic acid, 5.0 mL
Water to make 1.0 L
*28% acetic acid, 18.0 mL

The quantity of dye to use varies:

Auramine O (yellow), 0.4 g
Bismark brown, 0.2 g
Fuchsin (red), 0.2 g
Methyl violet, 0.1 g
Methylene blue BB, 0.2 g
Rhodamine B (red), 0.4 g
Safranin O (red), 0.2 g
Victoria green, 0.4 g

The nature of the tone varies with the time of toning. Eventually a point is reached beyond which it is unsafe to continue, as the gradation of the toned image becomes affected. Average toning time at 68°F/20°C is from 3 to 9 minutes.

FORMULA #136

Two-Solution Dye Toner

Toning Bath (Mordant)

Iodine, 15.0 g
Potassium iodide, 50.0 g
*Glacial acetic acid, 25.0 mL
Distilled water to make 1.0 L

*28% acetic acid, 90.0 mL

Dye Toner

*Dye 3, 0.2 g
+Acetic acid, 10% solution, 5.0 mL
Distilled water to make 1.0 L

*Thoroughly dissolve the dye in hot water, filter, add the acid, and dilute to 1 liter. For methyl violet dye, use 0.5 grams.

+1 part glacial acetic acid slowly added to 9 parts water.

Place the print in the mordant for 1–5 minutes. The image will turn brownish gray. The longer the image is in the bleach, the more silver is mordant and the deeper the dye tone. Wash for 5 minutes or until all of the bleach is removed from the print. Place in the dye toner for 2–5 minutes. Rinse, use stain remover if necessary, and wash.

The dye can be cleared from the highlights by submerging in a clearing bath made of 60 mL of glacial acetic acid in 1 liter of water. An alternative method is to use 10 mL of household bleach to 1 liter of water.

Green Toners

FORMULA #137

Ansco 251 Green Toner

This formula produces rich green tones by combining the effects of iron blue toning and sulfide sepia toning. It must be carefully used, with attention both to the directions and to cleanliness in handling prints throughout the process. The formula is not adaptable to all types of papers and surfaces, and it is suggested that tests be run before committing important prints.

SOLUTION A

Potassium ferricyanide, 40.0 g
Water, 1.0 L
Ammonia (25–29% solution), 15.0 mL

SOLUTION B

Ferric ammonium citrate, 17.0 g
Water, 1.0 L
Hydrochloric acid, concentrate, 40.0 mL

SOLUTION C

Sodium sulfide, 2.0 g
Water, 1.0 L
*Hydrochloric acid, concentrate, 10.0 mL

*Do not add the hydrochloric acid to Solution C until immediately before use.

Prints to be toned should be darker and softer than normal prints. Use approximately 25% overexposure on the next softer grade of paper. Development of the print should be carried out in a standard developer, such as Kodak D-72, with particular attention given to avoid underdevelopment or forcing the print with overdevelopment. Prints should be fixed as usual, thoroughly washed, and completely dried before toning.

Prints to be toned should be first soaked in cold water until limp and then placed in Solution A until bleached. This should take about 60 seconds or less. The bleached prints should be immediately transferred to running water for at least 30 minutes.

Bleached prints are placed in Solution B for 45 seconds to 1 minute until the deepest shadows are toned. Wash for 4–6 minutes; excessive washing is undesirable because of the solubility of the blue image. If wash water is slightly alkaline, it should be acidified with acetic acid to prevent degradation of the blue tone during washing.

The blue-toned prints are next immersed in Solution C for about 30 seconds, or until the green tone is sufficiently strong. Toned prints should then receive a final washing of 20–30 minutes in neutral or slightly acidified wash water and should be dried. Avoid belt and heat-drying machines for drying.

Author's Note: All solutions should be prepared within 24 hours before use. Care should be taken to avoid cross contamination of Solutions A and B. Even slight traces of Solution A carried over on hands or prints into Solution B can cause blue stains.

***Cautions*:**

1. Always add the hydrochloric acid to the water slowly, stirring constantly. Never add the water to the acid. See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.
2. Solution C should be used in a well-ventilated room, preferably near an open window or exhaust fan to lessen the chance of inhaling hydrogen sulfide formed in the solution.

FORMULA #138

GT-16 Indirect Green Toner

This formula is most effective on warm-tone papers. Give 10–25% more exposure than usual.

SOLUTION A

Oxalic acid, 7.8 g
Ferric chloride, 1.0 g
Ferric oxalate, 1.0 g
Water to make 285.0 mL

SOLUTION B

Potassium ferricyanide, 2.0 g
Water to make 285.0 mL

SOLUTION C

Hydrochloric acid, concentrated, 30.0 mL
Vanadium chloride, 2.0 g
Water to make 285.0 mL

Heat the solution to the boiling point and then add the vanadium chloride.

Using the Toner: Mix Solution B with Solution A. Stir vigorously while adding Solution C.

Tone until the print appears deep blue. Then remove and wash until the tone changes to green. After the green tone appears, continue to wash for 10 minutes. Treat the print with HCA and give it a final wash of at least 1 hour.

If a yellowish stain appears, you can remove it by placing the print in the following solution:

Ammonium sulfocyanide, 1.6 g
Water at 68°F/20°C, 285.0 mL

This should be done before treating the print with a washing aid and giving the final wash.

***Caution*:** Always add the hydrochloric acid to the water slowly, stirring constantly. Never add the water to the acid.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Protective Toners

FORMULA #139

Kodak GP-1 Gold Protective Solution

Water, 750.0 mL
*Gold chloride, 1% solution, 10.0 mL
+Sodium thiocyanate, 10.0 g
Water to make 1.0 L

*To make a 1% solution, mix 1 gram of gold chloride with 100 mL of distilled water. Gold chloride is deliquescent and rapidly absorbs atmospheric moisture. The solid may have liquefied by the time you wish to use it. Since you will be transferring it to a water solution, prior liquefaction is not detrimental. However, when gold chloride liquefies, some of the liquid clings to the container cap. Because of the small amount used, it is important that all of the residual gold chloride is salvaged.
+An equal weight of potassium thiocyanate may be substituted.

Add the gold chloride 1% stock solution to 750 mL of water. Dissolve the thiocyanate separately in 125 mL of water. Then add the thiocyanate solution slowly to the gold chloride solution while rapidly stirring.

Using the Toner: Immerse the well-washed print for 10 minutes at 68°F/20°C or until a just perceptible blue-black tone appears. Then immerse in a washing aid and wash for 1 hour.

Toning time can be increased up to 20 minutes for increased blue-black tone.

***Capacity*:** Approximately thirty 8 × 10-inch prints can be toned per gallon. For best results, mix immediately before use.

Author's Note: Due to the cost of gold chloride, the best method for obtaining a 1% solution is to purchase it premixed from Photographer's Formulary.

***Cautions*:**

1. Thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.
2. Work in a well-ventilated room and wear protective gloves when mixing and using.

FORMULA #140

Kodak GP-2 Gold Protective Solution

Water, 750.0 mL
Gold chloride (50% Au), 0.5 g
Tartaric acid, 1.0 g
Kodak thiourea, 5.0 g
Sodium sulfate, anhyd., 15.0 g
Water to make 1.0 L

Tone for about 1 minute with continuous agitation at 80°F/27°C. Wash the toned print for 10 minutes.

FORMULA #141

Kodak GP-2R, Replenisher for GP-2

The gold chloride in GP-2 is rapidly depleted and should be replenished using this formula.

Water, 750.0 mL
Gold chloride (50% Au), 2.0 g
Tartaric acid, 1.2 g
Kodak thiourea, 10.0 g
Sodium sulfate, anhyd., 18.0 g
Water to make 1.0 L

The replenishment rate is 11.0 mL per 80^2 inches of film processed.

Red Toners

FORMULA #142

Bartolozzi Red for Rich Red Tones

*Ammonium carbonate, saturated solution, 30.0 mL
Copper sulfate, 0.6 g
Potassium ferricyanide, 1.5 g

*Make up a saturated solution of ammonium carbonate by adding 90 grams of the crushed salt to 300 mL of cold water; shake as often as possible for several days.

Any precipitate that forms when the copper is added will be redissolved. The solution should be perfectly clear, but should be used immediately. Toning should be continued until the deepest shadow is converted, and then for 1 minute longer. The print should be refixed and then washed.

Any pink stains in the whites can be removed by treating with a 1% solution of ammonia water.

FORMULA #143

Crimson Toner, Crimson Tones on Hypo-Alum Toned Prints

A print toned in hot hypo-alum may be further toned to a rich crimson by gold toning.

SOLUTION A	**SOLUTION B**
Gold chloride, 1.0 g	Potassium thiocyanate, 6.0 g
Water, 450.0 mL	Water, 450.0 mL

Add Solution A to Solution B, stirring slowly so as not to precipitate the gold.

Using the Toner: After the print has been toned and thoroughly washed, it should be put through a bath made by dissolving 30 grams of sodium chloride in 1 liter of water. Rinse the prints and then immerse in the toning bath. Prints tone in about 10 minutes and should be fixed and rewashed. The working solution of 900 mL will tone about eighteen 8 × 100 prints.

***Caution*:** Thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.

Selenium Toners

Safety Precautions: Selenium powder is highly toxic. Avoid inhaling the powder before or during mixing. Use ample darkroom ventilation, including a fume hood over the mixing area, and a face mask. If a fume hood is not available, then the powder should be mixed and completely dissolved outdoors and an appropriate fume mask used. Also, use chemical-proof neoprene gloves when handling caustic chemicals such as selenium, whether in powder or solution. Read the additional cautions in Appendix 1.

FORMULA #144

Dassonville T-55, Direct Selenium Toner

This toner produces rich plum-purple to brown tones.

*Sodium sulfite, 25.0 g
Selenium powder, 1.0 g

**Sulfite* not sulfide as in other selenium toners.

Dissolve the sodium sulfite in 100 mL of warm water. Add the selenium powder and slowly heat until dissolved. Allow to cool.

Add:

Ammonium chloride, 31.0 g
Water, 67.0 mL

Dilute 1:5 to 1:9. Tone the prints for 2–3 minutes with continuous agitation. Wash the prints thoroughly before drying.

A small amount of thiourea can be added to vary the tone, or this toner can be used after a light thiourea toning.

This formula deteriorates rapidly once diluted; dilute only enough for immediate use.

FORMULA #145

Dassonville T-7 Flemish Toner

Although this toner is similar to Dassonville T-56, it produces a more subtle change in tone. Flemish toner was a very popular commercial formula until it was discontinued in the 1970s.

BLEACHING SOLUTION

Potassium ferricyanide, 30.0 g
Potassium bromide, 30.0 g
Water to make 1.0 L

Use full strength. Prints must be thoroughly washed before bleaching or loss of highlight detail will result. Bleach the print completely, wash, and tone in.

SELENIUM-SULFIDE STOCK SOLUTION

Sodium sulfide, 40.0 g
Selenium powder, 1.0 g
Water to make 1.0 L

Dissolve the sodium sulfide in 100.0 mL of warm water. Add the selenium powder and slowly heat until dissolved. Allow to cool.

Using the Toner: Dilute 1:10 with water. Tone the bleached prints for 3–5 minutes with continuous agitation. Rinse the prints for 5 minutes in Berg Bath (or HCA) and wash for 30 minutes.

For the best tones, prints must be fully developed. Overexposed and underdeveloped prints will give inferior tones. To vary the color the print can be soaked for 1–2 minutes in the selenium-sulfide stock solution prior to bleaching. A small amount of thiourea can also be added to vary the tone.

Author's Notes:

1. If the whites in the print stain, add a few drops of ammonia to the working solution. If this does not help, pass the prints through one or more baths of 1% sodium sulfite.
2. This formula deteriorates rapidly once diluted; dilute only enough for immediate use.

FORMULA #146

Dassonville T-56 Bleach and Redevelop Selenium Toner

This toner produces rich plum-purple to brown tones. Although this toner contains sodium sulfide, the odor is minimal.

BLEACHING SOLUTION

Potassium ferricyanide, 100.0 g
Potassium bromide, 100.0 g
Water to make 1.0 L

Dilute 1:9. Bleach prints before immersing in the selenium-sulfide stock solution.

SELENIUM-SULFIDE STOCK SOLUTION

Sodium sulfide, 25.0 g
Selenium powder, 5.0 g
Water to make 1.0 L

Dissolve the sodium sulfide in 100.0 mL of warm water. Add the selenium powder and slowly heat until dissolved. Allow to cool.

Using the Toner: Dilute 1:19. Tone the prints for 3–5 minutes with continuous agitation. Rinse the prints for 5 minutes in Berg Bath (or HCA) and wash for 30 minutes.

To vary the color the print can be soaked for 1–2 minutes in the selenium-sulfide stock solution prior to bleaching. A small amount of thiourea can also be added to vary the tone.

If the whites stain, add a few drops of ammonia in the working solution. If this does not help, pass the prints through one or more baths of 1% sodium sulfite.

This formula deteriorates rapidly once diluted; dilute only enough for immediate use.

FORMULA #147

Rapid Selenium Toner

This toning formula works similarly to Kodak Rapid Selenium Toner.

Sodium sulfide, 250.0 g
Powdered selenium, 5.7 g
Water to make 1.0 L

Dissolve the sodium sulfide in 500.0 mL of warm water. Add the selenium powder and slowly heat until dissolved. Add cold water to make 1 L and allow to cool for use.

Using the Toner: As with Kodak Rapid Selenium Toner, 1:9 will produce a color shift toward red, while greater dilutions, 1:19 and higher, will intensify the black areas of the print without altering the color. The amount of dilution is paper dependent.

Negative Intensifiers

FORMULA #148

Ilford In-3 Chromium Intensifier

For more information on chromium intensification see Chapter 14.

BICHROMATE STOCK SOLUTION

*Potassium bichromate, 100.0 g
Distilled watqer to make 1.0 L

*Potassium bichromate is an allergen and a suspected carcinogen. See precautions under potassium bichromate in the Pharmacopoeia.

The bichromate stock solution keeps indefinitely, but the working solutions A and B, shown next, should be made fresh just before using.

Solution A provides more intensification than Solution B.

BLEACHING SOLUTION A	BLEACHING SOLUTION B
Bichromate stock solution, 100.0 mL	Bichromate stock solution, 100.0 mL
Hydrochloric acid, concentrate, 2.4 mL	Hydrochloric acid, concentrated, 12.0 mL
Distilled water to make 1.0 L	Distilled water to make 1.0 L

Immerse the washed negative into either of these solutions until it is entirely bleached, wash until the yellow stain is completely removed, and redevelop in strong artificial or subdued daylight with a universal developer such as Kodak D-72. An alternative developer recommended by Ian Grant is Pyrocat HD. The advantage is additional staining density from the pyrocatechin. Wash thoroughly.

***Caution*:** Always add the hydrochloric acid to the water slowly, stirring constantly. Never add the water to the acid.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #149

Kodak In-5 Silver Intensifier for Fine-Grain Film

This formula gives proportional intensification and is easily controlled by varying the time of treatment. In-5 acts more rapidly and produces greater intensification on fine-grain materials than on coarse-grain materials. The formula is equally suited for positive and negative film. It is the only intensifier known that will not change the color of the image on positive film during projection.

***STOCK SOLUTION #1**

Silver nitrate, 15.0 g
Distilled water to make 250.0 mL

STOCK SOLUTION #2

Sodium sulfite, 15.0 g
Water to make 250.0 mL

STOCK SOLUTION #3

Sodium thiosulfate, 26.0 g
Water to make 250.0 mL

STOCK SOLUTION #4

Metol, 6.5 g
Sodium sulfite, 3.8 g
Water to make 750.0 mL

*Store in a brown glass bottle.

To use, prepare the intensifier solution as follows: Add 1 part of Solution #2 to 1 part of Solution #1, stir well. A white precipitate will form but will dissolve with the addition of 1 part of Solution #3. Allow the mixture to stand for a few minutes until clear.

Add, while stirring, 3 parts of Solution #4. The intensifier is ready for use, and the film should be treated immediately. The mixed solution is stable for approximately 30 minutes at 68°F/20°C.

After intensification, immerse the film for 2 minutes in a 30% plain hypo bath (30.0 grams of sodium thiosulfate to 100.0 mL of water).

I recommend not intensifying with silver beyond 10 minutes, even though Kodak claims it can be used for up to 25 minutes. If you do overintensify, use two-solution Farmer's Reducer R-4b to remove some of the silver.

Author's Note: When mixing Stock Solution #4, add a pinch of the sodium sulfite first, stir in the metol until well dissolved, and then add the balance of the sulfite.

FORMULA #150

Kodak In-6 Intensifier for Coarse-Grain Film

This intensifier produces the greatest degree of intensification of any known single-solution formula when used with high-speed negative materials. The intensified image is a brownish hue and is not completely permanent. However, the negative will remain in satisfactory condition for several years if stored properly.

SOLUTION A

Distilled water at 65°F/18°C, 750.0 mL
*Pot. bichromate, anhyd., 22.5 g
Sulfuric acid, concentrate, 30.0 mL
Water to make 1.0 L

SOLUTION B

Distilled water at 68°F/20°C, 750.0 mL
Sodium bisulfite, anhyd. 3.8 g
Hydroquinone, 15.0 g
Photo-Flo 200, undiluted, 3.8 mL
Water to make 1.0 L

SOLUTION C

Distilled water at 68°F/20°C, 750.0 mL
Sodium thiosulfate, pentahydrate, 22.5 g
Water to make 1.0 L

*Potassium bichromate is an allergen and a suspected carcinogen. See precautions under potassium bichromate in the "Pharmacopoeia" chapter.

The order of mixing is important and should be followed. To 1 part of Solution A, add with constant stirring, 2 parts of Solution B. Still stirring, add 2 parts of Solution C, and finally 1 part of Solution A.

Using the Intensifier: To intensify negatives, first wash the negatives to be treated for 5–10 minutes. Harden them for 5 minutes in Kodak SH-1 Formalin Supplementary Hardener and wash them again for 5 minutes.

The greatest possible degree of intensification is achieved by treating the negatives for approximately 10 minutes at 68°F/20°C. If a lesser degree of intensification is desired, treat the negatives for shorter times. Agitate them frequently during treatment to prevent streaking. Treat only one negative at a time when processing in a tray.

When a satisfactory degree of intensification is reached, wash the negative for 10–20 minutes and dry as usual.

Author's Note: The stock solutions will keep in stoppered bottles for several months; the mixed intensifier is stable for 2 or 3 hours without use. After using it once, discard the working solution, as it may leave a silvery scum on subsequent negatives.

Caution: When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, always add the acid to the solution, otherwise the solution may spatter causing serious burns to the hands or face.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Negative Reducers

FORMULA #151

Ammonium Thiosulfate Reducer

Ammonium thiosulfate reducer is prepared by adding citric acid to an ammonium thiosulfate rapid fixing bath, such as ATF-5. This reducer can be used to remove silver stains and dichroic fog from negatives and for the reduction of both prints and fine-grain negative materials.

Normal Ammonium Thiosulfate Reducer: Dilute 1 part of rapid fixer containing hardener with 2 parts of water. To each liter of the diluted fixer add 15 grams of citric acid, anhydrous.

This dilution is for correcting slight overexposure or overdevelopment of fine-grain negatives and overall print reduction (bleaching). For print reduction follow the instructions given under the section "Print Reducers, Farmer's Reducer."

Removal of Silver Stains and Dichroic Fog: Immerse the negative or print in the solution and swab the surface with absorbent cotton to hasten the removal of surface scum. The action is usually complete in 2–5 minutes. Remove the negative or print from the solution immediately if any reduction of low-density image detail is noted.

Strong Ammonium Thiosulfate Reducer: Dilute 1 part of rapid fixer containing hardener with 2 parts of water. To each liter of the diluted fixer add 30 grams of citric acid, anhyd.

This dilution is useful for reducing high-speed negative materials. The reaction is very slow and will depend on the specific emulsion and the degree of reduction desired.

Author's Notes:

1. Before reducing a negative or print, clean thoroughly with film cleaner to remove any surface grease left from handling. To promote uniform reduction, prewet the emulsion in a wetting agent such as Edwal's LFN.
2. Possible sulfurization of the fixer can be avoided by dissolving the citric acid in a portion of the water used for dilution.

***Caution*:** This reducer gives off a strong odor of sulfur dioxide and should be used in a well-ventilated room. Do not use near sensitized photographic products.

FORMULA #152

DuPont 4-R Eder's Harmonizing Reducer

This reducer acts in a unique fashion, intensifying lighter densities and reducing the heavier densities. It is useful for correcting excessive contrast.

BLEACH SOLUTION

Water, 750.0 mL
Hydrochloric acid, concentrate, 30.0 mL
*Potassium dichromate, 10.0 g
Alum, 50.0 g
Water to make 1.0 L

*Potassium dichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium dichromate in the Pharmacopoeia.

Bleach to completion. Wash thoroughly until the yellow stain has disappeared. The removal of yellow stain is accelerated if, after a 2- to 3-minute wash, the negative is immersed in a 2% solution of sodium bisulfite for a few minutes and then returned to the wash. Redevelop in a slow-acting developer, such as D-23 diluted 1:5, then fix and wash in the usual manner.

***Caution*:** Always add the hydrochloric acid to the water slowly, stirring constantly. Never add the water to the acid.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #153

Flattening Reducer for Heavy Negatives

This reducer is useful for lessening the density and contrast of dense negatives.

Potassium ferricyanide, 35.0 g
Potassium bromide, 10.0 g
Water to make 1.0 L

Bleach the negative in this solution, and after thorough washing, redevelop to the desired density in negative developer Ansco 47. Then fix and wash in the usual manner. Conduct the operation in subdued light.

Developers containing a high sulfite and low alkali concentration, such as Kodak D-76 and ID-11, should not be used for redevelopment because the sulfite tends to dissolve the silver image before the developing agents have had time to act upon it.

FORMULA #154

Kodak R-4a, Farmer's Cutting Reducer for Overexposed Negatives

STOCK SOLUTION A	STOCK SOLUTION B
Potassium ferricyanide, 37.5 g	Sodium thiosulfate, 480.0 g
Water to make 500.0 mL	Water to make 2.0 L

Immediately before use take 30.0 mL of A, add 120.0 mL of B, and add water to make 1.0 L. Pour the mixed solution over the negative in a white tray. Watch the reducing action carefully. When the negative has been reduced sufficiently, wash for at least 5 minutes and dry. Any residue left on the film can be removed during the final wash with a cotton ball.

