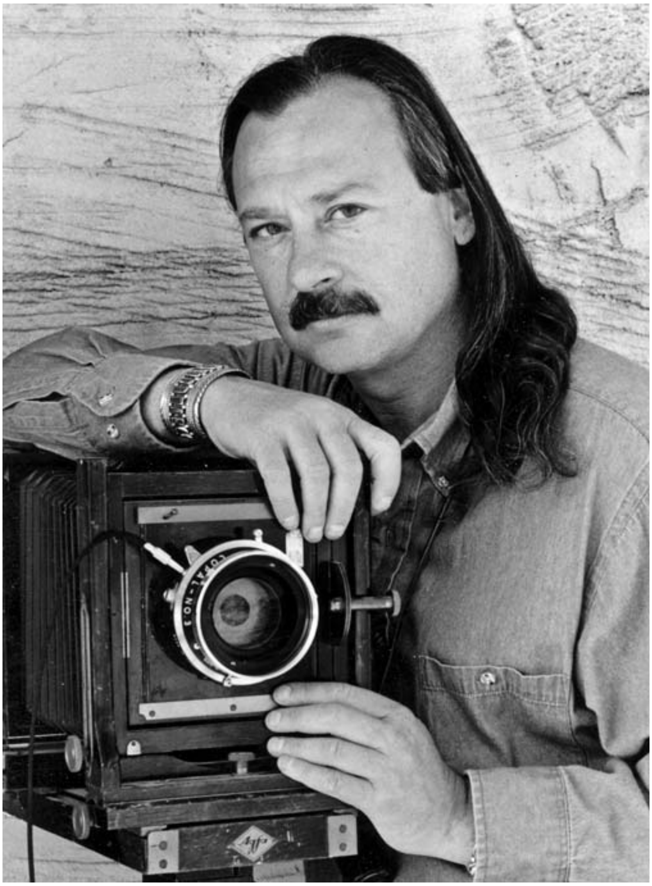
THE DARKROOM COOKBOOK

THIRD EDITION

STEVE ANCHELL

Focal Press

The Darkroom Cookbook



Henry and Steve, 1999. © 2008 Donna Conrad. All rights reserved. Courtesy of the artist.

The DARKROOM COOKBOOK

Third Edition

Steve Anchell

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Dedication

This book is dedicated to all the selfless photographers who have shared their experience and darkroom discoveries. To these photographers, known and unknown, we owe a debt of gratitude.

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

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Preface

The Darkroom Cookbook is based upon a series of articles originally appearing in *Camera & Darkroom* magazine. The articles were inspired by a brief encounter at a camera store. I was browsing the chemical section searching for potassium bromide. When I found it, a young woman inquired what it was used for. I pointed to the 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!"

This made me realize that one photographer's basic craft is another photographer's "oh my goodness!" Yet, I have never considered myself to be technical. Even though I learned the Zone System in 1976, half the time I do not use light meters and have no use for a densitometer. To me, adding bromide or carbonate to a developer is about as technical as exposing for the shadows. Every photographer should know that!

Since the first columns appeared in *Camera & Darkroom, The Darkroom Cookbook* has taken on a further significance. As a photographer, educator, and writer, I put great importance on the future of the silver-based process. I have a strong desire to keep the flame alive, to pass on experience and technique to new generations of photographers.

At the turn of the last century, platinum/palladium printing was the most popular printing process among professionals. It was not until well into the 1920s that silver printing became widely accepted. When it did, platinum/palladium all but disappeared.

Today platinum/palladium is enjoying a resurgence of interest among fine-art photographers. Unfortunately, though there have continued to be a number of practitioners through the years, the wealth of information and techniques developed by thousands of platinum/palladium printers has been lost. The publishing and, specifically, "how-to" book industry was not what it is in our time, and most photographers either abandoned the process or simply took their skills with them to the grave. Today's practitioners are in the position of having to rediscover, or reinvent, techniques that were often considered standard practice.

The purpose of this book, then, is twofold. The first is to enable photographers to create images in the darkroom which reflect their emotional state and response to their subject. The second is to preserve and share the knowledge and techniques that have been so arduously developed by creators in silver.

For those reading this who are already familiar with the first and second editions of *The Darkroom Cookbook*, I hope this third edition will add to your knowledge and enjoyment of the traditional black and white darkroom process. For those of you just starting to work in a black and white darkroom, or just discovering *The Cookbook*, you are in for a pleasant surprise.

When I first set out to write *The Darkroom Cookbook* in 1992, it was my intent to share little-known photographic facts and formulas which I had gathered over the years. Many of these were on scraps of paper lying about my darkroom, and some were stored in my head. Although I felt there was a need for this information to be shared, the number of photographers that were thirsting for this information came as a great surprise. *The Darkroom Cookbook* not only contains many useful formulas for processing your film and paper, but it is a compendium of tips, tricks, and techniques handed down from one photographer to the next during the last century.

The Darkroom Cookbook is meant to be a point of departure for creative photographers to discover and explore new techniques and formulas in order to create a unique signature. It is also meant to be a potpourri for photographers who just want to play with their craft. As I like to tell my students, when photography ceases to be fun, it's time to find a different outlet for your creativity.

In spite of what you may think, or have heard, this is not a book about chemistry, darkroom or otherwise. The "complex" chemical formulas in the back of the book are no more than mixtures of powders. The names of the chemicals are on the bottles, you use an inexpensive scale, or teaspoons if a scale is not available, and you mix the published amounts in water. It's no different than mixing flour and eggs with a little milk to make pancakes.

Despite its seeming complexity and daunting technicality, *photography ain't rocket science*. You have to be pretty far off to fail completely. For example, if a formula calls for sodium carbonate anhydrous and you accidentally use monohydrate, what's going to happen? 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 usual grade 2.

While some of this book remains the same as the second edition there are numerous changes and improvements. For one, I have eliminated formulas which I no longer feel are of value to the modern darkroom worker. These include special developers for Kodak Tech Pan film, which is no longer being made, and intensifiers which contain mercuric chloride, a highly toxic chemical. Silver nitrate intensifiers are nearly as good as mercuric chloride and not as toxic, though they do stain everything. You'll find stain removing formulas under Miscellaneous Formulas.

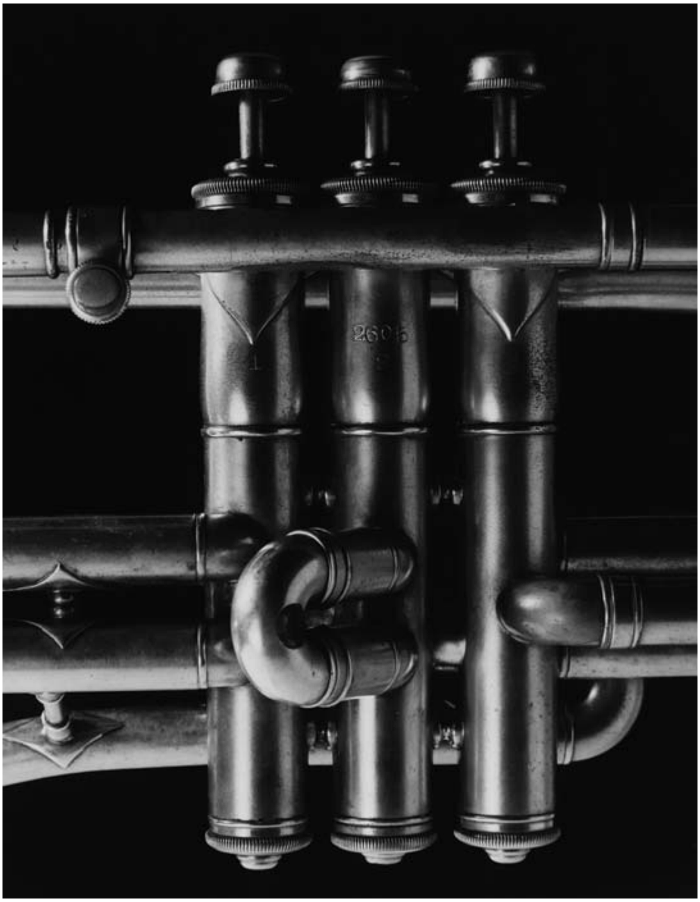
Just for fun there are a few new pyro formulas for those who like to dabble with pyro. More importantly is a chapter on making enlarged negatives for the growing number of darkroom workers who wish to express themselves through alternative processes. A new chapter on printing techniques has been further embellished by contributions from Bruce Barnbaum, Rod Dresser, Henry Gilpin, Les McLean, Saïd Nuseibeh, and John Sexton.

The importance of this book to the future of darkroom workers was foreseen in the Preface to the first edition of *The Darkroom Cookbook*, published in 1994. The last sentence of that Preface reads, "Today, it is possible to take negatives to a lab for processing and printing ... tomorrow?" Well, tomorrow is here. Good black and white labs, while still around, won't be much longer. If you intend to work with black and white film you are going to have to at least develop your own film. You may, or may not, wish to mix your own formulas. I say this because there are many excellent pre-mix developers available today, among them Ilford DDX®, as well as John Wimberley's WD2H (available from the Photographers' Formulary, see Material Sources).

Which brings us to the question, why work with black and white film at all? What we are witnessing today is not much different than the transition from platinum/palladium printing to silver printing in the 1920s. In fact, 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 Edward Weston were printing on silver-based emulsions.

This is not to say that silver printing will disappear. Platinum/palladium printing is still with us, even if Weston did jump ship. As is gum dichromate, cyanotype, albumen, and printing-out paper, among other alternative processes. But is the digital print better than silver? Is it as good as platinum? Gum? In every case, it's not a matter of one being better than the other. It is simply a matter of difference. And as our French counterparts would say, *vive la différence*!

For the artist, it comes down to how do 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, under the subdued otherworldly glow of an orange light, hearing the flow of water, experiencing the solitude which is near impossible to find outside of 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 . . .



Cornet, 1984. © 2008 Larry Hussar. All rights reserved. Courtesy of the artist. 4 × 5 inch Tri-X Film developed in Kodak D-76.

Acknowledgments

There are two husband-and-wife photography teams who influenced and encouraged me to become a photographer. They are Frank and Daughtee Rogers, and Cornelia and Rodger Davidson.

Frank and Daughtee gave me a solid grounding in basic photography and darkroom techniques, unselfishly sharing their knowledge. 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 first heard it said, "There are no secrets, only photographers who think there are."

Cornelia and Rodger taught me basic color technique. Their specialty was color transparency, specifically 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.

Pertaining directly to *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 made a present to me of three *Morgan & Lester Photo-Lab-Indexes* from the 1930s and '40s. This generous gift sparked my interest in older formulas and darkroom techniques and made it possible, at a later date, for me to share them with other photographers. Without Samy, there would be no *Darkroom Cookbook*.

Ira Katz, of Tri-Ess Sciences in Burbank, California, freely shared his vast knowledge and experience of chemistry. Ira's knowledge was not limited to photo chemistry, and his insights and suggestions for storage, mixing, and safety are an indispensable part of this work. Sadly, Ira passed away on April 9, 2005.

In this, the 3rd Edition of *The Darkroom Cookbook*, I have invited a few of my associates, Bruce Barnbaum, Rod Dresser, Jay Dusard, Patrick Gainer, Richard Garrod, Henry Gilpin, Gordon Hutchings, Sandy King, Les McLean, Saïd Nuseibeh, France Scully Osterman, Mark Osterman, Tim Rudman, Ryuijie, John Sexton, and John Wimberly to share some of their personal darkroom methods to which they have each graciously assented. In addition Tim Rudman edited Chapter 10 on toning; David Wood of .dr5 Lab edited the section on reversal processing in Chapter 13; and the Ostermans contributed important content to Chapter 14 on printing-out paper.

Special thanks is due to Mark Booth of Washington, Patrick Gainer of West Virginia, Ian Grant of the U.K. and Turkey, Larry Hussar of Michigan, and Paul Lewis of Canada for their many suggestions and technical editing of the manuscript. I would also like to thank Donna Conrad for her invaluable final edit of the manuscript. A sincere thank you is due to both my editors at Focal Press, Valerie Geary and Paul Gottehrer. Without their belief in film as a viable medium of expression and her faith in *The Darkroom Cookbook* as a conduit for sharing ideas between photographers the third edition would never have been written much less published.

As I was wrapping up the content for the third edition, a remarkable event transpired. I was introduced to Reece Vogel, a friend of Brett Weston, by David Wood. Reece in turn introduced me to Michael Andrews, Richard C. Miller and his daughters, Janice and Margaret. Between them they are in possession of an extensive archive of letters, notes, and Richard's personal photographs of the Westons. Among them are Richard's handwritten notes with both Edward and Brett's formulas for Amidol. Even though they were in the process of creating their own portfolio of this work for reproduction they generously granted permission to reproduce the notes with the formulae and a photograph of Brett. This is a gift from Richard and his daughters to all photographers for all time.

Introduction

Today everybody seems to be a genius, but nobody can draw a hand anymore.
—Renoir

Why invest the time and money necessary to develop and print your own photographs? Historically there have been many photographers, especially in the field of photojournalism and commercial photography, who have never printed their own images; one of the most famous would be Henri Cartier-Bresson, proponent of capturing the "decisive moment."

But consider that the camera only records what we see. Tripping the shutter only freezes a moment in time. The moments recorded by Cartier-Bresson have become images only after they have been developed and printed in a way they can be presented and shared with others in magazines or through books and exhibits. The fulfillment of the photographer's inner vision is not realized until the film has been processed and reproduced.

If your interest in photography does not go beyond recording moments in time, there is no reason to practice darkroom techniques. The question to ask yourself is, do you wish to become a creator of images? If you do, then you must learn to develop and print your own work.

Brett Weston, one of the greatest practitioners of the West Coast School of Photography, pioneered by his father, Edward Weston, Ansel Adams, Wynn Bullock, and Imogen Cunningham, destroyed almost seventy 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 was fond of saying that photography was 20 percent in the camera and 80 percent in the darkroom. Ansel was heard to say he wasn't as much a photographer as he was a printer, while Imogen said that printing was the hardest thing one could do in photography, but she refused to allow anyone else to do it for her. When Edward was no longer able to print his own negatives because of Parkinson's disease he spent ten years training his sons Brett and then Cole to print his work exactly as he would, including watching over their shoulders for each negative and preparing copious notes for them to follow so there could be no deviation after he was gone.

There was a time when photographers each had their own version of a particular formula and knew several others that enabled them to achieve specific results. In the field, the photographer could concentrate on composing images and achieving the best possible exposure, aware that anything was possible in the dark. Many of these skills have been overlooked by contemporary darkroom workers.

Through *The Darkroom Cookbook* you will learn methods to alter and improve published formulas. Through the use of chemicals and additives you can fine-tune over-the-counter 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; a chef creates formulas 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 still mixes and matches formulas to suit his taste. Edward could be considered a cook, Paul a chef.

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

But even packaged formulas can be used by a chef to great advantage. Mixing soft-working, warm-toned Ilford Warmtone® with varying amounts of cold-toned Ilford Coldtone® paper developer will open entire new worlds in print color and tonal scale. The manufacturers do not suggest this in their literature, but then the manufacturers are not artists. They're probably not even photographers.

The formulas and techniques in this book, while not exhaustive, have been chosen to aid the photographer attempting to express a personal vision. It begins with the choice of film developer to emphasize speed, graininess, or acutance. Some photographers may be surprised to learn there are so many. I assure you this only scratches the surface. Why are so many developing formulas necessary? After all, if you get to know one or two formulas what else do you need, right? In the early stages of learning the craft this is a good idea. But notice the headings for each set of developers: high-definition, low-contrast, fine-grain, high-energy, tropical. There is a developing formula to create almost any effect you can imagine; sharp, clean edges or superfine grain; low-contrast, long tonal scales; or high-contrast and short tonal scales. There are developers that will allow you to process film in the Brazilian rain forest, at temperatures near 100°F, and some that permit you to develop in Antarctica at below 0°! Complete knowledge of one or two developers is important, but knowing what else is available and how to make use of it to create the image you want 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 main message. Each developer formula varies slightly in its rendition of blacks. It is a good idea to select one warm-tone paper and one cold-tone paper and, over a period of time, test each of the other print developers. 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 are applicable to your style, try several, or all, of the toning formulas. Keep a book of these also. These reference sources will greatly enhance your ability to communicate through your images.

Under Miscellaneous Formulas you will find a number of useful items. Kodak S-6 stain remover, for example, which 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!

Under Printing-Out Paper Formulas you will find a formula for sensitizing paper. There are many others, but this one is a start. If it should ever come to pass that silver papers are no longer available, this may be one way to continue hand-making prints. Or you may find that coating your own paper may be worth experimenting with for the special results that can be obtained.

Intensification and reduction techniques are of special value to photographers. Even Ansel Adams required the technique of local negative intensification to save his most famous photograph *Moonrise, Hernandez, New Mexico* c. 1941. The negative was exposed for the moon's luminance, at 250 c/ft^2. As a result the foreground was badly underexposed and difficult to print. Ansel intensified the foreground of the 8 × 10 inch negative while carefully holding the buildings, sky, and moon out of the solution. A simple procedure. But without the necessary darkroom skills the image might not have survived.

Seattle Street Photography, 2005. © 2008 Mark and Timothy Booth. All rights reserved. Courtesy of the artists. Bergger BPF 200 film developed in Thornton two-bath developer. Photo made with Leica M rangefinder camera.

Contributing Photographers

Bruce Barnbaum
Chapter 8—An Efficient Way to Get to the Final Print.
Bruce Barnbaum was drawn to photography through his love of the landscape, and as time passed his interests expanded into architectural subjects, to abstracts, and anything that 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 area of prime interest. He has been teaching 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*. More of Bruce's work can be seen at www.barnbaum.com.

Rod Dresser
Chapter 8—Exposure and Developing Technique for Photographic Printmaking.
Rod Dresser is a graduate of the United States Naval Academy. He served on destroyers and submarines while in the Navy. After retirement he changed a photographic hobby into a career. Rod was an assistant to Ansel Adams and after Adams' death Rod took over the position as business manager for the Ansel Adams Publishing Rights Trust.

Rod later spent five years in San Francisco doing commercial photography. His clients included Apple, Union Bank, University of California, Harvard University, and others. 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. His images are in black and white in the West Coast tradition and tend toward minimalism. More of Rod's work can be seen at www.roddresser.com.

Jay Dusard
Chapter 11—Print Bleaching.
After teaching photography for seven years at Prescott College, Arizona, Jay Dusard was awarded a 1981 Guggenheim Fellowship to do view camera portraits of working cowboys, buckaroos, and vaqueros from Canada to Mexico. His solo publications include *The North American Cowboy: A Portrait* (1983), *Open Country* (1994), and *The California Vaquero* (2005 portfolio).

Considered for many years one of the most influential photographers in the West, Jay is uniquely a master of both the landscape and portrait genres. One of the finest black and white darkroom printers, he is now concentrating on the presentation of his rarely seen abstractions.

Jay lives with his wife, Kathie, near Douglas, Arizona, where, between trips to photograph and teach workshops, he punches cows and plays jazz cornet. More of Jay's work can be seen at www.tinysatellitepress.com.

Patrick Gainer

Chapter 3—Ascorbic Acid: Developing Agent or Anti-Oxidant?; Three Long-Lasting Single-Solution Sulfite-Free Developers.

Sixty years ago Patrick Gainer see-sawed his first roll of Verichrome Pan in a tray of MQ. The darkroom was a large closet in his home in Webster Groves, Missouri. 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 first oboist with the Norfolk Symphony Orchestra. His photographs of conductors, musicians, and guest artists appeared in many program booklets. He is retired and living in Tanner, West Virginia.

Richard Garrod

Chapter 1—How safe is your Safelight?

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 in Ansel Adams' first postwar workshop at Yosemite. In 1961, *Art in America* magazine selected Garrod as one of the top-forty "New Talent USA" members and one of the seven featured photographers. In the introduction to the book *Garrod and Gilpin Photographs*, Ansel Adams referred to Garrod's work as displaying "... a great solidity and constant awareness of beauty."

Garrod has taught photography workshops for more than thirty years, including Ansel Adams' Workshop 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 fifty solo and group exhibitions, and are held in many private and institutional collections.

Henry Gilpin

Chapter 8—Changing Print Contrast.

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

Henry makes photographs merely for the enjoyment of it and considers himself as the audience. His work keeps him seeking the light, the design, and the order that is 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.

Gordon Hutchings

Chapter 6—PMK: Thirty Years On.

Gordon Hutchings began taking pictures when he was eight years old with a plastic camera acquired with a cereal box top and twenty-five cents. In high school, he was given a 5 × 7 revolving back "Cycle Graphic" with an uncoated Berlin Dagor in a most uncertain compound shutter. He set up a primitive darkroom in the cellar and was soon making contact prints. This kindled a life long 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 called PMK. About 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 and was immediately successful. The book is in its fifth printing and has sold over 20,000 copies.

Since that first workshop in 1980, Gordon has expanded the subject matter and has taught nearly 100 workshops in a variety of subjects. He has taught many on his own and for others including the Photographer's Formulary Workshops in Montana, the Ansel Adams workshops in Yosemite Valley, the California State University in Santa Cruz and Sacramento, and has taught large format photography at the Maine Photographic Workshops for the last ten years. Gordon has written for various photography magazines, predominately *View Camera* magazine. He has had numerous shows around the country and his work has been published here and in Europe. Gordon can be reached at gehutch@surewest.net.

Sandy King

Chapter 6—Pyrocat-HD.

Sandy King is landscape photographer who prints primarily with alternative processes, including carbon, kallitype, and palladium. He is a well-known carbon printer and has conducted numerous workshops on carbon printing, both in the United States and abroad. He is the author of *The Book of Carbon and Carbro: Contemporary Procedures for Monochrome Pigment Printmaking*, 2002. He also experiments with developer formulation and his technical article on pyro staining developers, "An Introduction to Pyro Staining Developers," first published in English at www.unblinkingeye.com and has been translated and published in on-line journals in the French and Russian languages. You can see more of Sandy's work on the Contact Printer Guild's web site, www.contactprintersguild.com.

Les McLean

Chapter 8—Pre- and Post Flashing to Control Contrast.

Well known for his fine art black and white printing skills, Les has traveled throughout the United Kingdom for twenty years and for the past ten years in the United States and Canada, leading workshops in traditional black and white printing as well as in many other areas relating to the craft and art of photography. For fifteen years in colleges throughout the United Kingdom, Les has taught master-classes in black and white darkroom practice and more recently in digital imaging and print making.

Les has regularly written for many of the popular U.K. photographic magazines since 1988 and currently writes for *Black and White Photography* in the United Kingdom. In 2002, his first book was published, *Creative Black and White Photography*. His black and white prints are held in museums and private collections throughout the world. More of Les's work can be seen at www.lesmcleanphotography.com.

Saïd Nuseibeh

Chapter 8—Rescuing Thin Shadows.

Saïd Nuseibeh is a photographer specializing in architecture, specifically of the Arab and Muslim worlds, who for fifteen years printed Ruth Bernhard's exquisite negatives (1990–2005). Just as Bernhard helped liberate the female form from the titillating gaze, so Nuseibeh works to provide new non-violent modes of access to Islamic culture. He was included in a *PDN* (*Photo District News*) article on Master Printers in February 2004. Nuseibeh has been the recipient of a Watson Fellowship and a Fulbright award. You can see his work at Scott Nichols Gallery, San Francisco, and Darat al-Funun in Amman, Jordan, or visit www.studiosaid.com.

Scully & Osterman

Chapter 14—On Gold Toning; Collodio-Chloride Printing Out Paper.

Mark Osterman is Process Historian for the Center for Legacy of Photography at George Eastman House International Museum of Photography. France Scully Osterman is guest scholar at the George Eastman House and manages Scully & Osterman Studio at their Rochester home.

The Ostermans are known internationally as respected artists, historians, and teachers of historic photographic processes. They are both represented by Howard Greenberg Gallery, in New York City and the Tilt Gallery in Phoenix, Arizona. To see more of the Osterman's work and find out about the wet-plate collodion process visit www.collodion.org.

Tim Rudman

Chapter 10—Toning: Workflow, Pittfalls, Choices, and Preferences.

Tim Rudman has an international reputation as a photographer, printer, and expert on darkroom techniques and 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 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 workshops in the United Kingdom, Ireland, Spain, Canada, the United States, and Australia. He is widely published and exhibited and his prints are held in public and private collections around the world. More of Tim's work can be seen at www.timrudman.com.

Ryuijie

Chapter 10—Spilt Toning with Polytoner.

Born in Otaru, Japan, Ryuijie showed an inclination to 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. For twenty-eight years, Ryuijie has steadfastly pursued his own photographic vision and has 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.

John Sexton
Chapter 8—Steaming Black and White Fiber-Base Prints.
John Sexton is known worldwide as a photographer, master print maker, workshop instructor, and lecturer. Author of four award-winning books, *Quiet Light*, *Listen to the Trees*, *Places of Power*, and most recently, *Recollections: Three Decades of Photographs*, Sexton is best known for his luminous black and white images of the natural environment. A former director of the Ansel Adams Workshops, he has conducted hundreds of photography workshops throughout the United States and abroad. Sexton served as photographic assistant and consultant to photographer Ansel Adams from 1979 to 1984. His finely-crafted large-format photographs have appeared in countless publications and are included in permanent collections and exhibitions throughout the world. In 2005, Sexton was honored with a Lifetime Achievement Award from the North American Nature Photography Association.

John Wimberley
Chapter 6—John Wimberly on WD2H+.
John Wimberley has been photographing the landscape in black and white since 1969. Since then, he has garnered an international reputation as a master photographer and printer, has had more than sixty exhibitions, and is represented in over five hundred public and private collections. His *Descending Angel* is one of the best-selling fine-art photographs of the last thirty years.

After seven years of research, John Wimberley published his noted article on WD2D in the October 1977 issue of *Petersen's Photographic* magazine. WD2D was the first pyrogallol developer formulated for the modern, post-1950s generation of films, and it sparked a revival of interest in this classic developing agent that continues to the present. WD2D differed from the classic three solution pyrogallol formulae of the past by eliminating the problematical B solution of sodium sulfite, and by adding the developing agent metol to the pyrogallol at a ratio of 1:10 to increase film speed. More of John's work can be seen at www.johnwimberleyphotography.com.

David Wood
Chapter 13—Contributed valuable content and formulas for reversal processing.
David Wood has worked as a professional photographer for over seventeen years in New York City. He attended Citrus College in Azusa, California in 1980 and holds an AA degree in Photography. He is the inventor and sole proprietor of the unique dr5 CHROME transparency film process, www.dr5.com. David now enjoys a client base of over two thousand professional and advanced-amateur photographers hailing from six continents. Currently, David has rendered the dr5 CHROME process compatible with more than twenty-five of the world's most popular black and white film types. He personally handles hundreds of rolls a week at his Denver, Colorado lab to insure the superior results. David resides with his wife Kathi and his Jack Russell terrier Buddy in their modest one hundred-year-old brick home located above the dr5 lab. For information on reversal processing and other services provided by .dr5 Chrome Labs visit www.dr5.com.

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Pynant, Nr Trefor, Nth Wales, 2004. © 2008 Ian Grant. All rights reserved. Courtesy of the artist. APX100 film developed in Rodinal 1:50.

List of Formulas

Many of the formulas found in the *Cookbook* can be purchased pre-packaged by the Photographers' Formulary (PF). You may wish to try a pre-packaged formula before purchasing bulk chemicals. Should you like the results you can later purchase the bulk chemicals to mix it yourself and save money. Any formula already packaged by PF is indicated with their initials next to the formula. Most formulas not packaged by PF can be special ordered. Their contact information can be found in Resources.

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Planning a Darkroom

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 darkroom is many things: It is a place where images are created; a place of magic; a refuge. When you enter the darkroom time stands still. The world outside is replaced by the sound of running water, music or silence. 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 (Figure 1-1). After all, a photograph is only recorded by the camera. The image you hang on your wall is created in the darkroom.

There are six requirements for a darkroom to safely and efficiently process, proof, and print negatives:

1. A source of water
2. A light tight environment
3. Proper ventilation
4. A dust-free environment for film drying
5. Electricity
6. Adequate space.

WATER

It is not necessary for water to be in the same room, just 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 water filter that fits on the end of the tap. These filters are inexpensive and reduce the risk of spots from dust, dirt, rust, and undissolved chemicals contained in tap water.

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

If you do invest in a prefabricated WTC, spend a few extra dollars and buy one with two filters. Two filters will increase the life of the valve. Use wound-polypropylene filters. Cellulose filters may come apart with use and contaminate the water.

Figure 1-1 The important thing is not the size or number of enlargers in my darkroom but the ample storage space, overall cleanliness, and the light-colored walls and ceiling. Regardless of the size or amount of equipment these, along with good ventilation, are prerequisites for a healthy, safe, and rewarding darkroom experience.

If you do not have a WTC, use a water temperature monitor (WTM). A WTM is simply a pipe with a built-in thermometer that attaches below the faucet to monitor temperature.

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 easily solved by using a changing bag.

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. When printing he opened all the windows and doors to allow the night air to circulate freely. The only light was that of the stars.

If you do not live in the country, leaving the doors and windows open is probably not an option. However, making a room light-tight enough 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® available from art suppliers. If your space doesn't have a door which can be closed, cover the opening in the same manner or purchase an inexpensive hollow-core door from a builder's supply store (more of this in the section on ventilation).

Sealing the light around the door is not difficult either. 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 frame or the door. 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 the bottom edge. You can also purchase an automatic door sweep that adjusts to irregular floor surfaces.

As a final step, paint the door jambs with flat black paint.

VENTILATION

Making a darkroom light-tight may be desirable. Making it air-tight 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.

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

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 leave early and unconsciously avoid spending time in the darkroom.

Current OSHA and 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. Ideally, the exhaust fan should be placed above the processing sink in order to draw the fumes directly from the processing trays. The passive vent should be low to the ground, usually, though not necessarily, opposite the exhaust fan. Both need to be light-tight.

The best way to ventilate a small darkroom is to purchase a light-tight exhaust fan. This is an investment that is as important as an enlarger, and you should not cut corners. The small, round, passive air vents available from retail outlets may be good to facilitate air flow in a small space, but do not consider them a substitute for real ventilation. A darkroom requires active 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 of paramount importance to the health and safety of the darkroom worker, clean, dust-free air is important to the quality of the work. It is an especially important 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 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.

One method for hanging film in a shower is to use a retractable clothesline available from a home-building or variety store. Install the retractable line above the showerhead, and the receiving hook on the opposite wall.

Another solution where traffic is heavy or there is no shower stall is to use a drying bag or cabinet. Drying bags and cabinets are available from many photo suppliers.

Do not make the mistake of hanging your film in a clothes closet unless a drying bag is used. You will have negatives so full of dust they will be unprintable.

ELECTRICAL CURRENT

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 will be using). The result is the number of amperes of current that would be drawn if everything were on at the same time. Add 10% to 20% for growth. Then provide one or more circuits sufficient to carry the current demand in amperes. Common circuits are 15 amperes. However, by using larger wiring, you can have 20- or 30-ampere circuits.

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 a smart idea to put the lights on one circuit and everything else on a separate circuit. Then, if a momentary overload trips the circuit breaker, you won't be "left in the dark."

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

A small darkroom should have at least four outlets, more if needed. Locate two of them spaced conveniently along the wall, and 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 were their darkrooms. They insisted 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 had my own darkroom, in a closet, kitchen, garage, wherever, and having always kept it clean and orderly, it came as a shock to me when I was invited to visit an associates darkroom in San Francisco and found it to be a pig sty. This is a photographer who has been working at least as long as I have and who also knew Ansel and Brett. It was dark, damp, and dirty. 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.

SPACE

Establishing a permanent darkroom presupposes the availability of a permanent space. The space does not have to be large. Ideally, there should be enough room to have 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. An attic, unless it is well-insulated, is likely to be too hot in the summer and too cold in the winter. Also, it is usually difficult and expensive to extend plumbing into an attic.

A dry basement with a drain is an ideal location. If the basement is damp, make it dry with a dehumidifier, available from appliance stores. The optimum relative humidity for a darkroom is between 45% and 50%; the ideal temperature is between 68F/20C and 75F/24C. It is often easier to maintain this temperature range in a basement 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.

Size

Bigger is not always better. A large-format photographer of my acquaintance 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.

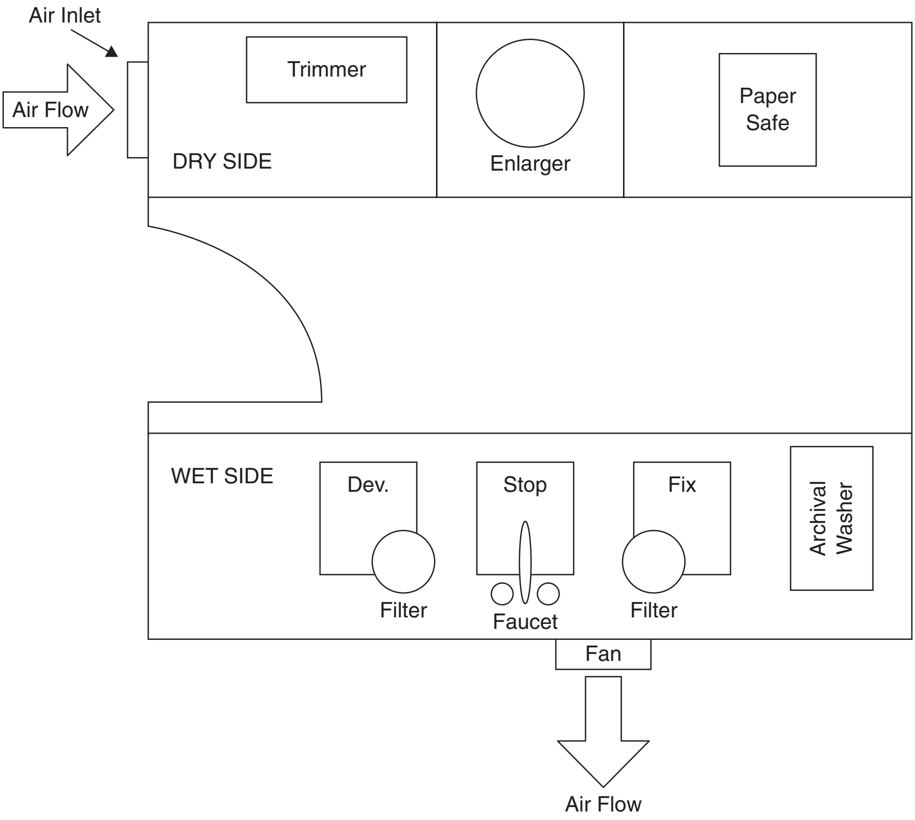

Figure 1-2 A possible darkroom configuration. The enlarger may be placed in the middle or at either end and the trays arranged accordingly. Fresh air should enter from a passive vent over the dry side or in the door. (Thanks to Brian MacNeil of Canada.)

Another photographer whom I know has a small, walk-in closet. He built shelves, put his enlarger at one end, stacked trays on a tray ladder, and added a paper safe and rotating drafting stool. He turns from his enlarger to his trays and back. When a print is finished, he carries it outside 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 when he's not printing.

From a practical point of view, a permanent darkroom should not be much smaller than 6 × 7 feet. For safety and comfort, the minimum open space to stand and move about should be at least 30 inches wide.

Figures 1-2 and 1-3 show two possible darkroom configurations. The size of either darkroom can be increased to accommodate a longer sink, drying cabinet, and the addition of a utility bench.

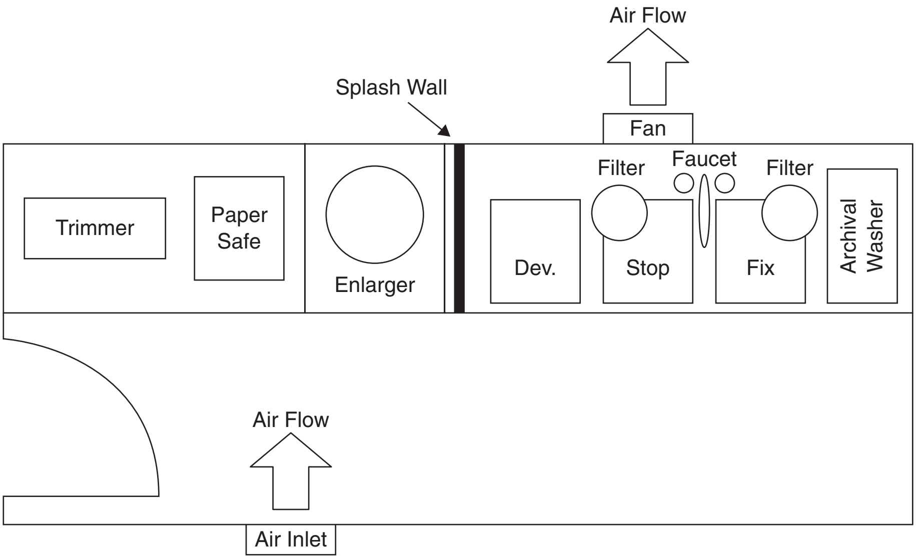

Figure 1-3 A possible darkroom configuration. The enlarger may be placed in the middle or at either end and the trays arranged accordingly. An active slot hood would be well placed above the tray, in which case fresh air should come in from the wall opposite or the door. (Thanks to Brian MacNeil of Canada.)

Placement of Equipment and Workflow

In planning a darkroom, the main objective is to arrange the equipment and materials for efficiency and convenience. The dry side and the wet side should be arranged to facilitate the flow of work, from enlarging to developing and back again, with a minimum of steps.

Study the work pattern in the darkrooms in Figures 1-2 and 1-3. You can see the reasons for the recommended arrangement of the benches and equipment. To make prints, for example, you would place the paper in a dark drawer (Figure 1-4) or in a paper safe next to the enlarger. After placing the negative in the enlarger and composing the image, you would place a sheet of printing paper in the easel and expose. After the paper is exposed, you either turn around or pass it on to the developer and the rest of the processing solutions. Then you turn on the light, inspect the print, and move it to the washer. Finally, you turn around or take the few steps back to the enlarger. Everything is accomplished with a minimum amount of time spent moving from one place to another.

Walls and Floor

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

Walls can only reflect the light that falls on them; if that light is safe for photographic materials, the light they reflect is also safe. Darkrooms should have light-colored walls.

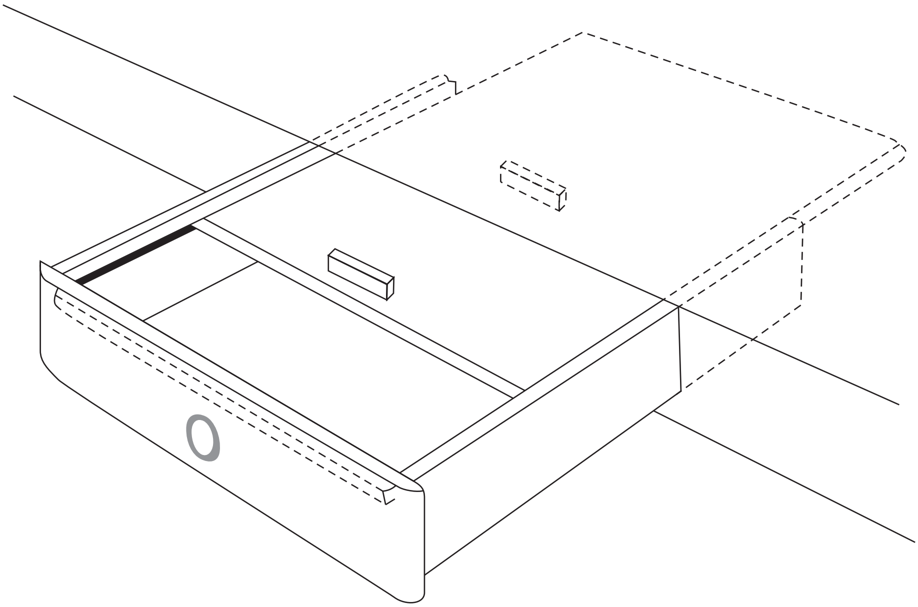

Figure 1-4 To make a dark drawer light-tight , install a sliding lid that fits in a groove around the top perimeter of the drawer. Paint the inside of the drawer and lid flat black. Attach a small block of wood on the top of the lid and another one on the underside of the counter top to push the lid closed when you close the drawer.