For less rapid reducing action and more control, use one-half the amount of Stock Solution A.

The stock solutions keep indefinitely; the combined A/B solution will exhaust in a matter of minutes. The process can be repeated, but a fresh solution should be used each time.

Print Reduction with R4-a: For print reduction with R-4a, mix 1 part A, 1 part B, and 10–15 parts water, depending on the desired rate of reduction.

FORMULA #155

Kodak R-4b Farmer's Proportional Reducer for Overdeveloped Negatives

For overdeveloped negatives.

STOCK SOLUTION A	**STOCK SOLUTION B**
Potassium ferricyanide, 7.5 g	Sodium thiosulfate, 200.0 g
Water to make 1.0 L	Water to make 1.0 L

These are working solutions. The ferricyanide will keep indefinitely if shielded from strong daylight.

To Use the Reducer: Place the dry film in Solution A for 1–4 minutes at 68°F/20°C. As with Kodak R-4a, watch the reduction carefully. Transfer the film to Solution B for 5 minutes, then wash.

You may repeat this process if necessary. If hypo contaminates Solution A through repeated treatments, the life of the ferricyanide will be shortened. Therefore, be sure to thoroughly wash the film before repeating. After the desired reduction has been achieved, wash the film thoroughly.

This formula also may be used to reduce general fog. In this case, mix 1 part of Solution A with 1 part water before using.

Capacity: Approximately 15 sheets of 8 × 10-inch film, which equates to 60 sheets of 4 × 5 inch, 30 sheets of 5 × 7 inch, and about 480 individual 35 mm frames!

FORMULA #156

Kodak R-15 Super Proportional Reducer for Extreme Overdevelopment

STOCK SOLUTION A	**STOCK SOLUTION B**
Potassium persulfate, 30.0 g	Water, 250.0 mL
Water to make 1.0 L	*+Sulfuric acid, 10% solution, 15.0 mL
	Water to make 500.0 mL

*4.25 grams of sodium bisulfate may be substituted for the sulfuric acid.

+ To prepare a 10% solution of sulfuric acid, take 1 part sulfuric acid and add it slowly to 9 parts of water with stirring.

To use, take 2 parts of Solution A and 1 part of Solution B. Fix with an acid hardening fixer and wash the negative thoroughly. Immerse in the reducer with frequent agitation and inspection until the required amount of reduction is attained. Remove the negative, immerse in an acid fixing bath for a few minutes, and wash thoroughly before drying.

The used solution does not keep and should be discarded. In storage, Stock Solution A should be kept away from excessive heat and light. The life of Stock Solution A is about 2 months.

When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, always add the acid to the solution, otherwise the solution may spatter causing serious burns to the hands or face.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Print Intensifiers

FORMULA #157

Chromium Intensifier for Prints

SOLUTION A	**SOLUTION B**
*Potassium bichromate, 30.0 g	Hydrochloric acid, con., 55.0 mL
Water to make 500.0 mL	Water to make 500.0 mL

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in the Pharmacopoeia.

Add 30 mL of Solution B to 30 mL of Solution A, plus 180 mL of water at 1:1:6. Soak the dry print for 10 minutes in plain water. Transfer the print to the bleach mixture, and continuously agitate for a minimum of 2 minutes or until most of the image either has disappeared or at least become faded brown.

Using the Bleach: Bleaching can take place in normal, artificial light. However, redevelopment should be done under safelight conditions to prevent solarization.

If, at the end of 2 minutes, the print has not changed much, continue the bleaching action for a few more minutes. If the print still does not react or if spots or streaks appear, strengthen the bleach by using as much as 240 mL of A, 60 mL of B, and 180 mL of water. If, after strengthening the bleach or extending the time, spots or streaks remain, they will probably disappear with redevelopment.

Rewash the bleached print until the water is perfectly clear. This may take as long as 1 hour in running water at about 70°F/21°C. This is the most critical step, as any residual bichromate will stain the print during redevelopment.

The washing time can be shortened by at least half by placing the print for 10–20 seconds in a 3% solution of sodium carbonate. If this method is used, handle the prints carefully. This is because carbonate considerably softens the emulsion. Redevelop the image with any nonstaining developer (e.g., Kodak D-72) for 2–5 minutes. The print should be washed for about ½ hour. Always use a fresh developer for print intensification.

Do not refix the print after redevelopment, as it will become reduced instead of intensified. Wash the print thoroughly and then hang to dry to avoid the emulsion sticking to the drying surface.

Author's Notes:

1. Prints for intensification should not be hardened. If they have been hardened, use a dehardener.
2. The stock solutions will keep well in brown glass bottles.

***Caution*:** Always add the hydrochloric acid to the water slowly, stirring constantly. Never add the water to the acid.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

Print Reducers

FORMULA #158

Agfa 503 Print Rehalogenating Bleach

Use this bleach to convert all silver metal to silver bromide in a print prior to using the redevelopment method of toning, see Chapter 9. After rehalogenating, any toning developer or toner can be used to give the purest tones possible for the paper being used.

Potassium ferricyanide	50.0 g
Potassium bromide	10.0 g
Sodium carbonate	20.0 g
Water to make	1.0 L

Use as you would print rehalogenating bleach see later).

Author's Notes:

1. Adding sodium carbonate will intensify the color tone with some papers; with others, it will cause a yellow stain. Try using papers with minimal hardener.
2. Agfa 501 is the same formula as Agfa 503 without the carbonate. It is a much stronger bleach than the print rehalogenating bleach given later.

FORMULA #159

Farmer's Reducer

STOCK SOLUTION A

Potassium ferricyanide	60.0 g
Potassium bromide	30.0 g
Water to make	250.0 mL

STOCK SOLUTION B

Sodium thiosulfate	120.0 g
Water to make	500.0 mL

Solution A will keep at least 6 months in a well-stoppered brown or green bottle. However, when A and B are mixed for use, they become unstable. The mixture may deteriorate within a few minutes or may work for as long as ½ hour. The weaker the working solution, the longer it will keep. You can tell when it is exhausted by its loss of color. It's a good idea to renew the mixture every 10 minutes.

- Overall reduction, mix 7.5 mL of Solution A with 180 mL of Solution B, and add 1500 mL of water. The amount of Solution A may be increased or decreased to control the time of reduction.
- Carry out local bleaching, use the same proportions of A and B as for overall reduction. Increasing the amount of ferricyanide solution will increase the rate of reduction.
- Alternately, dissolve approximately ¼ teaspoon of ferricyanide in 200 mL of water. If you are working on lighter tones, you will want to start with less ferricyanide in solution, as the bleach works rapidly on light areas; you can always add more ferricyanide to speed things up.
- For spot reduction, mix 1 part A to 2 parts B without adding water.

For instructions on bleaching see Chapter 11.

FORMULA #160

Kodak R-14 Non-staining Reducer

Farmer's reducer can cause a brownish stain with some papers. This problem can often be avoided by adding a small quantity of potassium iodide to the final print fixing bath. If the brownish residual stain still persists, a nonstaining reducer should be used instead of Farmer's.

SOLUTION A

Water, 500.0 mL
Thiourea, 15.0 g
Sodium thiosulfate, crystalline, 700.0 g
Water to make 1.0 L

SOLUTION B

Water, 200.0 mL
Potassium ferricyanide, 75.0 g
Water to make 250.0 mL

Add 14 parts water to 5 parts of Solution A and then add 1 part of Solution B. The resulting solution can be diluted again (1:1) to produce a convenient working concentration.

FORMULA #161

Print Rehalogenating Bleach #1

Use this bleach to convert all silver metal to silver bromide in a print prior to using the redevelopment method of toning, see Chapter 9. After rehalogenating, any toning developer or toner can be used to give the purest tones possible for the paper being used.

Potassium ferricyanide, 8.0 g
Potassium bromide, 12.0 g
Water to make 1.0 L

Using the Bleach

1. Develop, fix, and wash a print in the usual manner. Use a neutral tone developer such as Kodak D-72 for this first round.
2. Immerse the print in the rehalogenating bleach until only a faint brown image remains.
3. Rinse the print for 5 minutes in running water.
4. Redevelop the print in any warm or cold toning developer.
5. Wash fiber-based prints for 30 minutes.

Miscellaneous

FORMULA #162

Basic Scarlet N for Development by Inspection with MQ Developers

Chrysoidine, 1.0 g
*Phenosafranine, 1.0 g
Distilled water, 200.0 mL

Add:

Isopropyl alcohol 5.0 mL

*Safranine-O, a derivative of phenosafranine, may be substituted in the same amount. Safranine-O is considerably less expensive and more active.

To use, mix 1 part of the stock solution with 50 parts water. Soak the film for 2 minutes and then transfer to the developer without rinsing. After 2 minutes in the developer, a yellow-green safelight (Kodak #3) can be turned on. Some workers leave the safelight on; others prefer to inspect the film for 10–15 seconds at 1-minute intervals.

Author's Note: Basic Scarlet N tends to shorten development times by about 10%.

FORMULA #163

Dehardener

This solution should be used prior to toning prints that have been hardened during fixing. The formula will soften the emulsion, so the print will tone and spot more easily and washing will be more effective.

Water, 750.0 mL
Sodium carbonate, mono., 30.0 g
Water to make 1.0 L

To use, soak the print for up to 10 minutes in the solution, agitating occasionally. Handle the prints very carefully. The emulsion is soft and no longer protected by the hardener.

FORMULA #164

Developer Stain Remover for Clothing

Dampen the stains with a 5% solution of potassium permanganate. Allow to set for a few minutes and then apply a 10% solution of sodium bisulfite. Care should be taken with colored fabrics, as the area may become bleached. Test on an out-of-the-way area.

SOLUTION A

Potassium permanganate, 5.0 g
Water to make 1.0 L

SOLUTION B

Sodium bisulfite, 100.0 g
Water to make 1.0 L
Wash thoroughly with soap and water.

FORMULA #165

Developer Stain Remover for Hands

This formula is considered to be safe for removing silver stains from hands.

SOLUTION A

Potassium ferricyanide, 30.0 g
Potassium bromide, 30.0 g
Water to make 1.0 L

Keep hands in Solution B for a few minutes and then rinse in:

SOLUTION B

Sodium bisulfite, 30.0 g
Water, 750.0 mL

Wash thoroughly with soap and water.

FORMULA #166

Film Cleaner

This formula is good for removing water spots from the film base.

Ammonia, 28% solution, concentrated, 5.0 mL
Distilled water, 95.0 mL
Isopropyl alcohol to make 1.0 L

Apply by wiping the film base gently with cotton, Photowipes, or a soft microfiber photo cloth.

FORMULA #167

Fixer Test Solution

Water, 80.0 mL
Potassium iodide, 4.0–5.0 g
Water to make 100.0 mL

Add 10 mL of fixer test solution to 100 mL of used fixer. Shake the solution. If nothing happens or if a clear cloudiness appears, the fixer is okay. If a white or yellow-white precipitate is formed, the fixer should be thrown out.

Author's Note: The potassium iodide test solution must be 10 mL of a 4–5% solution, and the amount of hypo tested should be exactly 100 mL.

FORMULA #168

Haloid M-1 Print Flattening Solution

Glycerine, 60.0 mL
Water to make 1.0 L

Immerse prints in this solution for not less than 5 minutes following washing and before drying the prints.

Dampening the back of dried prints with a solution of 1 part glycerine to 3 parts of water before placing them under pressure will also ensure flatness and substantially eliminate their tendency to curl.

FORMULA #169

Haloid M-2 Ferrotype Polish

Frequent use on thoroughly cleaned ferrotype plates will assure an even, high-gloss finish of prints.

Benzene, 125.0 mL
Yellow beeswax, 2.7 g

Decant and use the clear portion only. If too thick or gummy, cut by adding more benzene. Apply sparingly to the ferrotype plates with tufted cotton, then polish briskly with a piece of soft flannel.

***Caution*:** Benzene is a highly inflammable liquid. Keep away from heat or open flame. Avoid handling in a badly ventilated room.

FORMULA #170

Hypo Clearing Agent (HCA)

Water at 125°F/52°C, 750.0 mL
Sodium sulfite, 200.0 g
*Sodium bisulfite, 15.0 g
Water to make 1.0 L

*The sodium bisulfite lowers the pH in order to prevent softening of the film emulsion. For paper the bisulfite may be left out in order to improve the paper's gloss.

Table F.17 Water Rinse after Fixer (optional)

	Water Rinse after Fixer (optional)	*HCA (with Agitation)*	*Final Running Water Wash*
SW Paper	1 minute	2 minutes	10 minutes
DW Paper	1 minute	3 minutes	20 minutes
Film	30 seconds	1–2 minutes	5 minutes

Dilute 1:9. After fixing, rinse the print or film for 1 minute in running water then transfer to the HCA.

Capacity: Fifty 80^2-inch prints or forty 80^2 inches of film per liter.

FORMULA #171

Kodak Amidol Redeveloper

Water at room temperature, 750.0 mL
Sodium sulfite, 25.0 g
Amidol, 6.5 g
Water to make 1.0 L

This developer can be used for redevelopment following the use of Kodak S-6 Stain Remover.

FORMULA #172

Kodak HT-1a Residual Hypo Test

Small traces of hypo in films or prints accelerate the rate of deterioration. It is difficult to test for small quantities of hypo, but the following test will indicate when the film or prints may be considered reasonably free from hypo.

Distilled water, 180.0 mL
Potassium permanganate, 0.3 g

Sodium hydroxide, 0.6 g
Distilled water to make 250.0 mL

***Caution*:** Slowly add the sodium hydroxide to the water, do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

To Test Film: Take 250.0 mL of distilled water in a clear glass and add 1.0 mL of the solution. Then take the equivalent of ten 35 mm frames (three frames of 120 or a single 4 × 5-inch sheet of film) from the wash water and allow the water to drip for 30 seconds into the glass of test solution. If a small percentage of hypo is present, the violet color will turn orange in about 30 seconds, and with a larger concentration the orange color will turn to yellow. In either case, the film should be returned to the wash until further tests produce no change in the violet color.

To Test Prints: Take 125 mL of distilled water in a clear glass and add 1.0 mL of the test solution. Pour 15 mL of the diluted solution into a clear 30-mL glass container. Take six 4 × 50 prints or equivalent from the wash water and allow them to drip for 30 seconds into the 15 mL of the dilute test solution. If a small quantity of hypo is present, the violet color will turn orange in about 30 seconds and become colorless in 1 minute. The prints should be returned to the wash and allowed to remain until further tests produce no change in the violet color.

Author's Note: Organic matter reacts with the test solution and changes its color in the same manner as hypo. The wash water should therefore be tested as follows: Prepare two samples of the test solution, using distilled water. Add a volume of tap water to one sample equal to that of the wash water drained with the film or prints into the second sample. If the sample to which tap water has been added remains a violet color, organic matter is not present. However, if the color is changed slightly by the tap water, the presence of hypo in the film or prints will be shown by the relative color change of the two samples. For example, if the tap water sample turned pink and the wash water sample became yellow, hypo is present. If both turned the same color, this would indicate the absence of hypo.

***Caution*:** Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide. Always wear gloves, mask, and eye protection when dissolving hydroxide.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #173

Kodak S-6, Stain Remover

This formula is used to develop or remove oxidation stains. It is also effective in removing water spots on negatives if they have not been allowed to set too long.

STOCK SOLUTION A

*Potassium permanganate, 5.2 g
Water to make 1.0 L

STOCK SOLUTION B

Cold water, 500.0 mL
Sodium chloride, 75.0 g
Sulfuric acid, concentrate, 16.0 mL
Water to make 1.0 L

STOCK SOLUTION C

Sodium bisulfite, 1% solution, 1.0 g
Water, 100.0 mL

*Dissolve the permanganate completely; otherwise, spots may appear on the negative.

Harden the film for 2–3 minutes in Kodak SH-1 Formalin Supplementary Hardener. After hardening, wash for 5 minutes. Bleach the negative for 3–4 minutes using equal parts A and B (the solutions should not be mixed until ready for immediate use, since they do not keep long after mixing).

When bleaching is complete, immerse the negative in Solution C to remove any brown stains. Rinse the negative well and redevelop in a strong light (not direct sunlight). Use a nonstaining developer such as Kodak D-72, diluted 1:2.

Author's Note: Developers containing high sulfite and low alkali concentrations (e.g., Kodak D-76) should not be used for redevelopment. The sulfite tends to dissolve the silver image before the developing agents have had time to act on it.

When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, always add the acid to the solution, otherwise the solution may spatter causing serious burns to the hands or face.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #174

Kodak ST-1, Residual Silver Test Solution

An overworked fixing bath contains complex silver thiosulfate compounds that can be retained by negatives or prints and cannot be removed completely by washing. This formula detects the presence of undissolved silver compounds in either negatives or prints. These can be the result of inadequate fixing or overfixing in which previously dissolved silver is absorbed into the material.

Distilled water, 100.0 mL
*Sodium sulfide, anhyd., 2.0 g

*Be sure to use sodium sulfide, not sodium sulfite.

Mix in a well-ventilated area and store in a small stoppered bottle for not more than 3 months. The dilute solution keeps for a limited time and should be replaced weekly.

Dilute 1:9 with distilled water.

To Use ST-1: Squeegee the print or negative and place one drop of the solution on a clear area such as the border (you can use an unexposed negative or print that has been processed in the fixer being tested). Wait 2 or 3 minutes and then remove any excess solution with a clean white blotter.

Any yellowing, other than a barely visible cream tint, or noticeable brown stain indicates excess silver in the emulsion. If the test is positive, residual silver can be removed by refixing in fresh hypo and rewashing for the recommended time. The yellow stain from the ST-1 is permanent.

Alternative Residual Silver Test Solution: An alternative residual test solution can be made from a 10% solution of selenium toner concentrate. Use this solution in the same way as ST-1. Residual silver is indicated by a red stain.

Author's Note: Prints previously toned in sulfide or selenium toner will not respond to this test because the residual silver has been toned together with the image.

FORMULA #175

Kodak TC-1 Tray Cleaner

Water, 1.0 L
*Potassium bichromate, anhyd., 90.0 g
Sulfuric acid, concentrated, 96.0 mL

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in the Pharmacopoeia.

Store the solution in a stoppered glass bottle away from light. Pour a small volume of TC-1 into the tray or vessel to be cleaned. Slosh it around so that the solution has access to all parts of the tray; then pour the solution out and wash the tray thoroughly with water until all traces of the cleaner disappear. This solution will remove stains caused by oxidation products of developers as well as some silver and dye stains. It should not be used to clean hands.

When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, always add the acid to the solution, otherwise the solution may spatter causing serious burns to the hands or face.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #176

Kodak TC-3, Stain Remover for Trays

SOLUTION A

Water, 750.0 mL
Potassium permanganate, 2.0 g
Sulfuric acid, concentrated, 4.0 mL
Water to make 1.0 L

SOLUTION B

Water, 750.0 mL
Sodium bisulfite, anhyd., 30.0 g
Sodium sulfite, 30.0 g
Water to make 1.0 L

To remove stains in trays from silver, silver sulfide, and many dyes, pour a small quantity of Solution A into the tray and allow to remain for a few minutes; rinse well and then replace with a similar volume of Solution B. Agitate to clear the brown stain completely then wash thoroughly.

Solutions A and B can be used to clean several trays but should be discarded after use. An acid-fixing bath may be used in place of Solution B, but it is important to wash thoroughly to eliminate hypo from the tray and hands.

Author's Note: Store the solution in a stoppered glass bottle away from light.

***Caution*:** When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, always add the acid to the solution, otherwise the solution may spatter causing serious burns to the hands or face.

See Pharmacopeia or Safety in Handling Photographic Chemicals for mixing strong acid and alkali.

FORMULA #177

Rapid Film Dryer, Paul Lewis

This formula will reduce the drying time of film without the risk of alcohol clouding the film.

Isopropyl alcohol, 30.0 mL
Distilled water 970.0 mL
Edwal's LFN, 12.0 drops

Soak the film for 3–4 minutes in the rapid drying solution. It will dry in less than half the normal drying time after removal from the solution. Do not wipe the excess solution off. The emulsion will be very delicate, so handle the film carefully. Exposure to a stream of flowing air (i.e., a fan or air conditioner) will shorten the drying time, though it will increase the risk of dust in the emulsion.

Salted Paper

FORMULA #178

Borax Toning Bath for Warm Tones

Water 100F/38C, 400.0 mL
Borax, 30.0 g
Gold chloride (1% solution), 6.0 mL

Dissolve the borax in hot water first and then add the gold chloride. Prepare the bath at least 1 hour in advance and allow it to cool before using. Toning can be done from 6 to 12 minutes. The longer the toning, the colder the tone. Be aware that when the prints are dry, the tone will become slightly cooler.

After toning is complete, wash the print for 10 minutes. This bath can be reused, but more gold must be added after each use. Let the bath sit for at least an hour before adding more gold.

FORMULA #179

Gelatin Chloride P.O.P

Sizing and Salting Solution

Water, 300.0 mL
Gelatin, 2.0 g
Sodium citrate, 6.5 g
Ammonium chloride, 6.5 g

Combine the gelatin with the water and let stand for 10 minutes. Heat slowly until the gelatin is completely dissolved. Add the ammonium chloride and sodium citrate; mix until dissolved. Pour the solution into a tray. While the solution is still warm, float the paper for 3–5 minutes. Hang to dry.

Sensitizing Solution

Distilled water, 60.0 mL
Silver nitrate, 9.0 g
Citric acid, 6.5 g

Dissolve the silver nitrate in the water. Add the citric acid and stir until dissolved. Float the dry, salted paper in the solution for 2–3 minutes. Allow the paper to dry in the dark.

FORMULA #180

Warm-Tone Printing Out Paper (P.O.P)

Gelatin Sizing

Cold water, 1.0 L
Knox gelatin, 28.0 g

Allow the gelatin to swell for about 10 minutes, then heat gently until the gelatin is completely dissolved, pour into a tray, and soak each sheet of paper for 1 minute. Hang the paper to dry. Do not touch the surface of the printing paper once it has been sized.

Sensitizing Formula

Ferric ammonium citrate, green, 85.0 g
Tartaric acid, 14.0 g
Silver nitrate, 35.0 g
Water to make 1.0 L

Dissolve the ingredients separately in water. Mix the ferric ammonium citrate solution and the tartaric acid solution, then add the silver nitrate solution while stirring with a nonmetal rod. Add water to make up the complete quantity. Keep in a brown glass bottle, away from light.

After the print is fixed, immerse in hypo clearing agent then wash for at least 15 minutes, after which the print may be toned.

FORMULA #181

Thiocyanate Toning Bath for Cold Tones

Water at 100°F/38°C, 400.0 mL
Ammonium thiocyanate, 12.5 g
Tartaric acid, 1.0 g
Gold chloride (1% solution), 10.0 mL
Water to make 500.0 mL

Tone for 5–10 minutes for blue-gray tones. After toning wash prints for 10 minutes. This bath will not keep; mix only when you plan to use it.

***Caution*:** Thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.

Pharmacopeia

> *"The artist lives to express himself and, in so doing, enriches the world."*
> —Henry Miller

The chemicals listed here represent those used in the formulas in this book. Familiarizing yourself with their properties and uses will greatly enhance your darkroom skills.

In a few cases, the chemical will be found under its common name. Information such as common grades and uses will be given where applicable. In a few instances substitutions will be given.

CHEMICAL TERMS

Acid A compound usually having a sour taste and capable of neutralizing alkali—most developers are alkaline. Solutions with a pH less than 7 are considered acid. An example of a common acid would be lemon juice.

Alkali The opposite of an acid is a compound, or salt (e.g., sodium metaborate, sodium carbonate), used as an accelerator in photographic developers. Solutions with a pH greater than 7 are considered alkaline. An example of a common alkali would be laundry soap.

Anhydrous A chemical with all water removed; it is free from water, or dry; see Appendix 2.

Crystalline Means that as many water molecules as possible are attached to the chemical's molecule.

Decahydrate Means having ten molecules of water.

Deliquescent A chemical able to absorb moisture from the air.

Denaturant Used to render alcohol unfit for drinking.

Desiccated An older word meaning the same as anhydrous.

Dihydrate Means having two molecules of water.

Dodecahydrate Means having 12 molecules of water.

Effervescence Means giving off bubbles of gas.

Efflorescent Means the crystals have broken down and become covered with powder.

Hygroscopic The property of a liquid or solid that attracts moisture from the air.

Inflammable Means being capable of being set on fire.

Monohydrate (monohydrous) Means having one molecule of water; see Appendix 2.

Octahydrate Means having eight molecules of water.

Pentahydrate Means having five molecules of water.

Viscid Indicates having a thick, sticky consistency.

Caution: Treat every chemical as if it were poison. Wear chemical proof gloves and other appropriate safety equipment when handling, either in powder or solution. Do not swallow and, most importantly, keep all chemicals away from your eyes.

PHOTOGRAPHIC CHEMICALS

ACETIC ACID

Synonyms: Methanecarboxylic acid, ethylic acid, purified pyroligneous acid, vinegar

Appearance: Clear, colorless liquid; strong pungent odor

Common grades: Glacial USP, 99½%; USP, 36%; photo, 28%. To prepare 28% photo grade from glacial grade, dilute 3 parts acid with 8 parts of water (e.g., 150.0 mL of glacial acetic acid to 400 mL of water). Glacial grade solidifies at about 60°F/15°C. It is easily melted by standing in warm water.

Uses: Hardening and acid fixing baths; stop baths; as a clearing bath after ferrous oxalate development of bromide paper. Glacial acetic acid can be used as a solvent of gelatin, celluloid, and pyroxylin.

Author's Note: To prepare lower-strength acids from glacial acetic acid (USP 99½%), use the following table:

Diluting Glacial Acetic Acid

Strength Acetic Acid Required	*Parts by Weight Water*	*Parts by Weight 99½% Acid*
28%	71	28
36%	63	36
56%	43	56
80%	19	80

Substitutions: White vinegar is a weak form of acetic acid, varying in strength from 3% to 15%, generally expressed in "grain" content, with 10 grain being equivalent to 1%. The usual vinegar sold in grocery stores is 45 grain or 4½% acetic acid.

Distilled vinegar of 40 to 150 grain (4–15%) may be purchased from vinegar manufacturers or wholesalers. A working-strength stop bath is usually in the 1–2% range; mixing 1 part 40-grain vinegar with 2.5 parts water will make a working-strength solution.

Glacial acetic acid should not be added to sodium sulfite without dilution. It may cause decomposition of the sulfite with the resulting formation of sulfur dioxide. A 28% acetic acid is the preferred concentration for photographic uses. It should never be added to hypo unless sulfite is present. Sulfurization of the hypo will result.

Caution: High concentrations of acetic acid can cause bad burns on contact with skin. However, working-strength stop bath is usually only 1–2%, less than ordinary household vinegar. **DO NOT MIX ACETIC ACID WITH HOUSEHOLD BLEACH**. Acetic acid reacts with household bleach to form a highly toxic gas.

ALUM

See Ammonium Alum; Aluminum sulfate; and Chrome Alum

ALUMINUM CHLORIDE HEXAHYDRATE

Author's Note: Not to be confused with aluminum chloride, anhyd.

Appearance: White or yellowish white, deliquescent, crystalline powder. It is nearly odorless and has a sweetish, very astringent taste.

Uses: In photography as a hardener in acid fixing baths that use ammonium thiosulfate as a solvent for silver halides.

Author's Note: 1 gram is soluble in 0.5 mL of water at 77°F/25°C.

***Caution*:** Incompatible with alkali.

ALUMINUM SULFATE

Synonyms: Concentrated alum, papermaker's alum, sulfate of alumina

Appearance: White, lustrous crystals, granules, or powder

Uses: Can be used as a substitute for alum as a hardener (ratio = 2 parts aluminum sulfate as a substitute for 3 parts alum).

AMIDOL

Formulas: Diaminophenol, 2,4 diaminophenol dihydrochloride

Tradenames: Acrol, Dianol

Appearance: Fine white or bluish-gray crystals.

Uses: A rapidly working developer requiring only sulfite as an accelerator. Primarily used for printing, but occasionally for negatives.

Author's Notes:

1. Amidol is one of the best developing agents for blue-black tones on soft-emulsion bromide paper and warm tones on chlorobromide paper. It is also capable of creating neutral blacks with a fine scale and transparency in the shadows.
2. Amidol is very soluble in water or sulfite. Amidol is energized by sodium sulfite alone, without the necessity of adding any alkali.

***Caution*:** Amidol is considered toxic. Avoid contact with eyes, skin, and clothing. In case of contact, flush eyes and skin with water. The dry powder should not be inhaled when mixing. Mixing should be performed in a well-ventilated area using gloves, goggles, dust mask, and an apron. Use gloves when using the formula. Amidol is highly staining to both skin and clothing.

AMMONIUM ALUM

Synonyms: Alum, aluminum-ammonia sulfate, ammonium alum

Appearance: Colorless crystals or white powder; styptic taste

Uses: Hardener in fixing baths; hypo-alum (sulfide) toning; hardener for gelatin

AMMONIUM CARBONATE

Synonyms: rock ammonia (a mixture of ammonium carbonate and ammonium bicarbonate)

Appearance: White, hard, translucent lumps or cubes

Uses: Replaces potassium and sodium carbonate as an accelerator; replaces ammonia water in some solutions.

Author's Note: Converts to bicarbonate upon exposure to air.

AMMONIUM CHLORIDE

Synonyms: Ammonium hydrochloride, chloride of ammonia, hydrochloride of ammonia, muriate of ammonia, sal ammoniac

Appearance: White, odorless granules or powder

Uses: To make rapid fixing baths, as an accelerator in sodium thiosulfate–based fixing baths; also used in chloride and salted albumen papers. Mild silver halide solvent.

AMMONIUM PERSULFATE

Synonyms: Persulfate of ammonia

Appearance: Colorless crystals or white crystalline powder

Uses: Flattening reducer (i.e., reduces highlight detail more than shadows); removes developer stains.

AMMONIUM SULFATE

Synonyms: Ferric ammonium sulfate, ferric ammonium alum, ferric alum, iron alum, ammonia sulfate, iron ammonium alum, iron sulfate

Appearance: Violet efflorescent crystals

Uses: In reducer formulas; toning solutions; sensitizing solutions.

AMMONIUM THIOCYANATE

Synonyms: Ammonium sulfocyanide, ammonium sulfocyanate, ammonium thiocyanide

Appearance: Colorless, deliquescent crystals

Uses: For gold-toning printing out paper.

***Caution*:** Keep well stoppered.

AMMONIUM THIOSULFATE

Synonyms: Ammonium hyposulfite, ammonium thiosulphate

Appearance: Colorless anhydrous crystals; sold in 60% solution

Uses: Sometimes substituted for the sodium salt in rapid fixing baths. A 15–20% solution of ammonium thiosulfate is capable of more rapid fixation than a 35–40% solution of sodium thiosulfate.

ANTIFOG #1

See benzotriazole.

ANTIFOG #2

Formula: 6-nitrobenzimidazole nitrate

Appearance: Colorless crystals or white powder

Uses: Can be used as an antifoggant and density depressant in developers. Also used in Kodak SH-5 Prehardener for high-temperature processing.

ASCORBIC ACID

Formulas: (5*R*)-[(1*S*)-1,2-Dihydroxyethyl]-3,4-dihydroxyfuran-2(5*H*)-one

Synonyms: Vitamin C, L-ascorbic acid, ascorbate, ascorbic acid

Appearance: White crystals

Uses: As a developing agent and as a preservative. As a developing agent, it acts more vigorously at higher alkalinities. It is slow to get started but gives images with low fog. At low alkalinities in combination with metol or Phenidone, ascorbic acid is an active, long-lasting developing agent.

Substitutions: The pure vitamin C powder, available from health food stores, can be used. Or you can use the tablet form and crush it to a powder with a mortar and pestle before adding. Do not weigh the tablets, as insoluble starch binder adds weight. Just add up the vitamin C contents (i.e., a 500-mg tablet = 0.5 grams of vitamin C; a 1000-mg tablet = 1 gram). To remove the starch binder, filter the developer solution through a coffee filter (do not use the filter for coffee afterwards!).

Sodium ascorbate or sodium isoascorbate can also be substituted. Use 1.125 times the weight of ascorbic acid: 11.25 grams of either is equivalent to 10 grams of ascorbic acid.

Ascorbic acid can also replace hydroquinone. Start by using 1.6 times the weight of hydroquinone, and increase the alkali (i.e., borax, carbonate) by 1.6 times to compensate for the acidity of the vitamin C.

BENZOTRIAZOLE (BZT)

Trade names: Edwal's Liquid Orthazite, which contains an approximately 3% solution of benzotriazole with sodium sulfite (no longer manufactured; see BB solution in the "Formulary"). Kodak Anti-Fog #1 (no longer manufactured).

Appearance: Colorless crystals or white powder

Uses: Organic antifoggant and density depressant in developers. Benzotriazole acts as a restrainer without affecting other properties of the developer. It can also be used as a fog restrainer when processing outdated paper.

Author's Notes:

1. When blue-black or cold-black image tones are desired with bromide papers, benzotriazole should be used in addition to, or substituted for, potassium bromide. Make a 0.2% solution of benzotriazole (2 grams benzotriazole in water at 125°F/52°C to make 1 liter) then reduce the bromide to 1⁄10 or 1⁄6 strength and use just enough benzotriazole solution to prevent developer stain or fog. A little experimentation will be required.
2. The same treatment can be applied to chloride and chlorobromide papers to eliminate any greenish-black tendencies and/or achieve a blue-black tone.
3. Benzotriazole does not dissolve readily in cold water. Use hot water—125°F/52°C or higher.
4. For more accurate measurement, prepare a 1% solution by dissolving 1 gram of benzotriazole in 100 mL of distilled water. Use 20 mL in place of 0.2 grams of dry chemical.

BORAX

Synonyms: Sodium tetraborate
Trade names: 20 Mule Team Borax
Appearance: Pure white crystalline powder
Uses: As a mild alkali accelerator in fine-grain developers and those of low activity; in certain hardening fixing baths and in some acid hardeners, especially those intended for prints that are to be dried through heated belt driers; and in gold toning baths to render them alkaline and to increase the rate of deposition of gold.

Author's Note: Borax is available as borax, pentahydrate but most commonly as borax, decahydrate, the form used in photographic formulas. The old term for decahydrate is crystalline. Borax, decahydrate, and 20 Mule Team Borax are one and the same.

BORIC ACID

Synonyms: Boracic acid, hydrogen borate, orthoboric acid
Appearance: Colorless, odorless, transparent crystals; fine white globules; or a white amorphous powder
Uses: As a buffer with borax to maintain a stable pH, even when the developer is greatly diluted.

Author's Notes:

1. Minimizes sludging tendency and improves the hardening properties of fixing baths containing potassium alum and acetic acid. Can also be used as a stop bath (use 3–5% in water).
2. Crystalline or granular boric acid should be used—there is no practical difference between the two. Powdered boric acid dissolves only with great difficulty, and its use should be avoided.

Caution: Boric acid is used as roach poison and should not be taken internally.

BROMCRESOL PURPLE

Appearance: Light pink, crystalline powder

Uses: As an indicator to test the acidity of rinse and stop baths. At pH 5.2 it is yellow, and at pH 6.8 it is purple.

Author's Note: Practically insoluble in water, but soluble in alcohol and dilute alkali. Mix it in a little alcohol or a small volume of dilute sodium hydroxide, then add to the water.

CALCIUM CARBONATE, PRECIPITATED

Synonyms: Aragonite; calcite; chalk; lime; limestone; marble; oystershell; pearl

Appearance: White, odorless, tasteless powder.

Uses: In gold toning.

Author's Note: Insoluble in water, slightly soluble in water saturated with CO_2, with increased solubility in water containing ammonium salts. Dissolves in dilute acids with effervescence.

CATECHOL

See pyrocatechin.

CHROME ALUM

Synonyms: Chromium alum; potassium chromium sulfate

Appearance: Dark violet-red crystals (ruby red by transmitted light) or light violet powder.

Uses: Preparation of chrome alum fixing bath; as hardening agent for gelatin.

CITRIC ACID

Appearance: Colorless, odorless crystals or granules efflorescent in dry air, deliquescent in moist. Very soluble in water; freely soluble in alcohol.

Uses: Preservative; as a sequestering agent and as a stop bath

Common forms: Citric acid can be purchased in powder form from many drug and health food stores.

DIAMINOPHENOL HYDROCHLORIDE

See amidol.

ELON

See metol.

FERRIC AMMONIUM CITRATE

Synonyms: Ammonium citrate, iron citrate, soluble ferric citrate

Appearance: Clear green crystals. Occurs also as brown scales, but green scales are preferred for photographic purposes.

Uses: In iron-toning solutions. Fresh ferric ammonium citrate tends to form a layer of mold after a few days. This can be filtered or lifted off. After the first time the mold rarely returns.

Author's Note: Both brown and green salts are light sensitive. Keep well closed and protected from light.

FERRIC CHLORIDE

Synonyms: Chloride of iron, ferric trichloride, flores martis, iron trichloride

Appearance: Orange-yellow opaque masses or lumps

Uses: Reduction; blue toning

Author's Note: Keep in a tightly sealed bottle.

FERRIC OXALATE

Synonyms: Iron oxalate, iron sesquioxide

Appearance: Greenish crystalline scales or pearls

Uses: Iron-toning solutions

Author's Note: Light sensitive

GELATIN

Appearance: Colorless or light yellow, transparent, brittle, practically odorless sheets, flakes, or coarse powder

Uses: Preparation of emulsions, sizing paper, adhesives, light filters

Author's Note: Swells up and absorbs five to ten times its weight of cold water.

GLYCERINE

Synonyms: Glycerin, glycerol, glyceryl hydroxide, glycol alcohol

Appearance: Clear, colorless, syrupy liquid

Uses: Prevents too rapid drying; keeps gelatin emulsions of paper and films flexible.

GLYCIN

Formulas: *p*-Hydroxyphenyl glycine; *p*-hydroxyphenylamino acetic acid

Trade names: Athenon (Kodak), Glyconol, Iconyl, Kodurol, Monazol (Edwal)

Appearance: Glistening white or gray powder

Uses: Nonstaining, clear-working developer; gives fine-grained negatives of a gray-black color. Commonly used with para-phenylenediamine in fine-grained formulas; also used in paper developing formulas.

Author's Notes:

1. Glycin is almost insoluble in water, but it dissolves readily in alkaline solutions; thus it should be added last to any developer formula. It oxidizes very slowly and is very clean working.
2. Until the advent of 35mm film, with the resulting emphasis on fine-grain developers, glycin was used mainly in paper developers. Now it is sometimes used in combination with other developing agents for fine-grained film development.
3. Glycin is very sensitive to bromide and also low temperature. With alkali carbonates, it makes slow-working developers, which have good keeping properties and give low contrast.
4. Must not be confused with glycocoll medicinal, sometimes called glycine.

GOLD CHLORIDE

Synonyms: Aurous chloride, gold trichloride (acid)

Appearance: Bright golden yellow crystalline compound

Uses: Gold toning

Author's Note: Contains approximately 50% of gold. Keep in a tightly closed bottle and protected from light.

Caution: Gold chloride can blister the skin and then on exposure to light will leave violet-brown spots. Wear gloves when working with the powder or solution.

HYDROCHLORIC ACID

Synonyms: Chlorohydric acid, HCL, marine acid, muriatic acid, spirit of salt

Appearance: Clear, colorless, or slightly yellow fuming liquid

Uses: Clearing pyro stains; vanadium, iron, and copper toning processes

Substitution: A satisfactory substitute for HCL is a mixture of sodium bisulfate and sodium chloride. Mix twice as much sodium bisulfate to sodium chloride to make the substitute. Use four times as much of the substitute as hydrochloric acid required in a formula.

Author's Note: Concentrated (35–37%) HCL is expensive. Considerably less expensive muriatic acid, available from pool suppliers and hardware stores, can be substituted by multiplying the formula amount by 1.17. For example, if the formula calls for 10 mL of HCL, multiply by 1.17 and use 11.7 mL of muriatic acid.

Caution: Poisonous and very corrosive. Always add the acid to the water slowly while stirring constantly, and never add the water to the acid; otherwise, the solution may spatter the acid on the hands or face, causing serious burns. Always wear a face mask, gloves, and eye protection. If any acid splashes on you wash it off immediately with cold water for 15 minutes and seek medical attention immediately. Wipe up spills immediately.

Always use adequate ventilation. **DO NOT BREATHE THE VAPOR**.

HYDRONYX

Appearance: Clear liquid

Uses: As a wetting agent for film used before drying.

HYDROQUINONE (HQ)

Formulas: 1,4 Dihydroxybenzene; *p*-dihydroxybenzene

Trade names: Hydrochinon, Hydroquinol, Quinol, Tecquinol

Appearance: Lustrous, silky, white needles

Uses: High-contrast developing agent; builds density in combination with other developers.

Substitutions: Ascorbic acid, sodium isoascorbate, and sodium ascorbate can be used as substitutes for hydroquinone.

Author's Notes:

1. Hydroquinone is generally a clean-working and nonstaining developer. It oxidizes easily both in solution and as crystals.
2. At temperatures below 50°F/10°C hydroquinone developers are inactive. It is extremely susceptible to the action of bromide. When compounded with alkali carbonates, it gives a slow-working but high-contrast developer. With caustic alkali (e.g., sodium hydroxide) its action is very rapid, with the highest possible contrast. For this reason, it is the most widely used developer for technical applications, especially in process work where the highest attainable contrast is essential. In the presence of caustic alkali (i.e., high pH), it is not temperature-sensitive and can be used for low-temperature developing. Hydroquinone developers keep well and are slowly exhausted.
3. Hydroquinone (HQ) alone is not often used, but in combination with metol (MQ) or Phenidone (PQ), it is among the most popular developing agents. By varying the relative quantities of metol and hydroquinone and adjusting the quantities of sulfite and carbonate, almost any desired contrast or rate of development can be obtained.

Caution: Hydroquinone can cause an allergic reaction in some people that manifests as a severe skin rash.

HYPO

See sodium thiosulfate

IODINE

Appearance: Violet gray scales

Uses: For bleaching bromide prints in sulfide toning; with potassium cyanide as a print reducer; for removing silver stains. Iodine stains on fingers disappear in hypo or sulfite.

IRON ALUM

See ammonium sulfate

ISOPROPYL ALCOHOL (IPA)

Synonyms: Dimethylcarbinol, IPA, isopropanol, secondary propyl alcohol

Appearance: Colorless liquid; weak alcoholic odor resembling that of acetone

Uses: In developing formulas for its high solvent properties. To replace alcohol wherever it is called for. To control the diffusion of solutions into emulsions.

***Caution*:** Inflammable

KODALK

See sodium metaborate

LIQUID ORTHAZITE

See benzotriazole

METHANOL

Synonyms: Carbinol, Columbian spirits, methylic alcohol, pyroligneous spirit, wood alcohol, wood naphtha

Appearance: Clear, colorless, mobile liquid

Uses: For denaturing ethyl alcohol; solvent; in preparing very concentrated solutions of developers; cleaning prints and negatives; to control diffusion of solutions into emulsions; the making of film cement.

***Caution*:** Burns with a nonilluminating flame. The presence of excessive amounts of methyl alcohol may cause softening of the film base.

METOL

Formulas: Monomethyl p-aminophenol sulfate; p-methylaminophenyl sulfate

Trade names: Claritol (Defender; half-strength metol), Elon (Kodak), Enol, Genol, Graphol, Metol (Agfa and others), Pictol (Mallinckrodt), Photol (Merck), Planetol, Rhodol (DuPont), Veritol (Defender)

Appearance: White to slightly yellowish powder

Uses: As a developing agent, usually with hydroquinone, but sometimes by itself, as in Kodak D-23.

Substitution: Phenidone can be substituted for metol. Start by using approximately 10% of the quantity of metol.

Author's Notes:

1. Although metol is easily soluble in water, it is not soluble in a strong sodium sulfite solution. It will dissolve readily in a weak solution of sulfite. Metol builds image detail rapidly, and it keeps well in solution.
2. Metol has low-fogging tendencies and responds well to the addition of bromide, giving a very clean-working developer without any staining of either film or fingers. The energy of the developer is only slightly affected by low temperature and is only slightly reduced by the addition of bromide.