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 major source of light leaks, you can paint neutral gray behind and around it. Use flat white for the ceiling.

Personal Appeal to Educators

I have guest instructed darkroom workshops from Los Angeles to New York City and in 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 student at a high school or college and faced with the choice of spending three hours in a black darkroom or in front of a computer I would choose the computer simply to get out of the black room. 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, even behind and around the enlargers, and the ceiling white. You will change not only your students attitude towards the darkroom experience but your own as well.

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 well 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 sub-floor. A drain is useful but not entirely necessary if the floor is dried after spills.

A chemical-resistant anti-fatigue floor mat is another good idea. An anti-fatigue 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

Benches for a darkroom can be built by a cabinetmaker, purchased ready-made as modular kitchen units, or built by you. Sinks can also be purchased or made. I prefer a sink at least 6 feet long, preferably 8 × 10 foot. However, many photographers must make do with four foot sinks. A four foot sink will accommodate three 11 × 14 inch trays. A six foot sink will accommodate four 11 × 14 inch trays with barely enough room for a vertical print washer. If you do not normally 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 will 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 foot long). Attach both ends to the line via clothespins or film clips.

Storage Space

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

A light-tight "dark" drawer (Figure 1-4) located near the enlarger is an added convenience. This will provide quick access to printing paper and eliminate the necessity of opening and closing the package of paper every time you need a sheet.

To make a dark drawer, install a sliding lid that fits in a groove around the top perimeter of the drawer. Paint the inside, including the lid, flat black. Attach a small block of wood on the top of the lid and another on the underside of the countertop. The blocks of wood will push the lid closed when you close the drawer. If you do not have a dark drawer use a paper safe, even though it occupies valuable counter space.

You can use the sink for mixing chemicals and for all processing operations. Storage space for trays and chemical solutions should be beneath the sink. Shelves mounted two feet above both the sink and 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 Figure 1-5) provide a place for film hangers and graduates. A towel holder mounted on or near the sink provides a place for a towel to dry your hands.

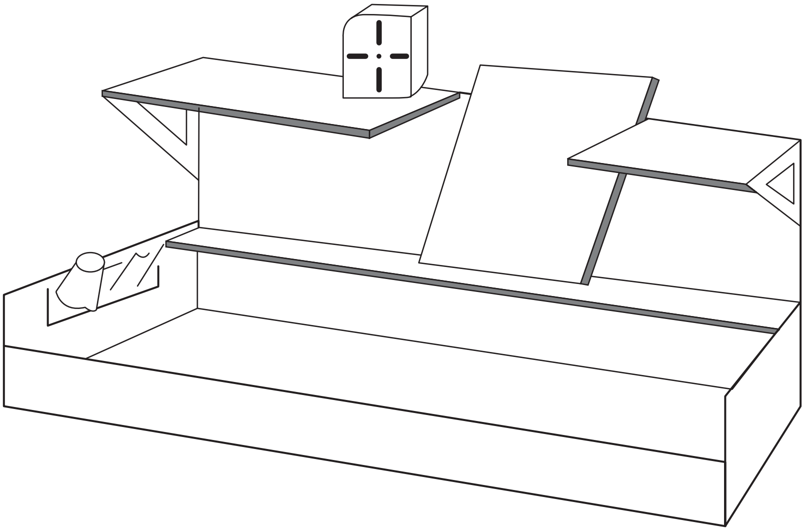

Figure 1-5 Diagram of a small sink. The faucet can be placed on the back wall or on either end. Pegs on the side, as shown, or splash wall behind can be used to dry measuring cups and small utensils.

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 color spectrum of the safelight. You can considerably shorten the time it takes your eyes to adjust by looking directly at the safelight for a few seconds.

SAFELIGHTS

Comfortable handling of negative material in the darkroom largely depends upon proper darkroom lighting. The lighting is a compromise between illumination of a color and intensity that does not fog sensitive materials but still enables the photographer to work with a minimum of inconvenience and eyestrain. It is essential that the correct safelight filter is selected and used in a housing of appropriate design and fitted with a bulb of the correct wattage.

Ordinary printing paper can be handled in a relatively high intensity of dark-brown or red-brown light, corresponding to Kodak OC or OA filters (OC is more commonly used for modern emulsions). Panchromatic papers (for example, discontinued Kodak Panalure® Select RC) are sensitive to all colors and require the use of a low-intensity Kodak #3 dark-green filter. Orthochromatic or red-blind materials such as high-contrast line films (also known as lith films) 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 that the illumination is evenly distributed over the entire area. This could be a safelight aimed at the ceiling, especially if the ceiling is painted flat white. A second location would be over the processing sink. Place the safelight at least four feet above the sink. If the light is aimed down, use a 15-watt frosted bulb. If it is bounced off a white ceiling use a 25-watt frosted bulb. If your darkroom is large enough, place a third safelight over the dry side in the same manner as over the wet side. If the size of your darkroom warrants it, use a Thomas Sodium Vapor Duplex Safelight.

TEMPORARY DARKROOMS

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

Finally, you can build a portable darkroom on a rolling cart. Substantial carts can be purchased that are designed as kitchen islands or butcher blocks on wheels. Chemicals, paper, etc. can be stored on the shelves, dodging tools and the like in the drawers, and the enlarger used and stored on top. The whole thing can be wheeled into the kitchen after the dishes are washed and then wheeled into a closet or the garage for storage.

For a lot less money and a little effort it is easy to build a cart to your specifications using 2 × 2 inch lumber and 3/4 inch to 1 inch plywood (do not use 1/2 inch plywood as it will not stay flat). Removing your enlarger from the baseboard it comes with and bolting it directly to the far edge of the plywood will greatly increase your working space and lower the top of the enlarger by an inch or so, making it easier to roll through doorways.

The top of the cart should be about 30 inches to 32 inches from the ground depending on 1) your height, or 2) the height of the doorways you need to maneuver through. Attach good-quality rolling casters to the feet 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 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 inches lumber or strips of excess plywood to keep things from falling off when you are 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 Figure 1-6.

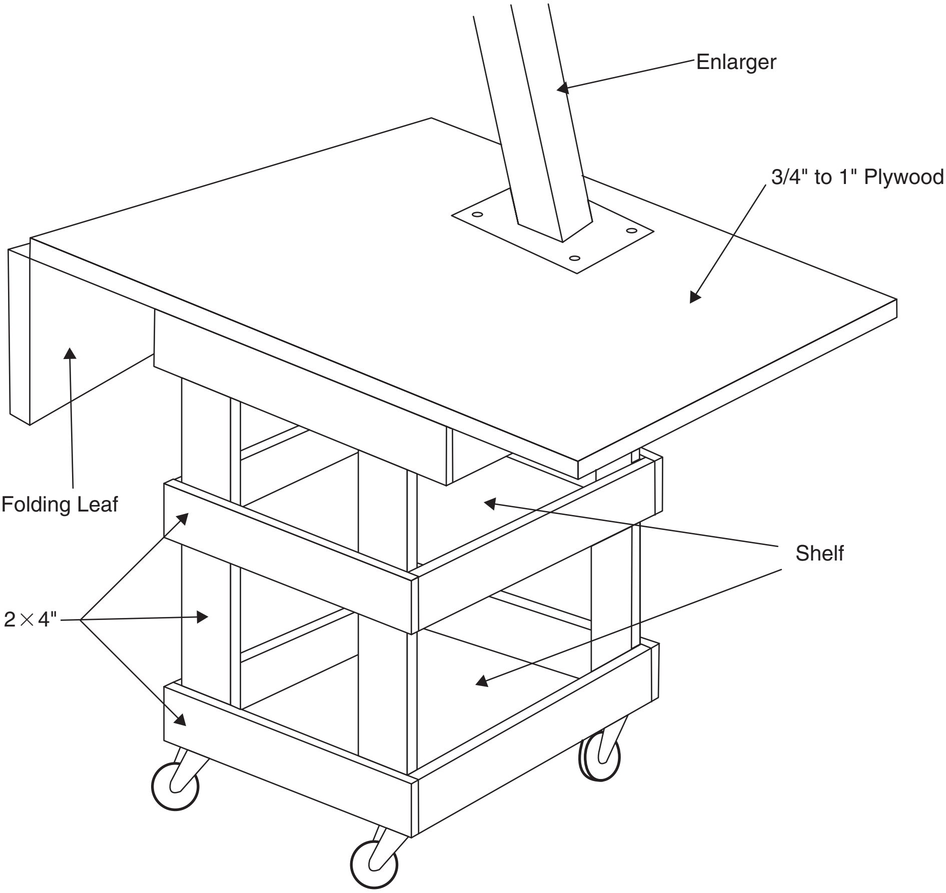

Figure 1-6 This is an example of a do-it-yourself roll away darkroom cart. The enlarger column has been bolted to the plywood to save space and lower the overall height (optional).

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 produces a degradation of 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 very important.

Nothing is more disappointing than to see the beautiful high values of an image degraded by a safelight that doesn't provide the proper protection. What is needed is a safelight testing procedure.

The procedure I use is as follows:

1. Turn the safelights off, without a negative in the enlarger. Using the fastest printing paper you use and with a short exposure, produce a light-gray tone just clearly above paper white. Brief testing will determine the correct exposure to produce this light gray (Chapter 8, Les McLean: Pre and Post Flashing).
2. After the base exposure level has been determined, expose a final sheet of paper, but don't develop it yet. All lights are still off.
3. Tape the paper emulsion-side up on a cardboard and set it 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 one inch section of paper and ruler with another piece of cardboard of around 11 × 14 inches and give the pre-exposed 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 exposure. This will produce a pattern of exposures 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 will be safe to use the safelight for about one-half of the safelight 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 four feet above the trays. Bouncing the light off the darkroom ceiling, assuming it is painted white, is another way to cut down on too much unsafe safelight.

Rolls Royce Running Board, Concours d'Elegance. © 2008 Richard Garrod. All rights reserved. Courtesy of the artist.

2

Equipment

> *People are under the illusion that it's easy … Technically, it is complex. You have a million options with equipment to distract you. I tell my students to simplify their equipment.*
>
> —Brett Weston

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 as long as the tanks are dry on the outside. Chemicals, liquid or powder, should never be placed on the dry side to avoid possible damage to negatives. The following is a list of recommended and optional items.

- Canned air for cleaning negatives (optional)
- Dark drawer or paper safe (optional)
- Enlarger
- Enlarger alignment tool (highly recommended)
- Enlarging lens
- Grain-focusing device
- Multicontrast filters
- Negative carrier(s)
- 4-blade paper easel
- Repeatable enlarging timer
- Soft brush and blower bulb for cleaning negatives

WET SIDE

The wet side includes the sink and an area in which 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 (Appendix 1: Safety in Handling Photographic Chemicals). The following is a list of recommended and optional items.

- Beaker or graduate
- Chemical resistant gloves

- Developing tank and reels
- Developing trays
- Dial thermometer
- Film-drying bag, cabinet, or a clothesline in the shower
- Film-hanging clips
- Film squeegee (optional)
- Film washer with hose attachment (the developing tank can often be used)
- Funnel
- Glass or photo-grade plastic storage bottles
- 1/4″ white Plexiglas® for viewing and squeegeeing wet prints (optional)
- Print-washing device
- Print-drying screens
- Process timer (e.g., GraLab® 300)
- Stainless steel tongs
- Stirring rod for mixing chemicals
- Water temperature control valve or water temperature monitor (optional)

MISCELLANEOUS

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

- Air cleaner or purifier (optional)
- Anti-fatigue mat (optional)
- Film-cassette opener or bottle opener
- Light box for judging negatives (optional)
- Magnifying loupe for negatives
- Measuring cups (optional)
- Measuring spoons (optional)
- Mortar and pestle (glass, porcelain, or dense plastic) (optional)
- Negative storage pages
- Paper trimmer (optional)
- Safelight
- Scale or balance beam (optional)
- Scissors
- Tape—drafting, black photographic, litho, and clear (optional)
- Trash can (extra large—highly recommended)
- Untreated coffee filters (optional)

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. An inexpensive mechanical scale, the Pelouze R-47, is available through camera stores in either metric or U.S.

customary models. It is accurate enough for quantities to 100.0 grams and has a good counterbalance system.

The next step up in a mechanical balance is the Ohaus Triple Beam Balance. The Ohaus will weigh up to 610.0 grams in 0.1 gram increments, which is more than enough for a small darkroom.

An electronic digital scale, such as a digital postal scale that reads in 0.1 increments, takes up less counter space and is accurate enough for darkroom work. You can even use an electronic scale made for measuring powder to make bullets.

If you will often be weighing small amounts of chemicals such as Phenidone, you will need a scale with readability to 0.01 grams. However, going from 0.1 grams to 0.01 grams readability almost doubles the price of the scale. If you feel you need 0.01 gram readability, a suitable model is Acculab's VIC-212 with 210.0 gram capacity.

A standard-issue two pound spring-loaded postage scale found in most stationery stores is also handy to have. This can be used for quick weighing of large amounts where accuracy is not critical—for example, weighing one pound of sodium thiosulfate for a standard hypo bath. I have a two-pound Pelouze postage scale for just this purpose. The best part is you do not have to worry if the postage rates go up!

TEASPOON MEASUREMENT

Even though a teaspoon conversion table can be found in the Conversion Tables at the end of the book, a completely accurate conversion of weight to volume is not possible. This is because as chemicals age they absorb or lose water molecules, which can cause a change in weight but not volume. As teaspoon measurement deals with volume, not weight, it is arguably more accurate than weighing. This is because were you to measure a level teaspoon of fresh sodium carbonate today, and again in a month or two from the same bottle, the second teaspoonful would weigh more because of water absorption. If you are consistent in your work habits, teaspoon measurement should prove to be as reliable as using a scale, especially since the change in weight caused by water absorption (or loss) affects the potency of chemicals measured by weight, as well.

STORAGE BOTTLES

Maintain a good selection of photo-grade storage bottles. Starting with 250.0 ml, double the size and have several containers that are 500.0 ml, 1.0 liter, 2.0 liter, and 4.0 liter. Photo storage bottles can be purchased from many photography stores and any chemical outlet. A list of chemical outlets is found in Resources.

Developers should be kept in brown amber glass bottles, particularly if stored for more than a few weeks. This is because developers easily oxidize and lose their potency when exposed to air and/or light. Plastic bottles breathe and will speed the rate of oxidation. High-density polyethylene storage bottles are suitable for solutions of fixer, stop bath, bromide, carbonate, and just about anything except developers.

BEAKERS, MIXING CONTAINERS, AND GRADUATES

In addition to bottles, 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 used for measuring liquids. A beaker is wider and sometimes has a handle; it may or may not have units of measurement on it. Graduates are primarily used for measuring liquids; beakers can be used for measuring but are more useful for mixing and pouring.

For the utmost convenience you should eventually obtain at least three graduates—25.0 ml, 100.0 ml, and 1.0 liter. The 1.0 liter graduate can be used in place of a 1.0 liter beaker for mixing. In addition to a 1.0 liter beaker or graduate, a 4.0 liter beaker is indispensable.

Developers

> *One developing agent is best, two is okay, three is very suspect, and four the guy is definitely a jerk.*
>
> —Bob Schwalberg

Developers are made up of four basic components:

- Developing agent.
- Preservative, which slows the rate of developer oxidation.
- Accelerator, which energizes the developer.
- Restrainer, which restricts the formation of excessive fog and/or slows the rate of development.

All four of these components are necessary for the development process to be successful. 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 (100.0 grams) serves to create 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 out of the film, acting as an effective restrainer. D-23 has only two chemicals—metol and sodium sulfite—yet as a developer it has all four of the required components!

DEVELOPING AGENTS

For the non-chemist, development is a reduction process. Silver halide[1] crystals are selectively reduced, through the action of a developer, to metallic silver. In order 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 action of the developer. When light is sharply focused by a lens, on film or paper, certain areas receive more exposure than others. The more light an area receives, the more silver halide is affected and sub-sequently reduced to metallic silver. The more metallic silver in an area of the film or paper, the darker it appears.

[1] Silver halide includes 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 of the two, usually with small amounts of silver iodide.

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

The following are the four most common developing agents in use today:

- Ascorbic acid
- Hydroquinone
- Metol
- Phenidone™

Other agents more commonly used in the past are as follows:

- Amidol
- Chlorhydroquinone
- Glycin
- Para-Aminophenol hydrochloride
- Para-Phenylenediamine (ppd)
- Pyrocatechin (catechol)
- Pyrogallic acid (pyro)

All of the above developing agents have unique characteristics, and some have a special purpose. The shortening of the list of modern developing agents has more to do with ease of manufacture, storage, and shipping than it does with their usefulness. The superadditive effects of hydroquinone, metol, Phenidone, and ascorbic acid (see discussion of superadditivity later in this chapter) has also added to their popularity with manufacturers.

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 better suited for film development than for paper development, while chlorhydroquinone is better suited for paper than film. Hydroquinone, metol, ascorbic acid, and Phenidone are well suited for either film or paper. This is an additional reason they are preferred by manufacturers. It is worthwhile to familiarize yourself with the brief description of each developing agent in Appendix 3: Pharmacopoeia.

Superadditivity

The phenomenon known as superadditivity plays an important role in many film developers. Superadditivity occurs when the combined result of two developing agents is greater than either one of them working alone.

As a developing agent, metol provides good low-contrast shadow detail but produces weak highlight density. It is also fast-acting. Hydroquinone, on the other hand, is a slow-acting developing agent, which, when used alone, is capable of creating strong highlights and high-contrast images.

Combining metol with hydroquinone can, in some formulas, result in a developer that is faster 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).[2] The optimum

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[2] Quinol is Kodak's trade name for hydroquinone.

quantity of metol to hydroquinone is said to be 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 exremely low-contrast negatives (an exception is the low-contrast developer, POTA, which is intended to produce low contrast negatives). By adding a comparatively small quantity to a hydroquinone developer, Phenidone retains its high activity and combines with it the higher contrast of hydroquinone. The optimum amount of Phenidone to hydroquinone is said to be 7%.

Under most conditions, Phenidone is about eighteen 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 often have a tendency to produce more fog. Fortunately, this can be controlled by the addition of benzotriazole in the amount of 0.1 to 0.2 g/L (because of the difficulty of measuring small amounts, it is easier to use 5.0 to 10.0 ml of a 2% benzotriazole solution, Appendix 2: Chemicals).

Finally, the higher the proportion of either metol or Phenidone, the lower the contrast of the negative or print. Conversely, the higher the proportion of hydroquinone, the higher the contrast.

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 above it would seem that the best developers to use are those that exhibit 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 high-value density than those that rely on one developing agent. A developer of the semi-compensating type using either metol or pyro alone in a solution of relatively low pH is capable of producing brilliant high values, full-scale midtones, and shadows, for example, Kodak D-23 and Kodak D-1/ABC Pyro.

With the average MQ or PQ developer, by the time the required shadow density is reached, the high-value densities may be too severe. 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 general purpose MQ or PQ developers use them as one-shot developers, diluted 1:1. This provides additional highlight compensation without greatly increasing the development time and without causing loss of emulsion speed.

Because superadditive formulas result in shorter development times, usually five to ten minutes, the advantage of prolonged development times, fifteen to thirty 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

During the development process the developing agent is oxidized, rendering it useless. However, developers will oxidize even without the development process. To prevent this, or at least inhibit the rate of oxidation, a preservative is added to the developer.

By far the most commonly used preservative is sodium sulfite. Potassium sulfite is only occasionally used in highly concentrated formulas such as Rodinal.

Sodium bisulfite is often preferred in pyro developers and in Phenidone concentrates (Appendix 3: Pharmacopoeia: Phenidone). Sodium bisulfite[3] is often used in formulas that are 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 immediately broken down into sulfite and bicarbonate, producing a useful buffering effect.

Potassium metabisulfite will sometimes be encountered in formulas. For photographic purposes, there is no practical difference between potassium and sodium metabisulfite 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 very 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 some form of 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 accelerator:

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

Increasing the amount of accelerator in a developer will increase the contrast. This is because it creates a more active environment in which 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.

pH

The pH of a developer plays a major 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 is 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 prior to 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.

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[3] Sodium bisulfite and sodium metabisulfite are for all practical purposes identical and are often the same chemical.

pH Scale The pH scale has a range from 1 to 14, 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. An example of an alkali would be laundry soap; an example of an acid would be lemon juice. Mild acids and alkalis fall close to 7 on the scale; 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 small change in pH indicates a sizeable variation in alkalinity. An inexpensive meter that will enable you to monitor pH levels is the pHep® made by Hanna Instruments.

Here are some examples of the pH value of chemicals used in developing, as well as common liquids for reference:

14.0 – Sodium hydroxide (4%); liquid drain cleaner
13.0 – Sodium hydroxide (0.4%); liquid bleach
12.0 – Developers containing caustic alkali; soapy water
11.5 – Sodium carbonate (5%)
11.3 – Trisodium phosphate (1%)
11.0 – Ammonia solution
10.5 – Sodium metaborate; developers containing carbonate
10.0 – Milk of Magnesia
9.9 – Balanced Alkali (0.2%)
9.5 – Borax (0.1%)
9.0 – Alkaline fixer (8.5–9.5); fine grain developers, baking soda
8.0 – Sodium sulfite (5%); sea water
7.0 – Deionized water; potassium bromide
6.0 – Saliva
5.2 – Boric acid (0.5%)
5.0 – Black coffee
4.3 – Sodium bisulfite
4.2 – Fresh acid fixers
4.0 – Stop baths; tomato juice
3.0 – Grapefruit and orange juice
2.9 – Acetic acid stop bath
2.2 – Citric acid (2%)
2.0 – Lemon juice; vinegar
1.2 – Sulfuric acid (1%)
1.1 – Hydrochloric acid (3 to 4%)
1.0 – Hydrochloric acid secreted by stomach
0.0 – Battery acid

pH has another implication for photographers and that is: Acid and alkali neutralize each other. With the exception of Amidol-based developers, developing formulas are all alkali and almost all fixing formulas used today are acid. That is why 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 alkali developer and place it directly into an acid fixer, the fixer will rapidly become neutral in pH and no longer work. This is perhaps more serious than going the other way because all the prints and negatives that appear to be fixed while the acid fixer is becoming less active due to alkali contamination, will deteriorate in a relatively short time after processing.

Buffering

A buffer acts to keep the pH of the solution fairly constant. A buffered developer will maintain a constant pH whether it is diluted 1:1 or 1:3. A non-buffered 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 of time in a working solution, especially in large concentrations.

Balanced Alkali is a proprietary chemical of Eastman Kodak, and until recently it was known as Kodalk®. Balanced Alkali is more alkaline than borax and more easily soluble, but less alkaline than carbonate. As Balanced Alkali contains no free carbonate, there is no danger of carbonic gas bubbles being formed when an acid stop bath is used (see the next section, Moderate Alkalis). Balanced Alkali can be substituted for carbonate (Conversion Tables: Alkali Substitutions), and for almost all purposes it is identical to sodium metaborate.

A substitution for Balanced Alkali can be made by mixing sodium hydroxide with borax, decahydrate (Appendix 3: Pharmacopoeia: Balanced Alkali).

Borax is the mildest common alkali. It finds its widest use in low-contrast and fine-grain developers. Decahydrate is the preferred form. 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, generally referred to as "carbonate," is available in three forms: anhydrous (also known as desiccated), monohydrous, and crystalline. The difference between the three concerns the number of water molecules attached to each molecule of sodium carbonate. Anhydrous[4] has no water molecules attached, monohydrous[5] has one, and crystalline has ten.

The more water molecules there are, the greater the weight of chemical necessary to provide the same activity in solution. For example, the equivalent of 35.0 grams anhydrous would be 41.0 grams of monohydrate (Conversion Tables: Sodium Carbonate Conversion Table).

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[4] The prefix an- is from Greek and means "without." The word hydrous means "containing water." Anhydrous literally means "without containing water."

[5] 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 tends to lose 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 for this reason the most desirable.

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

Potassium carbonate is available in both anhydrous and crystalline forms. The crystalline contains 1.5 molecules of water and a small amount of bicarbonate buffer, depending on the grade. 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. Trisodium phosphate (TSP) can often be used as a moderate alkali.

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, as far as photography is concerned, 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 somewhat higher.

Phosphates

Sodium and potassium phosphate approach the pH of the hydroxides without being as dangerous to handle. Although technically speaking phosphates are not true alkalis, they can be considered as replacements for hydroxides when high alkalinity is desired.

One reason phosphates have been little used is that they can cause a 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 appear to be less stable than other alkalis.

RESTRAINERS

Restrainers are necessary to prevent excess fog. With film developers, this primarily means chemical fog. With paper developers, restrainers are used to retard both chemical and safelight fog.

Restrainers should sparingly be used in film developers. Some photo chemists recommend that they not be used at all. According to photo chemist Bill Troop, "A film developer should not need to use a restrainer—if it does then the alkali is too strong." Even so, most film-developing formulas rely on restrainers, partly to prevent fog and partly as "insurance" against errors in formulation.

Whereas a degree of base fog is permissible in a negative, no amount of fog, which would show up as gray highlights, is acceptable in paper. For this reason, paper developers always require restrainer, often in significant amounts.

Potassium Bromide

Potassium bromide, usually referred to as "bromide," is the primary restrainer found in most developers. Bromide has the effect of holding back the overall action of the developer, reducing the effective sensitivity of the film, and diminishing the amount of useful density created in the shadow areas. By inhibiting the reduction of silver halide, bromide also acts to increase contrast. This action varies with different developers.

As film is developed, soluble bromide is produced and passes into the developer solution. This buildup of bromide adds to the already existing restrainer. If too much bromide is initially present, the combined amounts can considerably affect the contrast and effective 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, altering the direction of agitation, and the use of "one-shot" developers or the proper replenishment of developers before use.

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 and fogging may occur.

Benzotriazole (BZT)

The antifogging effects of BZT are greater than bromide, 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.

For salvaging outdated papers, mix a 0.2% solution (2.0 grams in water at 125F/52C to make 1.0 liter). Add 15.0 ml of this solution to every liter of developer. If 15.0 ml does not do the trick, keep adding 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, when the paper is held up to a white surface, such as the back of another piece of paper, it should show no signs of gray.

It is advisable with all old paper, 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 1/10th the solution concentration of the bromide.

Potassium Iodide

Although it is recommended by no less an authority than Geoffrey Crawley, former editor of the *British Journal of Photography* and formulator of FX and Paterson proprietary developers, potassium iodide has not been thoroughly investigated for its use as a restrainer. However, what little research has been done indicates that it is superior to potassium bromide. As a substitute, it is usually recommended to use 1/10 to 1/100 the weight of bromide. Iodide can also be used in combination with bromide.

OTHER ADDITIONS TO DEVELOPERS

Water Softener

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, a precipitate of calcium carbonate and sulfite may be deposited on film.

In areas of hard-water concentration, it is best to compound developers using distilled, deionized, or demineralized water. However, if none of these is available, a water softener can be added directly to the developer. Do not add a water softener unless it is absolutely necessary as it will change the pH balance of the developer.

If a water softener is required, use a small amount of sodium hexametaphosphate, available as the proprietary compound Calgon™. One part per 1,000 (1 g/L) should be sufficient, except for very hard water, in which case the amount can be increased up to 3 g/L. Always dissolve the water softener before adding the developing ingredients.

OTHER CONSIDERATIONS FOR DEVELOPERS

All developing agents in developer solution 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, developers containing pyrogallol, pyrocatechin, catechol, amidol, and many 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 in order to prevent oxidation. This can be achieved through the addition of glass marbles that take up extra space. However, do not use glass marbles with developers with high acid or alkali content (Appendix 2: Chemicals: Dos and Don'ts).

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 one to a new purpose. In doing so, keep these six aspects of the process in mind:

1. The developing agent—its nature, concentration, and, in cases where several are used, the ratio between them.
2. The alkali or accelerator—its nature and concentration. Also, keep in mind with film that if you have too much fog, you have too much alkali. Reduce the alkali content before adding restrainer.
3. The restrainer—its type and quantity.
4. The preservative can greatly affect both the graininess and compensating effect of the developer.
5. The percentage of each component in the formula.
6. Never compare stock solutions of formulas. Compare working dilutions only.

The following is a good way to teach yourself how to manipulate developing formulas and 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 Variable Contrast filter. Make a good print and write “control” on the back. Make thirteen 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 1.0 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 this time using only the hydroquinone and sulfite in 1.0 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 only 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 more than normal (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 only 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 1.0 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.

Ascorbic Acid: Developing Agent or Anti-oxidant?

Patrick Gainer

We know it as Vitamin C, an anti-oxidant essential to human life. Photographers think of it as a secondary developing agent in superadditive pairs such as Metol-Ascorbate or Phenidone-Ascorbate. These have been known for years but recently made popular by Kodak XTOL film developer.

The traditional synergistic or superadditive developer solution has four active ingredients: two developing agents, sulfite, and an alkali. We tend to take the sulfite for granted for control of grain and/or pH, but don't try leaving it out as it is also the preservative (anti-oxidant) which keeps the developer from going flat part way through development. Sodium sulfite is used as the preservative in nearly all developers, film or paper.

But a photographic developer can be made without sulfite by substituting ascorbic acid, 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 anti-oxidant 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 Ed Buffaloes's web site, www.unblinkingeye.com/articles, under Film and Film Developers: Vitamin C Developers).

A simple formula to try is:

Hot water, 250.0 ml
Ascorbic Acid , 2.0 g or 1/2 tsp
Metol, 0.2 g or 1/16 tsp
Sodium Carbonate, 5.0 g or 1 tsp
Water to make 1.0 liter

Use this formula as if it were D-76 undiluted.

For photographic use it is best to purchase either ascorbic acid or its isomer (mirror image) erythorbic acid. There are other perfectly legitimate forms of Vitamin C that are not legitimate for photo use, such as calcium ascorbate, especially if it is to be dissolved in propylene glycol or triethanolamine.

Three Long-Lasting Single-Solution Sulfite-Free Developers

Patrick A. Gainer

PCTEA

PCTEA is a Phenidone-ascorbic acid developer with triethanolamine (TEA for short) activator. Using this formula, I can't find the grain in HP5+ or TMAX 400 at less than a 20-power enlargement. Even in very thin negatives of low contrast, shadow detail is still apparent. The following formula may be scaled up to any desired amount.

TEA, 100.0 ml
Phenidone, 0.5 g
Ascorbic acid, 9.0 g

Heat the solvent to 250F/121C in a water bath, such as a double boiler with the top part covered to prevent condensation of water vapor into the developer concentrate. It won't boil, but some steam may be given off if there is any water in the solvent mixture. Steam will arise when the powdered ingredients are added, which I presume to be water produced in the reaction between the ascorbic acid and part of the TEA. Once the powders have dissolved they will remain in solution and as long as water is kept out of the stock it will not oxidize by exposure to air.

NOTE: Metol is not soluble in this solvent.

You can play with the dilution. I recommend 1 part of concentrate to 50 parts of water for starters. Dilute 1 + 50 and use the same initial developing times as D-76 1:1.

CATPTEA

The name does not refer to its appearance or its bouquet. I just couldn't resist. This is a staining developer containing catechol and Phenidone. You may use hydroquinone in place of the catechol if you like to save money. They are both dihydroxybenzene, the difference being in the location of one of the OH groups on the benzene ring. Both are staining developers.

TEA, 100.0 ml
Catechol, 10.0 g
Phenidone, 0.25 g

Heat as for PCTEA. Dilute 1 + 100 for use. The negatives will look thinner and of lower contrast to the eye than to the printing paper, and lower in contrast to VC than to #2-graded paper. If you use a 10% sodium sulfite solution to dilute the stock, you will have a developer similar to D-76. You can experiment with different proportions of stock, sulfite solution, and water.

PPTEA

This name does not refer to its appearance but to the fact that pyrogallol and Phenidone are the developing agents.

TEA, 100.0 ml
Pyrogallol, 10.0 g
Phenidone, 0.25 g

Heat as for PCTEA. Again, the negatives will be stained and look thinner and less contrasty to the eye than to the paper, and of lower contrast to VC than to graded paper.

Effects of Adding Sulfite

There is no sulfite in either the stock solution or the working solution. There are, in fact, no inorganic compounds in the stock solution. There is nothing to keep you from adding sulfite to the working solution, but try it first as is. If you add a tiny amount of sulfite to CATPTEA or PPTEA, say one-quarter teaspoon to the liter, its activity will increase because of the activation by the sulfite of the superadditivity between Phenidone and hydroquinone, catechol or pyrogallol. Graininess will also increase. It will still be a staining developer until you add a fair amount of sulfite.

Alicia De Larocha, soloist, Russell Stanger conductor, some members of Norfolk Symphony Orchestra at rehearsal, Virginia, 1971. © 2008 Patrick Gainer. All rights reserved. Courtesy of the artist.

Cold Springs Station, Nevada, 1999. © 2008 Steve Anchell. Ilford HP5+ developed in Edwal's FG-7 for 12 minutes at 70F/21C. The smooth tones of the fine grain effect are enhanced by the use of a medium format negative. Photo made with Mamiya RZ67 with a 65 mm *f*/4 lens.

Film Development

> *It is the photographer's job to see more intensely than most people do. He must keep in him something of the child who looks at the world for the first time or of the traveler who enters a strange country.*
>
> —Bill Brandt, 1948

The choice of which film developer to use is perhaps the single most important decision a photographer can make. Film developers directly affect the sharpness (acutance), graininess, tonal scale, and contrast of the image. 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.

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

Enlarging equipment must also be taken into account. Condenser enlargers emphasize contrast and crispness. A photographer using a condenser system may prefer a softer negative with lower grain acutance. Diffusion enlargers generally work best with negatives that exhibit maximum sharpness. With diffusion systems, graininess is not usually as important because diffused light has a tendency to mask it. In the following sections, developers will be discussed according to their specializations or unique qualities.

EMULSION TYPES

Three distinct emulsion types are used to make film for pictorial black and white photography. The films mentioned are not exhaustive but given to represent films in each category. The emulsion types are:

- Old-style emulsions which are represented by Efke® 25, 50, and 100. These are films coated using technology from the 1960s and are the last of their kind. The grain in these films appears like microscopic pebbles and is known as cubic crystal grain. These films rely entirely on the light sensitivity of silver halide suspended in gelatin to create the film's speed or ISO. In general, they have less hardener than other emulsion types, which means they must be handled carefully when wet. If an acid fixer is used it should contain hardener or a liquid hardener should be added.

  These are good films to use for Zone System–style expansion and contractions particularly with large format. They also respond well to variations in developers.

  Elsewhere in the *Cookbook* these will be referred to as old-style emulsions.

The Anatomy of Film

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.

Definitions

- Acutance: The separation of adjoining objects or details on a film. Also known as sharpness of definition and edge sharpness. When two objects are adjoining on a film, acutance describes how sharp and clear the line is between them. All the things that cause graininess can lower the acutance of a film. 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 Kodak Technical Pan or Ilford Pan-F, developed in high-definition developers such as Windisch Extreme Compensating Developer or POTA, will produce negatives, even from 35 mm, of extremely high acutance with the ability to enlarge to mural size. The trade-off is an extremely low EI.
- Grain or Granularity: The measurable grain size of any undeveloped film. Generally, slower films have smaller grain, faster films have larger grain. Grain size is predetermined by the manufacturer.
- Graininess (grain aggregation): The clumping together of individual grain particles during development. Graininess 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 grain size.

  Factors that can increase graininess are over-vigorous agitation during development with old-style emulsions, solutions that vary more than ±2 degrees, storage at high temperature; and overexposure in the camera.

Grain and graininess can be 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: The ability of the emulsion to record fine detail. Resolving power is determined by photographing a line graph. Although the quality of the lens does affect the resolving power of the film, most lenses made today have higher resolving power than the film is able to reproduce. Both fineness of grain size and graininess affect the smoothness of tone and the resolving power of the film.

- Conventional-grain emulsions use grain which is either flat or a hybrid of cubic and flat grain. To varying degrees all of the films in this category utilize color dye sensitization in order to replace some of the silver in the emulsion and increase the film's sensitivity to light. Among others these films include Efke 400®;[1] Neopan® 400 and 1600; Ilford Pan F®, FP4+®, and HP5+®, and Kodak Plus-X® and Tri-X®. These films respond somewhat to changes in developer formulae but not as much as old-style emulsions. They have more hardener in the emulsion and are not as easily damaged when wet. With reasonable care in handling, it is not necessary to add additional hardener to the fixer.[2]

  Elsewhere in the *Cookbook* these will be referred to as conventional-grain emulsions.
- Modern flat-grain emulsions use flat grains of silver which have almost no depth. Instead of appearing like grains of salt or pebbles, these flat grains appear more like microscopic flagstones. Flat-grain emulsions rely heavily on color-dye sensitization to further 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 (see: And in This Corner: Tri-X vs. T-Max).

  Typical of these are Ilford Delta® 100, 400, and 3200; Fuji Acros® 100; Kodak T-Max® 100, 400, and P3200.

  Elsewhere in the *Cookbook*, these will be referred to as flat-grain emulsions.

FILM TYPES

In addition to different types of emulsions, there are different types of film. These include panchromatic films, which are sensitive to all colors of visible light to varying degrees (these include all those films mentioned in the previous section); orthochromatic films, which are primarily blue-sensitive; infrared films, which record in the infrared or near-infrared spectrum; document films, which are extremely high in contrast exhibiting little or no mid-tones unless

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[1] Efke 400 is the discontinued Agfa APX 400 and is a conventional-grain emulsion, not an old-style emulsion as are the other three Efke films. There is some speculation that it will soon be available under the Adox label as ADX 400.

[2] Hardener protects the film while it is wet and vulnerable. It serves no purpose for a dry emulsion.

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

In the 1950s Kodak introduced Tri-X film. At ISO 400 Tri-X was the first fast film made for general use. Even though the 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. Within a short time Kodak had improved the grain size of Tri-X and over the years other improvements and tweaks were made. As a result Kodak Tri-X became the world's best-selling black-and-white film.

In the 1980s Kodak introduced T-Max tabular grain films. These films were based on "growing" flat silver halide crystals with the flat surface of each crystal facing the surface of the film to more efficiently collect light. In order to further increase the sensitivity of the flat-grain crystals to light, color-dye technology, developed through years of research on color negative and transparency films, was added. This allowed Kodak to use less silver. The result was a line of films that Kodak was able to make for less money and label as "modern" allowing them to be sold at a higher price.