3. Metol alone with either sodium or potassium carbonate gives a rapid-working developer when the alkali is in high concentration, but the speed of development can easily be controlled by dilution.
4. The use of caustic alkali (e.g., sodium hydroxide) is not recommended with metol, as there is a tendency for excessive fog. When used with sulfite alone, without additional alkali (Kodak D-23), metol provides a slow-working, fine-grain developer. This type of film developer often works well with a mild alkali, such as borax, which accelerates the rate of development without increasing the grain size appreciably (Kodak D-25).
5. Developers containing metol as the sole developing agent are not widely used, but metol with hydroquinone provides the most widely used developer combination.

***Caution*:** Metol has a reputation for causing skin poisoning—a painful rash that looks and feels like poison oak. It includes severe itching, red rash, and peeling skin. This poisoning usually occurs after exposure to the substance over a period of years but in some cases can happen sooner.

It is believed that metol poisoning results from trace contamination of *p*-phenylenediamine (ppd), not from the metol itself. Knowledge of this has changed the manufacturing process, and as a result, metol poisoning is less common than it once was.

Good-quality metol does not usually cause a rash. However, some people are still sensitive to even the purest grade of metol. It is possible to avoid metol poisoning either by wearing protective gloves or by substituting Phenidone.

OXALIC ACID

Synonyms: Ethanedioic acid, wood bleach, crab acid, carboxylic acid, carboxylformic acid, dicarboxylic acid, diformic acid

Appearance: Transparent, colorless, and odorless crystals. Freely soluble in water and alcohol; slightly soluble in ether

Uses: Preservative for pyro solutions; sensitizer of platinotype paper; acts as a restrainer with some developers. Removes ink and some developer stains; used in toning and mordanting formulas.

P-AMINOPHENOL HYDROCHLORIDE

Formulas: 4-Amino-1hydroxy-benzene hydrochloride; *p*-hydroxyaniline

Trade names: Activol, Azol, Kodelon (Kodak), Paramidophenol (Agfa)Rhodinal

Appearance: White, crystalline substance

Uses: As a developing agent used in conjunction with sodium or potassium carbonates or with caustic alkali. The sodium salt of this is the developing agent in the concentrated solution of prepared developer. It is marketed under the trade name of Rodinal by Agfa.

Author's Notes:

1. At one time this was a very popular developing agent. In 1931 the Eighth International Congress of Photography adopted the following formula as a standard developer for scientific sensitometric work:

   p-Aminophenol hydrochloride, 7.25 g
   Sodium sulfite, anhydrous, 50.0 g
   Sodium carbonate, anhydrous, 50.0 g
   Water to make 1.0 L

2. *p*-Aminophenol hydrochloride is very soluble in cold water. Its principal use is in the preparation of very concentrated developers with caustic alkali that could be diluted from 20 to 100 times. Concentrates keep well and should not be diluted until immediately before use.
3. Carbonate should not be used with this substance, as it precipitates out the base and prevents the preparation of any but very dilute solutions.

P-PHENYLENEDIAMINE (PPD)

Formulas: para-diaminobenzene; 1,4-diaminobenzene

Trade names: Diamine, Diamine P, Paramine Metacarbol (free base), and Para D

Appearance: White to slightly reddish crystals in photo grades

Uses: Very low-energy developer; produces negatives of minimum graininess. Often used in combination with glycin and/or metol.

Author's Note: *p*-Phenylenediamine is the classic superfine-grained developing agent. Besides the cautions that follow, it requires strong overexposure of the film and a very long developing time, often 20 minutes or more, and even then, the contrast of the resulting negatives is rather low.

As a result, there have been efforts to replace ppd with other agents. One of the more successful is the Windisch Superfine-Grain Developer that uses *o*-phenylenediamine. This agent also has weak developing properties, but it works as a good solvent for silver halide. *p*-Phenylenediamine is only slightly soluble in water.

***Caution*:** Toxic and stains hands, clothing, and other things on prolonged contact. The free base of ppd and its water-soluble salts may cause eczema or other skin irritations. Always wear a good dust mask when working with the powder and gloves when working with the powder or the solutions.

PHENIDONE

Formulas: 1-Phenyl-3-pyrazolidone; 1-phenyl-3-pyrazilidinone

Trade names: Fotodone (Mallinckrodt), Graphidone

Appearance: White or slightly yellow powder; colorless crystals

Uses: As a hypoallergenic low-contrast developing agent that can be substituted for metol. Sufferers of metol poisoning can often use phenidone-based developers without ill effects.

Author's Notes:

1. Phenidone is only slightly soluble in plain water. It is more easily dissolved in 91% isopropyl alcohol, glycerin, methanol, or triethanolamine. It is readily soluble in both aqueous acids and alkali, including solutions of alkali bisulfites and carbonates. Alternatively, it can be dissolved by adding it to hot water, stirring, then allowing it to sit until it dissolves.
2. Used alone in sodium carbonate/sulfite solutions, it is very fast but extremely soft working and is only capable of producing negatives of low contrast. In combination with hydroquinone, it produces developers with superadditivity that are even more efficient than MQ developers.
3. Phenidone-based developers keep better than those based on metol. The reason is the oxidation product of phenidone is more efficiently regenerated by hydroquinone than is metol. Additionally, while the first oxidation product of hydroquinone, mono-sulphonate, forms an almost inert system with metol, it has a superadditive effect with phenidone, increasing developing power.
4. Because very small amounts of phenidone are required, it is often desirable to use a percentage solution. A concentrate of phenidone, containing a preservative, can be made as follows:

   Water at 125°F/52°C, 750.0 mL
   Sodium bisulfite, 6.0 g
   Phenidone, 2.0 g
   Cold water to make 1.0 L

100 mL of the concentrate contains 0.2 grams of Phenidone. The preservative will have no appreciable effect on any developing formula. Alternatively, a 5% concentration can be made using methyl hydrate instead of water, but it does not keep well.

Substitution: Most general-purpose developers in use today are metol hydroquinone based (MQ) rather than Phenidone hydroquinone based (PQ). This is in part because Phenidone has not been around that long as a developing agent and because phenidone is more expensive. However, because of the allergic reaction to metol suffered by many photographers, it may be desirable to substitute Phenidone for metol.

There is also evidence that as a substitute for metol, Phenidone causes a true increase in film speed. Try substituting approximately 10% of the amount of Phenidone by weight for metol required in the formula. Develop a test roll, inspect the results, and add as needed until your formula produces the desired results.

Author's Note: Phenidone should not be used as a substitute in developers in which metol is the sole developing agent, such as Kodak D-23.

POTASSIUM ALUM

Synonyms: Alum

Appearance: Large, colorless, hard, transparent crystals or white crystalline powder

Uses: Hardening solutions for fixing baths; ingredient of the hypo-alum toning bath; clearing bath

Substitutions: Cake alum, found in grocery stores, can be substituted for potassium alum.

POTASSIUM BROMIDE

Synonyms: Bromide, bromide of potash, bromide of potassium

Appearance: White crystalline granules or powder

Uses: Fog preventer and restrainer in developing solutions.

Author's Note: Potassium bromide is the most commonly used restrainer in developing formulas, especially those using hydroquinone, pyrocatechin, or pyrogallol. The addition of potassium bromide usually results in a reduction of contrast and can have a warming effect on image tone when used in paper developers. It is also used as an ingredient in intensifying, reducing, toning, and many other photographic solutions.

POTASSIUM CARBONATE

Synonyms: Carbonate of potash, pearl ash, potash, salt of tartar, salt of wormwood, subcarbonate of potash

Appearance: White, deliquescent, granular powder

Uses: Since potassium carbonate is more soluble than sodium carbonate, it is used in concentrated solutions where an alkali is needed.

Substitution: To substitute potassium carbonate anhydrous, multiply the amount of sodium carbonate monohydrate by 0.90.

Author's Note: Potassium carbonate can be substituted for sodium carbonate as an alkali accelerator in developers. As its solubility is much greater, developers with greater concentration can be formulated. Thirteen parts by weight are equal to 10 parts by weight of sodium carbonate. Substituting potassium carbonate for sodium carbonate will help obtain warmer tones in paper development.

POTASSIUM CITRATE

Synonyms: Tribasic citrate of potash

Appearance: White granular powder

Uses: As a restrainer in alkaline development; used in several copper toning baths.

POTASSIUM DICHROMATE

Synonyms: Bichromate of potash, potassium bichromate

Appearance: Bright, orange-red crystals

Uses: Bleaching ingredient in tray cleaners and chromium intensifiers.

Author's Note: Bichromate is an older word for dichromate.

***Caution*:** Potassium dichromate is corrosive and can cause burns. Avoid contact with eyes, skin, and clothing. In case of contact, flush eyes and skin with water.

Potassium dichromate can also cause allergic skin reactions; the dust can cause irritation. Mixing should be performed in a well-ventilated area using gloves, goggles, and aprons. Potassium dichromate is a suspected carcinogen.

POTASSIUM FERRICYANIDE

Synonyms: Ferricyanide, ferricyanide of potash

Appearance: Ruby red, lustrous crystals

Uses: Principal use is in bleaching baths; iron printing processes; and as a bleach before sulfide toning. Also used in dye-toning formulas.

Author's Note: Keep protected from light.

POTASSIUM FERROCYANIDE

Synonyms: Ferrocyanide of potash, yellow prussiate of potash

Appearance: Lemon yellow crystals or powder.

Uses: A small amount in pyro and hydroquinone developers tends to lower fog and give greater density.

Author's Note: Light sensitive in solution.

POTASSIUM IODIDE

Synonyms: Iodide of potash.

Appearance: White crystals, granules, or powder

Uses: Has the property of reducing emulsion fog. Can be used as a restrainer, although this application has not been adequately explored.

POTASSIUM METABISULFITE

Synonyms: Metabisulfite of potash, potassium pyrosulfite

Appearance: Transparent needle crystals or crystalline powder

Uses: As a preservative in developers; used in place of sodium sulfite in some developers. Also used for acidifying fixing baths.

Author's Note: Substitution of 1.17 grams potassium metabisulfite is equivalent to 1 gram sodium metabisulfite. Deteriorates rapidly in air.

POTASSIUM PERMANGANATE

Synonyms: Permanganate of potash

Appearance: Purple-black crystals of metallic luster

Uses: As a reducer (acid solution); test for hypo; hypo eliminator; stain remover and bleacher in redevelopment.

***Caution*:** Powerful oxidizing agent; its stain can be removed with a solution of potassium metabisulfite or sodium bisulfite.

POTASSIUM PERSULFATE

Synonyms: Anthion
Appearance: Colorless or white odorless crystals.
Uses: As a hypo eliminator; bleach bath for reversal development; reducers.

Author's Note: Keep well closed in a cool place.

***Caution*:** A powerful oxidizing agent.

POTASSIUM POLYSULFIDE

Synonyms: Hepar sulfuris, liver of sulfur, potassium trisulfide
Appearance: Yellowish-brown lumps; slight odor
Uses: To precipitate silver from photographic waste. Used in toning formulas.

Author's Note: Decomposes upon exposure to air. Potassa sulfurated often becomes coated with a hard crust having no value. This crust should be broken away as much as possible before weighing out the inner part.

POTASSIUM THIOCYANATE

Synonyms: Potassium rhodanide, potassium sulfocyanate, potassium rhodamide
Appearance: Colorless, deliquescent crystals
Uses: Thiocyanate toning baths; silver halide solvent

Author's Notes:

1. Potassium thiocyanate can produce actual reduction in the size of individual silver halide grains by virtue of its dissolving action. As a result of physical development, it produces a more homogeneous deposition of silver. It is used in concentrations of 1–1.5 g/liter in certain developers, such as Kodak DK20–DK-20 is not included in the formulas found in this edition.
2. Because of its deliquescent nature, thiocyanate should be used in percentage solutions.

PYRO

See pyrogallic acid

PYROCATECHIN

Formulas: 1,2-Dihydroxybenzene; ortho-dihydroxybenzene
Synonyms: catechol, pyrocatechol, catechin, pyrocat
Appearance: Colorless crystalline needles or scales
Uses: Developing agent for film or paper; gives warm black images; with caustic soda, gives rapid development with high contrast.t54r

Author's Notes:

1. Pyrocatechin is easily soluble in warm water. It is chemically akin to hydroquinone but with special properties, notably the fact that it oxidizes readily, and its oxidation products have a tanning effect upon gelatin.
2. When used without sulfite or a very low sulfite content, it gives a heavily stained image and tans the gelatin in proportion to the density of the image. This property has led to its use for high-definition and tanning developers (Windisch Extreme Compensating Developer). Used with caustic alkali, it is one of the best compensating developers (Maxim Muir's Pyrocatechinic Compensating Developer).
3. All developers containing pyrocatechin should be mixed with distilled water, whether or not the formula calls for it.
4. Dilute pyrocatechin developers will typically provide a speed increase.

***Caution*:** Poisonous; wear a dust mask and gloves when working with the powder, use adequate ventilation, and wear gloves when using the working solutions. Clean up any powder or spilled solutions and dispose of the residue safely.

PYROGALLIC ACID

Formulas: 1,2,3 trihydroxy-benzene; 1,2,3-benzenetriol

Trade names: Piral, Trihydroxybenzene

Synonyms: pyro, pyrogallol

Appearance: Fine, white powdery crystals (sublimed) or heavy, prismatic crystals; properties of the two forms are the same.

Uses: Active agent in pyro developers.

Author's Notes:

1. At one time, pyro was a universally used developer. It was even available in prepackaged formulas from companies such as Eastman Kodak. Unfortunately, it has been almost entirely replaced by metol hydroquinone– and Phenidone hydroquinone–type developers. The main reasons are that pyro stains, it must be handled carefully, and it does not keep well in solution. In other words, it is not as commercially viable as other forms of developers.
2. When used correctly, pyro creates a stained image of unprecedented tonal scale, especially in the high values. In combination with either metol or Phenidone, it exhibits super-additive characteristics. It produces an overall stain on the negative, which adds to the contrast of the silver image. The stain is a desirable part of a properly developed pyro image.
3. Pyro tends to oxidize very rapidly in solution and cannot be kept without the aid of preservatives such as sulfuric or other acids, sulfites, etc. Pyro should be added after these preservatives have been mixed with the water. Pyro oxidation products act as strong antifogging agents.

Caution: Pyrogallol is toxic. Avoid contact with eyes, skin, and clothing. In case of contact, flush eyes and skin with water. The dry powder should not be inhaled when mixing. Mixing should be performed in a well-ventilated area using gloves, goggles, dust mask, and an apron. Use gloves when using the formula.

SILVER NITRATE

Synonyms: Lapis caustic, luna caustic, lunar caustic, nitrate of silver

Appearance: Colorless, flat crystals

Uses: Most important silver salt used in photography; emulsion making; intensification; etc.

Caution: Stains on fingers can be removed by rubbing with tincture of iodine followed by a strong solution of hypo.

SODIUM ACETATE

Synonyms: Acetate of soda

Appearance: Colorless, transparent, efflorescent crystals

Uses: Toning baths; retarder in hydroquinone developer; used to buffer acidity of acid solutions.

Author's Note: Keep in a tightly sealed bottle in a cool place.

SODIUM ASCORBATE

Synonyms: Soda ascorbate, sodium isoascorbate

Appearance: White crystals

Uses: An ecologically friendly developing agent, usually used in combination with metol or phenidone.

Substitutions: Sodium ascorbate is available in health food stores and the canning goods department of some grocery stores. Ten grams of sodium ascorbate can be substituted for 8.89 grams of ascorbic acid. Sodium ascorbate can be replaced with sodium isoascorbate, weight for weight.

Author's Note: Sodium ascorbate is usually used in combination with metol or phenidone. It may also be used as a substitute for hydroquinone. Try using 1.8 times the weight of the hydroquinone. The alkali does not have to be increased because sodium ascorbate is not acidic.

SODIUM BICARBONATE

Synonyms: Baking soda, bicarbonate of soda

Appearance: Fine, white powder

Uses: In hypo baths for fixing self-toning papers; in gold toning baths. It can be used to buffer sodium carbonate or as a weak alkali on its own.

SODIUM BISULFATE

Synonyms: Sodium acid sulfate, sodium bisulphate, sodium hydrogen sulfate

Appearance: White, crystalline powder

Uses: Acid rinse and stop baths. In combination with sodium acetate, used as a substitute for acetic acid.

Author's Note: Sodium bisulfate can be used in conjunction with sodium chloride to make a substitute for hydrochloric acid.

SODIUM BISULFITE

Synonyms: Acid sulfite of soda, leucogen

Appearance: White, crystalline powder

Uses: In acidulating and preserving fixing baths; as a preservative for pyro developer; for removing silver stains from printing out paper.

Author's Note: Can be substituted weight for weight with sodium metabisulfite.

SODIUM BROMIDE

Synonyms: Bromide of soda

Appearance: White or colorless granules or granular powder

Uses: As a restrainer in developers.

SODIUM CARBONATE

Synonyms: Carbonate, soda, soda ash, sodium trioxocarbonate, washing soda

Appearance: White or colorless, granules or granular powder

Uses: One of the principal alkalis (accelerators) used in development.

Substitutions: Balanced Alkali (Kodalk) can be used as a substitute for carbonate or vice versa. Sodium carbonate is commonly available in anhydrous and monohydrous forms. The crystalline form is available as Arm & Hammer Washing Soda, which is sodium carbonate decahydrate—use the yellow, unscented box. This can be safely substituted in almost all formulas calling for carbonate.

Author's Note: Sodium carbonate releases a gas when added to an acid stop bath or an acid fixing bath; this gas may cause pinholes, or "blistering," to develop in film emulsions.

SODIUM CHLORIDE

Synonyms: Salt, carbonate of soda, common salt, muriate of soda

Appearance: Colorless, transparent crystals or white crystalline powder

Uses: In preparation of chloride emulsions; salting papers before sensitizing and before toning; in hypo alum toning formulas.

Substitutions: Sodium chloride is simply common table salt. However, in the United States, it is almost always mixed with iodine and the iodine is variable in nature and amount. Therefore, if you wish to buy your sodium chloride from your grocer, use kosher salt, which is not iodized.

Author's Note: Can be used in conjunction with sodium bisulfate to make a substitute for hydrochloric acid.

SODIUM HEXAMETAPHOSPHATE

Synonyms: Graham's salt, sodium polymetaphosphate

Appearance: White flaky crystals or granules; small, broken, glasslike particles.

Uses: Water softener. has the property of holding calcium and magnesium salts in solution, even when boiling.

SODIUM HYDROXIDE

Synonyms: Caustic alkali, caustic soda, hydrate of soda, hydrated oxide of sodium, mineral alkali, soda lye, sodic hydrate, sodium hydrate

Trade names: Red Devil Lye

Appearance: White, deliquescent lumps or sticks.

Uses: High-energy accelerator or alkali sometimes used to activate low-energy developing agents (e.g., hydroquinone).

Substitutions: Red Devil Lye, available in hardware and grocery stores, can be substituted in almost all formulas for sodium hydroxide.

Author's Notes:

1. Caustic alkalis are most often used where a powerful and quick-acting developer is required. Developers compounded with caustic alkali have poor keeping properties and are soon exhausted. Store in a well-sealed bottle. Weigh it rapidly, as it can pick up moisture from the air and change its weight.
2. The use of sodium hydroxide is not recommended with metol, as there is a tendency for excessive fogging.

***Caution*:** Of all the chemicals commonly used in the black-and-white darkroom, this is perhaps the most caustic. It is the same chemical used in many commercial drain cleaners.

Slowly add the sodium hydroxide to the water; do not pour water on the hydroxide; otherwise, the solution may boil and spatter the acid on the hands or face, causing serious burns.

Always have ice present when mixing sodium hydroxide. Dissolve hydroxide separately in cold water, as considerable heat is generated, then add the solution after the developing agent has been dissolved, stirring vigorously. If the water is not cold enough, the solution may start to steam. If this should occur, add some ice to cool the solution and leave the room until it is cool. **DO NOT BREATHE THE VAPOR**.

It is highly recommended that you wear a face mask, gloves, and eye protection when working with sodium hydroxide in powder or solution. If any hydroxide splashes on you or the counter, wash it off immediately with water. If you detect a soapy feeling on your skin, sodium hydroxide is present. Rinse with cold water for 15 minutes and seek medical attention immediately.

There are many excellent developing formulas that don't use sodium hydroxide. If you don't want to handle sodium hydroxide, simply avoid formulas that call for it.

SODIUM ISOASCORBATE

See sodium ascorbate

SODIUM METABISULFITE

Synonyms: Sodium pyrosulfate, sodium disulfite

Appearance: Colorless crystals or white powder

Uses: As a preservative in developers; used in place of sodium sulfite in some developers, particularly in two-solution formulas where the increased acidity of the metabisulfite inhibits oxidation. For acidifying fixing baths.

Author's Note: Can be substituted weight for weight with sodium bisulfite.

SODIUM METABORATE

Trade names: Kodak Balanced Alkali,Kodalk.

Kodalk was Kodak's proprietary name for sodium metaborate. Circa 2003 the name was changed to Balanced Alkali. Whether or not Kodak added another ingredient to Balanced Alkali is not known. If they did, it was not enough to make it into the material safety data sheet (MSDS). Neither Balanced Alkali nor Kodalk are still being produced by Kodak. However, sodium metaborate can be substituted weight for weight.

Appearance: White crystals.

Uses: An alkali used as an accelerator in developers of intermediate activity between that of carbonate and borax. Developers containing sodium metaborate usually have a pH range of 9–10, and the concentration varies from 2 to 50 g/L.

An advantage of sodium metaborate is the almost proportionate change in developer activity with varying alkali concentrations, permitting precise adjustments of the activity of a moderately alkaline developer.

Sodium metaborate is used to avoid the creation of gas when it comes in contact with an acid. For this reason, the possibility of blister formation is minimized. A second advantage is that sodium metaborate does not release gas when added to an acid rinse or an acid fixing bath; hence it minimizes "blistering."

Substitutions: Sodium carbonate can also be used as a substitute for sodium metaborate. In normal developers, 2 parts by weight of metaborate is approximately equivalent to 1 part by weight of sodium carbonate, mono. A more precise substitution is to use 5.9 grams of carbonate for each 10 grams of metaborate.

Yet another substitution is to use 4 parts carbonate, mono and 1 part borax to equal the same weight of sodium metaborate (e.g., 10 grams of metaborate equals 8 grams of carbonate and 2 grams of borax).