At first many photographers, myself included, anxious to be in the forefront of new and better film technology fell for the marketing hype. Kodak executives watched closely as the sale of Tri-X dropped precipitously and the sale of T-Max 400 soared. When sales of Tri-X reached a predetermined baseline, Kodak planned to discontinue it altogether. Unfortunately for Kodak, in a very short time photographers *worldwide* realized that T-Max was inferior to Tri-X. The reason is that the thin, flat grains of silver literally do not have the depth of rounded pebble shape grains which enable them to record microscopic variations in contrast. In other words, the flatter the grain the less capable it is of recording micro-contrast. Almost overnight the sales figures reversed, and T-Max 400 nearly fell off the sales charts. Kodak's response was to increase the advertising budget for T-Max.

But the story does not end here. Excited with the increased profit that color dye–sensitized films could bring if only photographers would cooperate, Kodak reengineered all of their films, including Tri-X, reducing the silver content and replacing it with increased color-dye sensitization, and semi-flattening the silver grains. So, instead of a flat-grain film with color-dye sensitizers like T-Max 400, Tri-X is now a semi-flat grain film with color-dye sensitizers. (In fairness to Kodak, the same treatment appears to have improved Plus-X which was formerly noted for "mushy" grain.)

The end result is that while Tri-X remains a better film than T-Max it has lost the grainy, gutsy Tri-X look so prized by photographers. It now has a homogeneous appearance with no distinct characteristics other than being a fast film with "super-fine grain."

developed in extreme low contrast developers; and chromogenic films, which are meant to be processed in C-41 color chemistry.

As panchromatic film choices have narrowed, so too have choices in alternative films. Current orthochromatic films include Adox 25 ORT® and Rollei Ortho 25®. Infrared films include Efke IR820®, Rollei Infrared®, and Kodak High Speed Infrared®. Ilford SFX 200® is considered a near-infrared film, as it is only able to record in the 740 nm range. (The higher the spectral sensitivity the further into the infrared spectrum the film is able to record. Efke and Rollei both have spectral sensitivity in the 820 nm range, while Kodak records in the 900 nm spectrum. This makes SFX easier to use although the results are not as dramatic as those obtained with true infrared films.)

With the demise of Kodak Tech Pan® only two document films remain: Adox CMS 20® and Rollei ATP 1.1®.

Ilford XP2® Super chromogenic film is an excellent film choice for those who are not able to develop their own. Based on color negative film technology it can be taken to any one-hour photo lab for development, and the resulting negatives can be printed using an enlarger. Because of the orange dye mask, similar to the one seen on color negative films, it does take longer to expose photo paper when making a print, especially if the film has been overexposed. Use at the rated ISO of 400 or EI 500 for a slightly thinner negative that is easier to print.

PRESOAKING FILM

There is absolutely nothing wrong with presoaking film prior to development—it just isn't necessary in most cases. Presoaking is necessary and should always be used for the following:

- Tray development of multiple sheets of large-format film using the shuffle method.
- With development times less than five minutes. Presoaking will ensure the complete removal of the anti-halation backing with short development times—otherwise unevenness may occur. Always presoak when making internegatives which are typically developed for 1.5 to 2 minutes in D-72 (see also Chapter 13: Interpositives).
- With stand development (see below).
- When a specific process calls for presoaking.

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 has a direct effect on image sharpness. The first benefit, preventing chemical defects, is accomplished within the first minute of development. This is because there are certain irreversible chemical defects that can *begin* within that time. If allowed to begin, they become worse during the course of development. The solution is continuous agitation for the first 50 to 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 areas 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, which continues to develop the highlights, increasing the contrast.

The third, increased sharpness is the result of adjacency effects that occur at the boundaries of image detail. One of several adjacency effects is the Eberhard effect, which increases fine-line detail in the negative, essential to maintaining quality in prints greater than approximately 10× enlargement. Adjacency effects only occur when the negative is allowed to stand without agitation for at least 50 seconds. This allows naturally occurring convection currents to move the developer across areas of high and low density.

There are four methods of agitation: Intermittent, minimal, continuous, and stand development which will be discussed in its own section below. In order to obtain negatives with the highest degree of edge sharpness and contrast of fine detail, intermittent, minimal, or stand development must be used. Continuous agitation should be avoided.

Intermittent Agitation To take full advantage of adjacency effects to achieve a high degree of sharpness, agitate continuously for the first 50 to 60 seconds to prevent chemical defects and then for 10 seconds every minute thereafter.

Minimal Agitation You can gain additional sharpness by using minimal agitation. This is accomplished by adding 50% to your normal development time and agitating continuously for the first 50 to 60 seconds and then for 10 seconds every 3 minutes.

Continuous Agitation This method is especially popular among those using JOBO rotary processors. The film is agitated non-stop for the full time of development. The direction of agitation should be varied to avoid streaks or patterns on the film. Development time should be reduced by 20%.

The difference between intermittent, minimal, and continuous agitation will only be apparent with enlargements greater than approximately 10×. If you never intend to make greater than 10× enlargements, it is not as important which agitation method you use. A 35 mm negative enlarged 10× will be approximately 8 × 14 inches. A 4 × 5 inch negative enlarged 10× would be approximately 40 × 50 inches. In other words, those developing 4 × 5 inches or larger negatives usually will not need to concern themselves with the difference as most photographers rarely if ever print as large as 40 × 50 inches. However, those using 35 mm or 120 film should use intermittent agitation unless they may someday wish to make 20 × 24 inch prints (20× enlargement), in which case they should consider using minimal agitation or stand development.

Shorter Agitation Intervals Before adjacency effects were thoroughly researched and understood a number of film makers, chief among them Agfa, recommended agitation every 30 seconds.

Today, if a formula requires a more frequent agitation cycle than once per minute you should consider the reason. If the reason is to prevent staining or some other form of negative defect, I highly recommend not using the formula. There are too many excellent formulas to choose from without chancing damage to your negatives with a poorly formulated developer that might damage your film if you do not agitate in a proscribed manner. One agitation cycle per minute or minimal agitation will work with any correctly formulated developer to prevent artifacts of any kind from appearing on your negatives while creating a high degree of sharpness.

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. It is not necessary to shake a developing tank as though you are mixing martinis. This method of agitation only serves to agitate the photographer. All that is required to properly agitate film is a random flow of fresh developer. Inverting and twisting a developing tank clockwise and then inverting and twisting it counter-clockwise at a rate of three to four inversions in 10 seconds should provide sufficient agitation for almost any film-developing process.

When developing sheet film in a tray either develop one sheet at a time or use a sheet film developing tray[3] which holds each negative in a separate compartment. Agitate continuously for the first 60 seconds by gently lifting one corner of the tray, then the other, then both corners, at the rate of about 3 to 4 seconds for each lift. Set the tray down between each corner lift, which will help to break up the flow of the developer creating a more random pattern. At the end of the first minute let the film sit in the tray without motion for 50 seconds then agitate for 10 seconds. Repeat this cycle for the balance of the development time.

Stand Development

Stand development is a method of film development used by many early photographers. There are stories of the French photographer Eugéne Atget who would leave his large-format negatives in separate trays of developer while he entertained guests or enjoyed dinner. Every half hour or so he would pop into the darkroom and inspect his negatives under a safelight, moving some to the fixer and then to be washed and leaving the others to continue to develop. (See *Flower Composition* on page 51.)

There are several advantages to stand development. First, it maximizes adjacency effects creating negatives of the highest acutance. Another is that it 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. Yet another is that it tends to increase emulsion speed. These benefits also accrue with minimal agitation, mentioned earlier, but to an even greater extent using stand development.

Along with the advantages, stand development has several disadvantages. First, it does not work well with high-speed films—dichroic fog is likely to occur. I recommend not using any film with an ISO higher than 125. Stand development should only be used with developing agents that do not rapidly exhaust. Developers containing pyrogallol or pyrocatechin should be avoided for this method. An ideal developer would be one containing glycin which is clean and long-lasting. One of the best formulas for stand development was Crawley's FX 2.

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[3] Sheet film developing trays are available from the Photographers' Formulary (see Resources). I highly recommend their use for 4 × 5 inch, 5 × 7 inch, and 8 × 10 inch sheet film in trays.

Unfortunately, one of the ingredients in FX 2, Pinacryptol Yellow, is no longer readily available. If FX 2 is not available try using Photographers' Formulary TFX-2, which is a variation of FX 2.

The method of stand development is relatively easy. Presoak the film for one to three minutes. Use a few drops of Edwal LFN® to help with uniform development. Transfer the film to the developer[4] and agitate for one full minute. The film is left in the developer without movement for about 45 minutes (plus or minus). At that time the progress of development can be checked with a green safelight filter and a 15 watt bulb placed approximately four feet from the film. The inspection should be for 20 seconds or less. After that, return every 15 to 20 minutes as needed. When the film is developed to your satisfaction move it to a running water rinse for one minute, then fix with Photographers' Formulary TF-4, and wash in the usual manner.

The rate of development is so slow that noticeable changes in contrast take at least 10 minutes. To avoid additional base fog, it is recommended to not go much beyond 90 minutes. My experience has shown that if the film is left for two hours or longer, all that occurs is the developer exhausts itself and the negative soaks in the inert solution—though fog levels may increase, which result in longer print times. Of course, negatives should not be left longer than necessary if for no other reason than to avoid further softening of the emulsion.

DEVELOPER VOLUME

One roll of 36-exposure 35 mm film contains approximately 80 square (80^2) inches of film surface. Likewise, one roll of 120 film contains 80^2 inches of film surface. Four 4 × 5 inch negatives or one 8 ×10 inch negative measures out to have 80^2 inches of film surface. If you are not certain, lay any of the above out on an 8 × 10 inch piece of enlarging paper and you will see this is so. For this reason, when discussing the amount of developer required to develop a negative it is customary to refer to 80^2 inches of film.

According to the Kodak Research Lab it only takes 150.0 ml of developer to cover the surface of 80^2 inches of film and to develop that film. What is missed by some 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 in order to maximize profits to the last penny. What is also missed is that there is a difference between minimal development and full development of a negative or roll of film. What is further missed is that Kodak's final conclusion was that while 150.0 ml could develop 80^2 inches of film, far better results would be obtained by using a minimum of 250.0 ml of *undiluted* developer.

The one thing all photographers can do to instantly improve the quality of their negatives and guarantee full and complete development of every negative on a roll of film or batch of sheet film is to increase the volume of developer that they routinely use. The bare-bones minimum that should be used to develop 80^2 inches of film is 250.0 ml of undiluted developer. This means that if you are developing a single roll of 120 in a two-reel metal tank and using 500.0 ml of D-76 straight (undiluted), you are in good shape as you are using double the

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[4] The developer is often used at half its usual strength (e.g.,TFX-2 1:1).

minimum. However, if you are developing two rolls of 35 mm 36-exposure film in the same two-reel metal tank you are back down to 250.0 ml per 80^2 inches. You will obtain consistently better results were you to remove one roll of film, replace it with an empty reel as a spacer and use 500.0 ml of developer—it is not possible to use too much developer, and more is always better.

All developers require a minimum amount of developing agent in solution per roll of film to prevent oxidation and underdevelopment. While some developers are meant to be diluted in order to make a working solution, others can be used undiluted or with a variety of dilutions. An example of the former would be Ilford DD-X® which is meant to be used 1:4. Though developers such as DD-X diluted 1:4 can be used at 250.0 ml per 80^2 inches of film 350.0 ml would be better. An example of the latter would be D-76, which is able to be used at various dilutions. Undiluted D-76 can be used at 250.0 ml per 80^2 inches of film (though I recommend a minimum of 350.0 ml). However, if you dilute D-76 you should increase the volume of developer to maintain the quantity of developing agent in solution. A good rule to follow would be to increase the amount of developer by the amount of dilution. In the case of D-76 1+1, use 500.0 ml instead of 250.0 ml to adjust for the reduced amount of developing agent in solution and the longer development time. If you were to use D-76 1+3 then use three times the amount of the undiluted developer for a total of 750.0 ml per 80^2 inches.

There are two reasons photographers might wish to use a lesser volume of developer. The first is they believe they will save money, and the second is that they are afraid of burning out the motor on their rotary processor. In the first case, the extra twenty-five cents spent on developer will be well worth the expense. As far as the motor on the rotary processor, the film you are developing does not care whether you are using a rotary processor, tray, tank, brush, or Versamat. If you insist on using a rotary processor then develop only as many rolls of film as will allow you to use 250.0 ml of developer per 80^2 inches at a time.[5]

My personal recommendation is to use a Paterson System 4® tank and fill it with 500.0 ml of developer for one 120 roll and 700.0 ml of developer for two rolls of 35 mm film. You will find your negatives are of consistently higher quality.

WASHING

All that is required for complete and thorough washing of film (and paper) is a continuous flow of fresh water over the surface of the material. The speed of the flow is not important—the flow rate can be minimal as long as it is continuous and fresh. The presence of air bubbles can be detrimental to a thorough wash. This is because where air bubbles come in contact with the material, no washing is taking place. Leaving the film in the developing tank and pushing a rubber hose down the center of the reels is all that is required.

The amount of time required for a thorough wash depends on the type of fixer and whether or not a hypo clearing agent is used. This will be discussed in Chapter 9: Stop Baths and Fixers.

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[5] Some readers may conclude that I have it out for JOBO rotary processors. Not at all. I highly recommend them for use with all color processes, C-41, E6, Ilfochrome, etc. They are also fine to use for paper development and negatives larger than 4 × 5 inches as long as sufficient volume of developer is maintained. They should never be used with developers that contain pyrogallol or pyrocatechin.

TYPES OF DEVELOPERS

Divided Developers

Divided developers are used for what is known as either divided or two-bath development. 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.

Divided development has a number of secondary advantages:

- It produces even, consistent development.
- Development takes place primarily on the surface of the film so there is less halation and irradiation, resulting in the best possible sharpness.
- Depending on the choice of developing agents, there can be little or no loss in emulsion sensitivity; often sensitivity is increased.
- Temperature variations have minimal effect on contrast and density.

Another advantage is that the cost of developer per roll of film is much less than with single-solution developers. A safe number of rolls of film to develop using one liter of the first bath is twenty, as long as the solution is not contaminated or does not oxidize. The second bath, which contains the less expensive chemicals, should be discarded after processing ten rolls of film. Divided development can be used for all films except document films (for example, Rollei ATP®).

When formulating a divided developer the addition of sodium bisulfite to the first bath will help prevent oxidation. The rule is to make the preservative approximately 20% bisulfite (for example, D-23 Divided Developer requires 100.0 grams of sodium sulfite; instead use 80.0 grams of sulfite and 20.0 grams of bisulfite).

Technique of Divided Development In divided development, two separate baths are used. The first bath contains the developing agent(s), restrainer, and preservative. The second bath contains the accelerator. The second bath is used to activate the developer. 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.

Film is placed in the first bath where the emulsion absorbs the developing agent. Because the pH is low, little or no development takes place. The film is then transferred directly to the second bath *without* rinsing.

Development takes place in the second bath until the developing agent 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 the compensating action mentioned earlier.

Do not use a presoak and do not rinse between the first and second baths. After the second bath, use a water rinse or place the film directly into 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 ten seconds every minute. It is usually recommended to use continuous agitation in the second bath.

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

Water Bath Development

Water bath development is similar to divided development. Both methods are useful for reducing overall contrast while maintaining density in the key shadow areas.

There are two major differences between divided and water bath development. The first is agitation. In divided development, agitation takes place in both the first and second baths. In water bath development, the film is gently placed into the second bath and left without motion for two to three minutes.

The second difference is that divided development is a once-in, once-out process: once in A, once in B, rinse, then fix. Water bath development is meant to be a repeatable process. After immersion in the second bath, the film is returned to the A bath and the process repeated as many times as necessary to achieve the desired contrast or density. For this reason, water bath development is best used in conjunction with development by inspection.

A problem sometimes experienced when using water bath development with conventional and modern emulsions is streaking, which can ruin the film. It may be possible to eliminate the problem by using a 3% sodium sulfite solution (3.0 grams sulfite to 100.0 ml of water) in place of plain water in the second bath. This will create somewhat less compensation, but it is better than ruining the negative.

Additionally, water bath methods usually result in a loss of film speed. Should you choose to use this method, overexpose by at least one stop.

Technique of Water Bath Development The overall method for water bath development is to immerse the film in the developer for two to three minutes with continuous agitation in a tray. The film is then moved to the plain water or 3% sodium sulfite bath. It should be completely immersed in the water bath and left motionless for two to three minutes then moved back to the developer. The entire procedure is repeated as many times as necessary using a green safelight with a 15-watt bulb to check the progress of development. Turn the light on briefly after each immersion in the water bath and hold the negative up to it at a distance of three to four feet for 20 seconds or less.

It is recommended to use a 1 minute running water bath in place of a stop bath with this method.

Extreme Compensating Developers

Compensating developers are those that give proportionally full development to the shadow and middle values, while limiting the degree of development in the high values. Extreme compensating developers, such as those included in the *Cookbook*, are used to arrest the development of the highlights in order to record extremely high-contrast subjects while maintaining separation throughout the high subject values. (See *Highway 10 to Idyllwild* on page 52.)

Fine-Grain Developers

All films have a grain structure predetermined by the manufacturing process. As a rule, faster films have larger grain than slower films. The choice of developer will make some difference in grain size, but it is impossible to produce the same fine grain in fast films as in slow films. Even so, today even high-speed films such as Ilford HP5+ have finer grain structure than many slow films of the 1960s and '70s.

Fine-grain developers tend to inhibit acutance (sharpness). This is because they effectively etch each grain particle into individual "islands." These islands do not connect with one another, as do less fine grains that are clumped together. The result is that visible lines in the image that should appear continuous are broken into small segments as they jump from grain to grain. This effect is often useful, as in portraits, where the opposite effect (high acutance) would tend to accentuate wrinkles and other physical defects often thought to be unflattering.

A good fine-grain developer is considered to be one that yields fine grain without any serious loss of speed. Fine-grain developers should be compensating, that is, they should prevent the formation of heavy, unprintable deposits in the highlight areas.

To take full advantage of fine-grain developers, you must choose a fine grain film of low or medium speed. Fast, medium-to-coarse-grain, low-contrast films do not usually benefit from fine-grain development. Exceptions to this would include Ilford HP5+ and Kodak Tri-X processed in a compensating fine-grain developer such as Edwal FG-7®. Even finer grain can be achieved with FG-7 by adding a 9% solution of sodium sulfite.

General-Purpose Developers

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 also because Phenidone is more expensive. However, because of the allergic reaction to metol suffered by many photographers (Appendix 3: Pharmacopoeia), it is sometimes desirable to substitute Phenidone.

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 then add more or less as needed until your formula produces the desired results.

The most widely used developer in the world, Kodak D-76, falls under the category of general-purpose developers. D-76 was formulated in 1927 by J. G. Capstaff of Kodak as a black and white movie film developer. However, not long afterwards better movie-film developing formulas were introduced and D-76 found use as a still-film developer. Eventually, it became the standard by which to judge all other developers. It was not that D-76 was the best developer ever formulated. It was more 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.

Not long after Capstaff formulated D-76 it was discovered that the pH of the developer increased with storage. Not a good sign for a standard! A number of solutions were proposed over the next thirty years, but the simplest and most elegant was proposed by Grant Haist, also of Kodak. Haist suggested removing hydroquinone from the formula and increasing the metol to 2.5 grams. The resulting developer, D-76H, is indistinguishable from D-76 without the tendency to change pH. Not only that, but without hydroquinone it is less expensive to make and more environmentally friendly.

High-Contrast Developers

In general, these developers are used where a high degree of contrast is required, such as 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.

High-Definition Developers

A high-definition developer (also know as high-acutance) is one that enhances negative acutance and leads to prints of good image sharpness. To get the optimum quality out of modern films, a high-definition developer should be both soft-working and compensating. The developers included in this section have a relatively low concentration of developing agent so they exhaust rapidly in the highlights. At the same time, they contain a relatively high alkali content to fully develop the shadows.

A high-definition developer gives increased definition to photographic images by enhancing the contrast of edges and fine detail in the negative, although the resolving power of the emulsion may not be any higher than usual. This is usually achieved through the use of a formula containing low concentrations of developing agent, sulfite, and bromide, and a high pH.

In addition to using a high-definition developer, edge effects can be further enhanced through agitation (see Agitation, above). For additional high-acutance developing formulas see Extreme Compensating Developers.

Low-Contrast Developers for Document Films

Document films, such as Rollei ATP and the now discontinued Kodak Technical Pan (also known as Tech Pan), 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 specially formulated low-contrast developer they are capable of producing 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 native to the film whereas extreme compensating developers are designed for compressing the high contrast of the subject. Most low-contrast developers for document films are very simple formulas based on a single developing agent.

Low-Contrast Developers for Panchromatic Film

Low-contrast developers for panchromatic films are designed to give lower than normal contrast with conventional films. To distinguish them from low-contrast developers for high-contrast films they are often known as soft-working developers. Used with slow-speed films, soft-working developers are capable of creating an image with smooth grain, full gradation, and low contrast that is ideal for portraiture.

Low-Temperature Developers

Many developing agents become inactive or extremely sluggish at low temperatures, especially below 65F/18C. Although development should be avoided at such low temperatures, there may be times when this is not possible.

The problem that must be overcome is the loss of developer activity. Therefore, it is a good idea to start with a developer that is normally very active, for example, a caustic hydro-quinone developer such as Kodak D-8 or a still more alkaline variation of a caustic MQ developer such as Kodak D-82 + Caustic. D-8 is usually preferred over D-82 + Caustic since it produces less base fog, though this can be adjusted somewhat during printing.

For very low temperature processing a caustic solution of two powerful developing agents, such as amidol and pyrocatechin, may be required, as used in Kodak SD-22.

Film also takes longer to fix at low temperatures. When temperatures drop below 65F/18C fixing time will need to be extended. Observe how long the milkiness takes to disappear from the surface of the film and multiply that time by three. Below freezing a thiocyanate fixer should be used (Formulas: Fixers: Defender 9-F Rapid Thiocyanate Fixer).

Superfine Grain Developers

When exposed silver halides are reduced to metallic silver via the development process, there is always a degree of extraneous, unexposed silver halide that remains attached. Fine grain and superfine grain developers make use of solvents to dissolve as much of the extraneous silver halide as possible. The more efficient the solvent action of the developer, the finer the grain.

The classic superfine grain developing agent is para-phenylenediamine (ppd), which is capable of giving an exceedingly fine grain but requires strong overexposure and a long developing time; even then the contrast of the negative is very low. Additionally, ppd is poisonous and has a strong tendency to stain film, clothes, fingers, and work surfaces, leaving brown spots that are difficult to remove. Always use gloves, cover the work surface, wear an impervious apron, and try not to spill any!

These disadvantages have led to attempts at discovering developing agents, and combinations of other agents with ppd, that would give superfine grain results and shorter development times without the troublesome properties. Three such agents are glycin, o-phenylenediamine, and diethyl-p-phenylenediamine bisulfite.

Glycin, used in combination with ppd (Formulas: Superfine-Grain Developers: DuPont No. 3 Superfine-Grain Developer), makes a fine-grain developer with improved emulsion speed and faster rate of development. Unfortunately, because of the presence of ppd, it still suffers from the unpleasant side effects 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 the Windisch Superfine-Grain Developer, metol acts as the primary developing agent for the silver halide. The opd works on the silver being developed, dissolving any extraneous unexposed halide and resulting in superfine grain.

Geoffrey Crawley's FX 10 makes use of a ppd derivative, Kodak CD-2®, commonly found in modern color developers. As a developing agent, CD-2 works faster with less tendency to stain than ppd but is not capable of producing as fine a grain.

As far as the general composition of superfine grain developers, nearly all of them have a high sodium sulfite content as sodium sulfite is an effective silver solvent. For an alkali, they use small quantities of either carbonate or borax in order to minimize the energy of the developer and produce a finer grain. 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.

Tropical Developers

With most developers an increase in temperature means increased rate of development, increased danger of fogging, and excessive swelling of the gelatin emulsion that could result in its melting away. The faster the film, for example Tri-X, the more susceptible it is to increased fogging at high temperatures.

There may be times when it is not possible to cool solutions to below 80F/27C. This includes photographers working in non-insulated darkrooms during the summer where a water-cooling system is not available and those working in the tropics. Should this situation occur there are special developers known as "tropical developers" and modifications that can be made to other developers for extreme heat conditions. Tropical developing formulas prevent excessive swelling of the gelatin, either by the addition of a substance that reduces swelling or by eliminating those that cause excessive swelling. Tropical developers often include sodium sulfate and extra antifoggant.

When processing at high temperatures a mildly alkaline, buffered borax developer is recommended. Alkali-free developers of the amidol type or one of the mildly alkaline fine grain developers such as Kodak D-23 are preferable to those with normal alkali content. Additionally, a pre-hardening bath such as Kodak SB-4 Tropical Hardener Bath or a specially formulated tropical developer may be used.

Modifying Developers For Tropical Development Most developers can be made suitable for use at high temperatures (up to 95F/35C) through the addition of 105.0 grams of sodium sulfate, anhydrous, to each liter of working solution. This addition prevents the gelatin in the emulsion from excessive swelling. With most developers it will also alter the development time. The required adjustment can be found in the following table:

Normal Development Time (minutes) in nonsulphated developer at: 68F/20C	*Development time (minutes) in sulphated developer:*			
	75F/24C	*80F/27C*	*85F/29C*	*90F/32C*
3¼	4	3	2	1½
4	5	3½	2½	1¾
4¾	6	4½	3	2¼
6½	8	6	4	3
8	10	7	5	3½
9½	12	8½	6	4½
12	15	11	8	5½
16	20	14	10	7
20	25	18	13	9

Using Sodium Sulfate With D-72 or D-76 By adding sodium sulfate, anhydrous, to Kodak D-72 paper developer or Kodak D-76 film developer, as in the following table, the normal development time recommended for 68F/20C can be maintained through the range of temperatures shown. After adding the sulfate to the developer solution, stir until dissolved completely.

Developer	*Temperature*	*Sodium Sulfate anhyd. per liter*
D-76	75F/24C to 80F/27C	50.0 grams
	80F/27C to 85F/29C	75.0 grams
	85F/29C to 90F/32C	100.0 grams
D-72 (1:1)	75F/24C to 80F/26C	100.0 grams
	80F/27C to 85F/29C	125.0 grams
	85F/29C to 90F/32C	150.0 grams

Stop Bath for Tropical Development Films should be immersed for three minutes in either Kodak SB-4 Tropical Hardener Bath or Kodak SB-5 Nonswelling Acid Rinse Bath after development and before fixation. Agitate the negative in the stop bath frequently.

Between 68F/20C and 80F/26C use SB-5.
Between 80F/26C and 95F/35C use SB-4.

REPLENISHMENT OF DEVELOPERS

Several of the film developers included in *The Darkroom Cookbook* have companion replenishers whose formulas are also given. However, 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 are the possibility of bromide buildup, resulting in bromide drag, developer oxidation, and inconsistent results.

PUSH PROCESSING

One of my early influences in photography, Rodger Davidson, told me, "You can't push film! All you are doing is underexposing and attempting to compensate in the development! Don't you know, if it's not on the film you can't develop it?"

Technically, Rodger was right—you can't push film. But in situations where it is necessary to squeeze the last nth of shutter speed and maintain as much depth of field as possible, get an image on the film and do whatever has to be done in the darkroom to make a good print.

Pushing film means to ignore the manufacturer's ISO rating and creating your own Exposure Index (EI) by setting your ISO dial at a higher number.[6] For example, instead of using Ilford HP5+ at its factory rating of ISO 400, you would set the ISO dial to EI 1600, EI 3200, or even EI 6400. To be successful requires a developer that will reduce the maximum amount of silver possible. Crawley's FX 11 and Diafine-type developers are designed for that purpose. However, using high-energy developers such as these usually results in increased fog levels and graininess. Instead, I recommend using D-76H, Kodak T-Max developer, Kodak XTOL, or Ilford DD-X. Paul Lewis' Mytol formula, a substitute for XTOL which you can mix yourself, can be found under Formulas.

Almost any panchromatic film made today can be pushed one stop with little or no discernible loss in quality. For example, Kodak Tri-X can easily be pushed to EI 800 and Ilford Delta 3200 (which is closer to EI 1200 than it is to ISO 3200) can easily be pushed one stop to EI 2400. Try adding 25% to the normal development time for Tri-X, and 25% to 40% with other films for a one stop push. With testing and experience, you should be able to capture almost any event on film, regardless of how little ambient light is present. (See *Yuette at the Coffee House* on page 53.)

Increasing Film Speed

Increasing film speed is not the same as pushing. Pushing, as noted above, is to underexpose and overdevelop the film by simply turning the ISO dial to a higher EI and overdeveloping. Beyond one stop the primary result is a negative with loss of shadow detail and over developed highlights. Increasing film speed is a process by which the film's ability to respond to low levels of light and record detail in shadow areas is increased.

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[6] ISO is the speed rating of the film as per factory specifications, determined through controlled testing; EI is any speed other than the factory spec ISO that you choose to use.

With old-style emulsions, such as Efke 25, 50, and 100, it was possible to use methods found in the 2nd edition of the *Cookbook*, such as the Hydrogen Peroxide Pushing Method or Acetic Acid Latensification, to create a true increase in film speed. Unfortunately, modern emulsions, whether they are conventional or flat-grained, rely on color dye sensitization to achieve their sensitivity as much as upon silver sensitivity. Color dyes do not respond to these speed increasing techniques. Hydrogen peroxide will do little or nothing and acetic acid latensification may ruin your film. I no longer recommend either.

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 darkroom was in the basement of his home which was accessed by wooden stairs outside the back door of the house. One day his wife, Edna, was in a back room working on a project of her own. She heard Wynn clumping up the stairs from the darkroom, the back door thrown open, and then the sound of "clunk and clang" as Wynn tossed something into the circular metal trash can next to the back door. She then heard him say, "To hell with this damn testing! I'm going out and make some pictures!"

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

Flower Composition, 2007. © 2008 Steve Anchell. All rights reserved. This image was made using Ilford FP4+ film exposed for approximately one 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 with a 4 × 5 inch reducing back.

Highway 10 to Idyllwild, 1979. © 2008 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.

Yvette at the Coffee House, 2007. © 2008 Steve Anchell. All rights reserved. Ilford HP5+ exposed at EI 3200 and developed in Ilford DDX for eighteen minutes at 75F/24C. 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. The photograph was made with a Leica M7 rangefinder with a 35 mm *f*/1.4 Summilux-M lens.

Monobath Film Developing

If I could take a good picture, I would take one every time.

—Robert Doisneau

The ability to develop and fix film in one operation is appealing. 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. A monobath is a single solution that combines the actions of development and fixation in this manner.

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

For a monobath to work, it must combine a developer that acts so quickly that development is finished before fixation begins. But even after fixing has begun, development can be further assisted by a process of physical development that takes place concurrently.

Additional problems of the monobath method have included unsatisfactory gradation and maximum density, and a tendency to produce unacceptable levels of base fog. Storage and exhaustion properties have also tended to be poorer than with conventional developers that produce similar results.

To overcome these drawbacks, developing agents of high activity and short induction periods are required. Phenidone and hydroquinone are suitable monobath developing agents. A combination of these two generally leads to higher speed, improved contrast, and maximum density.

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 pH 11 to 12, while the hypo content must be reduced.

To increase the stability and exhaustion rates until they are equal to conventional developers, an appropriate buffer must be used. In Monobath #1, potassium alum has been added. The alum also helps prevent excessive swelling of the gelatin, which could otherwise result in reticulation at higher processing temperatures.

The target point of development is determined by the composition of the monobath and cannot be varied by change in dilution, time, or temperature of development. However, it is possible to obtain a wide gamma range without loss of film speed by simply varying the hypo (or salt) content. In Crawley's FX 6a, the use of 70.0 to 125.0 grams of hypo is recommended to increase or decrease the contrast of the film. Less hypo results in higher contrast. Similar variations in the amount of hypo can be made to the other formulas. The rate of fixation is also influenced by the amount of hypo.

The speed of development can usually be controlled by the alkali content. Sodium hydroxide is used in the monobath formulas given in the Formulas section. Most monobaths which use hydroxide will develop medium speed film in 3 minutes at 75F/24C. Testing is advised.

Working with the two variables of hypo and accelerator, monobath formulas can be modified for different films. In fact, 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 that will produce results comparable to normal processing. If you have an interest in monobaths, you may 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 following variations in monobath formulation and processing conditions, summarized by Haist, may be used to modify the results.

To increase contrast and emulsion speed:

1. Raise the pH.
2. Increase the concentration of the developing agent.
3. Reduce the concentration of the fixing agent.
4. Raise the processing temperature.
5. For more contrast, increase the concentration of hydroquinone.
6. For more speed, increase the concentration of Phenidone.

To reduce contrast or emulsion speed:

1. Lower the pH.
2. Increase the concentration of the fixing agent.
3. Increase the salt content or viscosity.
4. Use more vigorous agitation, increasing the rate of fixation (this may not be possible with in-cassette processing, see below).

IN-CASSETTE PROCESSING

Processing 35 mm film inside the metal cassette it comes in was originally described by Eastman Kodak. It should only be used with a 24-exposure roll or smaller, as a 36-exposure roll does not have enough room for the solution to flow evenly.

Other than the film, all that is needed is a household water glass or beaker for the monobath and washing, chemical resistant gloves, and an agitation rod. To make an agitation rod, pick up a 3/8-inch wooden dowel at a hardware store. Cut off about six inches and notch one end with a penknife or a hand saw. The notch should fit over the notch in the film spool.

When exposing the film it is important to leave two blank exposures at the beginning, and two more at the end. This means that a 24-exposure roll will yield 20 exposures. After the 20 exposures have been made, be careful not to rewind the film leader into the cassette. If your camera automatically rewinds the film, try taping the leader to the take-up spool when loading the camera. This may not work on all cameras, but give it a try. Otherwise, pick up a leader-retriever for a few bucks from a camera store.

Developing

To process the film, use the following procedure:

1. Cut the leader from the film, leaving approximately one inch protruding from the cassette.
2. Wrap the protruding film backwards around the cassette and secure it with a rubber band.
3. Insert the agitation rod into the cassette and rotate gently clockwise to tighten the film.
4. Slowly unwind the film by rotating the agitation rod counter-clockwise, counting the number of turns until resistance is felt.
5. Presoak the film in a glass or beaker containing sufficient water, preferably with a drop of wetting agent such as Edwal LFN, to cover the cassette. While slowly lowering the film into the water, wind and unwind the film by the number of turns counted in Step 4. Hold the cassette with the fingers of one gloved hand to keep it from turning.
6. Remove the cassette from the presoak water, drain, then immerse in the monobath solution following the same wind and unwind procedure described in Step 5. Do this twice for the initial agitation.

   Both hands should be protected with gloves, as sodium hydroxide, also known as caustic alkali, is not safe for skin contact.
7. When the cassette is fully immersed in the monobath, wind the film by half the number of turns determined in Step 4. For the rest of the recommended processing time, rotate the rod back and forth through about one and a half turns. It is normal for air bubbles to be released during processing.
8. When processing is complete, lift the cassette and allow the monobath solution to drain, discard the remaining monobath solution, and immerse the cassette in water of the same temperature. If the correct time and temperature have been used the film will be fully developed and fixed, though it will still require washing.

The key to success is in the winding and unwinding operations. These should be carried out gently, making certain the film is not wound too tightly on the spool; otherwise scratches may result. Generally, too much rotation of the agitation rod during processing causes dark bands to be formed across the width of the film, while light bands across the width are caused by insufficient agitation during processing.

Before trying to develop good images with this technique, expose a few rolls of the front of your house or similar subject and practice developing them. By the third or fourth roll, you will be an expert. Although the monobath method can be used in a tray or conventional processing tank, combined with in-cassette processing the photographer does not require a darkroom, changing bag, or developing tank.

Washing

If you are using in-cassette processing at home, you can remove the film from the cassette and wash and dry in the normal manner. If you happen to be traveling and staying in a motel or campground try using a method recommended by Ilford.

Remove the film from the cassette and place it loosely in the beaker or glass in which it was developed. Fill the vessel with fresh water. Cover the top with your hand, a small plate, or another appropriate item; turn it over five times, then dump the water out and fill it again. Let the film set in the fresh water for about 3 to 5 minutes, then invert the tank ten times, dump and fill again. Let the film set in the fresh water, again for about three to five minutes and then invert the tank 20 times, dump, refill, add a wetting agent, let soak for a minute, then dry.

Tips on Drying

Assuming you are in the field without access to a drying cabinet, you can hang the film in the bathroom where you are staying. 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 from a clothes hanger using a clothes pin.

If you do not have access to a place to hang the film, say you are on assignment in the middle of the Olympic National Rain Forest, you can rapidly dry film by using a rapid film dryer, such as the one suggested by Paul Lewis (Formulas: Miscellaneous: Rapid Film Dryer). When you return home, thoroughly wash and dry the film in a normal manner to ensure long-term preservation.

6

Pyrogallol and Pyrocatechin

> *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

PYROGALLOL (PYRO)

It has been said that there is nothing that can compare to a full-scale black and white negative properly developed in pyrogallol (pyro). Whether this is true there is no question that negatives developed in pyro exhibit exceptionally sharp edges and delicate highlight detail.

There was a time when pyro was the developer universally used by photographers. But the advantages of pyro were often offset by the disadvantages. Besides being subject to rapid oxidization, pyro can cause inconsistent staining and streaking during development. Also, formulas which rely upon pyro as the sole developing agent tend to loose 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 the work of two photographers working independently of each other, John Wimberly and Gordon Hutchings, pyro as a developing agent has regained renewed popularity among photographers.

ABC PYRO

The classic pyro formula, known as "ABC" because it uses three stock solutions, is the oldest published formula still in use, dating to the 1880s. At one time or another, the formula was used by Edward Weston, Brett Weston, Ansel Adams, and almost any 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, and different opinions as to the ratio of the three ingredients.

ABC is one of the most fickle pyro formulas to use. It is usually recommended for large-format negatives because of graininess issues. However, used properly the results are subtle tonal gradation and delicate highlight separation.

The Trouble with ABC The first problem is that when pyro is used as the sole developing agent, especially with low concentrations of sulfite, it tends to rapidly exhaust. As a result film developed in ABC Pyro is more susceptible to aerial oxidation than when pyro is combined with metol in formulas such as WD2H+ or PMK.

The second problem is that the sodium sulfite in Solution B slowly changes to sodium sulfate when stored. The result is decreased protection from aerial and auto-oxidation leading to undesirable image stains.

There are three things that can be done to avoid aerial oxidation and other forms of stains associated with ABC Pyro.

1. Develop only one sheet of film at a time or use a sheet film developing tray (see Resources: Photographers' Formulary). Use the intermittent agitation method I describe in Chapter 4: Agitation and do not lift the negative from the developer until it is time to move it to a water rinse.
2. Use at least 500.0 ml per 80^2 inches of film with a minimum of 1.0 liter in a tray.
3. Mix the developer fresh as a working solution just before using. This is the way I recommend using ABC Pyro and give the working dilutions in the Formula section.

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

Kodak D-1, ABC Pyro

Here is the classic Kodak D-1 formula as it is traditionally published.

Solution A

Water between 65F/18C and 70F/21C, 750.0 ml
Sodium bisulfite, 9.8 g
Pyrogallic acid (pyro), 60.0 g
Potassium bromide, 1.1 g
Water to make 1.0 liter

Solution B

Water between 65F/18C and 70F/21C, 1.0 liter
Sodium sulfite, 105.0 g

Solution C

Water between 65F/18C and 70F/21C, 1.0 liter
Sodium carbonate, monohydrate, 90.0 g

The standard ABC formula calls for a dilution of 1:1:1:7 for tray development. I recommend using 1:1:1:11, which is the dilution usually given for tank development. Develop between 6 to 10 minutes at 68F/20C.