Author's Note: A sludge of basic aluminum sulfite is occasionally formed when a developer containing sodium carbonate reacts with a partially exhausted acid-hardening fixing bath. This sludging tendency of certain fixing baths is minimized when developers containing sodium metaborate are used.

SODIUM SULFATE

Synonyms: Glauber's salt (decahydrate), sulfate of soda, sodium sulphate

Appearance: White powder

Author's Note: Use in nonswelling acid rinse baths for roll film. Store in a tightly sealed bottle and store in a cool place.

SODIUM SULFIDE

Synonyms: Sulfide of soda

Appearance: Colorless or slightly yellow deliquescent crystals

Uses: Sulfide toning; silver recovery

***Caution*:** Should not be kept near light-sensitive materials, as it tends to bring about their deterioration. Has the odor of rotten eggs or a high school chemistry experiment. Store in a tightly sealed bottle and store in a cool place. Do not handle with bare hands.

SODIUM SULFITE

Synonyms: Sulfite, sulfite of soda

Appearance: White crystals or powder

Uses: As a preservative of developing agents; constituent of the acid fixing bath; blackener in negative intensification; active energizer in amidol development.

Author's Notes:

1. Sodium sulfite is the most widely used preservative in developers. It also plays an important part in the process itself. By using a sufficient quantity of sulfite, you can prevent the formation of many undesirable by-products during development.
2. Sulfite is also an important solvent for silver halide. It can therefore have a noticeable effect on the graininess of the silver image at concentrations over 50 g/liter.

SODIUM THIOCYANATE

Synonyms: Sodium rhodanide, sodium sulfocyanate, thiocyanic acid, sodium salt

Appearance: Colorless or white deliquescent crystals

Uses: Substitute for potassium thiocyanate weight for weight.

Author's Note: When sodium thiocyanate is dissolved, the temperature of the water is considerably lowered. Due to its deliquescent nature, thiocyanate should be used in percentage solutions.

SODIUM THIOSULFATE (HYPO)

Synonyms: Hypo, hyposulfite of soda, sodium hyposulphite

Appearance: Large, white, transparent crystals and powder

Uses: In preparation of fixing baths; ingredient in various reducers

Author's Note: Sodium thiosulfate is one of a few known substances that will dissolve silver bromide. As such, it is universally used in modern photographic procedures. In this process, which is known as "fixation," the unexposed silver bromide is dissolved in the sodium thiosulfate by combining with it to form soluble complex thiosulfates of silver and sodium. Hypo is available in two forms: anhydrous and, more commonly, crystalline. Crystalline hypo, when dissolved, lowers the temperature of the water considerably, whereas anhydrous does not. Always begin with water of at least 90°F/32°C when mixing the crystalline form. Use 64% of the anhydrous salt as a substitute for crystalline hypo.

STARCH

Uses: For sizing papers and in preparing pastes and adhesives.

Author's Note: Insoluble in cold water; soluble in hot water, forming a jelly on cooling.

SULFAMIC ACID

Appearance: White or colorless, nonhygroscopic crystals.

Uses: As an acidifier in ammonium thiosulfate fixing baths.

SULFURIC ACID

Synonyms: Battery acid, Chamber acid, Contact acid, Dipping acid, Fortifying acid, Hydrogen sulfate, Oil of Vitriol, Tower acid, Vitriolic acid.

Appearance: A heavy, oily, colorless liquid.

Uses: Preservative for pyro solutions; in acid fixing baths and bleaching solutions; in chrome alum fixing baths.

***Caution*:** Poisonous and very corrosive. Always add the acid to the water slowly while stirring constantly, and never add the water to the acid; otherwise, the solution may spatter the acid on the hands or face, causing serious burns. Always wear a face mask, gloves, and eye protection. If any acid splashes on you wash it off immediately with cold water for 15 minutes and seek medical attention immediately. Wipe up spills immediately.

Always use adequate ventilation. **DO NOT BREATHE THE VAPOR**.

TARTARIC ACID

Appearance: Colorless transparent crystals or granules
Uses: Preservative for sensitized paper and emulsions

TEA

See triethanolamine

THIOUREA

Synonyms: Thiocarbamide
Appearance: White, prismatic crystals
Uses: In gold toning baths; clearing yellow stains from prints; in mordant solutions for dye toning.

THYMOL

Uses: Silver gelatin bromide emulsion

Author's Note: Thymol (10–64%) is one of the major constituents of essential oils of thyme, a medicinal plant with several therapeutic properties.

TRIETHANOLAMINE

Synonyms: TEA
Appearance: Clear liquid—available in solid form but not commonly used for photographic applications.
Uses: Developer accelerator and preservative.

TRISODIUM PHOSPHATE

Synonyms: Normal sodium ortho-phosphate, tribasic, trisodium orthophosphate, TSP, tribasic sodium phosphate
Appearance: Colorless, needle crystals; smaller than the dibasic crystals
Uses: An alkali used as a substitute for caustic and carbonate alkali in negative development. Used as a water softener. Good for cleaning and detoxifying vessels and trays that contained fixer.

Appendix 1

Safety in Handling Photographic Chemicals

> *"The camera never lies, but it is possible to be selective amongst the many statements it makes."*
>
> —Michael Gilbert

Toxic chemicals can enter your body in three ways: breathing them, absorbing them through your skin, or swallowing them.

To prevent inhaling chemical powders and toxic fumes use an appropriately rated fume mask as a dust mask will not block toxic fumes. And while placing your unprotected hands in developer trays to shuffle film or paper may be convenient, in time this can develop into sensitivity to common developing agents like metol and hydroquinone. To prevent absorbing chemicals through the porous membrane of your skin, wear chemical-proof gloves.

To keep from swallowing toxic chemicals, don't bring refreshments into the darkroom. Always wear safety goggles, glasses, or shields when mixing toxic solutions such as sodium hydroxide or sulfuric acid.

Common household latex gloves are not chemical proof. Gloves for the darkroom should be made with neoprene or nitrile and rated for use with chemicals.

While most darkroom chemicals are not harmful with occasional exposure, exposure to *any* chemical is never good, even household cleaners. Suppose you clean your house once a week with an over-the-counter household cleaner. Certainly, you should use gloves, but what if you don't? No lasting harm will necessarily come to you. But suppose you make your living as a janitor and use the same household cleaner multiple times during an 8-hour workday. In this case it is imperative that you use gloves due to the high incident of exposure. The same is true for the darkroom.

BASIC SAFETY PROCEDURES

The following list of basic safety procedures is not designed to frighten you but to ensure that you have a long and safe career in photography. Remember that your eyes, lungs, and skin are porous membranes and can absorb chemical vapors, liquids, and powders. Most of the procedures are common sense.

Reprinted from *Photographic Possibilities* by Robert Hirsch, Focal Press, 1991. Used by permission.

1. Read and follow all instructions and safety recommendations the manufacturer provides before undertaking any process. This includes mixing, handling, disposal, and storage. Request a Material Safety Data Sheet (MSDS) in the United States or Control of Substances Hazardous to Health Regulations (COSHH) in the UK from the manufacturers of photochemicals. Collect these in a loose-leaf binder and keep it where someone can find it in an emergency.
2. Become familiar with all the inherent dangers associated with any chemicals being used. When acquiring chemicals, ask about proper handling and safety procedures.
3. Know the antidote for the chemicals you are using. Prominently display the telephone numbers for poison control and emergency treatment centers in your working area and near the telephone.
4. Many chemicals are flammable. Keep them away from any source of heat or open flame to avoid a possible explosion or fire. Keep a fire extinguisher that can be used for both chemical and electrical fires in the work area.
5. Work in a well-ventilated space. Hazardous chemicals should be mixed under a vented hood or outside.
6. Protect yourself. Wear gloves rated to be chemical proof, safety glasses, and a plastic apron. Use a disposable face mask or respirator when mixing chemicals or if you have had any previous allergic reaction. If you have any type of reaction, consult a physician immediately and suspend work with all photographic processes.
7. Follow mixing instructions precisely.
8. Keep all chemicals off your skin, out of your mouth, and away from your eyes. If you get any chemicals on your skin, flush the area immediately with cool, running water.
9. Do not eat, drink, or smoke while handling chemicals.
10. Always pour acids slowly into water; never pour water into acids. Do not mix or pour any chemicals at eye level, as a splash could be harmful. Wear protective eye wear when mixing acids.
11. Avoid touching any electrical equipment with wet hands. Install shock-proof ground fault interrupter outlets (GFI) in your darkroom.
12. Follow instructions for proper disposal of all chemicals. Wash yourself and any equipment that has come in contact with chemicals. Launder darkroom towels after each session. Dispose of gloves and disposable masks to avoid future contamination. Keep your workspace clean and uncontaminated.
13. Store all chemicals properly. Use safety caps or lock up chemicals to prevent other people and pets from being exposed to their potential dangers. Store chemicals in a cool, dry area away from any direct sunlight.
14. Remember, people have varying sensitivities to chemicals. If you have had allergic reactions to any chemicals, pay close attention to the effects that darkroom chemicals have on you, and be extra careful about following safety procedures.

MIXING DRY POWDERS

While exposure to chemical solutions can be hazardous, the single greatest hazard to the darkroom worker is exposure to aerial-borne chemical powder and dust. Once most chemicals are in solution, they are so dilute as to be mostly harmless. This does not mean that they are safe with constant exposure, and some are never safe with any degree of exposure.

However, fine dust and powder can be damaging to the sensitive membranes of the sinuses and lungs. For this reason, the minimum precaution for mixing dry chemicals is to use a dust mask available in hardware stores and only mix in a room with good ventilation. If a dust mask is not available, mixing the chemicals outside is another option, though even outside, a dust mask is a good precaution.

THE SUBMERSION METHOD

A safe method for mixing prepackaged dry chemicals is one proposed by Richard Henry in *Controls in Black-and-White Photography*. Henry suggests cutting the top of the packet completely off with a pair of scissors then immersing the entire packet under water with a gloved hand. It is important to use a mixing container with an opening large enough for your hand to hold the packet under water and move it around to empty and dissolve the contents.

This method can also be used with chemicals that have been weighed on a scale. Weigh the chemicals in a plastic container, available from chemical supply houses, and simply immerse the entire container underwater. A dust mask should still be used while removing the powders from their storage containers.

MIXING SODIUM HYDROXIDE SOLUTIONS

Reprinted from *The Film Developing Cookbook,* 2nd edition, by Bill Troop and Steve Anchell, Focal Press, 2020. Used by permission.

Begin with cold water and have ice handy in case the solution starts to boil. If it does, drop in the ice and leave the room until it cools! If any of the material falls or splashes on you or the countertop, wash it off immediately with water. If you detect a soapy feeling on your skin, sodium hydroxide is present.

The cardinal rule when mixing sodium hydroxide is to add the chemical to the water or solution. **Never add water or solution to the sodium hydroxide**.

To begin, add a few pellets of sodium hydroxide to the cold water. Stir until dissolved. Monitor heat by touching the outside of the container. Keep on adding hydroxide slowly, a little at a time, allowing it to dissolve before adding more.

Always wear safety goggles when handling sodium hydroxide. In the event of a splash, rinse with cold water for 15 minutes and seek medical help immediately.

MIXING STRONG ACIDS

When mixing strong acids, such as hydrochloric or sulfuric, slowly add the acid to the water or solution, do not pour liquid on the acid, otherwise the solution may spatter causing serious burns to the hands or face. **Never add water to the acid**.

Dissolve the acid separately in cold, then add the cold solution to the formula, stirring vigorously. **DO NOT BREATHE THE VAPOR**.

It is highly recommended that you wear a face mask, gloves, and eye protection when working with acids in powder or solution. If any acid splashes on you or the counter, wash it off immediately with cold water for 15 minutes and seek medical attention immediately.

Always wear safety goggles when handling strong acids. In the event of a splash, rinse with cold water for 15 minutes and seek medical help immediately.

CHEMICAL STORAGE

Keep all chemicals away from children and pets. If necessary, lock up the chemicals. Label and date all bottles of mixed solutions—use white graphic arts tape. Do not use drink or food bottles for darkroom solutions that are not clearly relabeled. Be sure storage bottles have a secure cap. Protect all chemicals from air, heat, light, moisture, and contamination from other chemicals.

DISPOSAL AND SAFETY

When working with any chemical, you must assume the responsibility for its safe use and disposal. Follow any special instructions included with each chemical or process being used. Laws concerning disposal of chemicals vary widely. Contact the hazardous materials (HazMat) unit in your community. They will explain in detail exactly what you can and cannot do in terms of disposal in your area.

A Material Safety Data Sheet (MSDS), also known as a Safety Data Sheet (SDS), is a document that provides information on the safe handling, storage, and disposal of a chemical substance or mixture. Read MSDS/SDS sheets for disposal information. Do not mix any chemical with any other chemical unless you know it is safe to do so, see the Dangerous Mixtures of Chemicals section below.

Some noncorrosive liquids can be poured onto cat litter and placed in a plastic bag. Often, dry chemicals or contaminated materials can be disposed of by sealing them in a plastic bag. These should be left in a closed, outside dumpster. Do not mix liquid and solid waste together, as dangerous reactions might occur. Be sure to read and follow all safety recommendations that come with the chemicals.

For liquid disposal (e.g., spent developer, fixer, toner, etc.) in many countries, it is the water companies who must treat the effluent and thus regulate what may be disposed of. Those policies may vary in different regions in a country. Fixer and bleach fix (Blix) should be de-silvered before disposal.

In general, small quantities of chemistry do not need a license for disposal; however, larger commercial darkrooms and color processing labs usually require a license or permit, which will cover the maximum permitted volumes, and typically the level of silver in spent fixers must be 2 ppm or lower for discharge.

Some countries have stricter policies on liquid waste disposal. Belgium, Germany, and the Netherlands require photochemistry be disposed of through incineration in a qualified facility with flue gas purification. Fixer and bleach fix must be de-silvered first.

Follow instructions for proper disposal of all chemicals. Wash yourself and any equipment that has come into contact with any chemicals. Launder darkroom towels after each session. Dispose of gloves and disposable masks to avoid future contamination. Keep your workspace clean and uncontaminated.

Use soap with citric acid, such as orange, lemon, etc., to wash your hands. It will effectively neutralize anything that is alkali and wash away acids.

DANGEROUS MIXTURES OF CHEMICALS

Certain chemicals that are relatively innocuous by themselves may react dangerously, even explosively, when combined with other chemicals. Other combinations of chemicals may emit poisonous gases, such as cyanide fumes or chlorine. Dangerous mixtures of chemicals are shown in Table App1.1.

Do not mix any chemical with any other chemical unless you know it is safe to do so. Do not mix liquid and solid wastes together, as dangerous reactions might occur. Be sure to read and follow all safety recommendations that come with the chemicals.

ADDITIONAL INFORMATION

The Office of Radiation, Chemical and Biological Safety of Michigan State University, (517) 355–0153; www.ehs.msu.edu

Table App 1.1

DANGEROUS MIXTURES OF CHEMICALS

DO NOT COMBINE	*WITH*
Acetic acid	Chromic acid, nitric acid, peroxides, and permanganates
Ammonia	Halogens, calcium hypochlorite, or household bleach
Ammonia nitrate	Acids, chlorates, nitrates, combustible materials
Cyanides	All acids
Hydrogen peroxide	Most metals (particularly copper, chromium and iron) and their salts
Iodine	Ammonia
Nitric acid	Acetic, chromic or hydrocyanic acids, flammable substances
Oxalic acid	Silver
Potassium permanganate	Ethylene glycol, glycerol, benzaldehyde, and sulfuric acid
Sulfuric acid	Chlorates, perchlorates, and permanganates

Source: This table was compiled by Grant Haist and is reprinted from *The Film Developing Cookbook*.

CHEMICAL HAZARD HOTLINES

CHEMTREC CHEMTREC's Operations Center is available 24/7. CHEMTREC takes calls from anywhere in the world. CHEMTREC has interpretation capabilities in 240+ languages to assist non-English speakers during an emergency. CHEMTREC has immediate access to a library of over seven million material safety data sheets (SDS); +1 (800) 262-8200 (U.S.); +1 (703) 741-5500 (Worldwide); www.chemtrec.com

Ilford Emergency Response, North America, 24-hour hotline, (800) 842–9660

National Capital Poison Center connects you to local poison centers in the United States, (800) 222–1222, www.poison.org

National Poisons Information Service in the United Kingdom advises calling 111 for specific information on poisons. It advises health care professionals seeking poisons information to consult www.toxbase.org

Tox Info Suisse, 24-hour emergency hotline +1 44 251 5151 (Worldwide); inside Switzerland dial 145; www.toxi.ch

In the event of emergency situations (unintended incidents, such as a chemical spill, transport incident or unintended chemical exposure) please call the local number(s) below for immediate assistance.

The United States, Canada and México emergency response numbers are available for assistance 24 hours a day. Other regions offer emergency response support during regular business hours.

United States: 800-424-9300
Canada: 800-463-3216
Mexico SETIQ-ANIQ: 800-002-1400 & 55-5559-1588

South America

Argentina: CIQUIME 0800-222-2933 / 11 4552-8747
Argentina: Centro Nacional de Intoxicaciones 0800 333 0160
Brasil (orientações para emergência química - ABIQUIM / PROQUÍMICA): 0800 110 8270
Brasil (orientações para emergência ambiental - AMBIPAR): 0800 117 2020
Colombia, Bogotá: 288-6012 / 919 1919
Colombia, Fuera de Bogotá: 10 8000 916012
Chile CITUC: (+56-2) 2635-3600
Ecuador: 1800-59-3005
Venezuela: 800-62526
Estados Unidos: 703-527-3887 (Chemtrec, acepta llamadas por cobrar)

Europe

The emergency response numbers below are available for assistance 24 hours a day.

Trans European: +32 (0) 3 5755555
Austria: +43 720902372

Bulgaria: +359 24373541
Belgium: +32 35755555
Croatia: +385 18000010
Czech Republic: +420 228881362
Denmark: +45 78746855
Estonia: +372 8807977
Finland: +358 753252898
France: +33 975182341
Germany: +49 32 212249407
Great Britain: +44 1618841235
Greece: +30 2111987489
Hungary: +36 212111410
Ireland: +353 766805288
Italy: +39 694804893
Kazakhstan: +78 7273493094
Latvia: +371 67859955
Lithuania: +370 52140490
Netherlands: +31 852085762
Norway: +47 85295496
Poland: +48 222922722
Portugal: +351 308800808
Romania: +40 37-6300058
Russian Federation: +7 4956694219
Serbia: +381 0800-812-155
Slovakia: +421 233006502
Slovenia: +386 82880010
Spain: +34 902848598
Sweden: +46 101388060
Switzerland: +41 225181383
Ukraine: +380 893239806
Macedonia: +32 35755555

Asia Pacific

The emergency response numbers below are available for assistance during regular business hours.

Australia: 1800-205-506
China: 512-68255001 | Taiwan 00801-49-1821
Korea: 0-786-3116
India: 0-33-6740395
Indonesia: 62-21-8753175
Malaysia: 603-7628 5200
New Zealand: 0800-243-622
Philippines: 063-49-5451550
Singapore: 65-6861-4011
Thailand: 38-955-160

Appendix 2

Chemicals

> *"Photography, in the final analysis, can be reduced to a few simple principles. But, unlike most arts, it seems complex at the initial approach."*
>
> —Ansel Adams, 1948

Most of the chemicals used in the darkroom are safe and biodegradable. For example, the most common darkroom chemical, sodium sulfite, is a high grade of salt used as a food preservative and antioxidant. Borax is often used in laundry detergent, though it is toxic to plants, as are most laundry detergents. Sodium carbonate is used as a food additive for anticaking and acidity regulation.

Perhaps the most environmentally hazardous chemical commonly used is hydroquinone (HQ), found in many film and paper developers. HQ is anaerobic, that is, it absorbs oxygen from water; too much HQ can be harmful to algae and fish. The good news is that the trace amounts of HQ used in a home darkroom are not enough to be measured in the environment.

A few, such as selenium, pyrogallol, pyrocatechin, sodium hydroxide, and hydrochloric acid, require careful handling and disposal. Throughout *The Darkroom Cookbook* specific warnings and instructions will be given where appropriate.

The Pharmacopeia contains descriptions of most of the chemicals found in this book. Knowledge of these chemicals and their use will be of great advantage in manipulating formulas. This chapter is a general overview for those not familiar with handling chemicals.

OBTAINING CHEMICALS

Some of the chemicals can be obtained from photo suppliers. Less common chemicals, such as amidol and pyrogallol, can be obtained from various chemical suppliers. A few suppliers even specialize in photographic chemicals. Not all chemical suppliers will sell directly to the public. Some that do are listed in Material Sources.

NOMENCLATURE

Manufacturers often give their trade name to a chemical. For example, the developing agent monomethyl-*p*-aminophenol sulfate has been known as Kodak Elon, DuPont Rhodol, Defender Veritol, and others. Throughout *The Darkroom*

Cookbook, this widely used chemical will be referred to by its most common name, metol.

Spelling also varies between the United States and United Kingdom. For example, British spelling of sodium sulfite is sodium sulphite and sodium sulfate is spelled sodium sulphate. *The Darkroom Cookbook* will use the U.S. spelling.

CHEMICAL CLASSIFICATION

Chemicals come in different grades or classifications: analytical reagent (AR), pharmaceutical or practical, and technical or commercial.

- **AR.** Chemicals of AR quality are used primarily for analytical and testing purposes. Such chemicals meet the highest standard for purity and uniformity. Though they may be used for photographic work, they are the most expensive and not required. In the United States, AR-quality chemicals are labeled ACS (American Chemical Specification) and in the United Kingdom ANALAR™ (Analytical Analysed Reagents). ANALAR is a trademark of ANALAR Standards, Ltd., a subsidiary of British Drug House Chemicals, Ltd., a leading authority on international chemical standards.
- **Pharmaceutical or practical.** These chemicals meet the specifications of the U.S. Pharmacopeia (USP) or the National Formulary (NF). USP/NF-quality chemicals are approximately 97% pure and can be used for all photographic work. In United Kingdom, they are labeled either BP (British Pharmacopeia) or BPC (British Pharmaceutical Codex).
- **Technical or commercial.** These chemicals are primarily intended for use in manufacturing processes (e.g., making laundry detergents). In a few instances it may prove economical to use such chemicals, but generally speaking, they cannot be recommended for photographic work.

ANHYDROUS (DESICCATED), MONOHYDRATE, AND CRYSTALLINE

The terms anhydrous (desiccated), monohydrate, and crystalline are often a source of confusion. They refer to the various hydrate forms of some chemicals.

- Anhydrous and the older name desiccated mean “without water.”
- Monohydrate means that one water molecule is attached to the chemical’s molecule.
- Crystalline means that as many water molecules as possible are attached to the chemical’s molecule.

Monohydrate chemicals are generally the most stable. Anhydrous chemicals will try to absorb water from the air to become monohydrate. Crystalline chemicals will try to release their water to the air to become monohydrate. Due to these tendencies, it is important to store anhydrous and crystalline chemicals in airtight bottles to maintain their hydrate state.

The water bonded to the chemical makes the molecule weigh more. The extra weight is only water. In practice, this means that if a formula calls for an anhydrous chemical, you will need more monohydrate or crystalline chemical to make the same working concentration. You can use the sodium carbonate conversion table in Conversion Tables if you have a different hydrate than called for in the formula.

WEIGHTS AND MEASURES

Two systems of measurements are in common use for measuring and weighing: U.S. customary and metric. U.S. customary utilizes grains (gr), ounces (oz.), and pounds (lb.); metric uses grams (g) and milliliters (mL).

In this edition of *The Darkroom Cookbook*, formulas are only given in metric measurements. You do not need to know anything about the metric system. It's only numbers. Once you get used to it you will find it easier to calculate changes in measurements. For example, which is easier to add: 5 grams plus 10 grams (metric) or 73 grains plus 145 grains (U.S. customary)? Not convinced? Okay, try an exercise using liquid measures.

You need to make a 15% solution.

Example 1 – Metric: 15% of 1000 mL is 150 mL.

Example 2 – U.S. Customary: 15% of 32 oz. is, uh… let's see… 10% of 32 oz. is 3.2 oz., half of 3.2 is 1.6. Then 1.6 plus 3.2 is 4.8! That's it! Fifteen percent of 32 oz. is 4.8 oz!

I suggest you get used to working with metric measurements if you're going to mix your own formulas.

Even so, you may occasionally come across an older formula given in U.S. customary units. Should you wish to convert from one to the other, use the compound conversion chart found under Conversion Tables at the back of the book. This is because the figures are not directly interchangeable between U.S. customary and metric, because 1 liter of water does not exactly equal 32 oz. Therefore, they must be compounded to be equivalent.

PREPARING FORMULAS

Before attempting to mix any formula, read and follow all handling and safety instructions listed for the chemicals. Always wear protective equipment such as safety glasses, a plastic apron, rubber gloves, and a mask to avoid allergic reactions, burns, and irritation to the skin or lungs.

Refer to Appendix 1 for explicit safety instructions and for a list of 24-hour poison center hotlines.

Do's and Don'ts

- Never place raw chemicals directly on the scale. Chemicals can be weighed by placing a piece of filter paper on top of the pan or a nonpleated paper cup, such as a Dixie cup. The second method is preferred, as there is a tendency, when using paper, for the chemical to spill over the sides and make a mess. Instead of a paper cup, reusable plastic weighing cups can also be purchased from chemical suppliers.

- When mixing an acid, always pour the acid into the water. *Do not pour water into the acid*, as splattering can occur, causing dangerous burns. Be sure to wear eye protection.
- Use a funnel when pouring solutions into bottles.
- Tightly secure the top and label the bottle with the solution's name and date. Most developers keep for only a few months.
- Do not prepare formulas in the containers or tanks in which they are to be used. Glass or porcelain jars, wide-mouthed glass bottles, plastic beakers, or graduates are suitable for mixing.
- Never use metal other than stainless steel. In particular, do not use iron, copper, aluminum, or tin.
- Although solutions may be shaken to dissolve the ingredients, stirring is preferred, as shaking causes oxidation. When adding water, do so slowly and, whenever possible, indirectly (i.e., allow the water to run down the side of the mixing container rather than directly into the liquid). This will help to slow the rate of oxidation.
- Keep a record of what you do so you can adjust and customize the formulas.

Author's Note: There are a few exceptions to these do's and don'ts, particularly with some alternative processes. Follow instructions for the specific process.

Weighing Chemicals

A set of plastic or stainless steel measuring spoons will facilitate transferring chemicals from the bottle to the scales. They will help to prevent wasteful spills, which can cause contamination. Do not overfill the spoon; transfer a little at a time to prevent spilling.

Begin by placing the scale on a level, protected surface (e.g., newspaper or parchment paper) and zeroing it. Place a weighing cup in the middle of the balance pan. Always make allowance for the weight of the tare—the container the chemicals are in. If you are using a triple-beam balance without a built-in tare, weigh the cup first and subtract its weight from that of the chemical. When using a double-pan scale, place the same size cup in both pans so their weights will cancel each other.

Have all the chemicals to be used at hand in the order of use. Use a clean cup and spoon for each chemical to prevent contamination. Immediately recap the bottles to avoid confusion, spills, or contaminating one chemical with another.

A convenient method for weighing small amounts of chemicals is to place them on precut pieces of paper. Write the name and weight of each chemical on the paper and arrange the chemicals on the mixing bench in the order of use. For amounts over 20 grams, use a weighing cup instead.

Order of Dissolving

While in some cases it doesn't matter, unless otherwise specified, always dissolve the ingredients in the order given. No chemical should be added to a solution until all the other chemicals have been dissolved. Certain chemicals will not dissolve in the presence of other chemicals. Glycin, for example, should always be dissolved after the sulfite. It is usually dissolved last in most formulas.

In most developers, the sulfite is dissolved first because without a preservative, most developing agents easily oxidize in water. An exception is metol, which is mixed with difficulty in solutions containing a high concentration of sulfite. When mixing developers that contain metol, dissolve the metol before the sulfite. This has a minimal effect on the keeping properties of the metol, as it is not easily oxidized. Even so, many workers prefer to dissolve a pinch of sulfite before dissolving the metol to ensure against oxidation. The small amount of sulfite can be taken out of the premeasured amount.

Always begin with at least a quarter, or even a half, less water than called for by the formula. When all the chemicals have been dissolved, add cold water to make the required volume.

Water

The best way to ensure consistent results is to use deionized, distilled, or reverse osmosis (RO) water. However, if consistency is not an issue, unless a formula specifically calls for distilled water, in most cases, tap water can be used. Even when distilled water is indicated, good-quality, filtered tap water will usually suffice. A notable exception is those formulas that call for the use of pyrocatechin (catechol) or pyrogallic acid; these should always be formulated using deionized, distilled, or reverse osmosis water.

Author's Note: Although you can use tap water, you will achieve a higher level of quality and consistency if you use deionized, distilled, or RO water to mix all chemicals, especially film developers.

In areas where the water is hard, it can be treated with sodium hexametaphosphate or Calgon. Three g/L should be added before the other developing agents. Ethylenediaminetetraacetic acid (EDTA) can also be used, but it may increase the rate of aerial oxidation of the developing agents, possibly causing dichroic fog.

An alternative method is to allow the water to settle overnight and then decant the clear liquid, preferably through filter paper. This procedure is sufficient for most developers.

Formulas in Parts

Many formulas are given in parts. Parts can be converted into the equivalent number of grams and milliliters. For example, a formula calling for "1 part A to 1 part B to 1000 parts water" can be translated as "1 ml of A, 1 ml of B, to 1000 ml of water."

Often formulas in parts will be written as 1 + 1 + 1000 or 1:1:1000 or 1:1 to 1000 ml. Whichever way it is written, it comes out the same. The important point is to make sure that all the units are in the same system of measurement, either metric or U.S. customary in other words, grams with grams, ounces with ounces. This is also important when both liquids and solids are indicated in "parts." Be certain that solid ounces go with liquid fluid ounces and that solid grams go with liquid milliliters.

Author's Note: There is confusion about the difference between the meaning of "+" and ":" in photographic notation. In scientific use + means parts as in 1+3 (one part solution to 3 parts water) and ":" can mean parts but it can also represent a ratio. Kodak uses 1:3 in their formulas to refer to parts and Ilford uses 1+3. In either case that means 1 part formula to 3 parts water. In the DCB it will usually be written 1+3, but occasionally 1:3 (usually when I forget to change it during editing the manuscript).

Percentage Solutions

For convenience, and when the amount of a chemical may be too small to be weighed accurately, the amount is often given as a percentage solution. This can be simply stated as how many grams of a chemical are dissolved in 100 mL of water. For example, a 10% solution has 10 grams of a chemical dissolved in 100 mL of water.

Regardless of the amount used in the formula, the percentage is always the same. That means that every 10 mL of a 10% solution contains 1 gram of the chemical. If a formula requires 2 grams of chemical, use 20 mL of the percentage solution.

The following is an example of the use of percentage solutions. Suppose the formula calls for:

Potassium ferricyanide, 5.0 g
Potassium bromide, 1.5 g
Water to make 1.0 L

If we start with stock solutions of 10% potassium ferricyanide and 10% potassium bromide, we can quickly make our solution by multiplying the dry amount by 10 and taking:

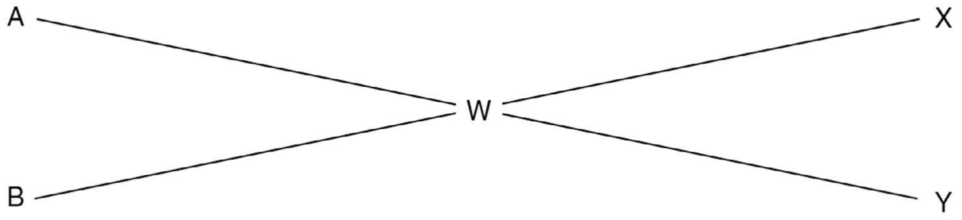
Potassium ferricyanide, 10% solution, 50.0 mL
Potassium bromide, 10% solution, 15.0 mL
Water to make 1.0 L

It is easy to see the advantage of this method, especially for chemicals that are often used in small amounts (e.g., Phenidone, potassium bromide, benzotriazole).

When mixing percentage solutions start with less than the total volume of water, after the chemical is fully dissolved, add the remaining water to make the required volume.

THE CRISSCROSS METHOD FOR DILUTING SOLUTIONS

An easy method for figuring dilutions is by the crisscross method. Place at A the percentage strength of the solution to be diluted and at B the percentage strength of the solution you wish to dilute with—in the case of water, this will be 0. Place at W the percentage strength desired. Now subtract W from A and place at Y. Also subtract B from W and place at X. If you take X parts of A and Y parts of B and mix, you will have a solution of the desired strength W.



For example: To dilute 99% Acetic Acid to 28%.
Take 28 parts 99% Acid and 71 parts water.

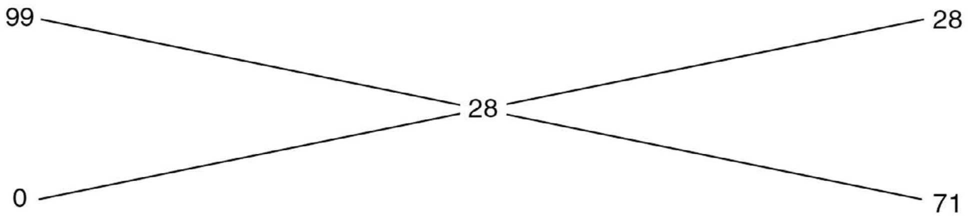


Figure App 2.1 Crisscross Chart.

Appendix 3

Proofing for Maximum Black

> *"It's not how you achieve the result; it's being able to repeat it."*
>
> —Daughtee Rogers

One of the most important habits to develop in the darkroom is consistency. Having achieved satisfactory results, you should be able to repeat them, alter them, and repeat the first result should it become necessary. In addition to being consistent in your work habits, it is important to practice standard procedures whenever possible. This will further facilitate the ultimate goal: to produce a perfect print.

One area of darkroom procedure that is conducive to standardization is making proof sheets. Standardizing how you make a proof sheet, doing so will streamline your workflow, help determine if your system is working properly—camera, meter, film, and developer. The method is known as proofing for maximum black.

Proofing for maximum black takes into consideration the base + fog density of the film and the maximum black that a given paper is capable of reproducing. The base + fog density is affected by the combination of film and developer. In theory this means that a test needs to be made for every film/developer combination you use. In practice you really only need to test one combination of film and developer for any given film as long as the paper remains the same. You will find that most film/developer combinations will proof for maximum black within a second of each other, and as the sole purpose is to achieve consistent results that can be compared, this is acceptable.

Before you can run your test, you need a strip of unexposed but developed and fixed film: four blank frames of 6 × 6, or three blank frames of 6 × 7, or five to six blank frames of 35mm, or one sheet of 4 × 5-inch sheet film. When using roll film hold the lens against your chest, set the f/stop to f/16 and the shutter speed at its fastest setting, and release and cock the shutter the appropriate number of times. The remaining film is yours to do as you like.

PROCEDURE FOR PROOFING FOR MAXIMUM BLACK

- With consistency in mind, choose a lens and negative carrier to use for all future proof sheets. It does not matter which you choose—just be consistent.
- With consistency in mind, raise the enlarger head to a comfortable working height. This should be about the height to make an 11 × 14–inch

print. If the enlarger column has a scale on it, make a note of this height and use it for all future proof sheets. If it does not have a scale, then mark the column with a white or black indelible marking pen or tape.

- Stop the lens down one stop. If you are using graded paper, choose grade 1 or 2. If you are using variable-contrast paper, use filter 1½ or 2.
- Rough focus the light on the baseboard. It does not have to be sharply focused.
- Place the proofing frame in the center of the light projected on the baseboard or easel. I place a contact printing frame in the center of an 11 × 14–inch easel so I can easily reposition it should it get moved.
- Place a sheet of enlarging paper,[1] emulsion side up, in the contact printing frame and lay an unexposed strip of negatives or a single 4 × 5–inch sheet of unexposed but developed and fixed film on top, emulsion side down. Close the glass and give a 2-second exposure to the entire negative and paper.
- Cover ½ inch of the negative with a piece of cardboard and give another 2-second exposure. Do not use paper to cover the negative, as light will migrate through and fog your enlarging paper.
- Continue giving 2-second exposures, moving the cardboard ½ inch between exposures until you reach the end of the blank film strip.
- Develop the paper for 2 minutes, wash, and fix. As with everything else, standardize on the paper developer and dilution.

Turn on the room light, squeegee the excess water from the print, and place it in your customary viewing light. It does not matter if you dry the print first or look at it while wet as long as you are satisfied with the final results and are consistent in how you achieved them. You will see a progression of strips across the film from light gray to pure black. Look for two adjoining black strips in which you cannot see any difference between them. This is the maximum black point, and there is no reason to give more exposure. Choose the shorter time of the two adjoining strips as your new time for proofing all negatives made with that film/developer combination on that enlarging paper at that f/stop and at that enlarger height. This is now your standard proofing setup. Test other film developer combinations to be completely accurate (recommended), or use this setup for all developers with this same emulsion.

Proofing for maximum black is not the only way to make proof sheets, but it is a way to standardize making proof sheets. By proofing for maximum black, you will streamline your working procedure, getting through the proofing stage and onto the printing stage in the shortest time possible. You will also have a standard by which to judge your negative quality. If your images are too dark, you will know that you are underexposing or underdeveloping your film. If the images are too light, you will know that you are overexposing or overdeveloping your film. If your exposures are consistently good and one day they start to appear uneven or too light or dark, there is a chance there is something wrong with your camera or light meter.

---

[1] It is not necessary to use your regular enlarging paper, though it's not a bad idea. Some workers like to use RC for proofing; I prefer to use FB.

Special Considerations

1. If the maximum black proofing time is less than 10 seconds, close the lens one stop and retest.
2. If there is no maximum black within the initial test, open the lens one stop and retest. If there is still no maximum black, give an overall first exposure between 10 and 16 seconds, cover the first strip, and continue with 2-second exposures. If this fails to produce a maximum black, then switch to using 3-second exposures instead of 2.

Appendix 4

Archival Print Procedure

> *"There was never anything by the wit of man so well devised or so sure established, which in continuance of time hath not been corrupted."*
>
> —Book of Common Prayer, 1549

To photographers, archival usually means negatives and prints that will last at least a century. Unfortunately, nobody knows for certain what will enable a print to last that long. Every time definitive research is announced, the Image Permanence Institute, Ilford, or anyone else involved in archival research, finds a spot on a print or negative that is supposedly archival by the new standard.

Until recently it was thought that toning with selenium at high dilutions (1:19, 1:29, etc.) would create an archival image. Research now shows that unless selenium is used to completion, resulting in a color shift, the print is only partially protected.

It was believed that mounting on 100% rag board with tape hinges would create an archival presentation for the image. It turns out that rag board absorbs and retains pollutants and will pass them on to a print. In a day? No. But certainly well within the 100 years we hope to achieve.

In the meantime, it has been discovered that dry mounting tissue can act as a barrier to the pollutants in rag board—unless the tissue is itself full of contaminants, and who is to say that the mounting tissue companies have done their homework? There is no government agency that says they can't call their tissue archival even if it is made of wood pulp and acid. And what happens to a print that is permanently mounted on a board when the board becomes damaged?

And so on.

There are several reasons a photographer/artist would want their prints to last beyond their years. The most obvious is that it raises the value of their art among collectors. It has become *de rigueur* that a print be "archivally" processed in order to demand more in the marketplace.

A second reason could be that a photographer/artist wishes to be remembered in 100 years. This is laudable. We all wish to be remembered. It is one of the reasons we have children and hope for grandchildren. For some photographers, their prints *are* their children. Unfortunately for those who see their prints as a gateway to immortality, it is doubtful that any of us will be remembered in 100 years. Perhaps Ansel Adams. For the rest, hope springs eternal.

A third reason is pride of craftsmanship. While our vision is our art, translating our vision to a print is our craft, and when we pass a print on to someone—a friend, a collector, a museum—pride dictates that it possesses the highest standards of quality. This to me is the most important reason for archival processing. You can chose your own favorite from those listed.

It has been shown in accelerated aging tests that the problem is rarely due to poor processing alone. The negatives and prints of photographers working in the nineteenth century were not processed to today's archival standards, and many of them are still held in collections with little or no deterioration. The problem it seems is not in processing or choice of mount board, it is one of environmental pollutants and in storage, two variables photographers often have no control over.

Regardless of our best intentions, once a print leaves our hands it may not last a day. It can be folded or torn. Coffee or worse can be spilt on it. It can be exhibited in an office overlooking a busy street with sunlight streaming in through the window.

What do we do? The best we can based on our collective photographic knowledge gained through experience and accelerated aging tests.

The following procedure is the one I use but is only one of several. It will help to produce prints that are archival by a photographer's definition. In any event, you would be well served to remember the opening quote to this appendix when attempting to create archival prints and negatives.

SELENIUM TONING FOR ARCHIVAL PRINTS

Begin by using wide borders when making prints, at least ½ inch all around. This is because residual chemicals are more likely to enter the edges of the print and can be difficult to remove even with washing. Wide borders can be trimmed off, removing the chemicals.

Selenium toner contains sodium sulfide that requires removal through washing. Hypo clearing agent (HCA) is effective at removing the sulfide.

Some workers recommend that instead of diluting the stock selenium toner with plain water to mix it with a working solution of HCA, which breaks down the sulfide while the toning is taking place. This helps to reduce the wet time by eliminating the need for HCA after toning. However, it will shorten the life of the selenium toner. The useful life of HCA is approximately eighty 8 × 10-inch prints or equivalent films, and the useful life of selenium toner is at least two hundred 8 × 10-inch prints or equivalent. When the HCA is exhausted, the bath must be replaced, which is a waste of selenium toner and results in more selenium being introduced into the environment. A better solution for both the environment and your pocketbook is to dilute the selenium toner with water and use the HCA bath after toning and before washing, as originally intended.

Procedure

1. After development, place the print in running water for 1 minute—do not use an acid stop bath.
2. Fix the print in alkaline fixer without hardener for 1 minute with continuous agitation. Do not overuse the fixer; generally you should be able to fix one hundred 8 × 10-inch prints per 4 liters/gallon (25 per liter/quart).
3. Drain and fix the print in a second fresh alkaline fixer without hardener for 2 minutes with continuous agitation. Use this fixer to replace the first fixer when the first fixer reaches exhaustion.
4. Rinse the prints for 3 minutes in running water to extend the capacity of the selenium toner (see the next step).

5. Selenium tone for 5 minutes. The dilution will vary depending on the paper. The first time you work with a new paper, test the first print in a dilution of 1:19. Have an identical wet but untoned print to compare against. If a noticeable color shift occurs try a 1:29 dilution, then 1:39 if necessary. Color shifts will usually be observed at about the 3-minute mark.
6. After toning immerse the print for 5 full minutes in HCA with continuous agitation.
7. At this point place the prints in a vertical washer if one is available or move them to a holding bath of running water until all prints are ready to be washed.
8. Wash the prints for 20–30 minutes in a vertical washer. If no vertical washer is available, shuffle them every few minutes in a deep tray with running water. If washing in a tray, make certain that they are floating back-to-back and face-to-face (see later).
9. Squeegee the front and back of each print and place them on print drying racks with a nylon screen, either face up or down, or hang them by one corner using stainless steel film clips in a dryer. If you have taken the precaution of leaving half-inch borders, you can use wooden clothespins.