The standard dilution for tank development is given as 1:1:1:11. I recommend 1:1:1:14. Develop between 8 and 12 minutes at 68F/20C.

Tray Development Using Stock Solutions of ABC Prepare everything in advance, combining the water and Solutions B and C in a tray. Then measure out Solution A and leave it where it can be found in the dark. Solution A will not begin to oxidize until it is mixed with B and C.

With the lights turned off, presoak the film in order to achieve more uniform development. (A drop or two of Edwal's LFN, or a ¾ teaspoon of sodium metaborate in a liter of presoak water will prevent the individual sheets of film from sticking together in the developer.) After one minute, lift the film to drain. While it is draining, use your other hand to locate the A solution in the dark, then carefully pour Solution A into the tray containing B and C. All three solutions should be thoroughly mixed before adding the film. 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 potent A solution comes in contact.

Daylight Tank Development Using Stock Solutions of ABC Follow the above procedure with the difference that Solution A does not have to be located in the dark since the lights are left on when using a daylight tank. Instead, mix Solutions B and C and add A with stirring just prior to pouring into the tank.

Because of pyro's self-hardening properties it is not necessary to use fixers containing hardener. If you wish to use an acid stop bath after the water rinse a good fixer to use is Kodak F-24 Nonhardening Acid Fixer. Otherwise, use plain running water and Photographers' Formulary TF-4 Fixer (recommended).

Alternate Dilutions It has been accepted practice among photographers that contrast with ABC can be controlled by altering the amount of carbonate (Solution C). As it turns out, 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: 50.0 ml, Solution B: 50.0 ml, Solution C: 50.0 ml, then it may be possible to increase contrast by using 75.0 ml of Solution A, 50.0 ml of Solution B, and 25.0 ml of Solution C. Theoretically, lower contrast could be achieved with 25.0 ml of Solution A, 50.0 ml of Solution B, and 75.0 ml of Solution C. I use the word theoretical as pyro's tendency to rapidly oxidize means there is a minimum amount of developing agent required in the working solution to maintain activity throughout the development cycle. For this reason, I do not recommend using less than 1 part Solution A. Instead, in order to decrease contrast mix the normal A-B-C dilution and use more water, for example, 1:1:1:18 for tank development, while keeping the development time constant. Testing is recommended prior to committing important negatives.

Variations on ABC Pyro

Ansel Adams' Variation Ansel Adams used a slight variation of the traditional D-1 formula. While his solution A is the same, his B solution calls for 75.0 grams of sodium sulfite instead of 105.0 grams. His C solution calls for 87.75 grams of sodium carbonate instead of 90.0 grams. The difference between 87.75 and 90.0 grams in the C solution is hardly important. 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 main difference between standard ABC Pyro and Edward Weston's variation is the dilution ratio. Weston diluted the formula with 30 parts of water. The result was a softer working developer with an even fuller than usual tonal scale.

In order to keep the developing time within workable limits and to prevent complete exhaustion of the developing agent before development was complete he increased the developer to 3 parts instead of one. His resulting dilution was 3:1:1:30, with a developing time of 15 to 20 minutes at 70F/21C 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.

PYROCATECHIN (CATECHOL)

Even though it has been in use since 1880 pyrocatechin (catechol) is one of the most overlooked developing agents. The working properties of catechol are very much like those of hydroquinone and it can even be used as a substitute for hydroquinone in many formulae, though it works more rapidly than hydroquinone.

As a developing agent, catechol tans the surface gelatin of the negative (see Tanning Developers, below). It is also easy to use catechol to compound formulas that create a desirable image stain density when low quantities of preservative (e.g., sodium sulfite) are used (see Image Stain, below). Both of these properties it shares in common with pyro.

In addition, catechol has a reputation as a useful developing agent for subjects of extreme contrast. This is because the use of minimal or no preservative with catechol (as stated above) will produce an image stain that enhances the image silver density in the shadow regions while the developing agent itself will rapidly oxidize preventing the high values from overdeveloping (Formulas: Extreme Compensating Developers).

Dilute catechol developers will provide a speed increase with most films.

TANNING DEVELOPERS

As developing agents, both pyro and catechol (pyro/cat) are commonly used to harden the gelatin of the film's emulsion. This allows development to take place only on the surface, thus minimizing the effects of halation and irradiation (Chapter 4: The Anatomy of Film). Negatives developed by this method, known as tanning, exhibit an extremely high degree of acutance. The effect is greatest in areas that have achieved the most exposure. The tanning process is enhanced by a low concentration of sulfite or its complete absence. In fact, if more than 2.0 to 3.0 grams of sulfite per liter are present in the formula the tanning action will be limited.

There are other developing agents, chief among them hydroquinone, that will produce a tanned image when used in a formula similar to D-175 (Formulas: Extreme Compensating Developers: D-175 Tanning Developer). Even so, pyro/cat are the two most commonly used for this purpose.

IMAGE STAIN

One of the desired features of pyro/cat development is the creation of an image stain, which adds contrast and printing density to the shadow regions and enhances areas of micro-contrast. Image stain occurs around silver grains in the emulsion and is proportional to the amount of silver in a given area. The color of the image stain can vary from yellow-green to brown. (General stain affects the entire negative equally, both image and negative edge; it serves no useful purpose except to increase base + fog.)

Whereas pyro/cat-staining developers can be formulated to produce some degree of image stain, with many the stain is minimal. However, emphasizing the stain has two benefits. It fills in the space between the silver grains, becoming an inherent part of the image density, and to some degree masks the film grain, particularly in highlight areas. Film speed and negative printing quality are improved. A stained pyro negative shows both acute sharpness and reduced visible grain effect (graininess).

If the maximum degree of pyro stain is desired, use a fixer that contains a minimal amount or no sodium sulfite. Sodium sulfite is a salt, and salt inhibits image stain. However, sodium sulfite is used in fixers as a preservative. Although the sulfite can be removed from any fixer formula, fixers without sulfite will not last beyond a single day's use. Plain Hypo is an example of a fixer with no sulfite.

Enlarging and contact printing paper reacts to image stain as density. Thus the total density of a stained pyro negative consists of the silver density plus the stain density. Because of the color of the stain 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. If an alternative process is intended (for example, platinum/palladium), a densitometer that reads UV would be the most accurate, as alternative processes have most of their sensitivity in the UV range.

Second Staining Bath

It has been suggested that pyro image stain can be increased after fixing, and before rinsing or washing, by immersing the negative directly into the used pyro developer for two minutes with 30 seconds of agitation every minute. The usefulness of this procedure is questionable as it appears to create a general stain affecting only base + fog without enhancing the overall image stain. If an alkaline fixer is used, (Formulas: Fixers: TF-2 and TF-3) the staining bath should not be necessary. In any event, avoid using hypo clearing agent (HCA) when using pyro developers as the high concentration of sulfite in them will remove the stain.

TROUBLE IN THE WOODPILE

Pyrogallol and catechol are considered to be more toxic than MQ and PQ developing agents. However, any danger associated with either of these developing agents can be avoided by wearing gloves when handling the solutions and mixing the powders by the submersion method (Appendix 1: Safety in Handling Photographic Chemicals: Mixing Dry Powders).

A larger problem that has vexed pyro/cat users is aerial oxidation. Aerial oxidation results in random and unwanted stains, mostly in areas of high density, which can ruin the negative.[1] The problem occurs because developers compounded with pyro/cat have a tendency to rapidly oxidize as the developing agent becomes exhausted—in no small part because of the minimal amount of preservative used to compound pyro/cat developers in order to produce image stain. When a negative is exposed to oxygen, either by pulling it from a tray or as the rotary drum of a JOBO processor goes around, an irreversible stain appears on any area of the negative where the developing agent is exhausted—which is most often in the highlight areas. The remedy is to use enough developer or developing agent in solution so that it will not exhaust during the development cycle even in areas of high density. If tray-developing sheet film, use a minimum of 1.0 liter of developer per 8 × 10 inch sheet of film in an 11 × 14 inch tray, or four 4 × 5 inch sheets in an 8 × 10 inch tray. This is a minimum recommendation.

If using a JOBO rotary processor it is not possible to use this volume of developer without burning out the motor. The simple remedy is to increase the amount of developing agent in solution. Try adding 30% or more of Solution A than called for by the formula. This will insure that the developing agent is not fully exhausted by the time the process is complete.

A second solution is to use Harald Laban's AB C+ Pyro (available as Photographers' Formulary Rollo Pyro). Adherents to Rollo Pyro claim that because of the use of ascorbic acid (vitamin C) as a preservative and a large quantity of pyro, it does not oxidize like traditional pyro formulas and can safely be used with JOBO rotary processing. Compared to other pyro/cat developers, Rollo Pyro creates a light image stain.

The simplest remedy is to not use a rotary processor with pyro/cat development. While JOBO rotary drum processors may work well for large format negatives souped in MQ and PQ developers they are not ideal for developers that potentially ruin negatives when they are exposed to air during routine development.

Two final notes on development with pyro/cat: Despite what some photographers claim for their formulas, pyro/cat formulas *should not* require vigorous agitation. If they do then *there is something seriously wrong with the formula and its use should be discontinued*. Agitation for pyro/cat developers should be the same as for any other developer:[2] continuous for the first minute; 10 seconds every minute thereafter with gentle inversions at the rate of three to four per 10 seconds. If using a tray follow the same cycle: Agitate by lifting the corners of the tray continuously for 60 seconds, allow the film to sit in solution, then lift the corners four times at the end of every minute (Chapter 4, Agitation).

One more problem associated with pyro/cat developers is their tendency to stain everything: fingers, clothing, and work surfaces. If you experience a problem with this try using one of the stain removing formulas in the Formulas: Miscellaneous section of the *Cookbook*.

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[1] Aerial oxidation stains can sometimes be removed with Kodak S-6 Stain Remover. However, it is better to avoid stains in the first place as this treatment is not always effective.

[2] With the exception of divided developing formulas.

WD2H+

John Wimberley

WD2H+ (Formulas: J. Wimberley's WD2H+) is a Pyrogallol/Metol/Sodium Carbonate developer formulated to achieve the highest possible contrast with continuous tone films, while also producing superb results at normal contrast levels. A variation of the classic WD2D formula, this new developer maximizes the beneficial effects of pyrogallol to produce negatives that are easy to print and display the following beneficial characteristics:

- Noticeably improved acutance caused by edge effects at tonal boundaries.
- A very smooth, long tonal scale.
- Unmatched tonal separation, especially in highlights, even when printed on variable-contrast paper.
- 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 gelatin/silver or platinum/palladium paper.

The emulsion of WD2H+ negatives contains a yellow-orange colored dye mask, traditionally called "stain," that is proportional to the density of the silver image. This mask has the effect of raising the contrast of the negative beyond the level produced by the silver image alone. This means that normally exposed and processed WD2H+ negatives have significantly lower silver density than is possible with conventional or many other pyrogallol 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 maximum contrast obtainable with WD2H+ is, in Zone System terms, +4.

The yellow-orange color of the dye mask is also more effective at increasing printing density than the more greenish 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, making an alkaline after-bath and extended washing time to intensify it unnecessary. Nor is the WD2H+ dye mask reduced by acid stop baths and fixers.

Crystal Springs #659, 2002. © 2008 John Wimberley. All rights reserved. Courtesy of the artist.

PMK: Thirty Years On

Gordon Hutchings

The PMK formula has been around for almost thirty years and fully described in *The Book of Pyro* published in 1992. I never imagined that the resurrection of the antique developer pyrogallol would create such a fuss nor serve as the basis for an almost cult following.

It was never my intention that PMK, or any pyro formula, should be looked upon as a social cause. Pyro is just a tool, a good one perhaps, but just a tool nonetheless. The potential usefulness of it should come from a straightforward analysis of one's own prints. Fortunately the furor is dying down, and pyro is beginning to be looked upon as a standard developer, which is all to the good.

I encourage those who want to try pyro to ignore the hype and mystique. Instead, proceed in a workmanship manner and you will be rewarded with a fine printable negative. Be patient, it takes several years to fully understand the dynamic range of printing qualities of stained pyro negatives. Most photographers are held back by their own working knowledge of the limits of conventional negative printing. It often takes a serious mistake or extreme shooting conditions of light and contrast to push them into the far reaches of the capabilities of pyro negatives.

In my opinion, it is much easier to make a "fine-art" print that really "sings" by using a pyro negative rather than a negative from conventional film developers. I have a file cabinet stuffed with letters collected over the last two decades from all over the world praising the PMK developer. A great advantage of a staining formula like PMK is that it masks the grain to a large extent and thus makes pyro an excellent developer for roll film as well as traditional sheet film.

I would be less than honest if I didn't admit that a pyro negative seems to have a "magic" quality to it. When laid on a light table they glow with light and promise. Even after thirty years I am still excited to see a new pyro negative on the light table. By comparison, conventional negatives just seem dead.

Printing pyro negatives is, for me, always exciting and exploratory. Often the working prints lead me in a direction I did not anticipate. These self-propelled excursions often result in a print more expressive than my original thought and I willingly go along for the ride. Serendipity is alive and well in my darkroom.

On the other hand (and allowing for personal bias), conventional negatives usually do not have this quality. Printing these negatives just seems to be straight ahead bricks-and-mortar work.

These comments may be an overstatement, but excitement and passion for the material, tools, and craft is an essential element of our art. I look upon a negative as a living thing, something that was formed by the fusion of light and silver. It is my job to coax the image, the tale, the truth, from out of the murky depths of the stained pyro negative. This blending of human spirit and materials by the craft of photography keeps me alive and excited.

What started out thirty years ago as a lone effort by John Wimberly, with his WD2D formula, and me, with the PMK formula, has grown into many branches. There are several pyro formulas introduced recently and pyro development now has a life of its own.

In the introduction to my book, Morley Baer said it best: "PMK puts force behind subtleties and nuances and makes available to all photographers the opportunity to speak with conviction."

Broken Vase, 2002. © 2008 Gordon Hutchings. All rights reserved. Courtesy of the artist.

Pyrocat-HD

Sandy King

Pyrocat-HD is a Pyrocatechin/Phenidone-based developer formula that can be used for development in tanks or trays. It is also recommended for JOBO and other rotary type processing in tubes and drums. Although originally meant for sheet film, subsequent use has shown that it is also an excellent developer for use with 35 mm and medium-format films because of its high acutance and tight grain pattern.

Pyrocat-HD 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 very pronounced adjacency effects and enhanced apparent sharpness.
- Pyrocat-HD is very economical to use.

Pyrocat-HD

To make one liter of Stock Solutions A and B.

Part A

Distilled water (125F/51C), 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 liter

Part B

Distilled water, 750.0 ml
Potassium carbonate, 750.0 g
Distilled water to make 1.0 liter

Mixing Directions For Part B

Start with 700.0 ml of distilled water.

Weigh out 750.0 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.

Add distilled water to make 1.0 liter.

Tests show that the Pyrocat-A stock solution is stable in partially full bottles for up to a year. If shelf life of longer than one year is desired, I recommend mixing Stock A in glycol. Pyrocat-HD Stock Solution A, when mixed in propylene glycol, has a shelf life of several years.

Stock Solution B has an indefinite shelf life.

Mixing 1.0 liter of Pyrocat-HD Stock A Solution in Propylene Glycol

1. Weigh out all of the chemicals for Stock A.
2. Pre-heat 750.0 ml of propylene glycol to about 150F/65C in a water bath 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 50.0 to 75.0 ml of hot distilled water at about 125F/51C. Stir until completely dissolved, and then add this solution to the propylene glycol solution.
6. Top off the solution with glycol to 1.0 liter.

Pyrocat-MC

Pyrocat-MC is a Pyrocat variant that I recommend primarily for rotary processing, where it tends to give slightly greater acutance than Pyrocat-HD. It can only be mixed with propylene glycol.

Mixing Directions for Pyrocat-MC Stock A

STOCK A

Propylene Glycol at 150F/65C, 750.0 ml
Pyrocatechin, 50.0 g
Metol, 2.5 g
Ascorbic Acid, 4.0 g

Start with about 8.0 ml of triethanolamine (TEA) at room temperature and a spoonful of water. Now add 2.5 grams of metol and stir to make a slurry. This is eventually going to make a liter but you can start in a 1/4-liter cup. After the slurry gets a little more fluid, add 15.0 to 20.0 ml of some warm propylene glycol. Now you can transfer the metol slurry to the 750.0 ml of warm propylene glycol and stir until dissolved. Now add 50.0 grams of pyrocatechin and stir until dissolved. Add 4.0 grams of ascorbic acid and stir until dissolved.

Stock B is mixed the same as for Pyrocat-HD.

Pyrocat-HD and Pyrocat-MC kits can be purchased pre-mixed 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

Old Mosque at Edirne. © 2008 Sandy King. All rights reserved. Courtesy of the artist. 12 × 17 inch carbon transfer print. The negative was developed for N-2 in Pyrocat-HD.

7

Print Developers

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

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!

While there are many similarities 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 an inconveniently long time.
- The composition of the print developer affects the image tone of the paper.
- 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 over a long printing session to avoid having to re-mix fresh developer every few prints. This is also 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 agents. 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 often substituted for warm tone results. Sodium hydroxide is occasionally used, mainly to increase contrast; sodium metaborate is found in universal developers.
- Restrainer, which is usually potassium bromide or benzotriazole.

THE USE OF RESTRAINER IN PRINT DEVELOPING FORMULAE

The amount of bromide or organic restrainer in a print developer should ideally be optimized for the particular 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 particular 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 with a specific paper. This can be achieved by adding small amounts of restrainer to the developer until the desired result is obtained. Once determined, the formula can be replicated.

TRAY LIFE OF PRINT DEVELOPERS

As print developer is used, each print adds bromide to the solution, removes a little 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, some speed is lost, contrast is increased, and development time is lengthened. In addition, the excess bromide in a print developer can often 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 of potassium bromide already in solution. Then the small amounts that are added with each print become a very small percentage of the total. Ansco 130 is formulated in this manner. In addition, Ansco 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 largely on the formulation, as noted above with Ansco 130, which has an exceptionally long life in working solution. As a rough guide, however, 15 to 20 8 × 10 inch prints per liter is not unusual for most print developers.

It is also 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 slightly more than double 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 35 seconds). However, to extend the working life of a print developer, it is possible to add 30.0 to 45.0 ml per liter of stock solution to the working solution in the tray (the actual amount is not critical but use 30.0 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 also not a good idea when making prints which are part of a limited edition from a single negative.

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 by inspection. The exception is when a limited edition of prints from a single negative is being made. When a print edition is being made it is important that the print developer have 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 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 build-up of bromide in solution 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 the print. While this will not affect the activity of the developer it will have some affect 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 a MQ developer, making the MQ combination easier to work with when using or formulating a print developer.

It has already been mentioned that when formulating PQ developers of 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.

When printing with Resin Coated (RC) papers the induction period may be reduced to a few seconds, and the full development time to less than 60 seconds if an active PQ developer is used.

BROMIDE AND CARBONATE

To increase the flexibility of MQ and PQ print-developing formulas, keep a bottle of carbonate solution and a bottle of 10% bromide on your darkroom shelf. 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.

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

50.0 to 100.0 ml to each liter of paper developer. As much as 200.0 ml can be used per liter, but beyond that your highlights may begin to fog.

To make a carbonate solution, dissolve 60.0 grams of carbonate in 750.0 ml of water and add water to make 1.0 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.

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. With shortened development times it will produce brownish to olive-brown tones with some warm-tone papers. Finally, it will enhance or increase warm tones by restraining development.

Add 15.0 to 25.0 ml of 10% bromide to 1.0 liter of developer. You can add more, but even though bromide helps to prevent fog, after a point it will actually cause fogging. This usually appears as a subtle graying of the highlights.

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, more restrainer may be added.

To make a 10% bromide solution, add 100.0 grams of potassium bromide to water to make 1.0 liter.

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, add 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 un-manipulated developer, observe the results, and then determine if one, the other, or both are needed.

Brett Weston & 11 × 14 Camera, Point Dume, Portrait #1, 02-07-1948. Richard C. Miller. Copyright © 2008 Miller Family Trust A. All rights reserved.

Brett Weston On Technique

Brett Weston was considered to be one the finest black and white photographers of his generation. This is an excerpt from an interview I conducted 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 ten 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 is 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.

8

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 a particular 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 subject or body of work. In printing, more than any other area of the darkroom, the only rules are those you make for yourself.

TYPES OF PAPER

Photographic papers are made from 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. 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.

Bromide papers are generally the most sensitive to light and almost always give neutral or cold (blue-black) tones. They are the best papers with which to achieve cold tones through direct development, as opposed to toning after development. Bromide papers include Kentmere Bromide® and Slavich Unibrom 160®.

Chloride papers are usually very slow. With chloride papers, projection prints made with an enlarger, though possible, could take 5 to 10 minutes or longer. Contact prints with the same paper, using a direct light source, such as a bare bulb suspended from the ceiling, would require printing times of only 30 seconds to 3 minutes. Kodak AZO®, now discontinued, may have been the last in a list that once included Convira, Apex, Velox, and others.

Chlorobromide papers are the most commonly used today. As the name implies, they are a compromise between the fast bromide and the slow chloride papers. Chlorobromide papers are usually slower than bromides. The percentage of bromide to chloride can allow manufacturers to create either warm- or cold-toned papers with a variety of sensitivities. Examples of chlorobromide papers include Ilford MG IV® and Warmtone®, Kentmere Kentona®, Fomatone MG Classic VC®, Slavich Bromportrait®, and Fotokemika Emaks®.

IMAGE COLOR: PRINT TONE VERSUS TINT

The image tone, or color, of a print, though it may be subtle, strongly affects the viewer's response to an image. Warm tones tend to engage viewers emotionally, 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, 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. Learning to manipulate and control the image tone of a print opens new vistas and ways to communicate a photographer's vision.

Changes and variations in image tone may not always be as glaringly apparent. Often the difference is subtle, so much so that someone viewing a print might not even be aware that it is neutral, cool, or warm, unless the fact is drawn to their attention, or they see an example of each, side-by-side. The simplest test to determine whether or not a paper is cold-, warm-, or neutral-toned, is to develop it for two minutes in a neutral tone developer such as D-72 and compare it to other papers developed similarly. If a paper is warm- or cold-toned the color can be seen in the shadows.

When discussing the image tone of paper, it is important to note the difference between tone and tint. Image tone is initially determined by varying the amounts of chloride and 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 which is brilliant white, cream, ivory, or some other variation of off-white. Although warm-tone papers can be coated on a brilliant white base, most warm-tone papers made today have a tint to their base. This allows the manufacturer to use less chloride, thereby increasing paper speed, and still produce a warm-tone paper, even though it is the tint, and not the image tone which we see. To determine if a paper has a warm tint study the highlights. If they are off-white the paper has a tint.

Manipulating Paper Tones

Paper, like film, has grain, though unlike film, paper grain is not visible to the eye. Paper grains start out very small but become larger as development proceeds. When the grain first starts to develop it is yellow in color, and then turns reddish, then brown, and with full development it becomes black.

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 chlorobromide paper and developer combination will further heighten this effect. With bromide papers the results may be less than satisfactory as the color may be "muddy" olive depending on the paper.

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 often possible to add as much as 50% used developer to fresh developer to achieve warm 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 two to five minutes. This technique is especially effective with developers containing glycin (Formulas: Ansco 130 and Dassonville D-3).

The four most important components in a developer for influencing image tone are the developing agent, bromide restrainer, organic antifoggant, and the amount of hardener. Developing agents such as glycin or pyrocatechin give a warm image tone in the absence of an organic antifoggant, such as benzotriazole. Organic antifoggant tends to cause a cold or bluish image tone. Also, as the bromide content is increased through successive prints the image tends to become warmer in tone.

Color-Dye Sensitization In Chapter 4, Film Development, I mentioned the use of color-dye sensitization to replace silver particles in film. Color-dye sensitization when applied to film is of questionable benefit to the photographer. However, when applied to paper it is not necessarily a bad thing. Color dyes enable the manufacturer to create papers with a fast printing speed and increased tonal scale. On the other hand, dye-rich papers do not respond as well to bleaching, toning processes, or direct image color manipulation through the use of print developers. This is doubly true of dye-rich papers with over-hardened emulsions which are discussed next.

While paper manufacturers are not legally constrained to disclose the nature of their emulsion formula, one thing to watch for are the buzz words "silver-rich." This usually indicates an older formulation that does not use dye. And while it does not mean the paper is better (some old formulas are pretty bad and some of the "dye-rich" papers are very good; for example, Ilford Multigrade IV), it usually means the paper will respond well to image color manipulation with toning.

Hardener Hardener is a necessary component of both film and paper. Without some hardener, the emulsion would slough off during development. Hardener also protects the emulsion from damage but only when the material is wet and during high temperature drying. Once the film or paper is dry, hardener serves no further purpose vis-à-vis protection of the emulsion.

Until the late 1960s, paper emulsions were "soft" and easily damaged. This was because they contained a minimal amount of hardener in their emulsion. Printers handled wet paper carefully or used hardener in their fixer to prevent damage. As a result, it was nearly impossible to machine-process black and white papers without damage. However, machine processing turned out to be far more profitable, both for commercial labs and the manufacturers who make, sell, and service the machines. Many modern papers have been overly hardened so they can be machine-processed. Unfortunately, if too much hardener is used in paper manufacture, it prevents the paper from responding to extended development, color changes with direct development, and toning.

If the paper you are using is resistant to toning it probably has more hardener than necessary and is probably heavily dye-sensitized. This does not mean it is a bad paper, it means you should use a different paper if you want to manipulate image tone or control contrast through extended development.

Image Color Through Direct Development

Neutral Tones Neutral-tone developers produce images with the least amount of bias toward either warm or cold tones. This does not mean that some bias may not exist, depending on the paper, only that it will be less pronounced than if a warm- or cold-tone developer is used.

Some papers will have a slight greenish cast when developed in a neutral-tone developer. Should this occur, either use less bromide or substitute Edwal's Liquid Orthazite or benzotriazole for the bromide. This can be done by eliminating the bromide altogether or lessening the amount and adding a small amount of benzotriazole (see Cold Tones, below). Selenium toning, after fixing, will also help to eliminate any green cast.

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 being that brown tone refers to the specific color, brown, whereas warm tone encompasses all shades and nuances of brown, including that 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/brown tones are as follows:

- Use less carbonate. The less carbonate used 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 30.0 and 125.0 ml of a 10% bromide solution. After that, increase by 30.0 ml until the image tone is satisfactory or fogging occurs (see Bromide and Carbonate, below). 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.

Redevelopment Method The halide type and composition of any given paper has some effect on the image tone. However, as manufacturers don't typically release this information, except in a general context (bromide, chlorobromide, chloride), it is impossible to know beforehand what the composition is. The technique of redevelopment eliminates the need to know, as it reduces all halide in the emulsion to silver bromide, which can then be redeveloped and toned.

To use this method, expose, develop in a neutral tone developer, fix, and wash a print in the usual manner. Next, use Print Rehalogenating Bleach (Formulas: Print Reducers: Print Rehalogenating Bleach) to convert all silver metal to silver bromide. Then rinse for 5 minutes and redevelop using any toning developer of your choice (this includes cold-tone developers).

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 (Formulas: 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 (Formulas: Paper Developers, Blue-Black Developer). In either case the results are usually very 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 (2.0 grams in water to make 1.0 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 10: 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 blue 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.

ADDITIONAL METHODS OF PRINT MANIPULATION

Variable Contrast 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 control is 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 variable contrast papers for tweaking contrast between filters.

Combining two developers, one high or normal contrast, and one low contrast, is another method for obtaining variable contrast results similar to Beers. Typically, varying amounts of stock solution high/normal contrast developer are added to a tray of working solution low-contrast developer. The more high or normal developer added, the higher the contrast.

Start by adding 25.0 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 be achieved. For example, combining D-72 with Ansco 120 will produce one image color, while using Agfa 108 and Agfa 105 will produce a different color. The color will vary with the paper and the amount of each developer.

The disadvantage of combining developers is that the high or normal contrast developer, which usually contains hydroquinone, may exhaust before the low contrast developer. This is not a problem if only a few prints are to be made from one negative, which is often the case when using developers in this way. However, if consistency is important for a large number of prints, it is important to make certain there is sufficient high/normal contrast developer in solution.

The general rule is to use a minimum of 10.0 ml of undiluted high/normal contrast developer for each 8 × 10 inch print. This may lead to doubling, or even tripling, the initial volume. For example, through testing you have found that 25.0 ml of D-72 in 1.0 liter of Ansco 120 1:1 produces the desired print result. That means that 4.0 liters of Ansco 120 1:1 and 100.0 ml of D-72 should be good for at least 10 consistent prints.

Two-Tray Development A variation of this technique is to use two separate developers, 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 solution 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 usually about 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, and 30 seconds in the high/normal developer, although as much as a 50/50 time 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 paper in a tray of standing water in order to allow the highlights to continue to develop. Because amidol is an exceedingly active developing agent it is considered to be a good choice for water bath development.

The technique could not be much simpler. Use the next higher grade of paper or filter than the desired final contrast you want in the print. For example, if the desired contrast is somewhere between grade 1 and grade 2, use grade 2 paper. Develop the paper using an amidol formula then move it immediately, without draining, to a bath of fresh water. Slide the paper under the water and let it sit without any agitation. The developing agent in the shadow areas will quickly exhaust, while the developing agent in the thinly exposed highlight areas will continue to work. The mid-tones will be relatively unaffected.

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 the amidol, and 30 seconds in the water bath. Keep an eye on the shadow areas of the print. When they appear to be about 80% complete, move the print to the water bath.

Manipulating Exposure and Development

Subtle control over contrast can also 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. The minimum time for developing a fiber-base (FB) print is about 1 minute and 15 seconds. For an RC print use a minimum time of 45 seconds.

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. Most FB papers have a useful range of 75 seconds to as much as 7 minutes in the developer. RC papers have a range of about 45 seconds to 3 minutes. Within this range, slight increases in mid-tone separation can often be achieved, though the results depend upon the paper used.

AMIDOL DEVELOPER

There is as much controversy surrounding the developing agent amidol as there is around pyro. According to some photographers, 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.

The best papers to use with amidol developer are: old-style, soft emulsion papers, such as those with minimal hardener, silver-rich papers (papers without excessive dye sensitization), graded bromide papers, long-scale chloride papers, or specially coated papers such as David Lewis Bromoil Paper (see Resources). With any other paper, 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.

Much has been written about amidol's tendency to both oxidize rapidly and to stain paper. My own experience using amidol is that it does not oxidize any faster than most other developers. According to Michael A. Smith, an expert on amidol, and David Lewis, a leading expert on the Bromoil process who uses amidol extensively, neither has experienced the rapid oxidation reported by some users. If anything, amidol should only be used for one session and then tossed.

Like pyro, amidol will stain skin, work surfaces,[1] and clothes but it should not stain printing 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 sand, it is old and will probably cause staining. The second reason amidol may cause stains is that an acetic acid stop bath has been used. Always use either citric acid or a running-water stop bath with amidol. The third reason is that the working solution is exhausted.

Amidol is also toxic—never put your hands into a solution of amidol; either use tongs or rubber gloves. This is good advice for all photographic chemicals, including MQ developers.

Further notes on using amidol will be found in the Formula section.

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[1] Fresh lemon juice is sometimes useful in removing amidol stains.

The Weston's Amidol

All three of the famous Westons—Edward, Brett, and Cole—used amidol paper-developing formulae. All three were famous for their rich blacks and full-scale print tones. All three used different amidol formulae. There is some confusion as to the formula each one used, and more than one has surfaced for Brett and Edward. It may be possible that they used different formulae during the course of their long careers.

I first came across the Weston formulae when Brett gave me a copy of an article which appeared in the November 1982 issue of *Camera Arts* magazine, written by Peter Nabokov. It was in this article that Brett's formula first appeared. By the time the first edition of *The Darkroom Cookbook* was published in 1994 Brett had passed away.

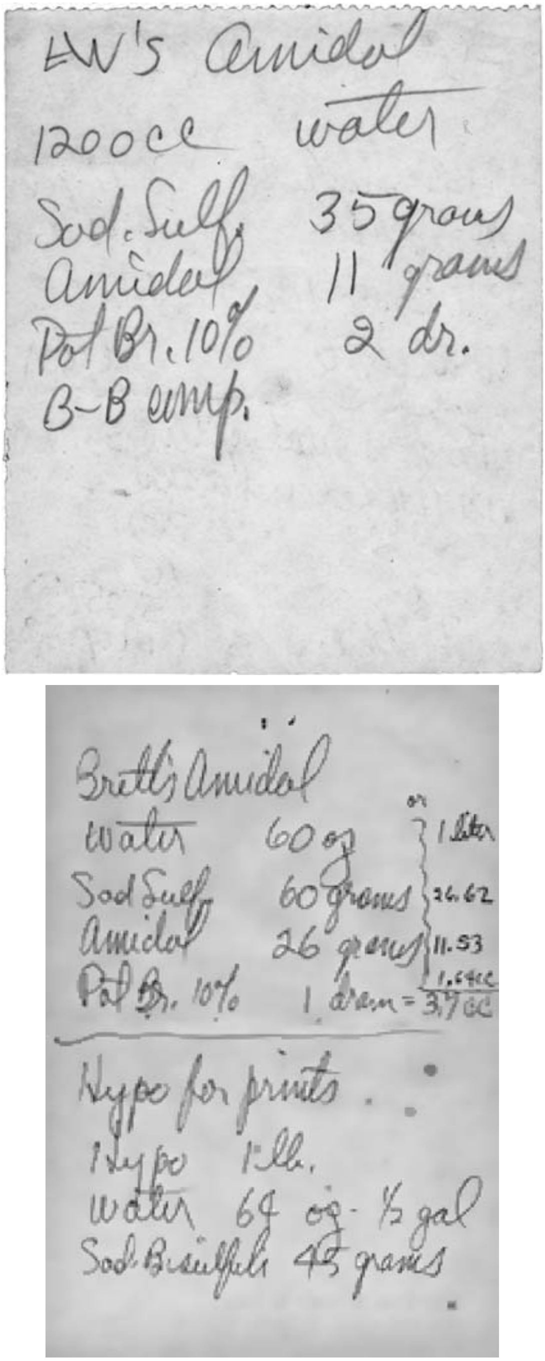
I mentioned to Cole that I was going to publish Brett's formula, and he generously provided me with his. I believe that Cole also gave me the formula his father is reputed to have used, but cannot recall for certain. If it wasn't Cole then it was Ira Katz of Tri-Ess Sciences, who also knew Edward. I tend to think it was Ira as I recall a conversation with him as to the chemical composition of DuPont BB formula which Edward was reputed to have used.

While working on this, 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 personally 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. To make matters more complicated, it is similar, but different, from Brett's formula given to me by Cole.

Brett began printing on Oriental Seagull paper in the '70s. Oriental was superior to any other paper being made at the time. Is it possible that Brett switched to a variation of Cole's formula that worked better with Oriental paper? We may never know as Cole has also passed on.

Finally, Richard found a second handwritten note with a formula given to him by Edward. It is nearly identical to the formula published in the first and second editions of the *Cookbook*. I have corrected the formula in this edition to correspond with the note found by Richard.

In any event, there is one similarity to all three of the Weston formulae. One clue as to how they achieved the quality for which they were famous. All three formulae use as much or more Amidol than other published formula. Indeed, Brett used to say he liked to use twice as much Amidol than called for in published formulae. 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 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 } or 1 liter
Sod Sulf 60 grams } 26.62
Amidol 26 grams } 11.53
1.64cc
Pot Br. 10% 1 dram = 3.7cc

Hypo for prints
Hypo 1 lb.
Water 64 oz - ½ gal
Sod Bisulfite 45 grams

Edward (top) and Brett Weston's Amidol formulae as given to Richard C. Miller. The handwriting is Richard's.

Changing Print Contrast

Henry Gilpin

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 variable contrast 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).

■■■■
#2-5041, 1996. © 2008 Henry Gilpin. All rights reserved. Courtesy of the artist.

Exposure and Developing Technique for Photographic Printmaking

Rod Dresser

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.

Note that there are two distinct steps in negative creation—expose and develop. The same distinction applies to printmaking—exposure and contrast control. Thus, our axiom for printmaking is expose (exposure time) for the highlights and contrast control (VC filters or paper grade selection) for the shadow areas.

Here are the steps to accomplish the most efficient and best print results for printing on variable contrast 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, 1 1/2, 2), and if it appears to be lacking contrast use a higher grade filter (3, 3 1/2, 4). If you are unsure start with a 2 1/2 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 three- to five-second intervals. It is only necessary to make the strips about 1 1/2 to 2 inches 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 four 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. As an example, clouds that have full detail but are brilliant. Be sure that you have a strip that is too light and one that is too dark on either side of your chosen strip. If not, you may be missing a time that is just right.
7. Calculate the optimum time from the selected strip and make this your base exposure time. An example is if you chose the fourth strip counting from the lightest strip and the exposure times were four seconds for each strip your base exposure time is 16 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. Keep making prints while changing exposure time until you have the highlights perfect. Note that I have not mentioned the shadow areas. They are to be ignored until the exposure time is properly obtained.
13. 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 grey) the contrast is too low.
14. Adjust the contrast by changing filters and reprint. You will have to adjust the exposure time due to the change in filter density. This requires that you run new test strip at the new contrast.
15. This may necessitate a number of prints to finalize the perfect exposure time and contrast.

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.

The last and really subtle process that I use I call the Darkroom Dance. Make small changes in developing time (no more than 15 to 30 seconds) with equally small exposure times (fractions of seconds). As an example, increase the developing time 30 seconds to get a smidgen of contrast while taking off a half-second of exposure time to compensate for the effect the developer has on the highlights. The opposite can be done to decrease the contrast. I know that I admonished you not to make two changes at once but these are subtle and only done when you are near the perfect print.

Four French Tulips, Carmel, California, 2001. © 2008 Rod Dresser. All rights reserved. Courtesy of the artist.

An Efficient Way to Get to the Final Print

Bruce Barnbaum

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 # 1 1/2 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 2 1/4 or larger film the original contact proof should be sufficient. If you are using 35 mm, I'd recommend selecting the best ones and making enlarged proofs for better evaluation, perhaps about 3 1/2 × 5 inches.

Step #2

Evaluate the contact proofs very 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, then lower your contrast accordingly.

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 2 1/2 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 end 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 3 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; sometimes diagonal sections. Vary as necessary for best evaluation.

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 3-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, 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' 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 very quickly.

Sequoias and Sunburst, 1976. © 2008 Bruce Barnbaum. All rights reserved. Courtesy of the artist.

Pre and Post Flashing to Control Contrast

Les McLean

How it Works

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 pre-sensitizing 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.

In describing how I make the prints illustrating this method, 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, or the Paper Flasher® that I use. 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 Paper Flasher manufactured by RH Designs, which can easily be attached to the enlarger. I find it quick, convenient and accurate (see Resources).

A second 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. This method will make the flashing exposures quite lengthy.

Making the Pre-Flash Test Strip

Use a full 8 × 10 inch sheet of enlarging paper to make your pre-flash test strip or cut 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 to 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 grey 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 three 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.

Editor's note: Visit Les' website www.lesmcleanphotography.com and access the articles section to see a complete description of this process including before and after illustrations.

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White Sand Dunes, New Mexico, 1998. © 2008 Les McLean. All rights reserved. Courtesy of the artist.

Rescuing Thin Shadows

Saïd Nuseibeh

I learned this simple trick from Ruth Bernhard while printing her negative, *Rockport Nude*. The figure in Ruth's negative has wonderful mid-tone 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 non-image, 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 H&D curve, the contrast increases, thereby giving more separation to this area than is otherwise possible.

To make the 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 was 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 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 + 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, then 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 to 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 a 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 useful for moving the weak densities progressively further 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.

Vanishing Points: Shadows along North Riwaq, Umayyad Mosque, Damascus. © 2008 Saïd Nuseibeh. All rights reserved. Courtesy of the artist.

Enhancing the Surface Characteristics of Silver Gelatin Prints

John Sexton

During the past few years a number of articles have appeared in photographic periodicals in which the author claims to have "invented" a new photographic technique. The vast majority of these "inventions" actually are the resurfacing of old, and sometimes forgotten, photographic procedures. Many of these techniques were first generated during the heyday of the growth of the craft of photography, the 1920s through the 1940s. During this time, many innovative thinkers came up with ideas that we accept as the norm today, and we often do not know their origins. The process that follows, or variations thereof, emerged at some point during this period. I wish I knew the person, people, or company that first came up with the idea so I could offer them my sincere appreciation. The process is the application of steam to the emulsion of air-dried silver gelatin fiber base 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.

I have encountered, in some photographic emulsions, great batch-to-batch variations in the surface characteristics of the paper. Though labeled double-weight glossy on all the boxes, the surfaces when air-dried 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 D-Max, 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 (or more correctly unspotting) prints, 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 down 8 to 10 inches above the steaming spout, and moved back and forth for 5 to 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 needing steaming. 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."

Bell Tower, Late Afternoon, Northern New Mexico, 2001. © 2008 John Sexton. All rights reserved. Courtesy of the artist.

9

Stop Baths and Fixers

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

STOP BATHS

It is important to provide a buffer between the developer and the fixer. This is because the fixer will rapidly exhaust if it is contaminated with developer. Maintaining the activity of the fixer is of utmost importance to the longevity of negatives and prints.

Whether or not to use an acid stop bath or a plain running-water bath has been a long-standing controversy among photographers. There are two reasons cited for using an acid stop bath. First, it arrests development in the shortest possible time. The second is, "That's the way I was taught."

Even so, the disadvantages to using acid stop bath are:

- When sodium carbonate, one of the most commonly used alkali in film developers, comes into contact with acid, carbon dioxide gas is released which can cause blistering in the emulsion of both film and paper. The problem is more critical in film where it is appears as a pinhole, usually in dense areas of silver deposits such as the sky.

  If an acid bath is to be used there are two methods to prevent pinholes from occurring.

  1. Use developers compounded with mild alkali, either sodium metaborate or borax, which do not create carbon dioxide gas.
  2. Use a 3% to 5% solution of sodium metabisulfite, a 3% solution of chrome alum, or a mildly acid stop bath, such as Kodak SB-1 Nonhardening Stop Bath. Or use a very gentle-acting stop bath, suggested by Jay Dusard, comprised of a solution of 10.0 grams of sodium bisulfite in 1.0 liter of water.
- The fumes which emanate from acetic acid stop baths are perhaps the single greatest health hazard in the darkroom. Over time, these fumes can cause damage to the delicate membrane of the sinuses, resulting in respiratory problems. For this there are also two solutions.
  1. Use an odorless citric acid stop bath such as Kodak SB-8.
  2. Stop using stop baths altogether. Instead, substitute a one 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 to 30 seconds, dump, and repeat three times.

While a running water bath will not stop development as rapidly as an acid stop bath, it will slow it down to the point that the amount of residual development is insignificant. This is because, depending on its strength, it takes an acid stop bath approximately 15 seconds to halt development and a running water bath takes approximately 30 seconds. The difference in the negative image could not be measured. If you are still not convinced consider that the slight additional development will automatically be factored in when you run your film development test.

If you still prefer to use an acid stop bath instead of water the most widely used formulas call for acetic acid in a 1% to 2% working solution. The only other ingredient sometimes added is a pH indicator dye (Formulas: Stop and Hardening Baths: Indicator for Stop Baths).

Other chemicals that can be used to make stop baths are boric acid, citric acid, and sodium bisulfite. Chemicals that should not be used are chrome alum and potassium salts, such as potassium metabisulfite or potassium sulfite, either of which 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.[1]

FIXERS

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. 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. They 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.

The fixing process for paper and film is similar, but film and paper have their own unique characteristics and requirements. Until the 1970s, the primary agent used for fixing was sodium thiosulfate (hypo). Other fixing agents, though not as common, include ammonium thiosulfate, alkali thiocyanate, thiosinamine, cyanide, sodium sulfite, ammonia, thiourea, and

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[1] 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.

concentrated solution of potassium iodide. Except for special purposes (for example, ammonium thiocyanate can be used to achieve fixing times of a few seconds; Formulas: 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. Those fixers using ammonium thiosulfate are commonly referred to as "rapid fixers."

For practical purposes the difference between the two thiosulfates is a matter of fixing time. According to Pierre Glafkides, in *Photographic Chemistry, Vol. 1*, ammonium thiosulfate is 400% faster than sodium thiosulfate.[2] At some point, ammonium thiosulfate gained a reputation for producing less-than-permanent images. The problem was that ammonium thiosulfate, even in an undiluted concentrate, was not stable. Therefore, photographers desiring a more rapid rate of fixation would add ammonium chloride to their standard hypo solution just before use. This produced ammonium thiosulfate in solution.

Today, a stable form of ammonium thiosulfate is readily available in two forms. The preferred form is a 60% solution. However, when it is inconvenient to ship or store liquids, it is also available in photo-grade crystalline form. Although there are five published ammonium thiosulfate formulas, the two most used in contemporary photographic practice are ATF-1 and ATF-5.

Types of Fixer

There are three general types of fixing baths: plain (or neutral), acid, and alkali. A plain fixing bath is one consisting of hypo in water only. A plain bath can be easily mixed by adding two pounds of sodium thiosulfate crystals to one gallon of water. When using the crystalline form of sodium thiosulfate, begin with water of at least 90F/32C, as the temperature will drop considerably.

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 (Fixing Paper, below), 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.

Most fixers are of the acid type. Acid fixers are made by adding acid to the solution. 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 in order 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.

Alkali fixers, especially those compounded with ammonium thiosulfate, are the most efficient and effective with modern emulsions in both film and paper. Although they have been used for scientific purposes since at least the 1930s, they have only recently become commercially available. Photographers' Formulary TF-4 is the first to be widely distributed. The formula for TF-3, a fixer having similar properties but a shorter shelf life, is given in the Formulas section.

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[2] This may be overly optimistic as other sources suggest 200% to 300%. The point is, AT is considerably more efficient than sodium thiosulfate.

There are numerous advantages to using alkaline fixers.

- Shorter washing times. Paper fibers are akin to the fibers found in clothing; the reason laundry soaps are alkaline is because they wash out more readily from clothing fibers; there is no such thing as an "acid" laundry detergent or soap!
- No hypo clearing agent (HCA) is required when using alkali fixer.
- No acid stop bath is required when using alkali fixer. In order to preserve the alkalinity of the fixer, acid stop bath should not be used.
- Greater 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

The purpose of hardener is meant to reduce the risk of injury to the emulsion of the film or paper while it is wet. This was of great importance when most film and paper were made with soft emulsions (Chapter 8, Printing Methods and Techniques: Hardener). After drying, hardener serves no useful purpose.

The reason not to use hardener is that it makes it more difficult for fresh fixer to penetrate the surface of the emulsion, and hardener is itself difficult to wash out of paper. The two most noticeable results are that fixing time is extended, even doubled, and some toners, such as selenium toner, will have an adverse reaction to hardener resulting in stains or uneven toning.

Even though most films made today are sufficiently hardened it is a good idea to include hardener in acid fixing baths for film, especially when processing sheet films in a tray. Roll film is mainly at risk when being removed from the reel for drying. Unless the fixer specifies not to use hardener (TF-4), the advantages of protecting film from scratches outweigh the disadvantages of using hardener.

For tray processing of paper it is not necessary to use hardener unless you habitually experience scratches on the print emulsion from handling. If scratches do occur, hardener should be added to the fixer. Start by adding 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 45.0 ml of hardener, start with 15.0 ml; if the problem persists, add another 15.0 ml. It will be necessary to neutralize or wash out the hardener prior to most toning processes (Formulas: Miscellaneous: De-hardener).

Chrome and potassium alum are the two most common hardening agents. Chrome alum has the greater effect, but fixers using this agent have poor keeping qualities. For this reason, potassium alum is usually preferred.

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, below).

Fixing Paper

The time-honored method for fixing 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 for the same amount of time. 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 there eliminated.

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 Determining Fixer Capacity, below, it is discarded and the second bath becomes 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.

While not faulting this method, Ilford suggests the use of a single, concentrated, rapid fixing bath for 1 minute to prevent the buildup of by-products in the paper's emulsion. This method works because the paper is 90% to 100% fixed within the first 15 seconds of a concentrated fixing bath.

For this method to be effective it is important to monitor the time exactly. The paper should be immersed for 60 seconds with continuous agitation, drained for 15 seconds, and immediately transferred to a fresh water bath, preferably with running water. Excess time in the fixer beyond 60 seconds allows by-products to infiltrate the emulsion negating any advantage of the method.

Both methods have their merits, and neither appears to be better than the other. One advantage of the two-bath method is that whichever fixing agent you choose, sodium or ammonium thiosulfate, the fixing time is not as critical as in the single-bath method.

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 in order to break them down. For film, agitation should be 30 seconds every minute.

Paper agitation depends on the method of fixation: Kodak Two-Bath or Ilford Single-Bath with Rapid Fixer (see Fixing Paper, above). If the two-bath method is used, agitate for 30 seconds each minute. If using the single-bath method, agitation should be continuous.

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 anytime after 45 seconds.

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 strong, it is reaching its capacity.

Working dilutions of fixer should not be kept more than two months, less if the ambient temperature is over 85F/29C. 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.

Both Film and Paper

There are two methods that can be used for testing either film or paper, and a third method for use with film. Use whichever works best for you.

- 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 4.0 liters/gallon) with acid fixer and 25 with alkaline fixer.[3]
- Using a liquid hypo check (Formulas: Miscellaneous: Fixer Test Solution) 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 10.0 ml of a 4% to 5% solution, and the amount of hypo tested should be exactly 100.0 ml. To create a precipitate, the combined solutions must be shaken; otherwise the test is prone to errors.

For Film

An alternative method for testing film fixer is to gently agitate an undeveloped piece of leader from a 35 mm 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.

The minimum fixing time is twice the time 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 to 20 seconds. Even so, I recommend a minimum fixing time of 3 minutes for all films and fixers, except for those that are meant for extremely rapid fixing, such as Defender 9-F Thiocyanate Fixer. This is not a "scientific" recommendation—it is my recommendation. One extra minute or two of fixing time will not adversely affect the film and it will help insure complete fixation as the fixer ages.

By periodically testing the fixer, ideally before each fixing session, the exhaustion rate of the fixer can be determined. When the initial clearing time has doubled it is time to mix a fresh fixing bath. If you find it too difficult to remember to test the fixer before each session then check when the fixer is about half way through its estimated useful life and more frequently as it nears its published capacity.

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.

[3] Most fixers will last considerably longer than this recommendation. However, if not certain it is better to err on the side of caution.

10

Toning Prints

There is a road from the eye to the heart that does not go through the intellect.

—G.K. Chesterton

> *Caution*: Toning involves some of the most toxic chemicals used in conventional darkrooms. Please follow standard laboratory safety procedures and use adequate safety precautions (Appendix 1: Safety in Handling Photographic Chemicals).

There are two reasons to tone prints: One is to change the color of the image, the other is for longevity. While the two are not mutually exclusive—some formulas both change the color and protect the image—they are not always complementary. For example, prints treated with iron toners, while attaining a rich blue color, often will not last more than a few years.

Many substances will color prints. In fact, a beautiful and permanent warm tint can be achieved on many papers by using your morning coffee.[1] After fixing 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. Also, the color of a toned print depends on the formula of the toner and its dilution; the paper type, surface, and paper base tint; and not least of all the processing method. This last includes not only the print developer used but often the choice of fixer.

POINTS TO REMEMBER FOR ALL TONING PROCESSES

The following points apply to all toning processes.

- Don't exceed the capacity of your developer when making prints. Contaminated or exhausted developer can cause image-color variations.

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[1] Coffee is not a toner but a tint as it only stains the paper base without affecting the silver.

- Do not use an exhausted or over-concentrated 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 or use an indicator stop bath.
- Improper fixing is probably the major cause of stains in toned prints. An exhausted fixing bath contains insoluble silver compounds that will be retained by prints and cannot be completely removed by washing. When these residual silver compounds come into contact with a toner, they form a yellow stain that is especially noticeable in the highlights and borders.
- Excessive fixing with acid fixers is almost as bad. Prolonged fixing expands the paper and allows the solution to penetrate the base. Acid fixer that is trapped in this way 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 toner when prints have previously stuck together in the fixer.
- Avoid the use of hardening fixers. Hardening fixers do just what the name implies: They harden the emulsion. This prevents toners from penetrating the emulsion and doing what they are supposed to do. Use Plain Hypo, Looten's Acid Hypo, Kodak F-24 Nonhardening Acid Fixer, TF-2, TF-3, ATF-1 Nonhardening Rapid Fixer, or commercial formulas such as Photographers' Formulary TF-4 Alkaline Fixer or Ilford Rapid Fixer.
- Insufficient agitation of prints, especially during the 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 washing. HCA is unnecessary after other toners unless re-fixing is indicated (for example, Nelson Gold Toner; partial redevelopment/toning, etc.).
- While it is perfectly acceptable to tone prints that have just been fixed and washed the most consistent results are obtained from toning dry prints that have been re-wet for 5 minutes. This is because the emulsion of freshly processed prints 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 toner from the edges of a print. Therefore, when toning RC paper, keep toning times to a minimum to prevent the solution from penetrating the edges of the paper. If toning times longer than five minutes are anticipated with RC paper use salon borders of at least one inch around the image. The same is true for fiber-based prints meant to be toned for times of ten 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. One exception is properly washed selenium toned prints, which may be safely dried face down. Drying racks should be cleaned 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.
- Do not use metal trays or tanks. Use trays made of nonmetallic material such as glass, inert plastic, or hard rubber.

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. Ideally the 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:

1. Cut the print into eight strips. The strips can be horizontal or vertical sections, whichever direction contains the most information.
2. One strip is not toned but held aside for reference.
3. The second is toned for fifteen seconds, the third for thirty seconds, the fourth for one minute, the fifth for two minutes, the sixth for four minutes, the seventh for eight minutes, and the last for sixteen minutes. If the published formula for the toner calls for a longer initial time than sixteen minutes adjust the test accordingly.
4. 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 work to completion, such as bleach and redevelop toners (for example, hypo-alum, sepia, etc.), as partial toning will result in an unstable final print. However, it may be desirable to tone a single strip of a correctly exposed and developed print and keep it among the toning swatches.

TYPES OF TONERS

There are two basic methods for toning prints. The first is by direct toning without the use of bleach and the second is by conversion, known as 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 (Formulas: Toners: Kodak GP-1 and GP-2 Gold Protective Solution and Nelson Gold Toner).
2. Those that convert the silver image into silver selenide (Formulas: Toners: Dassonville T-55 Direct Selenium Toner).
3. Those that replace the silver with another metal. The compounds produced are usually either ferricyanide (Formulas: Toners: Copper Toner, Dassonville T-5 Copper Toner) or iron (Formulas: Blue Toners: Ansco 241 Iron Blue Toner). 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

(Formulas: Toners: Ansco 221 Sepia Toner). In some formulas, a copper bleach may be used, but this should not be confused with direct copper toners (see Direct Toners, above).

The B&R process converts the metallic silver in a print back into clear silver halide by combining the metallic silver with a halide, or mixture of halides. 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 unless carefully timed. 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.

Many sulfide/sulfur-based toners can cause damage to light-sensitive materials, such as undeveloped negatives and papers. If you can smell the sulfur (rotten egg smell) then do not use the toner in a room in which undeveloped materials are stored. These toners can be used outdoors in daylight if necessary.

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. 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.

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, it also serves to protect the silver from degenerating.

Gold chloride works in direct ratio to the amount of silver in the print. When there is no metallic silver in the print, such as the 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 will be more successful for blue toning than fast chlorobromide or bromide papers.
- The paper developer affects the results. If you develop in glycin or pyrocatechin, the blue tones will be lighter. Any developer that produces a brownish color by direct development is good for

gold toning for cold tones. Edwal 106 is a good choice (Formulas: Paper Developers: Warm-tone Developers).

- If a fixer with hardener has been used re-fix in Plain Hypo (Formulas: Fixers: Plain Hypo) or use Dehardener (Formulas: Miscellaneous: Dehardener) before toning.
- After toning, if the emulsion feels soft to the touch, either re-harden 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 70F/21C, but when the action of the toner appears sluggish, it might help to heat the formula to 75F/24C or even as high as 95F/35C.
- The higher the contrast of graded paper, the harder it is to use gold 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 through the use of 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 give 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, 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.[2] While this is a loss to fine-art photographers, warm tones can still be achieved—and in great variety—through the use of toners.

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

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[2] One of the reasons for this was the ban on cadmium, a key component in warm tone papers before its use was banned by the EPA in the United States due to its environmental impact. Without cadmium, it is not as easy to formulate a warm-tone paper. It is easier to tint the paper base.

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. Commercially available copper toners are available from Berg, Tetenal, and Fotospeed.

OTHER COLORS AND TONES

Purplish to Reddish-Brown Tones

Purplish to reddish-browns are usually the result of using some form of selenium or copper. Several formulas are commercially available. Among them are Berg Selenium Toner® and Brown Copper Toner®, Ilford Selenium Toner®, and Kodak Rapid Selenium Toner®.

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 Flemish Toner (Formulas: Toners: Selenium Toners). The latter two are both bleach-and-redevelop selenium toners. The advantage to mixing your own is that it is possible to obtain colors not possible with the commercial products. The disadvantage is that selenium in powder form is highly toxic and all three formulas require heating to dissolve the selenium powder which poses the further risk of inhaling fumes. Only mix selenium toner in a well-ventilated area or outdoors and wear a face mask rated for hazardous chemicals.

Red Tones

Red tones can be achieved through the use of 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, then Kodak T-26 Blue Toner. To use this combination, wash the print thoroughly after using sepia or polysulfide toner then use T-26 as per directions. The red tone should appear after approximately 15 to 30 minutes in this solution at 90F/32C. 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.

There are two methods that can help prevent this from occurring. The first is to completely and uniformly convert the metallic silver to either silver sulfide or selenide. Once this is done, further deterioration is no longer possible. In other words, converting the silver all at once will protect the image, while allowing the silver to convert in a random manner will destroy it.

There are two types of toner that can be used to completely convert metallic silver. The first are sulfide/hypo alum toners which can be used to completely and uniformly convert the metallic silver to silver sulfide. 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, which 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.

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. When this occurs, the print is ruined. 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 Hypo-Alum Sepia Toner or Kodak T-8 Polysulfide Toner (Formulas: Toners: Brown Toners) 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—wear gloves.
- Use temperatures of around 110F/43C to reduce toning times. At this temperature, prints will still take from 15 to 45 minutes to tone. However, resin-coated (RC) papers should not be toned at this temperature as they may delaminate.
- While chrome alum can be used in hypo-alum toners, it is more hazardous to the environment and so potassium alum is preferred.

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 mid-tones, and finally the areas of least density, the highlights. When used at dilutions of 1:19 or greater and a time not to exceed five minutes, selenium toner will not affect image tone with many papers.[3] Unfortunately, recent tests indicate that selenium is a less than perfect archival toner,

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[3] The dilution is paper dependent. Some papers can stand a much lower dilution, some require more. Make a toner strip test as explained earlier in this chapter.

because in order to be fully effective, the print must be toned to completion, which means lower dilutions (1:9 or less) resulting in an often undesirable color shift.

Gold-Toning for Protection

The classic formula for gold protective toning is Kodak GP-1 Gold Protective Solution. Like selenium toner, GP-1 not only protects the print but causes a minimum color shift. What shift there may be is toward a slight blue-black that some photographers find pleasing. 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. More recent tests performed by Liam Lawless on Ilford Warmtone FB developed in Dassonville D-3 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 silver, mordant dye toners use a speical bleach to convert metallic silver to either silver iodide or silver ferrocyanide so that an organic dye will adhere to it. The dye is deposited in direct proportion to the density of the mordant (bleached) image. In other words, the more silver that is mordanted the stronger the final color (Formulas: 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 tend 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, below).

DuPont 6-T Toning System

The 6-T system consists of three separate bleaches, three separate toners, a sodium chloride solution, plus 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 purplish-brown to a bright sunlit sepia. This system works best with old-style soft emulsion papers. (Formulas: Toners: DuPont 6-T Toning System)

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 Photo Maskoid® or Grumbacher Miskit™ Frisket, both available from art supply stores. If you use rubber cement, dilute it 1:1 with rubber cement thinner. If you use Photo Maskoid, use the red variety as it is easier to see the areas you have covered.

Using an appropriately-sized soft brush that forms a good point and does not lose its bristles, apply two or three thin coats of the material to a dry print. 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 two 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 tends to bleed under the mask you may have to skip the presoak.

After the print has been washed according to the toner's instructions, you can remove the mask. Remove Photo Maskoid by touching tape to one edge and pulling it off. Remove rubber cement 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 such 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 vs. non-archival is a useful and simple starting point. Of the archival toners, polysulfide (smelly!), sepia (smelly or non-smelly 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 non-archival counterparts, which can produce strong and even vivid colours. Iron blue and copper red or brown are the most widely available of these, with titanium and vanadium yellow being obtainable in the Fotospeed Palette kits. These can give a wonderful range of greens when used with iron blue.

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 favourite choices depend on (1) the purpose of the print (for sale or collection), (2) the printing process (lith prints may tone idiosyncratically or more colourfully with the archival toners), and (3) the nature of the image (or the other works in that set) and my mood at the time. So describing my "favorite" is like being asked which one record would I 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 in particular can yield either very colourful 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 less relevant when gold toning after sepia to change the sepia colour (see below).

Secondly, 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 mid-tones. In the case of sepia, it could be just the lightest of highlights for very subtle effect, or down to the mid-tones 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 warmtone papers, or one of the many sepia hues on top of contrasting egg-plant 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 towards blue but towards 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 colour. If the mid tones are left as untoned silver, beautiful tri-tone effects are obtained.[3]

NOTE: Prints should be well washed between toning baths and in particular acidic prints (for example, from direct gold toner, acid stop baths, etc.) can stain if transferred straight to selenium without being well washed, or put through alkaline hypo-clearing agent.

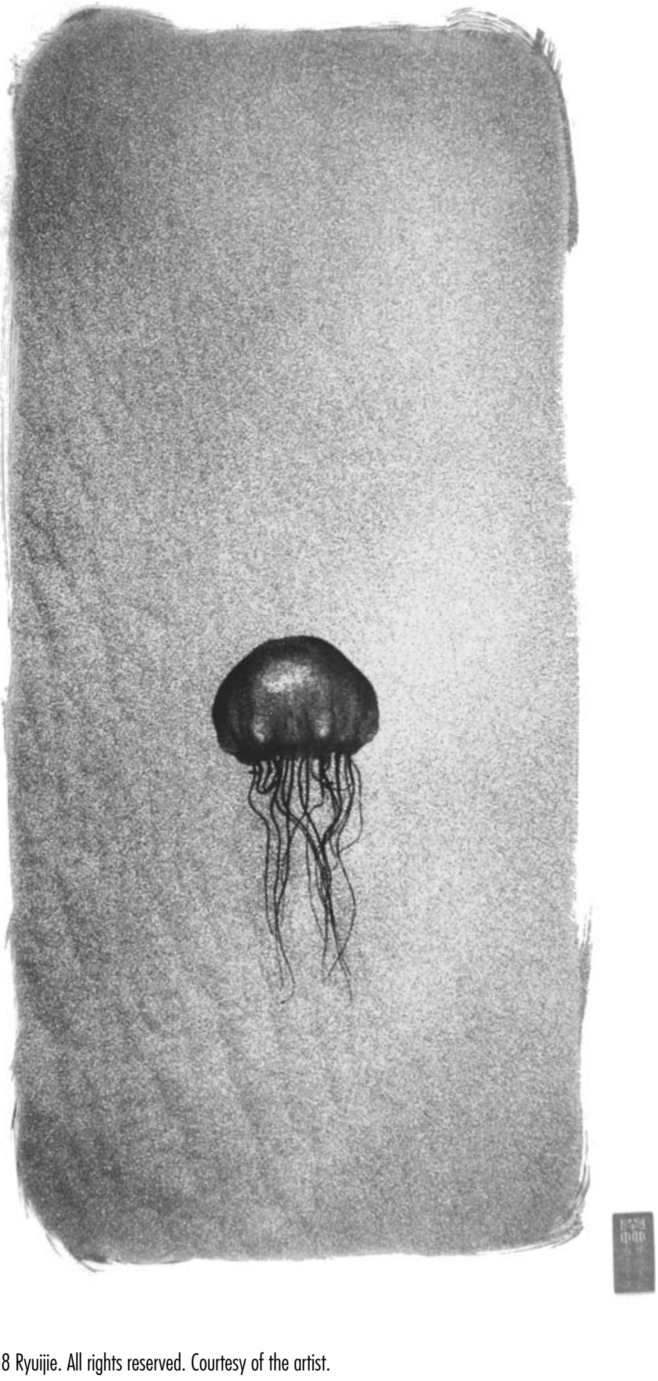
[1] This description refers to the widely available single-bath "off the shelf" toners, not necessarily to some of the many other formulae described in this book.

[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 at the back of the *Cookbook*.

■■■■

Rock in the Merced River. © 2008 Tim Rudman. All rights reserved. Courtesy of the artist.



K49 Jellyfish, 2008. © 2008 Ryuijie. All rights reserved. Courtesy of the artist.

Split Toning with Polytoner

Ryuijie Douglas

I use Ilford Multigrade IV and Polytoner to split-tone my ice form photographs. As Polytoner is no longer available, here is a 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
Water to make	1.0 liter

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.

11

Photographic Reduction and Intensification

> *What if I used a meter and the darn thing broke on me when I was out making photographs? Then what would I do?*
>
> —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 completely processed 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 onetime, 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, or subtractive, reducers act first on the shadow areas and then on the midrange and highlights. They are used for clearing film fog and for reducing prints. Kodak R-4a Farmer's Cutting Reducer for Overexposed Negatives is the most commonly 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. Kodak R-4b Farmer's Proportional Reducer for Overdeveloped Negative is most commonly 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 appropriate 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

Cutting and proportional reducers are the most common types used. 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 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, so the amount of hypo is flexible.

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 works by treating the negative in a ferricyanide solution first, then in a separate solution of hypo. This 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. Also, reduce only one negative, or strip of negatives, at a time. 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 in preference to the middle tones and shadows. Ammonium persulfate is able to 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 perhaps the best all-around after treatment and is a technique that should be known to all photographers. Among photographers, print reduction is commonly known as bleaching and will be referred to as that in the *Cookbook*. 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 (Formulas: Print Reducers: Print Rehalogenating Bleach).

There are three methods for bleaching prints: overall, local, and spot.

1. Overall: The print is completely immersed in the reducing solution. This is excellent for brightening the print and increasing overall contrast.
2. Local: This is the method for control work on comparatively large areas. 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.
3. Spot: This is the way to eliminate black spots, place catch lights in eyes, or when precise control is necessary. The bleach is applied with a spotting brush or toothpick.

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 before toning.

Like the technique of dodging during exposure, overall and local bleaching can be used to increase shadow detail. Bleaching is different from dodging in that while dodging retains the overall contrast of the print, bleaching increases the contrast. The reason may be best understood in the following example.

Suppose that after development the highlights contain 100 silver grains and the shadows, being denser, contain 1,000 silver grains. If you were to make a second print and dodge both areas for 20% of the overall exposure the highlights would then contain 80 silver grains and the shadows would contain 800. This is similar to proportional reduction.

Suppose that instead of dodging you were to bleach the print using the overall method removing 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. The highlights would be significantly lighter and the shadows would have hardly changed, effectively increasing the overall contrast. The same increase in contrast will occur in locally bleached areas.

The effect of bleaching largely depends on the paper. Some papers, such as Kentmere, Fomatone, Slavich, and Fotokemika, readily take to bleaching, whereas others, such as Ilford, are highly resistant.

Overall Bleaching For overall bleaching of prints you can use either Farmer's Reducer (Formulas: Print Reducers), Kodak R-4a, or Ammonium Thiosulfate Reducer (Formulas: Negative Reducers). But as in negative reduction the easiest and most versatile is still Farmer's. The action of Farmer's Reducer bleaches the weakest portions of the silver image first, and in a print that means the highlights. Then it begins to reduce the midtones, and finally the blacks. 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 1/3 stop darker in the highlights and a half-grade grade lower to keep the shadows open. Then bleach the print until the highlights are to your satisfaction.

Another technique that creates a unique effect with pronounced tonal separation is to overexpose the print by 1 to 1 1/2 stops using one full grade less contrast, then bleach using a fairly dilute solution of Farmer's Reducer. This accentuates the graininess of the image. Although the pre-bleached print will look dark, holding it up against a light will reveal the detail waiting to become visible.

Instructions for Overall Bleaching For overall proportional reduction of the highlights, midtones, and shadows, start with a wet print. For clearing 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 non-hardening 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 the center.

The print should remain in the solution for 5 to 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 Bleaching Local bleaching is an invaluable 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 bleaching increases contrast in an area, you may even want to refrain from dodging in order to both lighten and increase local contrast through bleaching.

Instructions for Local Bleaching 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 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. 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.

Instead of a cotton ball, there are a number of applicators that you can use. Try a #10 Winsor & Newton™ watercolor brush for large open areas. Jay Dusard (also known as Captain Ferricyanide) uses a Japanese calligraphy brush.

To halt the bleach process use the hose, mentioned above, directly on the area being bleached. If a hose is not available, use a water-saturated sponge. 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, non-hardening fixer and wash the print thoroughly.

Spot Reduction 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.

Instructions for Spot Reduction I was originally taught spot reduction by photographer Boyd Wetlauffer of Canada in 1974. Boyd always used 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. Photowipes® and Kimwipes®, available in camera stores, 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 used what he referred to as a "supersaturated solution" of straight ferricyanide in water and dispensed with solution B altogether. To make Boyd's supersaturated solution add ferricyanide to 30.0 ml of distilled water at 125F/52C until it stops dissolving. When no more ferricyanide will go into solution, filter the solution through a chemically untreated coffee filter. This is not a true supersaturated solution, as any real chemist will be quick to point out, but call it what you will it works.

Place one blotter on the right side of the print and hold a second in your left hand (reverse if you are left-handed). Dip the brush into the reducer and wipe it on the blotter to the right of 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 left 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 supersaturated 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 dyes available from darkroom suppliers.

When all black spots have been removed, catch lights added, and satisfaction achieved, rinse, fix, and wash. This must be done for even the smallest spot, otherwise the color of the print will eventually change.

An alternative to Farmer's Reducer is medicinal iodine tincture. 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. Black fogging along the border of prints can also be removed by carefully applying undiluted iodine tincture, making sure that it does not touch the image itself. 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 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, 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 lightening 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 after neutralizing it by dumping the remaining bleach solution into it. Plain Hypo is useful for this purpose as it uses only one ingredient and must be discarded after use anyway (Formulas: Fixers: Plain Hypo).

When bleaching is complete rinse the print thoroughly for 5 to 10 minutes in running water and then re-fix with a fresh non-hardening fixer. After fixing, the print must be thoroughly washed. If an acid fixer is used use a Hypo Clearing Agent (HCA) before the final wash to insure against residual staining. If toning is desired, this would be a good time to do it, although the prints can be dried and toned later.

INTENSIFICATION

Negative Intensification

Negative intensification is an invaluable 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 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.

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 re-fix the negative in plain hypo then soak the negative in selenium toner 1:2 for 3 to 5 minutes.

To dilute the selenium, he recommended using a working strength bath of Hypo Clearing Agent (HCA). He followed the toning bath with a second, full-strength, bath of HCA, without selenium, and then a thorough washing.

The purpose of re-fixing 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 in contact with selenium. If you are confident that your negatives have been thoroughly washed, or if you use fixer without hardener then re-fixing should not be necessary. But when in doubt, re-fix.

The list of intensifier formulas includes uranium, silver, copper, selenium, chromium, mercuric chloride, and mercuric iodide. Some of the formulas, such as uranium, create a high degree of intensification but a low degree of stability. Others, such as chromium, do not intensify nearly as well, but the image is reputedly quite stable.

Notes on Negative Intensification

- When possible, work with one negative or strip of negatives at a time.
- Use a white tray in order to better judge density increases. Experience will enable you to accurately judge increases.
- 35 mm 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 multi-contrast papers.

Chromium Intensifier 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. To be effective, chromium intensification must often be repeated several times.

The two main ingredients in chromium intensifier—potassium dichromate and hydrochloric acid—are both hazardous chemicals. Hydrochloric acid can burn a hole in your skin, and dichromate can cause serious skin irritation. Handle chromium intensifier with gloves and use a respirator, observing all safety precautions (Appendix 1: Safety in Handling Photographic Chemicals).

Instructions for Chromium Intensification Two formulas for chromium intensification are given in the Formula section. Intensifier #1 gives more intensification than #2.

Negatives to be intensified with chromium should first be hardened either in the fixer 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 compound. The negative is then washed until completely free from yellow stain, about 5 minutes, and redeveloped with a normal developer (not a fine-grain developer) until the image has blackened completely. A good developer to use for redevelopment is Kodak D-72 1:3. After redevelopment, fix the negative for 3 to 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.

Silver Intensification Silver intensification has a noticeable effect on low values, which is where thin, underexposed negatives usually need help. It does, however, have 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 found in Formulas. Instructions for silver intensification will be found in Formulas: Negative Intensifiers: Kodak IN-5 Silver Intensifier.

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 intensifier and will provide maximum archival protection for your negatives. The reason for the latter is explained more fully in Chapter 10, Toning Prints: Protective Toners, though simply put, converting an image from silver metal to silver sulfide makes the image as permanent as it possibly can be.

Instructions for Sepia Intensification These instructions can be used with any bleach and redevelop sepia toner.

1. Re-fix the negatives in rapid fixer *without* hardener for 1 minute.
2. Wash the negative for 5 minutes.
3. Move to the A bath and agitate for 30 seconds every minute for 5 minutes.
4. Rewash the negatives until they are completely clear of the yellow bleach.
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 3 minutes, with agitation.
7. Wash for 5 minutes.
8. Rinse in wetting agent, 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. 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.

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 upon the type of developer, the strength of the intensifier, and the paper used.

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 for Prints The technique is to bleach the print and then redevelop it in a non-staining 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 it a try.

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. If you want to use selenium toning on prints for longevity without noticeable intensification, compensate by reducing the development time of the print by about 10%.

Selenium toning should be done after fixing and bleaching. If a non-hardening 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 re-fixed in a non-hardening fixer, such as F-24. Immerse the prints for

5 minutes, with agitation. After toning, soak the prints in a second bath of HCA (without the selenium), then wash for the recommended time.

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.

Some workers recommend mixing the stock selenium toner with a working solution of Hypo Clearing Agent. Others, such as Bruce Barnbaum, suggest that this will shorten the life of the toner. Bruce reasons that the useful life of HCA is approximately eighty 8 × 10″ prints or equivalent films, and that the useful life of selenium toner is at least two hundred 8 × 10″ prints or equivalent. When the HCA is exhausted the bath needs to be replaced, which is a waste of selenium toner and results in more selenium being introduced into the environment.

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 final fix from a previous print finishing session).
- Large tray of water for holding prints that have been bleached.

Bleach Mixture

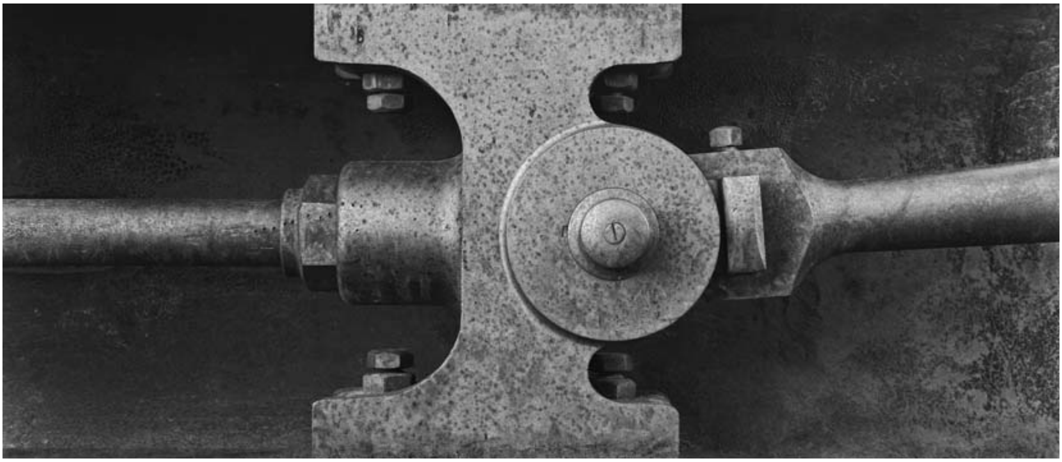
Pour a small pile (approximately the size of a dime) of potassium ferricyanide crystals into a small white plastic container. Add about 90.0 ml of water, then a splash of plain hypo. The splash will vary based on desired contrast of the mixture. The hypo acts as a catalyst, but ultimately neutralizes 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 wet 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 some 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 and 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 (this could keep you from hyperventilating and collapsing in the sink). 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 one and a half to two 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 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 use a hose to control bleach placement and rinsing-off.



Pitman Arm, 2000. © 2008 Jay Dusard. All rights reserved. Courtesy of the artist.

12

Development by Inspection

> *You have to take a lot of bad images to realize what's good. But, if there is one piece of advice I would like to give photographers, all photographers, it's this: Keep it simple.*
>
> —Ryuijie Douglas

Although it is apparent that the development of film by time and temperature is here to stay, this was not always the case. Even after the discovery of time and temperature development, development by inspection remained the method of choice for most professionals well into the 1930s. The reason was that many photographers learned their craft using material that was hand-coated or manufactured under loose tolerances and its sensitivity varied greatly. In order to ensure usable negatives, photographers had to develop by inspection. Even as more sensitive plates and films became available along with consistent mechanized manufacturing processes, many photographers steadfastly refused to give up the tried-and-true practice of development by inspection.

It wasn't until the publication of the first edition of Morgan and Lester's *Photo-Lab-Index* in 1936 (the title was eventually changed to Morgan and Morgan's *Photo-Lab-Index*) that a complete and reliable source of time and temperature tables was generally made available. Henceforth, development of film by time and temperature became the industry standard.

Nonetheless, there are still a few valid reasons to learn how to develop by inspection. The most important is that it allows complete and total control over every image. A second reason is that it might help save negatives when there is doubt as to the correctness of exposure. A third reason is that when developing films by the water bath method to control contrast it is often desirable to visibly monitor development (Chapter 4: Film Development: Water Bath Development). The fourth, and final reason, is there may come a time when film will again be hand-coated with loose tolerances.