Author's Notes:

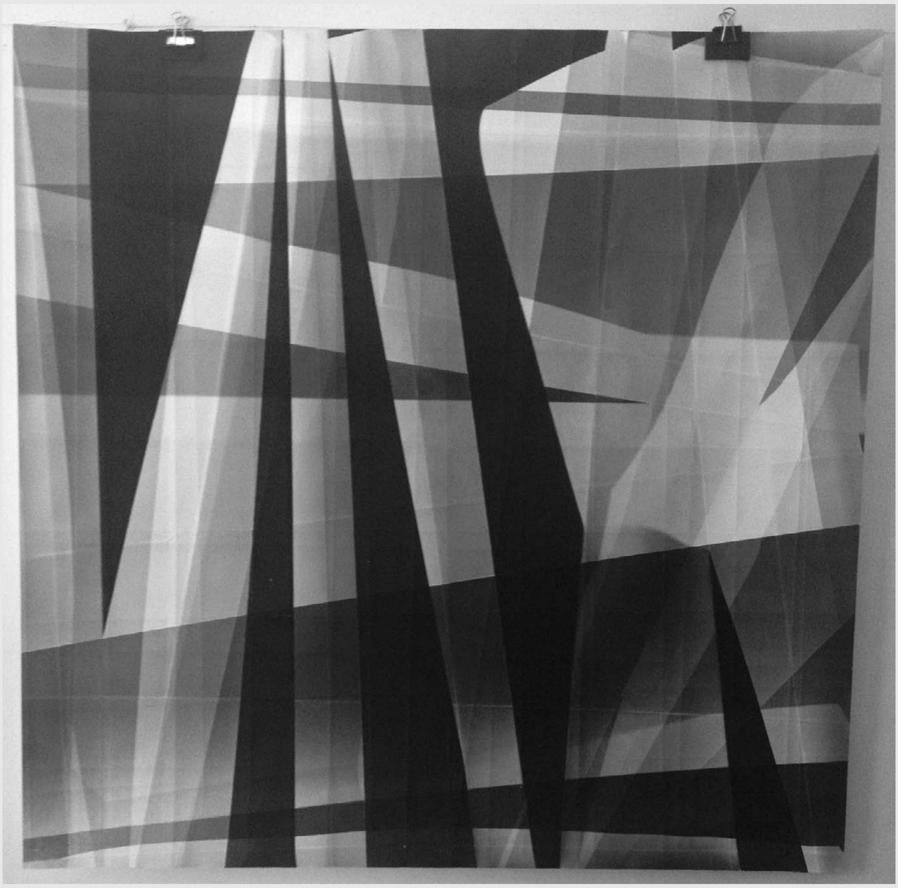
1. Multiple prints may be processed simultaneously. However, it is critical that they be placed in solution back-to-back and face-to-face. Never place prints face-to-back.
2. Unless the first fix has reached exhaustion (which it should not if you only process one hundred 8 × 10-inch prints per 4 liters), the print will be completely fixed by the time it is moved to the second bath. The second bath acts as insurance, converting any remaining argentothiosulfates into soluble by-products that can be easily washed out. It is not necessary to count prints in the second bath until it is moved to the first position.
3. After the first or second fixer has been completed, the print may be washed for 15 minutes and dried before selenium toning within a few weeks. If this is done, the dry print needs to be soaked for 5 minutes before continuing the process.
4. Selenium toner, if used for 5 minutes at a high enough dilution to avoid color shifts, is believed to protect the densest areas in the print (shadows) but not the midtones and highlights. And while some protection is better than none, you may wish to use a lower dilution, 1:6 or 1:9, and accept the resulting color shift, or if you are willing for your prints to be brown toned use a polysulfide toner instead of selenium, or use a highly dilute version of polysulfide toner, 1:100, or use Kodak GP-2 Gold Protective Toner instead of selenium.
5. The purpose of a vertical washer is to keep the prints separated while the water flows over them. Even if one side of the print appears to stick to the vertical dividers, the constant flow of water will leach out any chemicals in the paper through the back of the print.
6. There is only one requirement to achieve a complete and thorough washing of prints or negatives: a continuous flow of fresh water. The flow rate is not significant, as long as it is continuous—air bubbles are superfluous, though they look cool and demand a higher price for the washer.

7. Under no circumstances should prints be allowed to wash for more than 1 hour; the prolonged immersion in water will weaken the fiber of the paper, shortening its life. All of your archival processing will be a waste if the paper begins to come apart in 20 years.
8. Be certain there are no residual chemicals on the drying rack. The best way to clean residual fixer from a washer, print drying racks, trays, sink, and other surfaces is with a solution of common household bleach diluted 1:4 with water (200 mL of bleach with 800 mL of water). Sponge the bleach solution on and thoroughly wash it off with fresh water.

Amanda Means

Alternative Means

I'm scoring, folding, crushing, and letting the developer drip down the paper's surface.



Folded & Crushed #38, 2016. Silver print with darkroom manipulation. © Amanda Means. All rights reserved. Courtesy of the artist.

Appendix 5

Time Adjustment for Enlarging and Reducing Prints (Inverse Square Law)

Daughtee Rogers taught me this simple calculation in the early 1970s for adjusting print time. Once learned, it will save you time and paper. The only thing you need is a cell phone with a calculator app. Before your eyes cross, remember that if I can figure this out, you can, too.

T(ime)
L(ength)

$$\frac{(T1\ x\ L2)^2}{(L1)^2} = \mathrm{T2}$$

T1 = Original exposure time
L1 = Original length
L2 = New length
T2 = Adjusted exposure time

1. Measure the distance between two points on the print (*L*1).
2. Enlarge or reduce the image and measure the same two points (*L*2).
3. Use the formula.
4. If you are using inches as your unit of measure, convert fractions to decimals as follows:

   ½ inch = 0.5
   ¼ inch = 0.25
   ⅛ inch = 0.125
   1⁄16 inch = 0.0625

Example
You make an 8 × 10–inch print and want to enlarge it to 11 × 14 inches. First measure the distance between two widely spaced points. You can measure on the wet print or the image projected on the easel. You can round off the measurements to whole numbers, but the more accurate you are, the more exact the adjusted time. But if you're off by a little, you will still be close to the adjusted printing time.

In the photo of the Pan Pacific Auditorium, the measured distance on the 8 × 10–inch print is 7¼-inch (7.25). Enlarging the print to 11 × 14 inches increases the length to 10⅛-inch (10.125). Assuming the initial exposure was f/11 at 18 seconds, the calculation would be as follows:

18 (*T*1) × 105 (*L*2 × *L*2) = 1890 / 53 (*L*1 × *L*1) = 35.7

18 × 105 = 1890 / 53 = 35.7 seconds (round up to 36)

Your new exposure is f/11 at 36 seconds. The calculation works for reducing the size of the print as well. Easy-peezy.

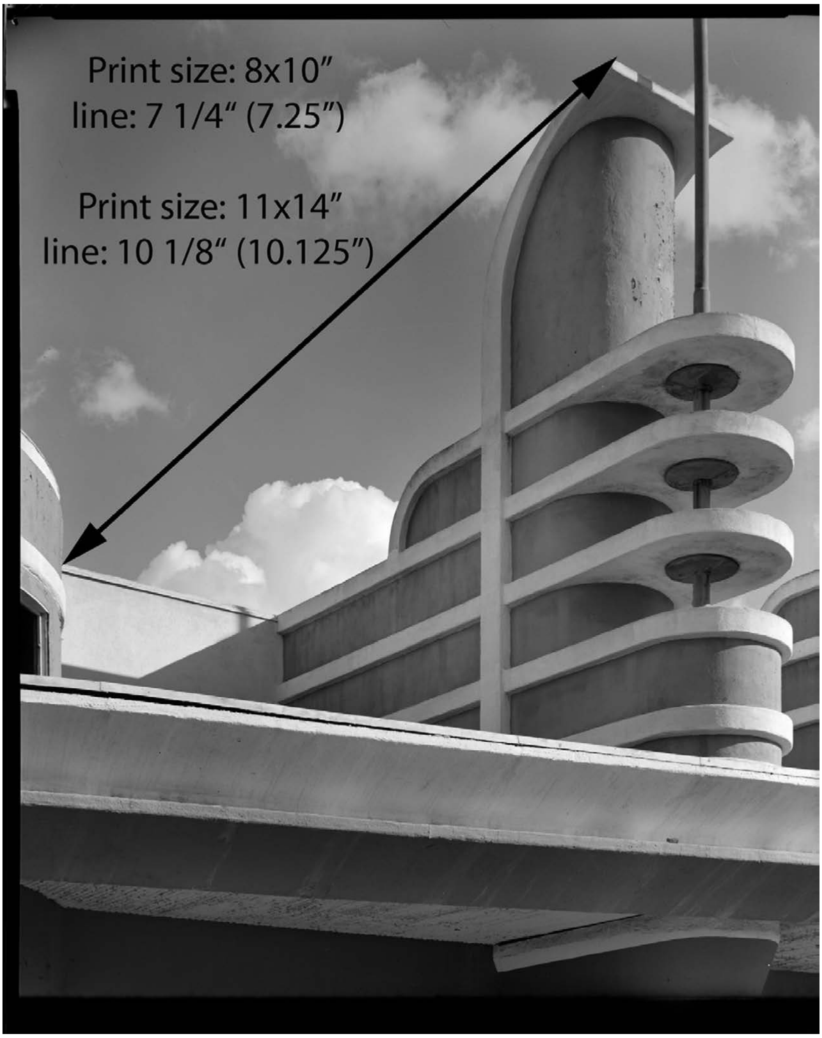


Figure App 5.1 Measure the same two points on the original print and the enlarged (or reduced) print.

Conversion Tables

DIRECT EQUIVALENTS

For direct conversions between metric and U.S. customary units, use the following tables. However, if you intend to convert an entire U.S. customary formula using 32 ounces of liquid to a metric formula using 1 liter, or vice versa, use the compound equivalents following these tables. To convert an individual measure, use the direct equivalents.

Direct Conversions

Ounces × 28.35 = grams
Grams × 0.0353 = ounces
Pounds × 453.6 = grams

U.S. Customary Solid Measures

1 pound = 16 ounces
1 pound = 7000 grains
1 pound = 453.6 grams
1 ounce = 0.0625 pounds
1 ounce = 437.5 grains
1 ounce = 28.35 grams
1 grain = 0.0648 grams

U.S. Customary Liquid Measures

1 gallon = 4 quarts
1 gallon = 128 fl oz
1 gallon = 1024 fl drams
1 gallon = 3785 mL
1 gallon = 3.785 liters
1 quart = 0.25 gallons
1 quart = 32 fl oz
1 quart = 256 fl drams
1 quart = 946.3 mL
1 quart = 0.9463 liters
1 fl oz = 8 fl drams
1 fl oz = 29.57 mL
1 fl oz = 0.02957 liters
1 fl dram = 0.000975 gallons
1 fl dram = 0.0039 quarts
1 fl dram = 0.125 fl oz
1 fl dram = 3.697 mL
1 fl dram = 0.003697 liters

Metric Solid Measures

1000 grams = 2.205 pounds
1 gram = 0.03527 ounces
1 gram = 15.43 grains

Metric Liquid Measures

1 liter = 1000 mL
1 liter = 270.5 fl drams
1 liter = 33.81 fl oz
1 liter = 1.057 quarts
1 liter = 0.2642 gallons
1 mL = 0.001 liters
1 mL = 0.2705 fl drams
1 mL = 0.03381 fl oz

Liquid Measurements Conversions

		Teaspoon	*US Volume*	*Metric*	*Misc.*
1 teaspoon (tsp.)	=	⅓ Tblsp.		5 mL	75–100 drops
3 tsp.	=	1 Tblsp.	½ oz.	15 mL	
2 Tablespoon (Tblsp.)	=		1 oz.	30 mL	
8 ounces (oz.)	=	48 tsp. 16 Tblsp.	1 cup	237 mL	
2 cups	=			437 mL	
2 pints	=		32 oz. 1 quart	946 mL	
4 quarts	=		1 gallon	3785 mL	

Direct Equivalents from U.S. Customary to Metric Units

Fluid Ounces to Milliliters		*Fluid Ounces to Milliliters*		*Fluid Ounces to Milliliters*		*Fluid Ounces to Milliliters*	
fl oz	*mL*	*fl oz*	*mL*	*fl oz*	*mL*	*fl oz*	*mL*
1	30	1.69	50	11	325	13.52	400
2	59	2.54	75	12	355	15.21	450
3	89	3.38	100	13	384	16.91	500
4	118	5.07	150	14	414	25.36	750
5	148	5.92	175	15	444	30.43	900
6	177	6.76	200	16	473	33.81	1000
7	207	7.61	225	24	710	67.63	2000
8	237	8.45	250	32	946	101.44	3000
9	266	10.14	300	64	1892	135.26	4000
10	296	11.83	350	128	3785	169.07	5000

Grains to Grams		*Grains to Ounces*		*Grams to Ounces*		*Ounces to Grams*	
Grains	*Grams*	*Grains*	*Ounces*	*Grams*	*Ounces*	*Ounces*	*Grams*
1	0.06	30	0.07	5	0.18	1	28.3
2	0.13	50	0.11	10	0.35	2	56.7
3	0.19	60	0.14	15	0.53	3	85.0
4	0.26	80	0.18	20	0.71	4	113.4
5	0.32	90	0.21	25	0.88	5	141.7
6	0.39	100	0.23	50	1.76	6	170.1
7	0.45	150	0.34	100	3.53	7	198.4
8	0.52	200	0.46	150	5.29	8	226.8
9	0.58	250	0.57	200	7.05	9	255.1
10	0.65	300	0.69	250	8.81	10	283.5
15	0.97	400	0.92	300	10.58	11	311.8
20	1.30	500	1.15	350	12.34	12	340.2
25	1.62	750	1.72	400	14.10	13	368.5
30	1.94	1000	2.29	450	15.87	14	396.9
35	2.27	2000	4.58	500	17.63	15	425.2
40	2.59	3000	6.88	600	21.16	16	453.6
45	2.92	4000	9.16	800	28.21	24	680.4
50	3.24	5000	11.45	1000	35.27	32	907.2
75	4.86	6000	13.75				
100	6.48	7000	16.00				
500	32.40						
1000	64.80						

COMPOUND CONVERSIONS

Although 1 ounce equals 28.35 grams, the conversion between U.S. customary and metric amounts is not equivalent. This is because a liter is slightly more than 32 ounces (1 quart). This means that it takes 30 grams in 1 liter to make the same working-strength solution as 1 ounce in 1 quart. Therefore, if you need to convert a U.S. customary formula into a metric formula, or the other way around, you need to compound the amount of chemical used in order that the percentage of chemistry remains the same in both formulas.

The following dry and liquid tables will help you quickly make compound conversions. Any amount not found in one of the tables can be converted by using one of the compound conversion formulas given here:

Grams/liter × 14.6 = grains/32 ounces
Grams/liter × 0.03338 = ounces/32 ounces
Grams/liter × 0.002086 = pounds/32 ounces

The following compound conversion formulas can be used to convert from U.S. customary to grams/liter:

Grains/32 ounces × 0.06847 = grams/liter
Ounces/32 ounces × 29.96 = grams/liter
Pounds/32 ounces × 479.3 = grams/liter

The following compound conversion formula can be used to convert liquid measures from metric to U.S. customary:

mL × 0.032 = fl ounces

The following compound conversion formula can be used to convert liquid measures from U.S. customary to metric:

fl ounces × 31.25 = mL

The smaller the amount, the more critical it is to be accurate. For example, the difference between 100 grams of sodium sulfite and 101 grams is an error of 1%. The difference between 1 gram of sodium sulfite and 1.1 grams is a 10% error.

DRY MEASURE COMPOUND EQUIVALENTS

The tables in this section, one for dry measures and the other for liquids, show the conversions for many of the most commonly used amounts, from metric on the left to U.S. customary on the right.

Grams = Grains
0.1 = 1.5
0.2 = 2.9
0.7 = 10
0.8 = 11.7
0.9 = 13
1.0 = 14.6
1.1 = 16
1.2 = 17.5
1.25 = 18
1.3 = 19

0.25 = 3.7
0.3 = 4.4
0.4 = 5.8
5.5 = 80
5.6 = 81
5.7 = 83
5.75 = 84
5.8 = 85
5.9 = 86
6.0 = 88
6.1 = 89

0.5 = 7.3
0.55 = 8
0.6 = 8.8
11.5 = 168
12.0 = 175
12.5 = 183
13.0 = 190
13.5 = 197
14.0 = 204
14.5 = 212
15.0 = 219(½ oz)

1.4 = 20
1.5 = 22
1.6 = 23
1.7 = 24.8
1.75 = 25.6
1.8 = 26
1.9 = 27.7
2.0 = 29
2.1 = 30.7
2.2 = 32
2.3 = 33.6
2.4 = 35
2.5 = 36.5
2.6 = 38
2.7 = 39.4
2.75 = 40
2.8 = 41
2.9 = 42
3.0 = 44
3.1 = 45
3.2 = 47
3.3 = 48
3.4 = 49.6
3.5 = 51
3.6 = 52.6
3.7 = 54
3.75 = 54.8 (⅛oz)
3.8 = 55.5
3.9 = 57
4.0 = 58.4
4.1 = 60
4.2 = 61
4.3 = 62.8
4.4 = 64
4.5 = 65.7
4.6 = 67
4.7 = 68.6
4.75 = 69
4.8 = 70
4.9 = 71.5
5.0 = 73
5.1 = 74
5.2 = 76
5.3 = 77
5.4 = 79
6.2 = 91
6.3 = 92
6.4 = 93
6.5 = 95
6.6 = 96
6.7 = 98
6.75 = 98.6
6.8 = 99
6.9 = 101
7.0 = 102
7.1 = 103.7
7.2 = 105
7.3 = 106.6
7.4 = 108
7.5 = 109.5 (¼ oz)
7.6 = 111
7.7= 112
7.75 = 113
7.8 = 114
7.9 = 115
8.0 = 117
8.1 = 118
8.2 = 120
8.3 = 121
8.4 = 123
8.5 = 124
8.6 = 126
8.7 = 127
8.75 = 127.8
8.8 = 129
8.9 = 130
9.0 = 131
9.1 = 133
9.2 = 134
9.3 = 136
9.4 = 137
9.5 = 139
9.6 = 140
9.7 = 142
9.75 = 142.4
9.8 = 143
9.9 = 145
10.0 = 146
10.5 = 153
11.0 = 161
15.5 = 226
16.0 = 234
16.5 = 241
17.0 = 248
17.5 = 256
18.0 = 263
18.5 = 270
19.0 = 277
20.0 = 292
21.0 = 307
22.0 = 321
22.5 = 329(¾ oz)
23.0 = 336
24.0 = 350
25.0 = 365
26.0 = 380
27.0 = 394
28.0 = 409
29.0 = 423
30.0 = 438 (1 oz)
35.0 = 1 oz 73 grains
40.0 = 1 oz 146 grains
45.0 = 1 oz 219 grains (1½ oz)
50.0 = 1 oz 292 grains
55.0 = 1 oz 365 grains
60.0 = 2 oz
65.0 = 2 oz 73 grains
70.0 = 2 oz 146 grains
75.0 = 2 oz 219 grains
80.0 = 2 oz 292 grains
85.0 = 2 oz 365 grains
90.0 = 3 oz
95.0 = 3 oz 73 grains
100 = 3 oz 146 grains
105 = 3 oz 219 grains
110 = 3 oz 292 grains
115 = 3 oz 365 grains
120 = 4 oz
125 = 4 oz 73 grains
130 = 4 oz 146 grains
135 = 4 oz 219 grains
140 = 4 oz 292 grains
145 = 4 oz 365 grains
150 = 5 oz
155 = 5 oz 73 grains
160 = 5 oz 146 grains
165 = 5 oz 219 grains
170 = 5 oz 292 grains
175 = 5 oz 365 grains
180 = 6 oz
185 = 6 oz 73 grains
190 = 6 oz 146 grains
195 = 6 oz 219 grains
200 = 6 oz 292 grains
210 = 7 oz
225 = 7 oz 219 grains
240 = 8 oz
390 = 13 oz
400 = 13 oz 146 grains
420 = 14 oz
425 = 14 oz 73 grains
450 = 15 oz
475 = 15 oz 365 grains
480 = 16 oz
500 = 16 oz 292 grains
510 = 17 oz
525 = 17 oz 219 grains
540 = 18 oz
550 = 18 oz 146 grains
700 = 23 oz 146 grains
720 = 24 oz
725 = 24 oz 73 grains
750 = 25 oz
775 = 25 oz 365 grains
780 = 26 oz
800 = 26 oz 292 grains
810 = 27 oz
825 = 27 oz 219 grains
840 = 28 oz
850 = 28 oz 146 grains
870 = 29 oz

250 = 8 oz 146 grains
270 = 9 oz
275 = 9 oz 73 grains
300 = 10 oz
325 = 10 oz 365 grains
330 = 11 oz
350 = 11 oz 292 grains
360 = 12 oz
375 = 12 oz 219 grains
570 = 19 oz
575 = 19 oz 73 grains
600 = 20 oz
625 = 20 oz 365 grains
630 = 21 oz
650 = 21 oz 292 grains
660 = 22 oz
675 = 22 oz 219 grains
690 = 23 oz
875 = 29 oz 73 grains
900 = 30 oz
925 = 30 oz 365 grains
930 = 31 oz
950 = 31 oz 292 grains
960 = 32 oz
975 = 32 oz 219 grains
990 = 33 oz
1000 = 33 oz 146 grains

LIQUID MEASURE COMPOUND EQUIVALENTS

Milliliters = Ounces
0.3 mL = 5 minims
1 mL = 0.032 fl oz (¼ fl dram)
1.1 mL = 0.035 fl oz
1.2 mL = 0.038 fl oz
1.3 mL = 0.042 fl oz
1.4 mL = –0.045 fl oz
1.5 mL = 0.048 fl oz
1.6 mL = 0.051 fl oz
1.7 mL = 0.054 fl oz
1.8 mL = 0.058 fl oz
1.9 mL = 0.06 (½ fl dram)
2 mL = 0.064 fl oz
2.25 mL = 0.072 fl oz
2.5 mL = 0.08 fl oz
2.75 mL = 0.088 fl oz
2.8 mL = 0.09 (¾ fl dram)
3 mL = 0.096 fl oz
3.5 mL = 0.11 fl oz
3.75 mL = 0.12 fl oz
3.9 mL = ⅛ fl oz (1 fl dram)
4 mL = 0.128 fl oz
4.25 mL = 0.136 fl oz
4.5 mL = 0.144 fl oz
5 mL = 0.16 fl oz (1¼ fl drams)
5.5 mL = 0.176 fl oz
6 mL = 0.19 fl oz
6.5 mL = 0.2 fl oz
7 mL = 0.22 fl oz
7.5 mL = 0.24 fl oz
7.8 mL = ¼ fl oz (2 fl drams)
8 mL = 0.256 fl oz
8.5 mL = 0.27 fl oz
9 mL = 0.288 fl oz
9.5 mL = 0.3 fl oz
10 mL = 0.32 fl oz (2½ fl drams)
11 mL = 0.35 fl oz
11.7 mL = ⅜ fl oz (3 fl drams)
12 mL = 0.38 fl oz
13 mL = 0.4l6 fl oz
14 mL = 0.448 fl oz
15 mL = 0.48 fl oz
15.6 mL = ½ fl oz (4 fl drams)
16 mL = 0.51 fl oz
17 mL = 0.54 fl oz
18 mL = 0.576 fl oz
19 mL = 0.608 fl oz
19.5 mL = ⅝ fl oz (5 fl drams)
20 mL = 0.64 fl oz
23.5 mL = ¾ fl oz (6 fl drams)
25 mL = 0.8 fl oz
27.3 mL = ⅞ fl oz (7 fl drams)
30 mL = 0.96 fl oz
31.3 mL = l fl oz (8 fl drams)
35 mL = 1.12 oz
39 mL = l¼ fl oz
40 mL = 1.28 fl oz
45 mL = 1.44 fl oz
46.9 mL = l½ fl oz
50 mL = 1.6 fl oz
55 mL = l¾ fl oz
60 mL = 1.9 fl oz
62.5 mL = 2 fl oz
65 mL = 2.08 fl oz
70 mL = 2.2 fl oz
75 mL = 2.4 fl oz
78.2 mL = 2½ fl oz
80 mL = 2.56 fl oz
85 mL = 2.7 fl oz
90 mL = 2.88 fl oz
93.8 mL = 3 fl oz
100 mL = 3.2 fl oz
110 mL = 3½ fl oz
125 mL = 4 fl oz
150 mL = 4.8 fl oz
156.3 mL = 5 fl oz
175 mL = 5.6 fl oz
187.5 mL = 6 fl oz
200 mL = 6.4 fl oz
203 mL = 6½ fl oz
218.8 mL = 7 fl oz
225 mL = 7.2 fl oz
250 mL = 8 fl oz
275 mL = 8.8 fl oz
281.3 mL = 9 fl oz
300 mL = 9.6 fl oz
312.5 mL = l0 fl oz
325 mL = 10.4 fl oz
344 mL = 11 fl oz
350 mL =11.2 fl oz
375 mL = 12 fl oz
400 mL = 12.8 fl oz
407 mL = 13 fl oz
425 mL = 13.6 fl oz
438 mL = 14 fl oz
450 mL = 14.4 fl oz
470 mL = 15 fl oz
475 mL = 15.2 fl oz
500 mL = I6 fl oz
532 mL = 17 fl oz
550 mL = 17.6 fl oz
563 mL = 18 fl oz
595 mL = 19 fl oz
600 mL = 19.2 fl oz
626 mL = 20 fl oz
650 mL = 20.8 fl oz
657 mL = 21 fl oz
689 mL = 22 fl oz
700 mL = 22.4 fl oz
720 mL = 23 fl oz
750 mL = 24 fl oz
775 mL = 24.8 fl oz
782.5 mL = 25 fl oz
800 mL = 25.6 fl oz
814 mL = 26 fl oz
845 mL = 27 fl oz
850 mL = 27.2 fl oz
876 mL = 28 fl oz
900 mL = 28.8 fl oz
908 mL = 29 fl oz
939 mL =30 fl oz
950 mL = 30.4 fl oz
970 mL = 31 fl oz
975 mL = 31.2 fl oz
1000 mL = 32 fl oz

CHEMICAL SUBSTITUTIONS

Alkali Substitutions

Alkalies can sometimes be substituted one for another, but only within a particular family. The three families are mild, alkali, and caustic. Even within a family, there may be limitations on substitutions. The only way to be sure is to test.

The Formula Specifies:	*You Have:*	*Multiply By:*
Borax, deca.	Borax, penta.	0.76
Borax, penta.	Borax, deca.	1.32
Potassium carbonate, anhyd.	Sodium carbonate, mono.	0.90
Sodium carbonate, mono.	Potassium carbonate, anhyd.	1.12
Potassium hydroxide	Sodium hydroxide	1.40
Sodium hydroxide	Potassium hydroxide	0.72
Sodium carbonate, mono.	Sodium metaborate	1.70
Sodium metaborate	Sodium carbonate, mono.	0.59

Other Substitutions

The Formula Specifies:	*You Have:*	*Multiply By:*
Acetic acid, glacial	Acetic acid, 28%	3.54
Acetic acid, 28%	Acetic acid, glacial	0.28
Aluminum alum	Ammonium alum	1.5
Ammonium alum	Aluminum alum	0.67
Ascorbic acid	Sodium ascorbate	1.125
Ascorbic acid	Sodium isoascorbate	1.125
Concentrated HCL (35% to 37%)	Muriatic acid	1.17
Muriatic acid	Concentrated HCL (35% to 37%)	0.855
Potassium metabisulfite	Sodium metabisulfite	1.17
Sodium metabisulfite	Potassium metabisulfite	0.855
Sodium ascorbate	Ascorbic acid	0.889
Sodium ascorbate	Sodium isoascorbate	1.0
Sodium isoascorbate	Ascorbic acid	0.889
Sodium isoascorbate	Sodium ascorbate	1.0
Sodium thiosulfate, anhyd.	Sodium thiosulfate, cryst.	1.57
Sodium thiosulfate, cryst.	Sodium thiosulfate, anhyd.	0.64
Sodium bromide	Potassium bromide	1.16
Potassium bromide	Sodium bromide	0.86
Sodium sulfate, cryst.	Sodium sulfate, anhyd.	0.44
Sodium sulfate, anhyd.	Sodium sulfate, cryst.	2.27

SODIUM SULFITE CONVERSION

Crystalline sodium sulfite is not as common as it once was. Photographic chemical suppliers will usually provide the anhydrous salt unless otherwise specified. If you happen to obtain the crystal or decahydrate form, you can use the following conversion factors:

The Formula Specifies:	*You Have:*	*Multiply By:*
Sodium sulfite, anhyd.	Sodium sulfite, cryst.	2.0
Sodium sulfite, cryst.	Sodium sulfite, anhyd.	0.5

SODIUM CARBONATE CONVERSION

Sodium carbonate is one of the most commonly used ingredients in photographic chemistry.

It is commercially available in three forms, differing by the amount of water molecules each contains. The three forms are anhydrous (also known as desiccated), monohydrate, and crystal. Crystal is rarely seen today in photographic practice.

Of the three, the monohydrate form is the most stable and the best to use for photographic purposes. The crystalline form is the least stable. However, as is often the case, a formula may call for anhydrous and you may have monohydrate, or a chemical supplier may sell you the anhydrous variety, and so on. In any case, the following table makes for easy conversion from one to the other.

Today, most formulas specify sodium carbonate, monohydrate. If a formula requires one of the other two forms, anhydrous or crystal, or if only one of the others is available, use the following table for conversion:

The Formula Specifies:	*You Have:*	*Multiply By:*
Sodium carbonate, mono.	Sodium carbonate, anhyd.	0.855
Sodium carbonate, mono.	Sodium carbonate, cryst.	2.31
Sodium carbonate, anhyd.	Sodium carbonate, mono.	1.17
Sodium carbonate, anhyd.	Sodium carbonate, cryst.	2.7
Sodium carbonate, cryst.	Sodium carbonate, mono.	0.433
Sodium carbonate, cryst.	Sodium carbonate, anhyd.	0.37

TEASPOON CONVERSIONS

For those who wish to use teaspoon measurements, the following table of commonly used photographic chemicals shows the metric equivalents for various amounts of dry measures.

The length of time the chemicals sit on a supplier's shelf and the storage conditions are important to take into account, as many chemicals will absorb water with storage, but it is not always possible to obtain this information. Therefore, you may wish to consider the following as "standards" and maintain a consistent work habit.

Spoon measurements may differ slightly in weight each time. The conversions were measured and weighed on an Acculab electronic scale, four times each, and averaged by the author, using the very best teaspoon-leveling techniques taught to him by Ms. Abernathy in high school home economics.

Teaspoon Conversions

Solid Measurements

	Dry Weight in Metric Grams	*Teaspoon Amount*
Amidol	1.6 grams	1 teaspoon
Ascorbic acid	4.4 grams	1 teaspoon

(*Continued*)

	Dry Weight in Metric Grams	*Teaspoon Amount*
Benzotriazole	0.2 grams	⅛ teaspoon
Borax	3.8 grams	1 teaspoon
Boric acid	4.1 grams	1 teaspoon
Chlorohydroquinone	3.4 grams	1 teaspoon
Citric acid	4.9 grams	1 teaspoon
Glycin	1.8 grams	1 teaspoon
Hydroquinone	3.3 grams	1 teaspoon
Metol	3.0 grams	1 teaspoon
Phenidone	0.5 grams	¼ teaspoon
o-Phenylenediamine	3.5 grams	1 teaspoon
p-Aminophenol hydrochloride	2.6 grams	1 teaspoon
p-Phenylenediamine	3.5 grams	1 teaspoon
Potassium alum	1.5 grams	¼ teaspoon
Potassium bromide	1.9 grams	¼ teaspoon
Potassium carbonate	6.4 grams	1 teaspoon
Potassium dichromate	6.4 grams	1 teaspoon
Potassium ferricyanide	4.7 grams	1 teaspoon
Potassium permanganate	7.2 grams	1 teaspoon
Potassium persulfate	6.4 grams	1 teaspoon
Pyrocatechol	3.3 grams	1 teaspoon
Pyrogallol	2.3 grams	1 teaspoon
Silver nitrate	1.7 grams	⅛ teaspoon
Sodium bisulfite, anhyd.	5.5 grams	1 teaspoon
Sodium carbonate, anhyd.	4.8 grams	1 teaspoon
Sodium carbonate, mono.	6.3 grams	1 teaspoon
Sodium chloride	6.1 grams	1 teaspoon
Sodium hydroxide	4.0 grams	1 teaspoon
Sodium metaborate	4.6 grams	1 teaspoon
Sodium sulfate	6.4 grams	1 teaspoon
Sodium sulfite, anhyd.	7.9 grams	1 teaspoon
Sodium thiocyanate	3.6 grams	1 teaspoon
Sodium thiosulfate (hypo)	21.0 grams	1 Tablespoon
Thiourea	3.0 grams	1 teaspoon
Tri-sodium phosphate (TSP)	4.5 grams	1 teaspoon

Temperature Equivalents

To convert Fahrenheit into Centigrade: Subtract 32, multiply by 5, and divide by 9. Example: 125°F − 32 = 93 × 5 = 465 ÷ 9 = 51.67°C

To convert Centigrade into Fahrenheit: Multiply by 9, divide by 5, and add 32 to the result. Example: 18°C × 9 = 162 ÷ 5 = 32.4 + 32 = 64.4°F.

°C ⟷	*°F*	*°C ⟷*	*°F*	*°C ⟷*	*°F*	*°C ⟷*	*°F*
+100	+212	29.44	85	25	77	20.55	69
71.11	160	28.89	84	24.44	76	20	68
51.67	125	28.33	83	23.89	75	19.44	67
46.11	115	27.78	82	23.33	74	18.89	66
43.33	110	27.22	81	22.78	73	18.33	65
37.78	100	26.67	80	22.22	72	17.78	64
35	95	26.11	79	21.67	71	17.22	63
32.22	90	25.55	78	21.11	70	16.67	62

FILM DEVELOPMENT TEMPERATURE CONVERSION CHART

This conversion chart can be used to easily determine changes in development time at different temperatures. Find the recommended time/temperature, then use the time to the left or right for changes in temperature.

The empty boxes with a dash at the top of columns 6, 7, and 8 indicate temperatures too short to use for film development. A minimum of 3 minutes is required to form an image, and 5 to avoid most negative defects.

Example: The recommended time at 68°F/20°C is 7 minutes. The temperature of the developer is 72°F/22°C. In the column for 68°F/20°C, find 7 minutes and use the time of 5.75 minutes to the right in the 72°F/22°C column.

64°F	*66°F*	*68°F*	*70°F*	*72°F*	*75°F*	*77°F*	*80°F*
5.0	4.5	4.0	3.5	3.25	–	–	–
5.5	5.0	4.5	4.0	3.75	3.0	–	–
6.0	5.5	5.0	4.5	4.0	3.25	–	–
6.5	6.0	5.5	5.0	4.5	3.5	–	–
7.25	6.5	6.0	5.5	5.0	4.0	3.75	–
8.0	7.25	6.5	6.0	5.25	4.5	4.0	3.5
8.75	7.75	7.0	6.5	5.75	5.0	4.5	3.75
9.25	8.25	7.5	6.75	6.0	5.25	4.75	4.0
9.75	8.75	8.0	7.25	6.5	5.5	5.0	4.25
10.5	9.5	8.5	7.75	7.0	6.0	5.5	4.75
11.25	10.0	9.0	8.0	7.25	6.25	5.75	5.0
11.75	10.5	9.5	8.5	7.75	6.5	6.0	5.25
12.5	11.25	10.0	9.0	8.0	7.0	6.25	5.5
13.0	11.75	10.5	9.5	8.5	7.25	6.5	5.75
13.75	12.25	11.0	10.0	9.0	7.5	6.75	6.0
14.25	12.75	11.5	10.5	9.25	8.0	7.25	6.25
14.75	13.25	12.0	10.75	9.75	8.25	7.5	6.5
15.25	13.75	12.5	11.25	10.0	8.75	8.0	7.0
16.0	14.5	13.0	11.75	10.5	9.0	8.25	7.0
16.75	15.0	13.5	12.0	11.0	9.25	8.5	7.25
17.25	15.5	14.0	12.5	11.25	9.75	9.0	7.5
17.75	16.0	14.5	13.0	11.75	10.0	9.25	7.75
18.5	16.75	15.0	13.5	12.25	10.5	9.5	8.0
19.25	17.25	15.5	14.0	12.75	10.75	9.75	8.25
19.75	17.75	16.0	14.5	13.0	11.0	10.0	8.5
20.5	18.5	16.5	14.75	13.5	11.5	10.25	8.75
21.0	19.0	17.0	15.25	13.75	11.75	10.5	9.0
21.75	19.5	17.5	15.75	14.25	12.0	10.75	9.25
22.25	20.0	18.0	16.25	14.5	12.5	11.25	9.5
22.75	20.5	18.5	16.75	15.0	12.75	11.5	9.75
23.5	21.0	19.0	17.25	15.5	13.25	12.0	10.25
24.25	21.75	19.5	17.5	16.0	13.5	12.25	10.5
24.75	22.25	20.0	18.0	16.25	13.75	12.5	10.75
25.25	22.75	20.5	18.5	16.75	14.25	12.75	11.0
26.0	23.5	21.0	19.0	17.0	14.5	13.0	11.25
26.5	23.75	21.5	19.5	17.5	15.0	13.5	11.5
27.25	24.5	22.0	19.75	17.75	15.25	13.75	11.75
27.75	25.0	22.5	20.25	18.25	15.5	14.0	12.0

(*Continued*)

64°F	*66°F*	*68°F*	*70°F*	*72°F*	*75°F*	*77°F*	*80°F*
28.25	25.5	23.0	20.75	18.75	16.0	14.5	12.5
28.75	26.0	23.5	21.0	19.0	16.25	14.75	12.75
29.75	26.75	24.0	21.75	19.5	16.75	15.0	13.0
30.25	27.25	24.5	22.0	19.75	17.0	15.25	13.25
30.75	27.75	25.0	22.5	20.25	17.25	15.5	13.5

(Courtesy of John Placko, Ilford Ltd.)

Material Sources

Not all chemical suppliers will sell directly to photographers.

INTERNATIONAL

Millipore Sigma (bulk chemicals); sigmaaldrich.com
Sciencelab.com, Inc. (chemicals and lab supplies); sciencelab.com
Spectrum Chemicals (bulk chemicals, lab apparatus); spectrumchemical.com

ASIA AND THE PACIFIC/AUSTRALIA

Vanbar (chemicals and darkroom supplies); vanbar.com.au
Science Supply Australia (chemicals, lab supplies, educational material); ssapl.com.au

Japan

Waveform Lighting (flicker free LED bulbs for enlargers); waveform.co.jp

EUROPE

France

Bergger (classic grain film; enlarging paper, chemical solutions); bergger.com

Germany

ADOX (photographic gelatin, papers and many other photographic processing chemicals); adox.de
Fotoimpex (paper, chemistry, film, darkroom supplies); fotoimpex.com
JOBO International GmbH (darkroom equipment manufacturers, including daylight development tanks for large format film); jobo.com
Linhof (large format cameras, tripods, and accessories); linhof.com

Italy

ARS-IMAGO (camera store featuring all things film, Lab-Box); ars-imago.com
Fotomatica (chemicals, film); fotomatica.it

Lithuania

Slavich (photo paper, holographic materials); slavich.com

Spain

Quimics Dalmau (bulk chemicals, lab equipment); quimicsdalmauonline.com

United Kingdom

APC Pure (chemicals, labware); apcpure.com

Firstcall Photographic Limited (alternative process, chemicals, darkroom equipment); firstcall-photographic.co.uk

Fotospeed Distribution (chemistry, equipment); fotospeed.com

Ilford Photo (film, paper, chemicals, darkroom equipment) ilfordphoto.com

Imaging Warehouse (film, paper, darkroom equipment, chemicals); theimagingwarehouse.co.uk

Mathers of Lacashire (film, paper, chemicals); mathersoflancashire.co.uk

Nik & Trick (film, chemicals, darkroom supplies and accessories); ntphotoworks.com

Parallax Photographic Coop (film, chemicals, paper, alternative processes); parallaxphotographic.coop

Paterson Photographic Ltd (darkroom accessories); patersonphotographic.com

Process Supplies (chemicals, darkroom supplies, equipment); processuk.net

RH Designs (stop clock enlarger timers, paper flasher, analyzers); rhdesigns.co.uk

Zone Imaging (Eco Zonefix, chemicals including pyrogallic acid [pyro] and phenidone); zoneimaging-photochemicals.co.uk

NORTH AMERICA

Affordable Scales (digital electronic scales); affordablescales.com

Antec (bulk chemicals in small quantities); kyantec.com

Archival Methods (archival storage solutions); archivalmethods.com

Artcraft Chemicals (bulk chemicals); artcraftchemicals.com

Bostick & Sullivan (alternative process, chemicals); bostick-sullivan.com

Canadawide Scientific Ltd (bulk chemicals, lab apparatus); canadawide.ca

Chemsavers (small and bulk chemicals); chemsavers.com

CineStill (monobath chemistry, chemicals, darkroom equipment, developing tanks); cinestillfilm.com

Clayton Chemical (photographic chemicals, developers, fixers); claytonchem.com

Cole-Parmer (international source for chemicals and lab supplies); coleparmer.com

David Lewis (Bromoil chlorobromide paper); bromoil.com

D.F. Goldsmith Chemical & Metal Corp. (plt/pld); dfgoldsmith.com

Del Amo Chemical Company (bulk chemicals); delamochemical.com

Delta Photography Supplies, LLC (delta 1 darkroom equipment, sinks, accessories); deltaphotosupplies.com

Digitaltruth Photo Ltd (massive developing chart, photochemistry, bulk chemicals, equipment, film, darkroom supplies, apps for the darkroom); digitaltruth.com

Edmund Optics (47 blue and 58 green filters for VC printing); edmundoptics.com

Film for Classics (respooled film in discontinued sizes such as 620); filmforclassics.com

Film Photography Project (FPP) (specialty films, classic film cameras); filmphotographystore.com
Freestyle Photographic Supplies (darkroom equipment and supplies); freestylephoto.com
Gorilla Grow Tent (lighttight hydroponic tents); gorillagrowtent.com
H & C Weighing Systems (scales and balances); affordablescales.com
Hanna Instruments (pH meters); hannainst.com
Hass Manufacturing (Intellifaucet water control monitors); hassmfg.com
Kodak (film, Wratten CC gelatin filters); kodak.com
Ohaus Balances & Scales (electronic and mechanical scales and balances); ohaus.com
OmegaBrandess (darkroom accessories and chemistry); omegabrandess.com
Photographers' Formulary (chemicals and kits); photoformulary.com
Photo Systems, Inc. (PSI) (photo chemistry for all analogue processes); photosys.com
Photo Warehouse (ultrafine photo paper and products, film, toy cameras, bulk film loading supplies; darkroom accessories); ultrafineonline.com
Printfile (archival negative sleeves, CP-1 Contact Proofer); printfile.com
Rosco Filters, (gelatin and polycarbonate filters for split printing); us.rosco.com
S.K. Grimes (camera accessories, repairs, custom machining, and modifications); skgrimes.com
Scales Galore (scales); scalesgalore.com
Smith-Chamlee Photography (Lodima silver chloride contact printing paper); lodima.org
Sprint Systems (Sprint proprietary darkroom chemicals); sprintsystems.com
Stearman Press (large format developing systems, darkroom equipment, chemistry); shop.stearmanpress.com
Stouffer Industries (step-wedges); stouffer.net
University Products (archival storage solutions); universityproducts.com
Waveform Lighting (flicker free LED bulbs for enlargers); waveformlighting.com

Websites

Caffenol, caffenol.org
Clay Harmon Blog, clayharmonblog.com
Darkroom Automation, darkroomautomation.com
Digital Truth, digitaltruth.com
Massive Development Chart, tinyurl.com/55skr6x3
Mike Ware Alternative Photography, mikeware.co.uk
Pictorial Planet, pictorialplanet.com
The Light Farm, thelightfarm.com
The Royal Photographic Society, rps.org
Unblinking Eye, unblinkingeye.com

FORUMS

Alternative Photography, alternativephotography.com
Black & White Photography Forum, digitalmonochromeforum.co.uk
Cameraderie.org, https://tinyurl.com/2z7cd3ud
Film and Darkroom Users, film-and-darkroom-user.org.uk
Film Photography Talk, tinyurl.com/54v4zv59
Large Format Photography Forum, largeformatphotography.info
Leica Forum, tinyurl.com/f44zv4zt
Photography Life, photographylife.com/forum/film
PhotoNet, photo.net
Photrio, photrio.com
Talk Photography Forum, tinyurl.com/ypbhcnvs
The Photo Forum, thephotoforum.com
UK Large Format Photography Forum, 5x4.co.uk

FACEBOOK GROUPS

Analog Photography
Darkroom Photography
Film Developing
Film Is Not Dead.
Film Developing and Scanning
Gelatin Silver Printers
Lith Printing
The Darkroom

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Index

Note: Page numbers in *italics* and **bold** refer to figures and tables, respectively.