The technique of development by inspection should be approached in the same way one would approach any new process. Start by creating practice negatives and developing them until you are confident in your ability to judge their quality. Only then should you work with important images.

One final point, development by inspection is really only suited for 4 × 5 inches and larger sheet film. This is because development by inspection assumes that each negative will be developed to an ideal density for that particular negative.

SAFELIGHT

Development by inspection is traditionally done using a Wratten #3 dark-green safelight. This is not because panchromatic films are not sensitive to green, but because green is the color to which our eyes are the most sensitive. This means that during the brief intervals that the safelight is on we get the most bang for our buck. The safelight should be fitted with a 10- to 15-watt bulb and placed at least 3 feet away if the light is to be reflected off a wall or ceiling and at least 4 feet away if it is to be aimed at the film.

Even if a chemical desensitizer has been used, the safelight should not be turned on until at least halfway through the estimated development time. This is because film looses its sensitivity as development proceeds. If a desensitizer has been used, the safelight can be left on when the estimated halfway point has been reached (see Desensitizers, below). Without the use of a desensitizer, the safelight should only be turned on for brief intervals, 15 to 20 seconds at a time, after the estimated halfway point. Pyro developers aid in desensitizing the film by hardening the surface of the emulsion as development proceeds (see Pyro and Development by Inspection, below).

A footswitch attached to the safelight is a good idea in order to avoid early termination of your darkroom career when you reach for the light switch with wet hands. It will also keep you from dripping developer across the room and down the wall.

JUDGING DENSITIES

Judging the correct density of film is a matter of experience, and it doesn't take long to learn. There are two basic methods: transmission and reflectance. With either method, there are two points to remember. The first is to always judge through the base of the negative, not through the emulsion side. The second is to always judge the highlights, not the shadow densities. The highlights are the densest areas of the negative image; the shadows are the thinnest.

Transmission

Frank Rogers taught me to judge negatives by transmission using the finger method. To do this, develop the film for about half the time you estimate it should require (base this on time/temperature charts or an educated guess). Hold the film up to the safelight with the base side towards you. The safelight should be at least 4 feet away and aimed at the sink. Then place a finger just behind the back (emulsion side) of the film. As the film develops, the highlights will become denser and your finger will be harder to see. When your finger is just barely visible, development is complete.

Check the density increase every 1 to 3 minutes, depending on how close you estimate you are to full development. As completion gets closer, you can begin checking every 30 seconds, but remember, the film is still sensitive to light, unless a desensitizer has been used; therefore, only check as often as necessary. You will find that after developing by inspection a few times you will need to check less as you will be able to estimate the progress of development without frequent inspection.

Reflection

The second method is by reflection. Some photographers claim this is a more accurate method. To use this method hold the film at least 3 feet from the safelight and look at the base side with the light reflected off of it not through it. Once again, judge the highlights which are the densest part of the film. When the highlights appear dense but not completely black development is complete.

Both the transmission and reflection methods work equally well with any panchromatic film. Using either method, as many sheets of film as can be safely handled at once can be developed. When a film is fully developed it should be moved into a holding acid stop bath or running-water rinse where it can be left until the other films catch up at which time they can all be moved to the fixing bath.

DESENSITIZERS

Desensitizing is a process that reduces the light sensitivity of emulsions so that they can be developed in comparatively bright light. Unfortunately, most of the desensitizers once in common use, such as Aurantia, Methylene Blue, Toluylene Red, and Amethyst Violet, don't work well with modern emulsions.

Phenosafranine was the first viable desensitizer and originally appeared on the market as Pinasafrol and Desensitol. Although phenosafranine can be used alone, diluted 1:10,000 with water, a better choice for modern MQ developers is Basic Scarlet N, a combination of phenosafranine and chrysoidine, two commercially available dyes. Basic Scarlet N is more efficient than phenosafranine alone and has greater keeping properties (Formulas: Miscellaneous).

The major drawback to both phenosafranine and Basic Scarlet N is that they stain everything. They can also cause excessive fog when used with pyro developers.

The disadvantage of the strong staining properties of phenosafranine and its allied compounds soon led to the discovery of other desensitizers that do not stain to the same extent. Pinakryptol Green was the first to receive wide application. In solution, it has a dark green color and the slight coloration of the film usually disappears with washing.

Pinakryptol Green was introduced in the 1920s by Dr. Köenig of the Hoechst Dye Works in Germany. It was originally available only as a proprietary powder from Agfa-Ansco. At one time, Pinakryptol was available in three formulas: the original green, then yellow, and finally white. Green was the least effective and could cause staining with some MQ developers, but could be used as either a forebath or mixed directly into most pyro developers. Yellow is more active for reducing panchromatic sensitivity and more compatible with MQ developers but can only be used as a forebath, as it is destroyed by sulfite.

White was sold in tablet form, and was meant to be used in the developer. White had the advantage of being compatible with both pyro and MQ formulas. The only Pinakryptol still available is Yellow and it is difficult to obtain.

There is still one commercially available desensitizer available. It is known as De-tec® and marketed by Antec (see Resources).

PYRO AND DEVELOPMENT BY INSPECTION

Pyro formulas are especially compatible with development by inspection because they reduce the sensitivity of the emulsion through the strong tanning effect that occurs during development. However, due to the staining properties of pyro, the highlights should not be developed to the same density as with other developers. This is because the contrast of a pyro-developed negative is dependent upon the stain density, not the silver density. Therefore, when using pyro for development by inspection, the highlights should appear less dense.

Reversal Processing and Enlarged Negatives

Photography is 90% sheer, brutal drudgery. The other 10% is inspiration!

—Brett Weston

Since the first edition of *The Darkroom Cookbook*, there have been an increasing number of photographers who have become interested in practicing alternative processes. The interest has become so great that in 1999 the Photographers' Formulary, one of the leading providers of photographic chemicals, established a school largely dedicated to teaching alternative processes. Because of this surge in interest, this edition of the *Cookbook* includes this chapter on reversal processing and enlarging negatives.

Alternative processes are many and varied. The list includes carbro, carbon, bromoil, gum printing, platinum/palladium (plt/pld), salted paper, Ambrotype, albumen, kallitype, photogravure, collotype, Woodburytype, and cyanotype. Except for the first two, carbro and carbon, all of these processes are made by contact printing a negative onto a sensitized material. From a practical point of view, this means that a 35 mm negative will produce a print approximately 1 × 1.5 inches. While this may satisfy some, most photographers prefer slightly larger prints.

There are three techniques for producing an enlarged negative for contact printing, and none are particularly difficult. The easiest technique is to copy a print made from an original negative using a large-format camera. The procedure is to first make a fine print in the darkroom with all the dodging, burning, and manipulation required, then place two lights on either side of the print at an angle of 45 degrees, measure the light falling on the center of the print with an incident light meter. The large-format camera should be placed straight on and square to the print with no swings or tilts—everything zeroed.

The problem with this method is that if you already have an 8 × 10 inch or 11 × 14 inch view camera with which to copy prints you are probably already making large negatives anyway and can skip this chapter. On the assumption that you purchase a large-format camera for the express purpose of making enlarged negatives keep the following in mind. The camera itself is not important as long as the bellows is in good condition and the camera doesn't leak light. What is important is the lens. Use either a process lens made for copy work or an apochromatic (APO) lens. Either of these will make excellent reproductions.

The other two methods both require a positive image, which is then projected onto another piece of film of the desired final size using an enlarger. This second piece of film is developed as a negative.

The first of these two methods involves processing the original film as a positive. The drawback to this method is that your original 35 mm, 120, or 4 × 5 inch image will always be a positive should you later wish to use traditional silver-gelatin enlarging techniques. However, if you are dedicated to contact printing processes then this is the best method to obtain high quality originals from which to work.

There are a number of ways to process your film as a positive; the easiest would be to send it to a lab such as .dr5 Chrome Lab (see Resources) and the next would be to purchase a reversal processing kit from Photographers' Formulary or Kodak and follow the directions.

The second method for creating a positive requires an interpositive (also known as diapositive) to be made from the original negative. The interpositive is made by contact printing the original negative onto another piece of film.

REVERSAL FILM DEVELOPMENT

Reversal processing to create a positive image is possible due to the fact that most emulsions contain a percentage of silver grains that at normal exposure levels remain unaffected by both light and development. By developing the normally exposed silver grains and then bleaching them away it is possible to redevelop the formerly undeveloped grains that remain to create a positive image.

- The first stage is known as primary development. In this stage, the exposed film is developed using an energetic developer to ensure that every exposed grain in the emulsion is developed. At this stage, the film is in the form of a negative.
- The second stage is known as bleaching. This stage uses a silver solvent to dissolve all of the exposed grains of film from the first stage.
- The third and final stage is known as the reversal stage. This is where the negative is reversed into a positive. This is accomplished by either re-exposing to light or through chemical reversal followed by secondary development. The second developer reduces all of the silver bromide not affected by the initial film exposure and left behind in the second stage. At the completion of secondary development the film is a positive.

The nature and quality of the final image will be determined by the quantity and structure of the silver bromide left behind after the removal of the primary silver image during the bleaching stage. If the primary image was dense, as in an overexposed negative, then the exposure will have extended well into the emulsion and the image left behind after secondary development will be thin.

On the other hand, if the initial image was thin, as in an underexposed negative, then the exposure would not have extended as far into the emulsion and the resulting image after secondary development will have more density.

This leads to two observations.

1. Primary development must be complete.
2. There is not a lot of leeway for over- or underexposure when using the reversal process. However, experience shows that a slightly overexposed negative works better for scans and enlarged negatives.

Almost any film can be used for reversal processing. Even so, some films work better than others and some work better in one process and not another. According to David Wood of .dr5 Chrome Lab which provides black and white reversal processing, Kodak Tri-X, 35 mm, 120, and 4 × 5 inch all work well with his proprietary process. At the same time, 35 mm Kodak Plus-X works very well, but 120 Plus-X does not work as well. All three of the Efke traditional emulsions, 25, 50, and 100, give excellent results, as do Ilford FP4+, HP5+, and Delta 100. While a very few films, such as Fuji Acros 100, don't work at all. If you decide to try your hand at reversal processing, you should test several emulsions to determine what works best for you.

Points to Remember for Reversal Processing

- There are two methods to achieve reversal of the image after the bleach bath. The first is to re-expose the developed and bleached film to light, and the second is to use chemical reversal. Both methods will work with modern emulsions but chemical reversal provides more consistent results. However, chemical reversal baths are usually formulated for specific emulsions and are compounded from hard to obtain organic chemicals. Therefore, light reversal is more practical for most small volume darkrooms.
- Processing time and temperature in the first developer is important and should be kept within +/− 1 degree. For this purpose a JOBO rotary processor is an excellent choice. If one is not available, try placing the developing tank in a water bath to maintain the processing temperature.
- When making a transparency overdevelopment and/or overexposure result in decreased maximum density and loss of highlight detail. Underdevelopment and/or underexposure result in dark highlights and increased density. See the point just below.
- The contrast of the final positive can be increased or decreased by changing the time of development if the EI of the film is also changed in order to over- or underexpose the film—this requires testing or in-camera bracketing.
- Each film will have its own ideal EI range when processed as a positive. Some films such as Kodak Tri-X TXP, T-Max 400 and P3200, Fuji Neopan 400, Ilford Delta 400, and Pan F require a lower EI. Others, such as Kodak T-Max 100, Ilford Delta 100, SFX and FP4+, Efke 25, 50, 100 and 820c, Rollei IR 400, and ATP all work well at their published ISO.

After reading the above, you may begin to feel that reversal processing is just too complex—not at all. Like most areas of photography, it takes an afternoon or two of testing to determine what EI and development time works best for you. The rest is simply a matter of being consistent in your procedures.

Procedure for Reversal Processing

In the Formula section of the *Cookbook*, only one bleach bath and one clearing bath formula is given, Bleach Bath DW-1 and Clearing Bath DW-2. Use both of these with any of the three developers given under Reversal Processing.

Most authors recommend the first developer be very active and include a silver solvent, such as potassium thiocyanate or sodium thiosulfate, in order to clear the highlights in preparation for redevelopment. D-19 + 30 ml of sodium thiocyanate = D-67 which fits the description as does D-76 + Thiosulfate. However, going against tradition David Wood recommends not using anything with thiocyanate or thiosulfate in the first developer. Instead, he recommends the use of Kodak D-11. All three first developer formulas are given in Formulas: Reversal Processing.

The following procedure varies slightly from that published elsewhere. It is based on suggestions from David. Keep all processing temperatures at 68F/20C.

Testing is advised. Expose a roll of film over a four-stop range by alternating exposure of the same scene (for example, with Tri-X frame 1 = EI 200, frame 2 = EI 400, frame 3 = EI 800, frame 4 = EI 1600, then repeat with frame 5 = 200, etc.). In the dark, cut the roll into four equal pieces and load onto separate reels. Develop one strip at a time until you find the right combination of developing time, bleach, re-exposure, and second development time. Only change one variable, beginning with first development time, until you get it right before changing another variable. Once you have determined your times and procedure you should not have to test again.

In the immortal words of Ansel Adams: Test, test, test.

1. First Development.
2. Wash for 2 minutes with running water or agitation. This wash is important. All of the developer must be removed or the positive may have an uneven appearance.
3. Drain = 15 seconds.
4. Bleach = 5 minutes.
5. Wash = 1 minute.
6. Clear = 2 minutes with 30 seconds of agitation each minute. Do not exceed 2 minutes in the clearing bath or some silver halide may be dissolved resulting in a loss of density.
7. Rinse for 2 minutes.
8. Re-expose to light.

Re-exposure Remove each strip of film from the reel, one at a time, and hold it up to a 150-watt bulb so the entire strip is exposed at a distance of about 1 foot for approximately 1 minute per side. Rewind the film onto the reel, replace it in the wash, and repeat with the next roll and so on.

- It doesn't hurt the film to be left in the wash.
- Because it is difficult to re-spool wet film onto plastic reels use stainless steel reels only.
- Do not splash water on the hot light bulb.
- Do not allow the film to get too close to the bulb in order to avoid heat damage.
- It's a good idea to keep a pair of sunglasses handy!

9. Second developer. *Do not use thiocyanate or thiosulfate in the second developer*. You may use D-72 (Dektol) 1:2 for 3 minutes at 68F/20C, Kodak D-19, or any other energetic developer.
10. It is important to use a full-strength stop bath after the second developer in order to stop development in the shortest possible time. This will also help to clear the highlights and aid in archival preservation.
11. Rinse for 1 minute.
12. Fix in an acid fixer without hardener such as ATF-1. Do not use an alkaline fixer.
13. Rinse in half strength Hypo Clearing Agent.
14. Wash thoroughly to insure the removal of all excess chemistry.
15. Dry as usual.

INTERPOSITIVE

The drawback to using an interpositive, as opposed to an original positive, is that each generation of negative to positive and back to negative gains contrast and suffers some loss of tonality. However, when using alternative printing processes the amount of gain and loss are often inconsequential. If you find your image quality compromised then the best method is to make original positives. Otherwise, it is usually easier to make an enlarged negative from an interpositive.

When making an interpositive it is important to keep the original negative and glass clean. Any dust will appear as a white spot on the interpositive, a black spot on the negative, and finally as a white or gray spot on the final print. All though it is not difficult to retouch light spots on a print it is more work down the line.

Making an Interpositive

Compared to reversal processing making an interpositive takes practically no time at all. In fact, except for the time it takes for the film to dry it seems almost instantaneous!

To make an interpositive you will need the following:

1. 4 × 5 inch Ortho film. Adox 25 ORT, available from Freestyle Photographic Sales (FPS), is a good choice.
2. An 8 × 10 inch contact proofing frame. These are available from both FPS and Photographers' Formulary (PF).
3. Wratten No. 1A or 2 red safelight with a 15- to 25-watt bulb or equivalent.
4. Kodak Dektol, D-72, Photographers' Formulary TD-3, or similar developer.

Interpositives can be made using any slow-speed fine-grained film. However, I recommend the use of orthochromatic film. Ortho film seems to confuse some photographers. All it means is that the film is not sensitive to red. As a black and white negative contains no color, including red, this is of no consequence to the enlarged negative. However, because ortho film does not have the extra sensitization to red it is almost always sharper than panchromatic films. And finally, as ortho film is not sensitive to red it can be handled under a red safelight. This makes lining up the negative to be contact printed with the ortho film a piece of cake compared to doing everything in the dark with panchromatic film.

Move the enlarger lamp head to a convenient and repeatable height. I set the negative stage of my Omega D5 at 36 inches above the baseboard for an 8 × 10 inch enlarged negative. Whatever height you use, the light should extend beyond the proofing frame, so that the center of the light source is being used. This will provide more even illumination across the negative.

With the red safelight at least 4 feet away from the baseboard place the negative, emulsion side up, onto the glass of the proofing frame. I recommend taping the negative down with lithographer's tape, available from artist supply stores. Place the 4 × 5 inch ortho film emulsion side down on top of the negative. The original negative and ortho film should be emulsion side to emulsion side. Carefully place the back of the proofing frame in place so as not to shift anything!

At this point, you will need to test to determine the best exposure using your equipment. When making interpositives the aperture size is not critical as it only controls the amount of light, not sharpness. Start with an exposure of f/11 at 1.5 seconds. Doubling the exposure time, make a second negative at 3 seconds, a third at 6 seconds, and a fourth at 9 seconds. If necessary, change the aperture and continue to test until you find an aperture that gives an exposure time between 1.5 and 9 seconds. Once this is determined, future interpositives should be close to the same exposure if the enlarger lamp is always placed at the same height.

Remove the ortho negative from the proofing frame and pre-soak the film to remove the anti-halation backing. I normally don't recommend presoaking; but developing times for this process are so short it is a good idea. Develop the negative in a 5 × 7 inch tray in D-72 1:6 (100.0 ml D-72 to 600.0 ml of water) for 1½ to 2 minutes at 68F/20C, rinse, fix, and wash according to your normal procedure. I recommend developing one sheet at a time to avoid scratching.

Carefully examine the interpositive, preferably on a light table, looking for detail in the shadows and highlights. The interpositive should be close in contrast and density to the original. If anything it is better to have an interpositive with slightly lower contrast than normal as the enlarged negative will gain contrast. If major changes in contrast are needed they should be made on the enlarged negative, either through increased exposure or development. With practice you will know what to look for with the alternative process you will be using. You will go through a number of sheets of film learning this process but it will be worth the final effort.

As a final note, it is possible to add density to highlight areas by using retouching dyes on the interpositive.

Don’t have an Enlarger?

No problem. Pick up a drop cord light from the hardware store, the kind mechanics and builders use when they have to work in tight spaces. Suspend it from a swag hook (the kind used for potted plants) from the ceiling at about 4 feet above your work surface (in the 1970s I would do this to make contact prints from 8 × 10 inch negatives). If possible plug the light into a timer. Start with a 15-watt tungsten bulb and using the same method as described above, turn the light on to expose a series of negatives for 1 second, 2 seconds, 3 seconds, 4 seconds, and 6 seconds. If this turns out to be too much or too little light, switch to a lower or higher wattage bulb or cover the bulb with layers of tissue paper, a trick Edward Weston used to control his printing light.

Of course, you will still need an enlarger to make the enlarged negative, but at least you can get this part done before going to a lab or borrowing a friend’s darkroom.

Don’t have a proofing frame?

No problem. Use a piece of glass with beveled edges and tape one of the long edges to a piece of smooth-finish plywood to create a hinge.

ENLARGED NEGATIVES

Now that you have your original positive or your interpositive you are ready to make an enlarged negative. Using an enlarger the original positive or interpositive can be projected onto any size or type of negative material, including ortho film. Kodak T-Max 100 is widely used for enlarged negatives as it has high resolution and good reciprocity characteristics. Because it has an ISO of 100 you may wish to use a neutral density filter under the lens to increase the exposure time from a fraction of a second at f/16 to one or more full seconds.

- Try to keep your f-stop between f/11 and f/16 for sharpness, with an enlarging time of 1.5 to 6 seconds to avoid reciprocity.
- Times less than 1.5 seconds (for example, 1 second, 0.5 second, 0.25 second) may lead to inconsistent results because of variables in lamp warm-up. Use neutral density (ND) filters to adjust the EI as necessary and allow for longer exposure times.
- Make three negatives, with a one-stop increment difference between each, for example, 1.5 seconds, 3 seconds, and 6 seconds.[1]

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[1] At the time of this writing a single sheet of 8 × 10 inch T-Max 100 costs $4.00, which means each enlarged negative will cost $12.00 if you make three. However, consider how much your time is worth if you have to set up and do another negative.

Procedure for Making an Enlarged Negative

Do not use a contact printing frame or cover the film with glass as you will pick up dust spots which will contact print later as black. There are a number of ways to position the film in the dark. One is to use a cut-sheet film holder placed in the corner of an easel and pull the dark slide just before making the exposure. Make certain the holder is sitting level.

Another method is to tape a cardboard corner to the enlarger baseboard. Into this corner, place a piece of black paper to absorb the light passing through the negative. If there is a problem with the negative curling (in areas of high humidity) use lithographers tape in the corners to hold it flat.

An alternative is to use an enlarging easel and black paper one size larger than the film size. For example, if you are going to enlarge to 8 × 10 inches use an 11 × 14 inch easel with an 11 × 14 inch piece of black paper. Close the blades down to 8 × 10 inches to fit the film. In the dark you can lay the film in-between the blades and on top of the black paper.

My favorite method is to use a Ganz Speed Ez-el®. Speed Ez-els come in various sizes from 2 × 3 inches to 16 × 20 inches and the negative can be easily slid in and out in the dark. If you use a Speed Ez-el paint the inside flat black to avoid light bouncing back through the negative.

A final possibility is to use an 11 × 14 inch magnetic copy board available from some camera stores and graphic supply houses. Again, use a black piece of paper and position the magnetic strips so that the film can be positioned in the dark.

When making enlarged negatives make certain there are no reflections or stray light striking the film. Also, because all enlargers leak some light, it is a good idea to use black photographers or gaffers tape to seal off any light leaks after the positive is positioned in the negative carrier.

Start by composing and focusing the positive image onto a sheet of white paper. Once composition is achieved remove the white paper and replace it with a scrap piece of film for final fine focus. If you don't have a piece of scrap film (because you never make mistakes) you will need to sacrifice one sheet, which you can keep to use over again. Any piece of 4 × 5 inch film will do for this purpose as they are all within microns of the same thickness. Always use a grain focuser for fine focus.

Remove the film used for focusing, make certain all the lights are off (unless using ortho film, in which case a red safelight may be left on), place the unexposed film into position emulsion side up, and cover one-quarter of the negative with cardboard (don't use paper as light will bleed through it). Horizontal or vertical makes no difference as long as the remaining negative contains enough of the subject to judge the densities later. Make a 3 second exposure of the remaining three-quarters. In the dark, cover each of the remaining quarters of the negative and expose in 3 second increments (you may want to set up some kind of raised guides to butt the cardboard against in the dark). You will now have a blank strip, 3 second exposure, 6 second exposure, and 9 second exposure.

If you want an enlarged negative with pyro stain use PMK. Otherwise, develop the negative in any film developer, MQ, PQ, pyro, etc. Use whatever developing procedure you would normally use.

When the negative is dry place it in a contact printing frame with the base side against the glass then do one of the following:

1. Make a proof for maximum black using the blank strip and a piece of photographic enlarging paper (Appendix 4, Proofing for Maximum Black).
2. Make a proof for maximum black using a piece of paper coated for the alternative process you intend to use (e.g., salted paper, plt/pld, etc.), and the appropriate light source (e.g., sun, UV printer, etc.).
3. Make a print using the entire negative using a piece of paper coated for the alternative process you intend to use (e.g., salted paper, plt/pld, etc.), and the appropriate light source (e.g., sun, UV printer, etc.).

Choose the strip that makes the best print according to your taste. You may now make your final enlarged negative using the settings for that strip or you can fine tune the negative, either by altering the enlarger exposure time, or by increasing or decreasing the development time. Remember, you are making a negative, not an interpositive, so expose for the shadows and develop for the highlights.

If necessary, you can intensify or reduce the final negative (Chapter 11, Photographic Reduction and Intensification). Or you can use retouching dyes to build up density in shadow areas of the enlarged negative. You only have to make the enlarged negative once. Once you get it right you can use it for years after to make prints.

Beverly and Stephanie, 2008. © 2008 David Wood. All rights reserved. Courtesy of the artist. This image is reproduced from an orginal Kodak T-Max 100 4 × 5 inch black and white transparency. The photo was made with a 4 × 5 inch Superspeed Graflex with a 135 mm f/3.5 lens.

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 term "printing out paper" and the associated initials P.OP. were introduced in 1891 by the Ilford Company for their gelatin-chloride papers. The term has since been applied to any paper that requires ultraviolet light to form a complete image without the need for chemical development. In particular, it is used when referring to salted paper and related processes.

The use of P.O.P. is a time-honored method for making inexpensive prints without a darkroom. The 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).

There are several different types of P.O.P., salted paper, albumen, gelatino-chloride, and collodio-chloride, differing in the medium used to suspend the light-sensitive substance and if 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 of these papers is silver chloride with an excess of silver nitrate. Once the image has been printed and toned, it is fixed, washed, dried, and preserved 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 actually the most stable silver printing process because the nitrocellulose binder hermetically seals the silver from the harmful atmosphere that fades all silver base photographic prints.

Printing out papers can only be contact-printed. For this reason a 4 × 5 inch or larger negative is usually preferred. 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 paper and block light from reaching the lower layers of the sensitive surface. The result is that the shadow areas are held back slightly allowing the highlights of the picture to print. A good print for these papers requires a dense negative with good shadow detail and clear base in the deepest shadows.

PAPER SELECTION

Making a simple silver-chloride salt print begins with the selection and preparation of the paper. Arches Hot Press Watercolor and Crane's Kid Finish AS 8111 are two good choices. Experiment with any good quality 100% cotton paper.

Before proceeding, identify the front of the paper. This is important, as fine papers are made to be used 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, the paper is oriented to 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 mark on the back with a pencil. Many experienced printers like to use paper one size larger than the negative. For example, with an 8 × 10 inch negative they may use a 9 × 12 inch 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 to 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 clothes pins.

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 bright Kodak OC safelight is preferable. The paper may be coated by floating or with a brush then hung to dry (see below for both of these methods). Do not immerse the paper as this will sensitize the back as well.

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 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 under Formulas: Miscellaneous.

Coating the Paper with a Brush

Cover a large flat board with a sheet of blotting paper. Good quality 3/4″ plywood or an old bread board 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 a cheap plastic Lazy Susan to place under the coating board. This will allow turning the paper at right angles quickly and easily for brushing 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 usual technique for brush coating the paper is to make tick marks with a pencil at the corners where the negative will be positioned. Tape or pin the corners of the paper to be coated onto the coating board. Then, using a good-quality artist brush (an inexpensive foam brush works well, but soaks up a lot of solution), coat the solution over a slightly larger area in overlapping rows. After coating the paper, quickly turn the coating board 90 degrees and brush the paper again *without adding any more solution*. Turn the board one more time and brush again. The second and third brushing is to aid in distributing the solution evenly on the surface of the paper.

An alternative to coating with a brush is to use a glass coating rod, such as those available from Photographers' Formulary and Bostick & Sullivan (see Resources). This is a method used by many platinum printers to obtain a smooth, even coat.

Floating the Paper

Coating paper by floating was the most common technique of the nineteenth century. The solutions, either salt or silver nitrate, were poured into a glass dish larger than the paper to be coated. For prints 8 × 10″ and smaller, Pyrex® baking dishes are perfect for this application. Plastic trays with flat bottoms are good, but 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 3/4″ flap along two opposite ends of the paper.

Holding the paper by the corners or the end flaps, allow 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 is floating. 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 salting and silver solutions between 1 and 2 minutes. Hang on a line using plastic clothes pins to dry.

PRINTING

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 of the same size as the glass. 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 historic negative, place a thin piece of clear acetate, available at art stores, between it and the paper.

When exposed to the light source (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 by taking the printing frame away from the primary light source in a darkened room and unhinging the long side of the back. Peel back the edge of the print 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

Four techniques can be used to control the contrast of the print.

1. Printing can be done slowly in the shade on a sunny day or by artificial light.
2. A piece of tracing paper can be placed on top of the glass to slow down the printing in the shade or under artificial light.
3. The sensitized paper can be fumed with ammonia.
4. Potassium dichromate can be added to the salting solution.

Chemical Control of Contrast

Fuming the paper with ammonia changes the pH of the silver halide to an alkaline state. This technique was used in the nineteenth century with all printing-out papers. Buy a large plastic storage box and line the bottom with cotton wool. Drizzle three ounces of household ammonia evenly over the cotton and close the lid. *Do not breathe the fumes when opening the lid*. To fume, tape the paper sensitive side down to the underside of the lid by four corners and replace the lid. Fume for about 1 to 3 minutes. Remove the paper and allow it to out-gas for about 2 minutes before placing in the printing frame. Fuming is very effective. The paper will print much faster and will have more contrast.

Controlling Contrast by Light

Further control can be gained through the choice of light source. The slower the printing, the higher the contrast. The higher the amount of ultraviolet (UV) light, the lower the contrast. Sunlamps and direct sunlight both contain relatively high amounts of UV and give the lowest contrast. However, by placing one or more sheets of tracing paper or a sheet of frosted glass over the printing frame, contrast will be increased dramatically. The printing frame may also be placed on the shaded side of a building on a sunny day for 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 your tap water does not contain chlorine add a pinch of table salt to the wash water. Wash 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 done *after* the first washing step and *before* the fixing bath. Without toning, the final print will tend towards 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 P.O.P. Borax Toning Bath, act slowly and tend to be warm; alkaline toners, such as P.O.P. 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. After fixing, immerse the print in Hypo Clearing Agent (HCA) and wash as you would any double-weight, fiber-base paper.

OTHER PROCESSES

That's all there is to making simple salted paper prints. The processing of salt prints is identical to the other printing out papers, so if you know one type you have a basic understanding of the whole family. Alternative printing processes, such as albumen, salt, gum, gelatin-chloride, collodio-chloride, platinum/palladium, carbro, and others, 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.

Scully & Osterman on Gold Toning

Most people don't realize how much depth of printing establishes the final image tone and are confused when they get weak tones from a toning formula. This is often the case when negatives don't have enough silver density, spectral density or have a fogged base.

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 the method of adding gold by *the grain* to the toning solution. The standard for making and using a gold chloride toning solution begins with dissolving 1.0 gram of gold chloride into a given quantity of water as follows. A gram is equal to 15.4 grains.

Gold Chloride Stock Solution

Gold chloride, 1.0 g (15.4 grains)
Distilled water, 154.0 ml

Based on the above example, every 10 ml will give you 1 grain of pure gold. So when a vintage formula calls for *x* quantity of water and so many grains of gold, it's very 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 given above)
Distilled water, 700.0 ml
Add: Bicarbonate of soda to test pH 8

More water or more gold can be added to make the bath more controllable if needed. For toning salt prints (which tone much faster) we start with 1.0 gram 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.

We usually mix this formula "to taste" but essentially it's about 4 to 6 grains of gold stock solution added to a mixture of 1000 ml with 150.0 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 to 10 minutes at room temperature for complete toning.

Sleepless, 2004. © 2008 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

Collodio-Chloride Printing Out Paper
***Also known as* Collodion Aristotype Paper**

The collodion chloride printing out process was first introduced by Gaudin in 1861 but never realized commercial success or general acceptance until the1880s when clay coated paper stock was adopted for photography. In 1884 Liesegang introduced a collodion chloride emulsion for paper which 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 below 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

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 the presence of sparks or flames. Purchase Collodion USP for this process.

Formulae 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 emulsion making. 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 fall from the marketplace. *If uncoated papers are used, the solvents in the collodion emulsion will flow right through the paper fibers*.

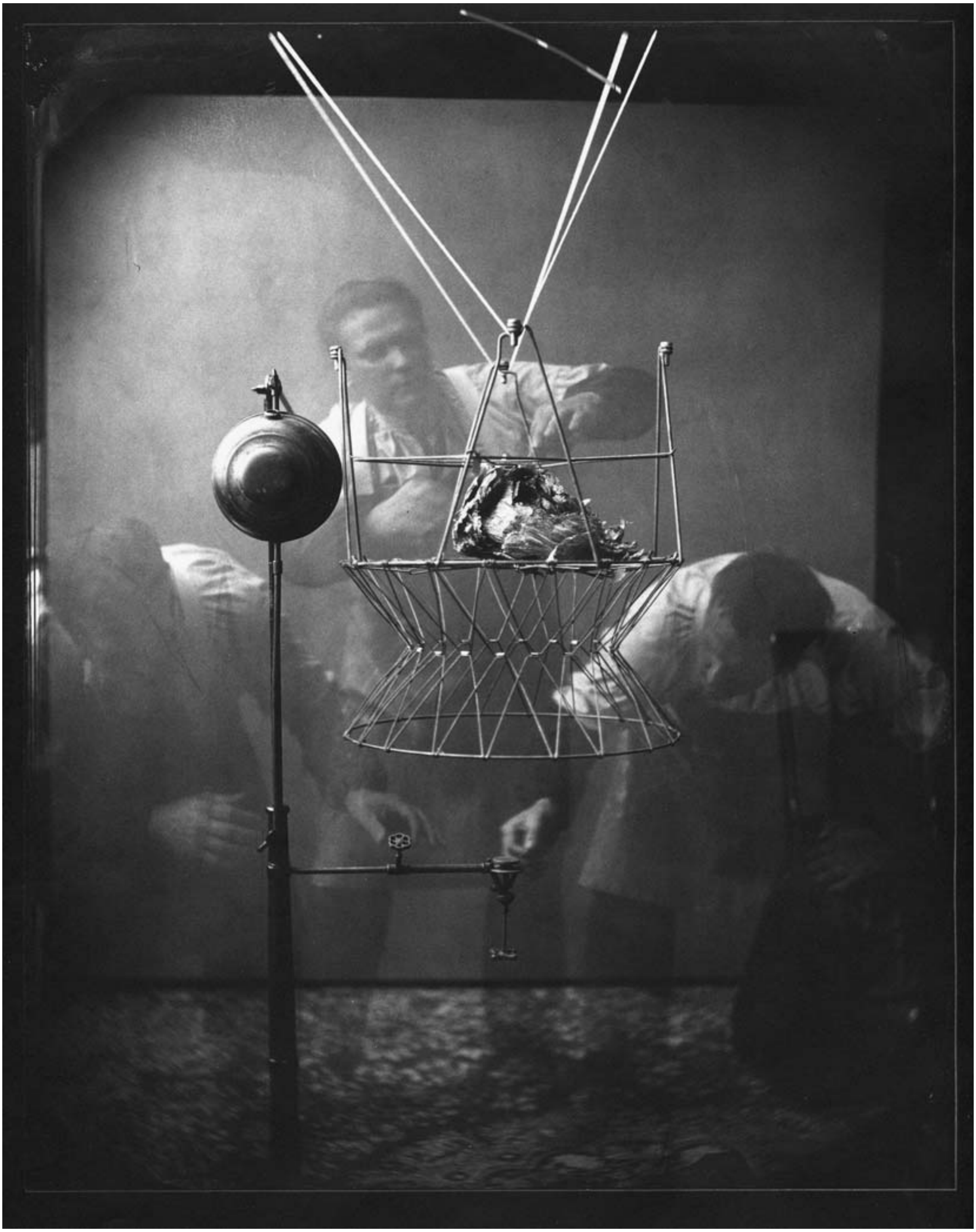
Cut a sheet of glass an inch larger on all sides than the paper you wish to coat. Desharpen all the edges with a sharpening stone to prevent accidental cuts. Fold up a ½ inch margin on all the edges of your paper and carefully secure the paper onto the glass sheet using small pieces of masking tape.

If you already do 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 pin it up 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.

Camera Obscured, 2001. © Mark Osterman. Courtesy of the Tilt Gallery. Gold-toned albumen print from collodion negative, 8 × 10 inches.



Paper Wasp Extraction, 2001. © 2008 Mark Osterman. All rights reserved. Courtesy Tilt Gallery. Gold-toned salt print from collodion negative, 10 × 8 inches.

Appendix 1

Safety in Handling Photographic Chemicals

> *With a good negative and good sense, a good print is inevitable.*
> —William Mortensen, 1940

Toxic chemicals can enter your body in three ways: breathing them, absorbing them through your skin, or swallowing them.

To prevent inhaling chemical powders wear a good quality, well-fitting dust mask. To prevent inhaling toxic fumes wear an appropriately rated fume mask. To prevent absorbing chemicals through the porous membrane of your skin wear neoprene gloves.[1] (Putting your unprotected hands in developer trays to shuffle film or paper may seem convenient, but in time this repeated exposure can develop into sensitivity to common developing agents like metol and hydroquinone.) To keep from swallowing toxic chemicals don't bring refreshments into the darkroom.

While the majority of 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 heavy-duty 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 every day. 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 are 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.

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[1] Common household latex gloves are not chemical-proof. Gloves for the darkroom should be made with neoprene or nitril.

This list was originally published in *Photographic Possibilities* by Robert Hirsch (Focal Press, 1991). Used by permission.

1. Read and follow all instructions and safety recommendations provided by the manufacturer before undertaking any process. This includes mixing, handling, disposal, and storage. Request a Material Safety Data Sheet (MSDS) from the manufacturers of photo chemicals. 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 outlets (GFI—ground-fault interrupters) in your darkroom.
12. 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 work space 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, and it is strongly advised that one use gloves and other appropriate safety equipment, 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, such as mercuric chloride, are never safe with any degree of exposure.

However, fine dust and powder, whether it is mercuric chloride or sodium carbonate, an ingredient sometimes found in food, can be damaging to the sensitive membranes of the sinus 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 one hand. It is important to have enough room to hold the packet under water and move it around to dissolve the contents.

This method can also be used with chemicals which have been weighed on a scale. Weigh the chemicals in a plastic container, available from chemical supply houses, and simply immerse the entire container—don't pour. A dust mask should still be used while removing the powders from their storage containers.

CHEMICAL STORAGE

Keep all chemicals away from children and pets. If necessary, lock the chemicals up. Label and date all bottles of mixed solutions. 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 of your local fire department. They will explain in detail exactly what you can and cannot do in terms of disposal in your area.

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.

ADDITIONAL INFORMATION

The Office of Radiation, Chemical and Biological Safety of Michigan State University, (517) 355-0153; www.orcbs.msu.edu.

Oxford University's Physical and Theoretical Laboratory, www.physchem.ox.ac.uk/MSDS.

CHEMICAL HAZARD HOTLINES

AAPCC (American Association of Poison Control Centers) National Hotline Poison Emergency (800) 222-1222.
Chemtrec, 24-hour hotline, (800) 424-9300.
Ilford, North America, 24-hour hotline, (800) 842-9660.
Ilford, International, 24-hour hotline, t +41 (0) 1251 5151, www.toxi.ch.

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 black and white processes are safe and biodegradable. 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.

Appendix 3: Pharmacopoeia, contains descriptions of chemicals, including most of those used 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 Resources.

NOMENCLATURE

Manufacturers often give their own trade name to the same 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 U.S. and Great Britain. The 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 Analyzed 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 almost all photographic work. In Great Britain, 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, means "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 at the end of the book if you have a different hydrate form 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 (g), ounces (oz.), and pounds (lb.); metric uses grams (g) and milliliters (ml).

In this 3rd 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: 5.0 grams plus 10.0 grams (metric), or 73.0 grains plus 145.0 grains (U.S. Customary)? Not convinced? Okay, try liquid measures. You need to make a 15% solution. Fifteen percent of 1000.0 ml is 150.0 ml. Fifteen percent of 32.0 oz. is, uh ... let's see ... 10% of 32.0 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 32.0 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 you will want to 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 1.0 liter of water does not exactly equal 32.0 oz. Therefore, they must be specially 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: Safety in Handling Photographic Chemicals for explicit safety instructions and for a list of 24-hour poison center hotlines.

Dos 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 non-pleated 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 wall 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.

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 (e.g., newspaper-covered) surface and zeroing it. Place a weighing cup in the middle of the balance pan. If you are using a triple-beam balance without a 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 and 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 20.0 grams, use a weighing cup instead.

Order of Dissolving

Unless otherwise specified, always dissolve the ingredients in the order given. In developers, the sulfite is usually dissolved first because most developing agents are easily oxidized in water without this preservative.

An exception is metol, which is only soluble with difficulty when mixed in solutions containing a high concentration of sulfite. Therefore, when mixing developers that contain metol you should dissolve the metol before the sulfite. This has a minimal effect on the keeping properties of the developer as metol 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 either be taken out of the measured amount or ignored as it is usually insufficient to upset the balance of the finished developer.

A good rule to follow in preparing developers is to make certain that each ingredient is completely dissolved before the next is added. 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

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 which call for the use of pyrocatechin (catechol) or pyrogallic acid (pyro or pyrogallol).

In areas where the water is very hard, it can be treated with sodium hexametaphosphate, or Calgon. Three g/L should be added before the other developing agents. EDTA, ethylenediaminetetraacetic acid, can also be used, but it may speed up the rate of aerial oxidation of the developing agents, possibly causing dichroic fog.

If neither Calgon nor EDTA is available, an alternative method is to allow the water to settle overnight then decant the clear liquid, preferably through filter paper. This procedure, while inconvenient, is sufficient for most developers.

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 100.0 ml of water. For example, a 10% solution has 10.0 grams of a chemical dissolved in 100.0 ml of water.

Regardless of the amount used in the formula, the percentage is always the same. That means that every 10.0 ml of a 10% solution contains 1.0 gram of the chemical. If a formula requires 2.0 grams of chemical, use 20.0 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 liter (1.0 liter = 1000 ml)

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 liter

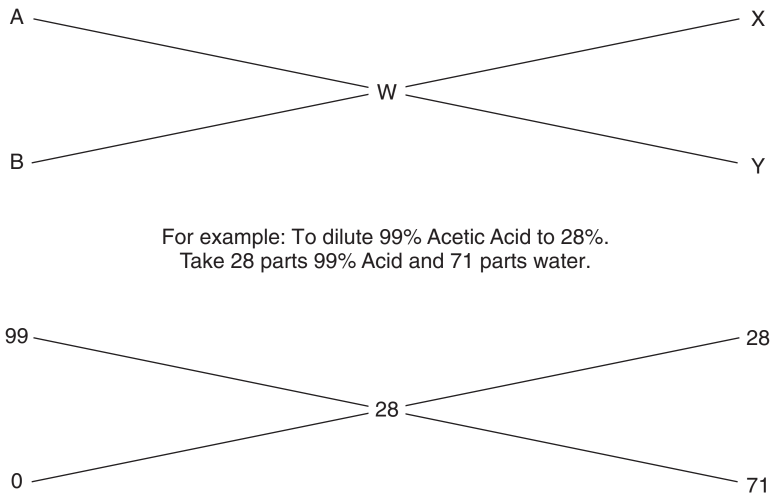
It is easy to see the advantage of this method, especially for chemicals that are often used in small amounts (e.g., Phenidone, potassium bromide, benzotriazole).

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.

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 "1.0 ml of A, 1.0 ml of B, to 1000.0 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 units; in other words, grams with grams, ounces with ounces. This is also important when both liquid and solids are indicated in "parts." Be certain that solid ounces go with liquid fluid ounces and that solid grams go with liquid milliliters.



For example: To dilute 99% Acetic Acid to 28%.
Take 28 parts 99% Acid and 71 parts water.

Figure A2-1 Crisscross chart.

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.

Appendix 3

Pharmacopoeia

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 the properties and uses of these chemicals 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

- An **acid** is 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.
- An **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.
- An **anhydrous** chemical is one with all water removed; it is free from water, or dry (Appendix 2: Chemicals).
- A **deliquescent** chemical is able to absorb moisture from the air.
- A **denaturant** is used to render alcohol unfit for drinking.
- **Crystalline** means that as many water molecules as possible are attached to the chemical's molecule.
- **Decahydrate** means having ten molecules of water.
- **Desiccated** is an older word meaning the same as anhydrous.
- **Dihydrate** means having two molecules of water.
- **Dodecahydrate** means having twelve molecules of water.
- **Effervescence** means giving off bubbles of gas.
- **Efflorescent** means the crystals have broken down and become covered with powder.
- **Hygroscopic** is 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 (Appendix 2: Chemicals).
- **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 a poison. Wear 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 (see Acid, Acetic)

ACETONE

Synonyms: Dimethyl ketone, Propanone.

Appearance: Colorless liquid.

Uses: As a solvent of most resinous substances. Used in some developer formulas as a source of alkali by reaction with sulfite; useful as a drier and as an ingredient in toning formulas.

Caution: Highly volatile and inflammable.

ACETONE SODIUM BISULFITE

Synonyms: Acetone sulfite.

Appearance: White crystals, fatty feel, almost odorless, slight sulfur odor.

Uses: Accelerator in Amidol developers.

ACID, ACETIC

Synonyms: Acid methanecarboxylic, Ethanoic acid, Purified pyroligneous acid, Vinegar.

Appearance: Clear, colorless liquid; strong pungent odor.

Common Grades: Glacial USP, 99½%; USP, 36%; photo, 28%. To prepare 28% photograde from glacial grade, dilute 3 parts acid with 8 parts of water (e.g., 150.0 ml of glacial acetic acid to 400.0 ml of water). Glacial grade solidifies at about 60F/15C. 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.

Notes: To prepare lower-strength acids from glacial acetic acid (USP 991/2%) 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, 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% to 15%) may be purchased from vinegar manufacturers or wholesalers. A working-strength stop bath is usually in the 1% to 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 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% to 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.

ACID, ASCORBIC

Synonyms: L-Ascorbic acid, 3-oxo-L-gulofuranolactone (enol form), Vitamin C.

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 500.0 mg tablet = 0.5 grams of vitamin C, a 1000.0 mg tablet = 1.0 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 vitamin C (11.25 grams of either is equivalent to 10.0 grams of ascorbic acid). Hydroquinone can also be replaced by vitamin C.

(see Hydroquinone; Sodium ascorbate; and Sodium isoascorbate)

ACID, BENZOIC

Synonyms: Flowers of benzoin, Phenylformic acid, Phenylmethanoic acid, Benzenecarboxylic acid.

Appearance: White crystalline needles or scales.

Uses: Preservative in emulsions; toning baths; preparing photographic paper. Restrainer in developers; has delaying action or affect upon the swelling of gelatin.

ACID, BORIC

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.

Notes: 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% to 5% in water).

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.

ACID, CITRIC

Appearance: Colorless, odorless crystals or granules efflorescent in dry air, deliquescent in moist. Very soluble in water; freely soluble in alcohol.

Uses: Preservative; in clearing baths, emulsions, etc. 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.

ACID, HYDROCHLORIC

Synonyms: Chlorhydric acid, HCL, Marine acid, Muriatic acid, Spirit of salt, Spirit of sea 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.

Notes: Concentrated (35% to 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 10.0 ml of HCL, multiply by 1.17 and use 11.7 ml of muriatic acid.

Caution: Poisonous; irritating vapor; corrosive. Always add the hydrochloric acid to the water slowly, stirring constantly. Never add the water to the acid; otherwise, the solution may boil and spatter the acid on the hands or face, causing serious burns. Always use a face mask and eye protection.

ACID, NITRIC

Synonyms: Acid axotic, Aqua fortis, Hydrogen nitrate.

Appearance: Heavy, transparent, colorless or yellow, fuming, corrosive liquid.

Uses: Preservative for pyro solutions.

Caution: Intensely poisonous; causes very painful burns. Extremely corrosive. Use proper ventilation and neoprene gloves when working with the concentrated acid. The fumes from concentrated nitric acid are harmful.

Add the acid slowly to the water; never add the water to the acid.

ACID, OXALIC

Synonyms: Ethanedioic 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.

ACID, SULFAMIC

Appearance: White or colorless, nonhygroscopic crystals.

Uses: As an acidifier in ammonium thiosulfate fixing baths.

ACID, SULFURIC

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 sulfuric acid to the water slowly, stirring constantly, and never add the water to the acid; otherwise, the solution may boil and spatter the acid on the hands or face, causing serious burns. Always wear a face mask and eye protection.

ACID, TARTARIC

Appearance: Colorless transparent crystals or granules.

Uses: Preservative for sensitized paper and emulsions.

AEROSOL OT (DOCUSATE SODIUM)

Appearance: A waxy, solid pellet.

Uses: As a wetting agent for film used before drying.

Notes: Aerosol OT is the dioctyl ester of sodium sulfosuccinic acid.

The standard working solution to make a wetting agent is 0.1%, but the exact strength is not critical.

AGAR

Synonyms: Agar-agar, Japan Agar; Bengal, Ceylon, Chinese or Japan Isinglass or Gelatin; Layor Carang.

Appearance: Long, transparent, odorless, tasteless strips or coarse or fine powder.

Uses: Making photographic emulsions.

Notes: Insoluble in cold water; slowly soluble in hot water to a viscid solution. A 1% solution forms a stiff jelly upon cooling.

ALCOHOL, ETHYL

Synonyms: Alcohol, Cologne spirits, Ethanol, Ethyl hydrate, Fermentation alcohol, Grain alcohol, Rectified spirits, Spirits of wine.

Appearance: Transparent, colorless, mobile, and volatile liquid, with a slight characteristic color.

Uses: As a preservative in photographic emulsions; concentrated developers; rapid drying and cleaning.

Notes: 40% alcohol is the equivalent of 40% by volume or 80 proof alcohol.

Caution: Inflammable.

ALCOHOL, ISOPROPYL

Synonyms: Dimethylcarbinol, 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.

ALCOHOL, METHYL

Synonyms: Carbinol, Colonial spirit, Columbian spirits, Methyl hydrate, Methylic alcohol, Methanol, Pyroligneous spirit, Pyroxylic 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 non-illuminating flame. The presence of excessive amounts of methyl alcohol may cause softening of the film base.

ALCOHOL, TERTIARY BUTYL

Synonyms: Trimethylcarbinol, Tertiary isobutyl alcohol, Tertiary butyl alcohol.

Appearance: Colorless crystals, camphor color. Melts at 78F/26C to a colorless, viscid liquid.

Uses: Film cleaner.

ALUM (see Alum, ammonia; Alum, chrome, potassium; Alum, potassium; and Aluminum sulfate)

ALUM, AMMONIA

Synonyms: Alum, Aluminum-ammonia sulfate, Ammonium alum.

Appearance: Colorless crystals or white powder; styptic taste.

Uses: In fixing baths; hypo-alum (sulfide) toning; hardener for gelatin.

ALUM, CHROME, POTASSIUM

Synonyms: Chrome alum, Chromium and potassium sulfate, 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.

ALUM, IRON

Synonyms: Ammonio-ferric alum, Ammonio-ferric sulfate, Ammonium sulfate, Ferric ammonium alum, Ferric ammonium sulfate, Ferric alum, Iron ammonia sulfate, Iron ammonium alum, Iron sulfate.

Appearance: Violet efflorescent crystals.

Uses: In reducer formulas; toning solutions; sensitizing solutions.

ALUM, POTASSIUM

Synonyms: Alum, Alum flour, Alum meal, Aluminite, Aluminum and potassium sulfate, Common alum, Cube alum, Double sulfate of aluminum and potassium, Octohedral alum salt, Potash alum, Potassic-aluminic sulfate, Potassium-aluminum sulfate, Roman alum, Sulfate of aluminum and potassium.

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.

ALUMINUM CHLORIDE HEXAHYDRATE
(Not to be confused with Anhydrous Aluminum Chloride)

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.

Notes: 1.0 gram is soluble in 0.5 ml of water at 77F/25C.

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).
(see Alum, ammonium; Alum, chrome; and Alum, potassium)

AMIDOL

Formulas: Diaminophenol, 2,4 Diaminophenol dihydrochloride.

Trade Names: 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. Oxidizes rapidly and keeps poorly.

Notes: Amidol is one of the finest developing agents for blue-black tones on soft-emulsion bromide paper. It is also capable of creating neutral-blacks with a fine scale and transparency in the shadows.

Amidol is very soluble in water or sulfite. The keeping properties of amidol in solution can be improved by the addition of a weak acid, such as lactic or citric acid. Amidol is energized by sodium sulfite alone, without the necessity of adding any alkali.

Caution: Amidol is considered to be toxic. Aovid 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 (see Alum, Ammonium)

AMMONIUM BROMIDE

Appearance: White crystalline powder.

Uses: As a restrainer.

Caution: Should not be used with caustic alkali or carbonates as ammonium is liberated.

AMMONIUM CARBONATE

Synonyms: Ammonium carbaminate, Harthorn, 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.

Notes: 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 HYDROXIDE

Synonyms: Ammonia water, Strong solution of ammonia.

Appearance: Colorless liquid; intense, pungent, suffocating odor.

Uses: Accelerator of developing solutions; caustic, tending to enlarge grain structure of negatives; hypersensitizing films. An emulsion softener; causes fog on fast films.

Caution: Keep cool in strong, glass-stoppered bottles not completely filled.

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 THIOCYANATE

Synonyms: Ammonium rhodanate, Ammonium rhodanide, 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.

Appearance: Colorless anhydrous crystals; sold in 60% solution.

Uses: Sometimes substituted for the sodium salt in rapid fixing baths. A 15% to 20% solution of ammonium thiosulfate is capable of more rapid fixation than a 35% to 40% solution of sodium thiosulfate.

ANTIFOG NO. 1 (see Benzotriazole)

ANTIFOG NO. 2 (6-NITROBENZIMIDAZOLE NITRATE)

Appearance: Colorless crystals or white powder.

Uses: Antifoggant and density depressant in developers.

BAKING SODA (see Sodium bicarbonate)

BALANCED ALKALI (KODALK)

Appearance: White crystals.

Uses: An alkali used as an accelerator in developers of intermediate activity between that of carbonate and borax. Developers containing Balanced Alkali usually have a pH range of 9.0 to 10.0, and the concentration varies from 2 to 50 g/L.

An advantage of this alkali is the almost proportionate change in developer activity with varying alkali concentration, permitting precise adjustments of the activity of a moderately alkaline developer.

A second advantage is that Balanced Alkali does not release a gas when added to an acid rinse or an acid fixing bath; hence it minimizes "blistering."

Substitutions: Balanced Alkali is a proprietary formula of the Eastman Kodak Company and is no longer being produced. However, there are many published formulas which still call for it. The composition is known to be sodium metaborate, octahydrate. Sodium metaborate is commonly sold in the octahydrate state, as it is the most stable. Therefore, weight-for-weight substitution can be made.

Sodium carbonate can also be used as a substitute for Balanced Alkali. Two parts by weight of Balanced Alkali is approximately equivalent to 1 part by weight of sodium carbonate, monohydrate, in normal developers. A more precise substitution is to use 5.9 grams of sodium carbonate, monohydrate, for each 10.0 grams of Balanced Alkali.

Yet another substitution is to use 4 parts sodium carbonate, monohydrate, and 1 part borax to equal the same weight of Balanced Alkali (e.g., 10.0 grams of Balanced Alkali equals 8.0 grams of carbonate and 2.0 grams of borax).

Notes: 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 Balanced Alkali are used.
(see Sodium Metaborate)

BENZOIC ACID (see Acid, Benzoic)

BENZOTRIAZOLE

Synonyms: Aziminobenzene, Benzisotriazole.

Trade Names: Edwal's Liquid Orthazite, which contains approximately a 3% solution of benzotriazole with sodium sulfite. 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.

Notes: 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 (2.0 grams benzotriazole in water at 125F/52C to make 1.0 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.

The same treatment can be applied to chloride and chlorobromide papers to eliminate any greenish black tendencies and/or achieve a blue-black tone.

Benzotriazole does not dissolve readily in cold water. Use hot water—125F/52C or higher.

BORAX

Synonyms: Biborate of soda, Biborate of sodium, Borate of soda, Borate of sodium, Purified borax, Pyroborate of soda, Sodium biborate, Sodium borate, Sodium pyroborate, Sodium tetraborate, Tetraborate of soda.

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.

Notes: 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 (see Acid, Boric)

BROMCRESOL PURPLE

Synonyms: Dibromo-ortho-cresol sulfonphthalein.

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.

Notes: 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.

BROMIDE (see Potassium bromide)

CALCIUM CARBONATE, PRECIPITATED

Synonyms: Aeromatt, Albacar, Purecal, Precipitated chalk.

Appearance: White, odorless, tasteless powder.

Uses: In gold toning.

Notes: 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.

CALGON

Synonyms: Graham's salt, Sodium hexametaphosphate, Sodium polymetaphosphate.

Appearance: White flaky crystals or granules; small, broken, glass-like particles.

Uses: Water softener. Calgon has the property of holding calcium and magnesium salts in solution, even when boiling.

Notes: This chemical is packaged as Calgon Water Softener.

CARBONATE (see Sodium carbonate)

CATECHOL (see Pyrocatechin)

CAUSTIC ALKALI (see Sodium hydroxide)

CHLORAMINE

Synonyms: Chloramine-T, Chlorazene, Chlorazone, Sodium para-Toluenesulfonchloramide, Tochloride.

Appearance: White or faintly yellow crystalline powder with a slight chlorine odor.

Uses: As an efficient hypo eliminator for negatives and prints. Used in very dilute solution (0.2%).

Notes: Slowly decomposes on exposure to air. Should be kept dry and tightly closed. Fairly soluble in water, decomposed by alcohol.

CHLORHYDROQUINONE

Formulas: 2 Chloro-1,4 dihydroxybenzene; 2-Chloro-1,4-benzenediol.

Trade Names: Adurol, Chlorquinol, C.H.Q. (Edwal).

Appearance: Fine white needles or leaflets.

Uses: For warm tones on papers, when restrained with bromide.

Notes: A derivative of hydroquinone, chlorhydroquinone was once a mainstay for warm-tone prints. Unfortunately, it is becoming increasingly hard to find, not because it is not useful as a warm-tone developing agent, but because it is both expensive and dangerous to manufacture.

Substitutions: Its developing properties roughly correspond to those of a mixture of hydroquinone with 5% of metol.
(see Hydroquinone)

CHLORINATED LIME
Synonyms: Bleaching powder, "Calcium Hypochlorite."

Appearance: White or grayish white powder with strong odor of chlorine.

Uses: As a hypo eliminator; in reducing and clearing negatives; stain remover.

Notes: Composition somewhat variable. Usually contains about 35% active chlorine. Becomes moist and rapidly decomposes on exposure to air. Must be kept dry in a tightly closed container.

Caution: Wear gloves and a mask when working with the powder, and use ventilation.

CHROME ALUM (see Alum, Chrome)

CITRIC ACID (see Acid, Citric)

DIAMINOPHENOL HYDROCHLORIDE (see Amidol)

ELON (see Metol)

ETHYL ALCOHOL (see Alcohol, Ethyl)

FERRIC AMMONIUM CITRATE
Synonyms: Ammoniocitrate of iron, 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.

Notes: 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 chloride, Iron perchloride, Iron sesquichloride, Iron trichloride, Sesquichloride of iron.

Appearance: Orange-yellow opaque masses or lumps.

Uses: Reduction; blue-toning.

Notes: Keep in a tightly sealed bottle.

FERRIC OXALATE
Synonyms: Iron Oxalate, Iron sesquioxalate.

Appearance: Greenish crystalline scales or pearls.

Uses: In iron-toning solutions.

Notes: Light-sensitive.

FERRICYANIDE (see Potassium Ferricyanide)

FORMALDEHYDE (see Formalin)

FORMALIN
Synonyms: Formaldehyde Solution, Formol, Morbicid, Veracur.

Appearance: Clear, colorless liquid; suffocating odor.

Uses: Hardening bath (10% solution). In connection with hydroquinone developer, yields negatives of great contrast; useful for developing litho film. A small amount prevents swelling of gelatin in warm solutions. Also useful as a preservative.

Notes: Formalin is an aqueous solution of formaldehyde, 37% by weight or 40% by volume.

Caution: Poisonous; vapors attack mucous membrane of the eyes, nose, throat, causing intense irritation. Use in a well-ventilated area and exercise all handling precautions. Unless your mixing area has an effective fume hood, it is highly recommended that you mix formaldehyde outdoors, and even then an appropriately rated fume mask should be used. These masks are available from chemical supply houses.

GELATIN
Synonyms: Glutin.

Appearance: Colorless or light yellow, transparent, brittle, practically odorless sheets, flakes, or coarse powder.

Uses: Preparation of emulsions, sizing paper, adhesives, light filters.

Notes: Swells up and absorbs five to ten times its weight of cold water.

GLYCERIN
Synonyms: Glycerine, Glycerol, Glyceryl hydroxide, Glycl alcohol.

Appearance: Clear, colorless, syrupy liquid.

Uses: Prevents too rapid drying; keeps gelatin emulsions of paper and films flexible.

GLYCIN
Formulas: para-Hydroxyphenyl glycine; para-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-grain formulas; also used in paper developing formulas.

Notes: 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.

Until the advent of 35 mm 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-grain film development.

Glycin is very sensitive to bromide and also to low temperature. With alkali carbonates it makes slow-working developers, which have good keeping properties and give low contrast.

Must not be confused with glycocoll medicinal, sometimes called glycine.

GOLD CHLORIDE

Synonyms: Aurochlorohydric acid, Chlorauric acid, Gold trichloride (acid).

Appearance: Bright golden yellow crystalline compound.

Uses: Gold toning.

Notes: 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 (see Acid, Hydrochloric)

HYDRONYX

Appearance: Clear liquid.

Uses: As a wetting agent for film used before drying.

HYDROQUINONE

Formulas: 1,4 Dihydroxybenzene; para-Dihydroxybenzene.

Trade Names: Hydrochinon, Hydroquinol, Quinol, Tecquinol, Hydroquinol.

Appearance: Lustrous, silky, white needles.

Uses: Developer; builds density in combination with other developers.

Substitutions: Vitamin C can be used as a substitute for hydroquinone. Start by using 1.6 times the weight of hydroquinone, and increase the alkali (i.e., borax, carbonate, etc.) by 1.6 times to compensate for the acidity of the vitamin C.

Notes: Hydroquinone is generally a clean-working and nonstaining developer. It oxidizes easily both in solution and as crystals.

At temperatures below 50F/10C 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.

Hydroquinone alone is not largely used, but in combination with metol (MQ) or Phenidone (PQ), it is among the most popular developers. 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.

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 Alum, Iron)

ISOPROPYL ALCOHOL (see Alcohol, Isopropyl)

KODALK (see Balanced Alkali)

LIQUID ORTHAZITE (see Benzotriazole)

METHYL ALCOHOL (see Alcohol, Methyl)

METOL

Formulas: Monomethyl para-aminophenol sulfate; para-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.

Notes: 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.

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.

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.

The use of caustic alkali (e.g., sodium hydroxide) is not recommended with metol as there is a tendency to 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).

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 being exposed to the substance over a period of years but in some cases can happen even sooner.

It is believed that metol poisoning results from trace contamination of para-phenylenediamine (ppd) in the metol, 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.

MONOMETHYL PARA-AMINOPHENOL SULFATE (see Metol)

6-NITROBENZIMIDAZOLE NITRATE (see Antifog No. 2)

ORTHO-PHENYLENEDIAMINE (opd)

Formulas: 1,2-Benzenediamine, ortho-Diaminobenzene, para-aminophenol hydrochloride.

Appearance: White to brownish-yellow crystals.

Uses: As a fine-grain silver solvent; a substitute for p-phenylenediamine; or very weak developing agent. Usually used in combination with metol.
(see para-Phenylenediamine)

PARA-AMINOPHENOL HYDROCHLORIDE

Formulas: 4-Amino-1hydroxy-benzene hydrochloride; para-Hydroxyaniline.

Trade Names: Activol, Azol, Kodelon (Kodak), Para, 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.

Notes: At one time this was a very popular developing agent. In 1931 the Eighth International Congress of Photography adopted as a standard developer for scientific sensitometric work the following formula:

para-Aminophenol hydrochloride, 7.25 g
Sodium sulfite, anhydrous, 50.0 g
Sodium carbonate, anhydrous, 50.0 g
Water to make 1.0 liter

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.

These developers work rapidly, are free from fogging properties, and do not stain. They are not sensitive to temperature variations, nor do high temperatures affect their clean working. Tropical Process Developer, Kodak D-13, is an example. (D-13 is not given in *The Darkroom Cookbook*; instead DK-15 and DK-15a are given.)

Carbonate should not be used with this substance as it precipitates out the base and prevents the preparation of any but very dilute solutions.

PARA-AMINOPHENOL SULFATE (see Metol)

PARAFORMALDEHYDE

Synonyms: Paraform, Polymerized formic aldehyde.

Appearance: White, crystalline powder.

Uses: Produces formalin when dissolved in water. It is also an emulsion hardener and reacts with sodium sulfite to form sodium hydroxide.
(see Formalin and *Cautions* under Formalin)

PARA-HYDROXYPHENYL GLYCIN (see Glycin)

PARA-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 photogrades.

Uses: Very low energy developer; produces negatives of minimum graininess. Often used in combination with glycin and/or metol.

Notes: p-Phenylenediamine is the classic superfine-grain developer. Besides the cautions that follow, it requires strong overexposure of the film and a very long developing time, often twenty minutes or more, and even then the contrast of the resulting negatives is rather low.

As a result, there have been efforts to replace p-phenylenediamine 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 p-phenylenediamine 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.
(see ortho-Phenylenediamine and para-Phenylenediamine Hydrochloride)

PARA-PHENYLENEDIAMINE HYDROCHLORIDE

Trade Names: Diamine H, P.D.H.

Appearance: White or grayish white to slightly reddish crystalline powder.

Uses: As a developing agent for fine-grain images; used in combination with other developing agents. Para-Phenylenediamine hydrochloride has the same general characteristics as its base (p-phenylenediamine), except that an alkali is required to make it function as a developer. It is preferable to the base on account of better solubility and keeping properties. Unfortunately, much larger quantities are required and therefore all standard formulas use the base.

Notes: Only slightly soluble in water, but much more soluble as the hydrochloride.
Caution: Toxic and stains hands, clothing, and other things on prolonged contact. Can cause eczema and other skin irritations. Always wear a good dust mask when working with the powder and gloves when working with the powder or 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 developing agent (this means it is unlikely to cause dermatitis) that can be substituted for metol. Sufferers of metol poisoning can often use Phenidone-based developers without ill effects.

Notes: Phenidone is sparingly soluble in cold water and moderately in hot and can require temperatures of 175F/80C to dissolve. It is readily soluble in both aqueous acids and alkali, including solutions of alkali bisulfites and carbonates, so that it can easily be incorporated into a developer solution.

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.

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.

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 125F/52C, 750.0 ml
Sodium bisulfite, 6.0 g
Phenidone, 2.0 g
Cold water to make 1.0 liter

100.0 ml of the concentrate contains 0.2 grams of Phenidone. The preservative will have no appreciable effect on any developing formula. Alternately, a 5% concentration can be made using methyl hydrate instead of water, but it does not keep.

Substitution: Phenidone can be substituted for metol. There is evidence that as a substitute for metol it causes a true increase in film speed. Try substituting approximately 10% of the amount of Phenidone for the amount of metol required. Phenidone should not be used as a substitute in developers in which metol is the sole developing agent, such as Kodak D-23 and D-25.

POTASSA SULFURATED

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.

Notes: 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 ALUM (see Alum, Potassium)

POTASSIUM BICHROMATE (see Potassium Dichromate)

POTASSIUM BROMIDE

Synonyms: Bromide, Bromide of potash, Bromide of potassium.

Appearance: White crystalline granules or powder.

Uses: Fog preventer and restrainer in developing solutions.

Notes: 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.

Notes: 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 to obtain warmer tones in paper development.

Substitution: To substitute potassium carbonate anhydrous, multiply the amount of sodium carbonate monohydrate by 0.90.
(see Sodium carbonate)

POTASSIUM CHLORIDE

Synonyms: Chloride of potash, Muriate of potash.

Appearance: Colorless or white crystals or powder.

Uses: In special developing formulas.

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, Bichromate of potassa, Potassium dichromate, Red chromate of potash, Red chromate of potassa.

Appearance: Bright, orange-red crystals.

Uses: Bleaching ingredient in tray cleaners and chromium intensifiers.

Notes: Bichromate is the 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, Red praised 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.

Notes: 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.

Notes: Light-sensitive in solution.

POTASSIUM HYDROXIDE

Synonyms: Caustic potash, Caustic potassa, Hydrate of potassa, Potassium hydrate.

Appearance: White, deliquescent lumps or sticks.

Uses: Caustic alkali accelerator in development.

Caution: Poisonous; attacks the skin, inflicting severe burns. Extremely corrosive. Keep in a tightly sealed bottle and wear gloves. It is good practice to dissolve potassium hydroxide separately in a small amount of cold water, then add the solution after the developing agent has been dissolved, stirring vigorously.

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.

Notes: Replaces sodium bisulfite weight for weight. 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.

Notes: Keep well closed in a cool place.

Caution: A powerful oxidizing agent.

POTASSIUM SULFIDE

Appearance: Yellow to yellowish red crystals.

Uses: Toning baths.

POTASSIUM THIOCYANATE

Synonyms: Potassium rhodanide, Potassium sulfocyanate, Potassium sulfocyanide, Sulfocyanate, Rhodamide.

Appearance: Colorless, deliquescent crystals.

Uses: Thiocyanate toning baths; silver halide solvent.

Notes: 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 1.0 to 1.5 g/liters in certain developers, such as Kodak DK20 (DK-20 is not included in the formulas found in this edition).

Because of its deliquescent nature, thiocyanate should be used in percentage solutions.

PYRO (see Pyrogallol)

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.

Notes: 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.

When used without sulfite, or 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 Pyrocatechin Compensating Developer).

All developers containing pyrocatechin should be mixed with distilled water, whether or not the formula calls for it.

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.

PYROGALLOL

Formulas: 1,2,3 Trihydroxy-benzene; 1,2,3-Benzenetriol.

Trade Names: Piral, Pyro, Pyrogallic acid, Trihydroxybenzene.

Appearance: Fine white powdery crystals (sublimed) or heavy, prismatic crystals; properties of the two forms are the same.

Uses: Active agent in pyro developers.

Notes: 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.

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 superadditive 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.

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 considered to be 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.

SODA (see Sodium carbonate)

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.

Notes: Keep in a tightly sealed bottle in a cool place.

SODIUM ASCORBATE

Synonyms: Soda ascorbate, Sodium Isoascorbate, Vitamin C sodium.

Appearance: White crystals.

Uses: Ecologically friendly developing agent.

Notes: Sodium ascorbate is usually in combination with metol or Phenidone. It may be used as a substitute for ascorbic acid in film developers. 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.

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 with 8.89 grams of ascorbic acid. Sodium ascorbate can be replaced with sodium isoascorbate, weight for weight.

(see Acid, ascorbic; Hydroquinone; and Sodium isoascorbate)

SODIUM BICARBONATE

Synonyms: Acid sodium carbonate, Baking soda, Bicarbonate of soda, Monosodic carbonate, Sodium hydrocarbonate, Sodium hydrogen carbonate.

Appearance: Fine, white powder.

Uses: In hypo baths for fixing self-toning papers; in gold toning baths; in developers to nhibit fog.

SODIUM BISULFATE

Synonyms: Sodium acid sulfate, 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.

Notes: 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.

Notes: 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, Carbonate of soda, Sal soda, Soda, Soda ash, Washing soda.

Appearance: White or colorless, granules or granular powder.

Uses: One of the principal alkali (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.

Notes: 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: Carbonate of soda, Common salt, Kosher salt, Muriate of soda, Rock salt, Salt, Sea salt.

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, also acts as a weak restrainer.

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.

Notes: Can be used in conjunction with sodium bisulfate to make a substitute for hydrochloric acid.
(see Acid, hydrochloric)

SODIUM HEXAMETAPHOSPHATE (see Calgon)

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.

Notes: Caustic alkali 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.

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.

Cold water should always be used when dissolving sodium hydroxide because considerable heat is generated. If hot water is used, the solution will boil with explosive violence and may result in serious burns. If the water is not cold enough, the solution may start to steam. If this should occur, add some ice to cool the solution. DO NOT BREATHE THE VAPOR. If it starts to steam, leave the room until it is cool.

It is good practice to dissolve sodium hydroxide separately in a small amount of cold water, then add the solution after the developing agent has been dissolved, stirring vigorously.

Wear a face mask, gloves, and eye protection when working with the powder and solutions.

SODIUM ISOASCORBATE

Synonyms: Isovitamin C sodium.

Appearance: White crystals.

Uses: As an ecologically friendly developing agent, usually in combination with metol or Phenidone. It can also be used as a substitute for hydroquinone. Start with 1.8 times the weight of the hydroquinone. Sodium isoascorbate is not acidic so the alkali does not have to be increased.

Substitutions: As with sodium ascorbate, 10.0 grams of sodium isoascorbate can be substituted with 8.89 grams of ascorbic acid. Sodium isoascorbate can be replaced with sodium ascorbate, weight for weight.

Notes: Sodium isoascorbate is made up of the same chemicals as sodium ascorbate, but they are combined in a different pattern. This matters to our bodies, but not to an emulsion!
(see Acid, ascorbic, and Sodium ascorbate)

SODIUM METABISULFITE

Synonyms: Sodium pyrosulfite.

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.

Notes: Can be substituted weight for weight with sodium bisulfite.

SODIUM METABORATE

Trade Names: Kodak Balanced Alkali, Kodalk.

Appearance: White crystals.

Uses: As a mild alkali accelerator in developers of moderate to high alkalinity. 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.

Substitutions: Sodium metaborate, octahydrate ($8H_2O$), and Balanced Alkali (Kodalk) are, for all practical purposes, the same. Substitution can be made weight for weight.

Another substitution for sodium metaborate, octahydrate is to use 9.5 grams of sodium hydroxide and 45.4 grams of borax, decahydrate in water to make 1.0 liter. This is equivalent to a 10% solution of sodium metaborate, octahydrate. This can be made from Red Devil Lye and 20 Mule Team Borax and safely used in formulas as a substitute (20.0 ml of a 10% solution = 2.0 grams; 25.0 ml = 2.5 grams; etc.).
(see Balanced Alkali)

SODIUM PHOSPHATE (DIBASIC)

Synonyms: Disodium orthophosphate, Disodium phosphate, DSP, Secondary sodium phosphate.

Appearance: Colorless, transparent crystals.

Uses: Gold toning; silver chloride emulsions.

SODIUM PHOSPHATE (TRIBASIC)

Synonyms: Normal sodium ortho-phosphate, Tribasic, Trisodium orthophosphate, Trisodium phosphate, 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.

SODIUM SULFANTIMONIATE

Synonyms: Sodium thioantimoniate, Schlippe's salt.

Appearance: Large colorless or yellow crystals.

Uses: Toning bromides; negative intensification.

SODIUM SULFATE

Synonyms: Dried sodium sulfate, Glauber's salt, Sulfate of soda, Vitriolated soda.

Appearance: White powder.

Notes: In nonswelling acid rinse baths for roll film and in tropical developers for use at high temperatures. 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.

Notes: 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.

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 50.0 g/liter.

SODIUM TETRABORATE (see Borax)

SODIUM THIOCYANATE

Synonyms: Potassium rhodanide, Sodium sulfocyanate, Rhodanide.

Appearance: Colorless or white deliquescent crystals.

Uses: Substitute for potassium thiocyanate weight for weight.

Notes: 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: Antichlor, Hypo, Hyposulfite of soda, Sodium hyposulfite, Sodium subsulfite.

Appearance: Large, white, transparent crystals and powder.

Uses: In preparation of fixing baths; ingredient in various reducers.

Notes: 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 90F/32C 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.

Notes: Insoluble in cold water; soluble in hot water, forming a jelly on cooling.

SULFAMIC ACID (see Acid, Sulfamic)

SULFOCYANATE (see Potassium thiocyanate)

SULFURATED POTASH (see Potassa sulfurated)

SULFURIC ACID (see Acid, Sulfuric)

TARTARIC ACID (see Acid, Tartaric)

TEA (see Triethanolamine)

TERTIARY BUTYL ALCOHOL (see Alcohol, Tertiary Butyl)

THIOCARBAMIDE (see Thiourea)

THIOUREA
Synonyms: Sulfocarbamide, Sulfourea, Thiocarbamide.
Appearance: White, prismatic crystals.
Uses: In gold toning baths; clearing yellow stains from prints; in mordant solutions for dye toning.

TRIETHANOLAMINE
Synonyms: TEA.
Appearance: Clear liquid (also available in solid form but not commonly used for photographic applications).
Uses: Developer accelerator and preservative.

TRISODIUM PHOSPHATE (see Sodium Phosphate (Tribasic))

Proofing for Maximum Black

> *The camera never lies, but it is possible to be selective amongst the many statements it makes.*
>
> —Michael Gilbert

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 then return to the first result should it become necessary. In addition to being consistent in your work habits it is important to set and 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. While it is not necessary to standardize on making a proof sheet doing so will streamline your workflow, help determine if your system is working properly, camera, meter, film and developer, and enable you to accurately read step wedges when making interpositives. 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 reaching. 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 3 blank frames of 6 × 7, or 5 to 6 blank frames of 35 mm, etc. So that you don't forget do it at the beginning of the roll. Hold the lens against your chest, set the f/stop to 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 Sharpie® 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 Print File® Custom Proofer 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 proofing frame and lay 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 1/2 inch of the negative with a piece of cardboard and give a second 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 1/2 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 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 set-up. Test other film developer combinations to be completely accurate (recommended) or use this set-up 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 stream line 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 immediately know that you are underexposing or under developing your film. If the images are too light you will immediately 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.

Special Considerations

1. If the maximum black proofing time is less than 10 seconds stop down 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 or use a faster paper to make your proof sheets!

[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 FB for everything I do. As John Sexton likes to say, we speak with our pocketbook. If we don't use FB the manufacturers will stop making it.

Appendix 5

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 by Kodak, the Image Permanence Institute, Ilford, or anyone else involved in archival research someone 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 percent 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 market place.

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 possess the highest standards of quality. This to me is the most important reason for archival processing.

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 19th 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 storage, two variables we photographers 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.

So what do we do? The best we can . . . based on our collective photographic knowledge gained both through experience and accelerated aging tests.

The following procedure is the one I use and 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 when attempting to create archival prints and negatives.

SELENIUM TONING FOR ARCHIVAL PRINTS

Begin by using wide borders when making prints, at least 1/2 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 effectively trimmed off removing the chemicals.

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 one minute with continuous agitation. Do not overuse the fixer, generally you should be able to fix 100 8 × 10 inch prints per 4.0 liters/gallon (25 per liter/quart).
3. Drain and fix the print in a second fresh alkaline fixer without hardener for two minutes with continuous agitation. Use this fixer to replace the first fixer when the first fixer reaches exhaustion.
4. Rinse the prints for three minutes in running water to extend the capacity of the selenium toner.
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 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 hypo clearing agent with continuous agitation. If available use Berg Bath as it is the only HCA which will also remove residual selenide which may still be on the paper.

7. At this point place the prints in a vertical washer or move to a holding bath of running water until all prints are ready to be washed.
8. Wash the prints for 20 to 30 minutes in a vertical washer or 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 below).
9. If available soak the prints in Agfa Sistan® or Fuji AG Guard®[1] according to directions. Do not rinse this treatment off as it will negate any benefit of coating the paper.
10. 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 with film clips in a dryer.

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 a print face to back with another.
2. Unless the first fix has reached exhaustion (which it should not if you only process 100 8 × 10 inch prints per 4.0 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 and the process continued within a week or two. 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 mid-tones and highlights. And while some protection is better than none you may wish to a) use a lower dilution 1:6 or 1:9 and accept the resulting color shift or b) if you are willing for your prints to be brown toned use a polysulfide toner instead of selenium or c) use a highly dilute version of polysulfide toner, 1:100 or d) use Kodak GP-2 Gold Protective Toner instead of selenium, and trust that one of these will adequately protect the print for a century.
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.

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[1] Agfa sistan is no longer made but there is talk that it may become available. Fuji does not export photographic chemicals to North America. I am not certain of other regions.

7. Under no circumstances should prints be allowed to wash for more than one 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 (200.0 ml of bleach with 800.0 ml of water). Sponge the bleach solution on and wash it off with fresh water.

Formulas

FILM DEVELOPERS

Development Time

For some formulas, such as Kodak D-76, time/temperature data is readily available from Kodak. Where possible I have included a range of times. Other formulas will have to have times determined for your working methods. When in doubt follow Gordon Hutching's maxim, "It's always 12 minutes."

When a film developing-time range is given it is for films rated by the manufacturer between ISO 100 and ISO 320, unless otherwise stated. To choose a starting time, use this rough rule of thumb: 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: Suppose a developing formula recommends using between 10 and 14 minutes. With an ISO 125 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. This is a rough rule, and you may find that it is too much or too little. That is why an initial test roll or two is recommended.

If you routinely overexpose film by rating it at a lower EI (e.g., Tri-X rated at EI 250 instead of the manufacturer's recommended ISO 400), try developing it at the time indicated for the new EI. In the example just given, that would mean developing Tri-X at 12 minutes, as you would for any film rated between ISO 100 and ISO 320. With most developers a variation of one minute on either side of full development will not seriously affect the results.

Testing

Take some film, walk down the street, and expose it to a range of subjects. Try to include textured whites (painted white buildings) and some deep shadows. Keep careful notes. In the darkroom, cut the test roll into two, three, or four equal strips. Develop each strip for a different time. Give at least a 10% increase or decrease in time from your best guess starting time. Round the time off to the nearest 30 seconds. When in doubt about what time to start with, do what I do—start with 9 minutes for slow films, 12 minutes for medium speed films, and 15 minutes for fast films. These times will probably be too much or too little which is why it is important to use a test roll.

Proof for Maximum Black

After developing the test roll proof it for maximum black and determine which way to go for a basic developing time (Appendix 4: Proofing for Maximum Black). **Remember: exposure is for the shadows; development is for the highlights**.

- 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.

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.

Contrast	*Density*	*Modification*
Increase	Increase	Increase pH Increase temperature (same developing time)
Increase	No change	Increase hydroquinone
Increase	Decrease	Increase restrainer
Decrease	Increase	Decrease restrainer Increase metol
Decrease	Decrease	Decrease pH 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 Kodalk or borax). The approximate relative pH of some commonly used alkalis, acids, and reducing agents can be found on the pH scale in Chapter 3, Developers.

Divided And Water-bath Developers

FORMULA #1

D2D Divided Developer

(William E. Davis)

SOLUTION A

Water at 110F/43C, 750.0 ml
Metol, 3.7 g
*Sodium sulfite, 67.5 g
Hydroquinone, 7.5 g
Water to make 1.0 liter

*Add a pinch of the total sulfite, dissolve the metol completely and then add the remainder of the sulfite.

SOLUTION B

Water at 110F/43C, 750.0 ml
Borax, 37.5 g
Sodium carbonate, anhydrous, 30.0 g
Potassium bromide, 0.5 g
Water to make 1.0 liter

Recommended development times are:

Solution A—4 minutes
Solution B—8 minutes (7 minutes with a rotary processor)

Agitate in both Solutions for an initial 15 to 30 seconds, then for 5 seconds every 30 seconds thereafter.

After development the film should be rinsed in 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. As long as 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, below. To replenish, discard $^1/_3$ 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 110F/43C, 750.0 ml
Borax, 37.5 g
Sodium carbonate, 22.5 g
Potassium bromide, 0.5 g
Water to make 1.0 liter

FORMULA #2

D-23 Divided Developer

This is one of the best divided developer formulas for fine grain and full tonal scale. For the first bath you can use classic D-23 or a modified version, given here. This is because when

D-23 was formulated in the 1940s it was felt that a minimum of 7.5 grams of metol were needed for full development. In the 1950s, when Microdol was formulated, it was discovered that less metol could be used with no loss in energy or capacity. As a result, many variations of D-23 have been formulated, some using as little as 3.0 grams of metol.

Modified D-23 Formula

Water at 125F/52C, 750.0 ml
Metol, 5.0 g
Sodium sulfite, 100.0 g
Water to make 1.0 liter

Second Bath

For the second bath, use one of the following accelerators in 500.0 ml of water.

Borax, granular, 18.0 g
or
Sodium metaborate, 7.5 g
or
Sodium carbonate, anhydrous, 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, coarsest grain, and greatest film speed. 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.

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.

Extending time in the A bath will increase overall density. Increasing time in the B bath will not appreciably alter the results.

NOTE: This developer may have a tendency to raise base and fog levels. If a problem occurs, the fog level can be contained by adding a 10% potassium bromide solution to the A bath. Use 10.0 ml to start.

FORMULA #3

D-76H Divided Developer

(David Vestal)

SOLUTION A

Water at 110F/43C, 750.0 ml
Metol, 3.0 g
Sodium sulfite, 50.0 g
Water to make 1.0 liter

SOLUTION B

Water at 110F/43C, 750.0 ml
Borax, 5.0 g
Sodium sulfite, 50.0 g
Water to make 1.0 liter

Recommended development times:

Solution A—3 minutes
Solution B—3 to 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. Alternately, agitate continuously in both solutions. After development the film should be fixed and washed in the usual manner.

FORMULA #4

Reichner's Divided Developer

(William Reichner)

SOLUTION A

Distilled water at 125F/52C, 750.0 ml
Metol, 1.8 g
Sodium sulfite, 100.0 g
Sodium bisulfite, 24.0 g
Hydroquinone, 5.0 g
Benzotriazole, 1.2 g
Phenidone, 0.7 g
Distilled water to make 1.0 liter

SOLUTION B

Balanced Alkali, 50.0 g
Sodium sulfite, 80.0 g
*Potassium iodide, 0.1% solution, 10.0 ml
Potassium bromide, 0.5 g
Water to make 1.0 liter

*A 0.1% solution of potassium iodide can be made by dissolving 1.0 gram in water to make 1.0 liter.

Develop conventional emulsion films for 3 minutes in each solution; do not rinse in-between. Develop T-grain films for 4 minutes in each bath. Use continuous agitation in both baths.

Capacity: Approximately 25 rolls of 35 mm or 120 film, if Solution A is not contaminated by Solution B. Both baths should be filtered if precipitation or cloudiness occurs.

NOTE: This formula may cause dichroic fog on some modern emulsion films. Testing is advised.

FORMULA #5

Stoeckler's Fine-Grain Divided Developer

(H. Stoeckler)
This developer is a hybrid of Kodak D-23 and Kodak D-25.

SOLUTION A

Metol, 5.0 g
Sodium sulfite, 80.0 g
Sodium bisulfite, 20.0 g
Water to make 1.0 liter

SOLUTION B

Borax, 10.0 g
Water to make 1.0 liter

Development times:

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

FORMULA #6

General Purpose Divided Developer

SOLUTION A

Water at 125F/52C, 750.0 ml
Metol, 1.8 g
Sodium sulfite, 46.0 g
Sodium bisulfite, 9.2 g
Hydroquinone, 6.0 g
Potassium bromide, 0.8 g
Water to make 1.0 liter

SOLUTION B

Water at 90F/32C, 750.0 ml
Sodium sulfite, 46.0 g
Borax, granular, 30.0 g
Water to make 1.0 liter

Develop all films for 3 minutes in Solution A and 3 minutes in Solution B. Leaving the film longer in Solution A will increase the contrast. Solution A will last indefinitely; Solution B should be discarded after 20 rolls of film.

Extreme Compensating Developers

FORMULA #7

D175 Tanning Developer

SOLUTION A

Pyrogallol, 4.0 g
Sodium sulfite, 5.0 g
Water to make 1.0 liter

SOLUTION B

Sodium carbonate, anhydrous, 28.0 g
Water to make 1.0 liter

Mix equal parts Solutions A and B immediately before use. Development time is between 5 and 8 minutes.

FORMULA #8

Pyrocatechin Compensating Developer

(Maxim Muir)
This developer is primarily 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

Presoak the film for 2 to 5 minutes in plain water, water with ½ teaspoon of borax per liter, or Edwal's LFN. Development time is approximately 6 to 8 minutes at 70F/21C, with slow-speed films. Continuous agitation is recommended.

For further contractions (N-2, N-3), Maxim Muir recommends an alternative Solution B.

ALTERNATE SOLUTION B

Water, 375.0 ml
Sodium carbonate, monohydrate, 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 70F/21C with slow-speed films.

For N-3 contractions, use 1 part A, 2 parts B, 100 parts water. Develop for approximately 8 minutes at 70F/21C with slow-speed films.

NOTE 1: Do not mix too much of Solution B, as it has a short shelf life.

NOTE 2: N-2 and N-3 development will cause a loss of film speed and compress the midtones.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents. Mix 2 parts A, 1 part B, and 200 parts water.

FORMULA #9

Windisch Extreme Compensating Developer

(Hans Windisch)
This developer is primarily used to retain definition in negatives with extreme high values.

Hans Windisch published two dilutions for this formula. They are almost always given as stock solutions. Here they are both given as working solutions—do not dilute for use. Development times should be approximately the same for either dilution. This developer works best with slow and medium speed films.

Dilution A

Distilled water at 125F/52C, 750.0 ml
Sodium sulfite, 0.3 g
Pyrocatechin, 2.0 g
Sodium hydroxide, 10% solution, 15.0 ml
Distilled water to make 1.0 liter

or

Dilution B

Distilled water at 125F/52C, 750.0 ml
Sodium sulfite, 0.5 g
Pyrocatechin, 3.2 g
Sodium hydroxide, 10% solution, 10.0 ml
Distilled water to make 1.0 liter

Use either Dilution A or B undiluted. Develop for 12 to 15 minutes at 68F/20C.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

Fine-grain Developers

FORMULA #10

Ansco 17

Water at 125F/52C, 750.0 ml
Metol, 1.5 g
Sodium sulfite, 80.0 g
Hydroquinone, 3.0 g
Borax, granular, 3.0 g
Potassium bromide, 0.5 g
Water to make 1.0 liter

Use the same developing times as you would with Kodak D-76. As with D-76, this developer can be used 1:1 for sharper images with a slight increase in graininess.

FORMULA #11

Ansco 17a

Replenisher for Ansco 17

Water at 125F/52C, 750.0 ml
Metol, 2.2 g
Sodium sulfite, 80.0 g
Hydroquinone, 4.5 g
Borax, granular, 18.0 g
Water to make 1.0 liter

Add 20.0 ml of replenisher for each 80^2 inches film developed. Maintain the original volume of the developer, discarding some used developer if necessary in order to add the necessary amount of replenisher. No increase in original developing time is necessary.

FORMULA #12

Agfa Atomal Type

Water at 90F/32C, 750.0 ml
*Hydroxyethyl-*o*-aminophenol, 6.0 g
Pyrocatechin, 10.0 g
Hydroquinone, 4.0 g
Sodium sulfite, 100.0 g
Sodium carbonate, 25.0 g
Potassium bromide, 1.0 g
Sodium metaphosphate, 1.0 g
Distilled water to make 1.0 liter

* *N*-(β-Hydroxyethyl)-*o*-aminophenol sulfate.

Use published development times for Agfa Atomal.

FORMULA #13

Kodak D-23 (circa 1940)

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 85F/29C. At temperatures above 75F/24C use stop-bath Kodak SB-4 Tropical Hardener Bath between development and fixing.

Water at 125F/52C, 750.0 ml
Metol, 7.5 g
Sodium sulfite, 100.0 g
Water to make 1.0 liter

Develop full-strength for 12 minutes at 68F/20C.

Diluted 1:3 development results in full midtones and lower contrast. Try 1.5 × the time used for the full-strength developer and use three times the developer volume for each 80^2 inches of film.

D-23 can also be used as with 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 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.

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 #14

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. This formula was originally designed to produce fine grain for small format negatives. As with most fine-grain developers it will cause a loss of emulsion speed of at least one stop.

Water 125F/52C, 750.0 ml
Metol, 7.5 g
Sodium sulfite, 100.0 g
*Sodium bisulfite, 15.0 g
Water to make 1.0 liter

*If it is not essential to obtain minimum graininess use half the quantity of sodium bisulfite.

Develop for 20 minutes at 68F/20C.

This formula can also be used as a divided developer. To use as a two-solution developer try 4 minutes at 68F/20C 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 #15

Kodak Balanced Alkali Replenisher

For D-23 and D-25

Water at 125F/52C, 750.0 ml
Metol, 10.0 g
Sodium sulfite, 100.0 g
Balanced Alkali, 20.0 g
Water to make 1.0 liter

For Kodak D-23 add 22.0 ml for each 80^2 inches of film discarding some developer if necessary to keep the original volume.

For Kodak D-25 45.0 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 22.0 ml per roll. Discard the developer after 20 rolls have been processed.

General-Purpose Developers

FORMULA #16

Ansco 42

Water at 125F/52C, 750.0 ml
Metol, 0.8 g
Sodium sulfite, 45.0 g
Hydroquinone, 1.2 g
Sodium carbonate, monohydrate, 8.0 g
Potassium metabisulfite, 4.0 g
Potassium bromide, 1.5 g
Water to make 1.0 liter

Do not dilute for use. Develop 15 to 20 minutes at 68F/20C.

FORMULA #17

Ansco 47

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 125F/52C, 750.0 ml
Metol, 1.5 g
Sodium sulfite, 45.0 g
Sodium bisulfite, 1.0 g
Hydroquinone, 3.0 g
*Sodium carbonate, monohydrate, 6.0 g
Potassium bromide, 0.8 g
Water to make 1.0 liter

*Sodium carbonate, anhydrous, 5.0 g

For tank development, dilute 1:1 with water and develop for 8 to 12 minutes at 68F/20C. For tray development, use undiluted for 5 to 8 minutes at 68F/20C.

FORMULA #18

Ansco 47a

Replenisher for Ansco 47
Water at 125F/52C, 750.0 ml

Metol, 3.0 g
Sodium sulfite, 45.0 g
Sodium bisulfite, 2.0 g
Hydroquinone, 6.0 g
*Sodium carbonate, monohydrate, 12.0 g
Water to make 1.0 liter

* Sodium carbonate, anhydrous, 10.0 g.

For every 80^2 inches of film processed add 15.0 ml of undiluted replenisher and pour off any excess in order to maintain the initial volume. No increase in original developing time is necessary when replenisher is used.

Only replenish undiluted Ansco 47. Follow the instructions for replenishing Kodak D-76, under Kodak D-76R.

FORMULA #19

D-76H

(Grant Haist)
This formula is indistinguishable from Kodak D-76 and can be used in exactly 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 than D-76.

Water at 125F/52C, 750.0 ml
Metol, 2.5 g
Sodium sulfite, 100.0 g
Borax, 2.0 g
Water to make 1.0 liter

Use as you would D-76.

FORMULA #20

E-76

(Chris Patton)
"Environmentally friendly" film developer similar to Kodak D-76.

Water at 125F/52C, 750.0 ml
Phenidone, 0.2 g
Sodium sulfite, 100.0 g
Ascorbic acid, 8.0 g
Borax, 10.0 g
Cold water to make 1.0 liter

Use as you would D-76.

FORMULA #21

FX 37

For Tabular-Grain Films
(Geoffrey Crawley)
This developer was specially 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 125F/52C, 750.0 ml
Sodium sulfite, 60.0 g
Hydroquinone, 5.0 g
Sodium carbonate, anhydrous, 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 liter

Dilute 1:3 to 1:5. The higher dilution will increase film speed.

Developing times for 1:3 dilutions at 68F/20C:

Film	*Time*
Iford Delta 100	7.5 minutes
Ilford Delta 400	8 minutes
Ilford FP4+	4.5 minutes
Ilford HP5+	6.5 minutes
Kodak T-Max 100	8 minutes
Kodak T-Max 400	9 minutes
Kodak T-Max P3200	8 minutes
Kodak Plus-X	5.5 minutes
Kodak Tri-X	6 minutes

FORMULA #22

Ilford ID-68 (1960)

(Thanks to Ian Grant)
Microphen-type developer
Microphen is a fine-grain PQ developer that produces a ½ stop increase in film speed without a corresponding increase in graininess.

Water at 125F/52C, 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 liter

Use undiluted and develop for 4½ to 6 minutes at 68F/20C. Microphen can also be diluted 1:1 (8 to 11 minutes) or 1:3 (14 to 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 72F/22C.

FORMULA #23

ID-68 Replenisher

(Thanks to Ian Grant)

Water at 125F/52C, 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 liter

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.

FORMULA #24

Kodak D-76 (1927)

(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.

Water at 125F/52C, 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 liter

Dilute 1:1. D-76 may be used undiluted, but there is no advantage in doing so. The negatives while slightly finer grained do not exhibit the same degree of sharpness or tonal scale.

Development times are available from most film manufacturers.

Variations on D-76: The packaged Kodak formula contains a number of additional chemicals to prevent the metol from deteriorating in the presence of the sodium sulfite and enable it to mix easily in all types of hard and soft water. This allows the formula to be sold as a single package.

Ilford markets the formula in two packages, separating the metol from the sulfite, under the name ID-11. This eliminates some, though not all, of the extra chemicals found in the Kodak version.

Many photographers feel that the original formula, as given in the *Cookbook*, without the "extras" is superior to either commercial product.

FORMULA #25

Kodak D-76R

Replenisher for D-76

Water at 125F/52C, 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 liter

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, 1.0 liter of D-76 should be discarded after it has been replenished with 1.0 liter of D-76R.

Replenisher is for undiluted D-76 only. Do not replenish D-76 that has been diluted 1:1 for use.

FORMULA #26

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 80F/27C, 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 liter

*Dissolve the Phenidone in 5.0 ml of methyl hydrate and then add to the solution.

Use as you would XTOL.

NOTE: In the original Mytol formula it was recommended to use 60.0 grams of sodium sulfite to increase sharpness. However, the effect was insignificant and the result was reduced shelf-life for the stock solution.

High-Contrast Developers

FORMULA #27

Ansco 22

This formula is recommended for tray or tank development of cine title film and positive film to obtain high-contrast results.

Water at 125F/52C, 750.0 ml
Metol, 0.8 g
Sodium sulfite, 40.0 g
Hydroquinone, 8.0 g
Sodium carbonate, monohydrate, 50.0 g
Potassium bromide, 5.0 g
Cold water to make 1.0 liter

Do not dilute for use. Normal developing times are 5 to 8 minutes at 65F/18C.

FORMULA #28

Ilford ID-13

For line and screen negatives.

Solution A

Water at 125F/52C, 750.0 ml
Potassium metabisulfite, 25.0 g
Hydroquinone, 25.0 g
Potassium bromide, 25.0 g
Cold water to make 1.0 liter

Solution B

Sodium hydroxide, 50.0 g
Cold water to make 1.0 liter

Mix equal parts of A and B immediately before use. The mixed solution has very poor keeping qualities and should be discarded immediately after using. With normal exposures development is complete in 4 to 4½ minutes at 65F/18C.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

FORMULA #29

Kodak D-19

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 (Reversal Processing, below).

Water at 125F/52C, 750.0 ml
Metol, 2.0 g
Sodium sulfite, 90.0 g
Hydroquinone, 8.0 g
Sodium carbonate, monohydrate, 52.5 g (45 g anhydrous)
Potassium bromide, 5.0 g
Water to make 1.0 liter

Use undiluted. Develop 6 minutes in a tank or 5 minutes in a tray at 68F/20C.

FORMULA #30

Kodak D-19R

Replenisher for Kodak D-19

Water at 125F/52C, 750.0 ml
Metol, 4.5 g
Sodium sulfite, 90.0 g
Hydroquinone, 17.5 g
*Sodium carbonate, 52.5 g
Sodium hydroxide, 7.5 g
Cold water to make 1.0 liter

*Sodium carbonate, anhydrous, 45.0 g

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: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

High-Definition Developers

FORMULA #31

Developer #105

(Willi Buetler; thanks to Lawrence Cooper)

SOLUTION A

Water at 125F/52C, 750.0 ml
Metol, 10.0 g
Sodium sulfite, 50.0 g
Water to make 1.0 liter

SOLUTION B

Water at 125F/52C, 750.0 ml
Sodium carbonate, anhydrous, 50.0 g
Water to make 1.0 liter

Mix 1 part A, 1 part B, and 8 parts water. Develop T-Max 100 for 8 minutes at 68F/20C.

FORMULA #32

FX 1 (1961)

(Geoffrey Crawley)
This developer was formulated for maximum acutance with conventional medium- and slow-speed films. It is not recommended for fast films or for tabular grain films.

Water at 125F/52C, 500.0 ml
Metol, 0.5 g
Sodium sulfite, 5.0 g
Sodium carbonate, anhydrous, 2.5 g
*Potassium iodide, 0.001% solution, 5.0 ml
Water to make 1.0 liter

*To make a 0.001% solution of potassium iodide, add 1.0 gram to 1.0 liter of water. Take 100.0 ml of this solution and dilute to 1.0 liter. Again take 100.0 ml of this solution and dilute to 1.0 liter (this is equal to 1.0 mg per 100.0 ml).

Use undiluted. Developing time is between 7 and 14 minutes at 68F/20C.

FORMULA #33

GSD-10

(Jay DeFehr; thanks to Mark Booth)
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 high acutance 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 liter

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 70F/21C:

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.

FORMULA #34

Ilford ID-60

Water at 125/52C, 750.0 ml
Sodium sulfite, 20.0 g
Potassium carbonate, 60.0 g
Glycin, 30.0 g
Water to make 1.0 liter

Dilute 1:7 and develop for about 12 minutes in a tray or 15 minutes in a tank at 68F/20C.

FORMULA #35

Rodinal type (circa 1880s)

This formula is similar to the original Agfa Rodinal. Rodinal is the oldest proprietary formula in use today, the original formula dating back to the 1880s. It is considered by some to be the finest all-around film developer even for modern T-grain films.

SOLUTION A

Water at 125F/52C, 750.0 ml
p-Aminophenol hydrochloride, 100.0 g
*Potassium metabisulfite, 300.0 g
Water to make 1.0 liter

*Although it is usually acceptable to substitute sodium metabisulfite for potassium metabisulfite, it is not recommended in this formula.

SOLUTION B

Sodium hydroxide, 200.0 g
Cold water, 400.0 ml

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 drop by drop, Solution B 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: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

Low-Contrast Developers for Document Films

FORMULA #36

POTA

(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 185F/85C, 750.0 ml
Sodium sulfite, 30.0 g
Phenidone, 1.5 g
Water to make 1.0 liter

Use undiluted for 11½ to 15 minutes in a tank or 6½ to 8 minutes in a tray at 68F/20C. Use this formula as soon as possible as the solution deteriorates quickly.

FORMULA #37

T/O XDR-4

Water at 125F/52C, 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 liter

*20.0 grams of sodium sulfite can be substituted for potassium sulfite.
+10.0 grams of sodium bicarbonate (baking soda) can be substituted for potassium bicarbonate.

Use undiluted for 8 to 12 minutes at 68F/20C.

Low-Contrast Developers for Panchromatic Film

FORMULA #38

Agfa 14

This is a metol–sulfite soft-working developer.

Water at 125F/52C, 750.0 ml
Metol, 4.5 g
Sodium sulfite, 85.0 g
Sodium carbonate, monohydrate, 1.2 g
Potassium bromide, 0.5 g
Water to make 1.0 liter

Use undiluted and develop from 10 to 20 minutes at 68F/20C.

FORMULA #39

Ilford ID-3

This formula takes advantage of the soft-working characteristics of metol.

Stock Solution A

Water at 125F/52C, 750.0 ml
Metol, 12.0 g
Sodium sulfite, 50.0 g
Water to make 1.0 liter

Stock Solution B

Water at 125F/52C, 750.0 ml
*Sodium carbonate, anhydrous, 75.0 g
Potassium bromide, 2.0 g
Water to make 1.0 liter

*Sodium carbonate, monohydrate, 87.0 g

Mix 1 part A, 1 part B, and 6 parts water. Develop films approximately 1 minute in a tray or 5 minutes in a tank at 68F/20C.

Low-Temperature Developers

FORMULA #40

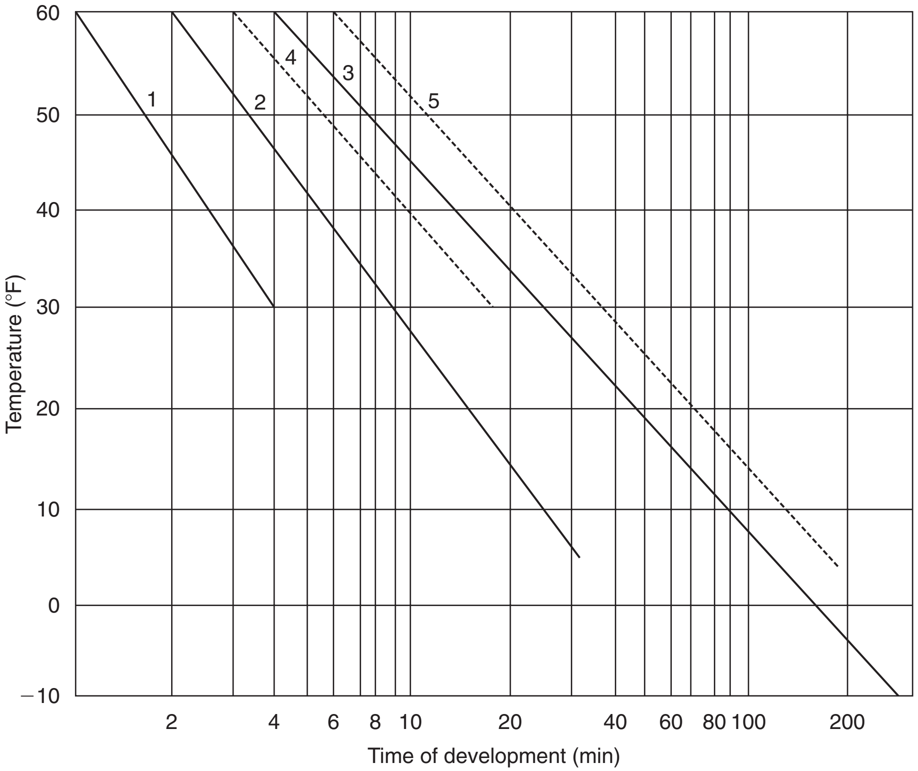
Kodak D-8

Water, 750.0 ml
Sodium sulfite, 90.0 g
Hydroquinone, 45.0 g
Sodium hydroxide, 37.5 g
Potassium bromide, 30.0 g
Water to make 1.0 liter

For use, mix 2 parts of stock solution and 1 part of water.

Procedures for Processing Film in the +30F/−1C to +60F/16C Range with D-8.

1. Develop for the times given on the time-temperature development chart in Table 2.
2. Rinse in dilute acetic acid (Kodak SB-1 Nonhardening Stop Bath) about 1 minute.
3. Fix in rapid fixer for 1½ times the time required to clear, which should be approximately 4 minutes at 60F/16C or 8 minutes at 40F/4C.
4. Wash in running water for 30 minutes or in four successive changes of water for 2 to 5 minutes each. Where water is scarce, these rinse baths may be saved, discarding the first bath each time, making the second bath the first, the third bath the second, the fourth bath the third, and employing a fresh fourth bath.
5. Air dry, or dry with heat if available. For more rapid drying, bathe in isopropyl alcohol or a good denatured alcohol for 1 to 2 minutes. The film should then be dried without heat or opalescence will occur. Use of an 85% alcohol solution will eliminate opalescence, but drying will be slower.
6. If the solutions are likely to be subjected to freezing temperatures during storage, 25% of ethylene glycol should be added to the total volume of developer and the processing times doubled. The alcohol bath is imperative when there is danger of freezing during drying.



Time-temperature development chart for low-temperature developers. This chart shows time-temperature for low-temperature developers labeled as follows: (1) Kodak SD-22 Amidol-Pyrocatechin, no glycol; (2) Kodak SD-22, 25% glycol; (3) Kodak SD-22, 50% glycol; (4) Kodak D-8, no glycol; (5) Kodak D-8 + 25% glycol.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

FORMULA #41

Kodak D-82 + Caustic

This formula is similar to Kodak D-82 (not reproduced in this edition) with an increase in hydroxide and the addition of benzotriazole for low temperature processing.

Water at 125F/52C, 500.0 ml
Methyl (wood) alcohol, 48.0 ml
Metol, 14.0 g
Sodium sulfite, 52.5 g
Hydroquinone, 14.0 g

Sodium hydroxide, 17.6 g
Potassium bromide, 9.0 g
Benzotriazole, 0.2 g
Water to make 1.0 liter

For temperatures down to 30F/−1C, use the above formula undiluted.
For temperatures down to 5F/−15C, use 3 parts stock solution, 1 part ethylene glycol.

The ethylene glycol should be added prior to storage at low temperatures.

NOTE: This formula may give fog or excessive contrast with some negative materials.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents

FORMULA #42

Kodak SD-22

Amidol–pyrocatechin

SOLUTION A

Water at 125F/52C, 500.0 ml
Sodium bisulfite, 100.0 g
Amidol, 40.0 g
Pyrocatechin, 40.0 g
Benzotriazole, 2.0 g
Water to make 1.0 liter

SOLUTION B

Water at 125F/52C, 500.0 ml
Sodium hydroxide, 120.0 g
Potassium bromide, 20.0 g
Potassium iodide, 4.0 g
Water to make 1.0 liter

Combine Solutions A and B immediately before use, since the mixed developer oxidizes rapidly. Solution A may also deteriorate on keeping and should be kept well-stoppered and as cool as possible.

For use down to 30F/−1C, mix 1 part Solution A, 1 part Solution B, and 2 parts water.
For use down to 5F/−15C, mix 1 part Solution A, 1 part Solution B, 1 part water, and 1 part ethylene glycol.
For use down to −40F/−40C, mix 1 part Solution A, 1 part Solution B, and 2 parts ethylene glycol.

NOTE: The glycol may be divided and added to each of these solutions before storing at low temperatures.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

Monobath Formulas

For monobaths using sodium hydroxide as an accelerator try 3 minutes at 75F/24C as a starting point for development.

FORMULA #43

Kodak Research Lab

Water, 750.0 ml
Sodium sulfite, 50.0 g
Phenidone, 4.0 g
Hydroquinone, 12.0 g
Sodium thiosulfate, pentahydrate, 110.0 g
*Sodium hydroxide, 4.0 g
Water to make 1.0 liter

To mix, 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.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

FORMULA #44

FX 6a

(Geoffrey Crawley)

Water, 750.0 ml
Sodium sulfite, 50.0 g
Phenidone, 1.0 g
Hydroquinone, 12.0 g
Sodium thiosulfate, pentahydrate, 70–125.0 g
Sodium hydroxide, 10.0 g
Water to make 1.0 liter

To mix, 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.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

FORMULA #45

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 liter

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.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

FORMULA #46

Orlando's Monobath

(C. Orlando)

Water, 750.0 ml
Metol, 12.9 g
Sodium sulfite, 70.9 g
Hydroquinone, 25.7 g
Sodium thiosulfate, pentahydrate, 180.0 g
Sodium hydroxide, 25.7 g
Benzotriazole, 10.0 g
Water to make 1.0 liter

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

Push-Processing Formulas

FORMULA #47

Diafine Type

This formula gives a one-stop true speed increase, with grain and sharpness equivalent to Kodak D-76. This developer is panthermic, meaning it can be used at any temperature between 68F/20C and 80F/28C without altering the time.

SOLUTION A

Water at 125F/52C, 750.0 ml
Sodium sulfite, 35.0 g
Hydroquinone, 6.0 g
Phenidone, 0.2 g
Sodium bisulfite, 6.0 g
Water to make 1.0 liter

SOLUTION B

Water at 125F/52C, 750.0 ml
Sodium sulfite, 65.0 g
Borax, 20.0 g
Water to make 1.0 liter

Soak 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.

Do not use an acid stop bath. Use a water rinse for 30 seconds to 1 minute. A good fixer to use with this formula is Photographers' Formulary TF-4.

FORMULA #48

FX 11 (1961)

(Geoffrey Crawley)
This formula produces at least a one-stop true speed increase with grain and sharpness similar to Kodak D-76.

Water at 125F/52C, 700.0 ml
Phenidone, 0.25 g
Hydroquinone, 5.0 g
Glycin, 1.5 g
Sodium sulfite, 125.0 g
Borax, 2.5 g
Potassium bromide, 0.5 g
Water to make 1.0 liter

The development times at 68F/20C are as follows:

Film	*Time*
Plus-X	7 minutes
Tri-X 35 mm	7 minutes
Tri-X 120	8 minutes

Pyro Developers

Unless otherwise specified, mixing and development with pyro formulas should be carried out between 65F/18C and 70F/21C.

FORMULA #49

510-Pyro (2006)

(Jay DeFehr)

Triethenalomine (TEA), 75.0 ml
Ascorbic acid 5.0 g
Pyrogallol 10.0 g
Phenidone 0.25 g
TEA to make 100.0 ml

The standard dilution is 1:100. Starting development time is 5 to 7 minutes at 70F/21C.

NOTE 1: Can be diluted up to 1:500 for extended development and reduced agitation techniques, for increased edge effects. Use 1 minute initial agitation, followed by one inversion every 10 to 15 minutes for up to one hour.

NOTE 2: TEA concentrates are easily measured with a measuring syringe. A 3.0, 6.0, or 25.0 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 #50

Kodak D-1, ABC Pyro (circa 1890)

The formula is given here as three separate working dilutions, 1:1:1:7, 1:1:1:11, and 1:1:1:14. For the traditional ABC stock solutions see Chapter 6: Pyrogallol and Pyrocatechin.

1:1:1:7

(This is the traditional dilution for tray development.)

Water between 65F/18C and 70F/21C, 750.0 ml
Sodium sulfite, anhydrous, 11.5 g
Pyro, 6.0 g
Potassium bromide, 10% solution, 10.0 ml
Sodium carbonate, monohydrate, 9.0 g
Water to make 1.0 liter

Develop between 5 and 7 minutes at 68F/20C.

1:1:1:11

(This is the traditional dilution for tank development. I recommend this dilution for tray development.)

Water between 65F/18C and 70F/21C, 750.0 ml
Sodium sulfite, anhydrous, 8.2 g
Pyro, 4.3 g
Potassium bromide, 10% solution, 7.0 ml
Sodium carbonate, monohydrate, 6.5 g
Water to make 1.0 liter

Develop between 6 to 12 minutes at 68F/20C.

1:1:1:14

(I recommend this dilution for tank development.)

Water between 65F/18C and 70F/21C, 750.0 ml
Sodium sulfite, anhydrous, 6.6 g
Pyro, 3.5 g
Potassium bromide, 10% solution, 6.0 ml
Sodium carbonate, monohydrate, 5.2 g
Water to make 1.0 liter

Develop between 8 and 14 minutes at 68F/20C.

FORMULA #51

Orwo 41 (1986)

Pyro + Citric Acid
This formula is meant to produce a negative with normal contrast.

SOLUTION A

Water between 65F/18C and 70F/21C, 500.0 ml
Citric acid, 4.0 g

Pyro, 28.0 g
Sodium sulfite, 100.0 g
Water to make 1.0 liter

SOLUTION B

Water, 750.0 ml
Potassium carbonate, 40.0 g
Water to make 1.0 liter

Dilute 1:1:2. Development times 6–8 minutes at 68F/20C.

NOTE: 2.0 grams of Calgon may be added to both solutions if needed.

FORMULA #52

Orwo 62 (1986)

This formula is meant to produce a long scale negative.

SOLUTION A

Potassium bisulfite, 5.0 g
Pyro, 30.0 g
Potassium bromide, 1.0 g
Water to make 500.0 ml

SOLUTION B

Sodium sulfite, 100.0 g
Water to make 500.0 ml

SOLUTION C

Sodium carbonate, 40.7 g
Water to make 500.0 ml

Dilute 1:1:1:17. Development time is approximately 10 minutes at 68F/20C.

NOTE: 2.0 grams of Calgon may be added to Solutions B and C if needed.

FORMULA #53

PMHQ (1949)

A non-staining, fog free pyro developer.

SOLUTION A

Water between 65F/18C and 70F/21C, 500.0 ml
Sodium sulfite, anhydrous, 15.0 g
Metol, 4.6 g
Sodium sulfite, anhydrous, 59.0 g
Potassium metabisulfite, 4.6 g
Pyro, 7.0 g
Hydroquinone, 7.0 g
Potassium bromide, 4.6 g
Water to make 1.0 liter

SOLUTION B

Sodium carbonate, anhydrous, 56.0 g
Water to make 1.0 liter

For tray development dilute 1:1:1. Develop for 5 minutes at 70F/21C.

For tank development dilute 1:1:4. Develop for 11½ minutes at 70F/21C. An alternative dilution for tank development is given as 1:1:7 with a development time of 18½ minutes at 70F/21C.

FORMULA #54

PMK (1991)

(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 liter

SOLUTION B

Water, 1400.0 ml
Sodium metaborate, 600.0 g
Water to make 2.0 liters

Mix 1 part A to 2 parts B to 100 parts water (e.g., 10.0 ml of A to 20.0 ml of B to 1000.0 ml of water). Measure the water and then add the A and B solutions. Development times are between 9 and 15 minutes at 70F/21C.

NOTE 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.

NOTE 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.

NOTE 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 1/3 to 1/2 stop without altering development times. Gordon Hutchings calls this PMK+.

NOTE 4: Unlike most other pyro developers PMK can be used at temperatures between 65F/18C and 80F/26C.

FORMULA #55

Rollo Pyro (AB C+ Pyro) (1997)

(Harald Laban)
This developer was formulated for use with a JOBO rotary drum processor.

Part A

Distilled water, 750.0 ml
Sodium bisulfite, 20.0 g
Metol, 20.0 g
Pyrogallic acid, 150.0 g
Ascorbic acid, 10 g
Potassium bromide, 1.5 g
EDTA tetrasodium, 2.0–5.0 g
Distilled water to make 1.0 liter

Part B

Distilled water, 900.0 ml
Sodium metaborate, 300.0 g
EDTA tetrasodium, 5.0 g
Distilled water to make 1.0 liter

Working solution for four 8 × 10 inch films:

10.0 ml Part A
20.0 ml Part B
500.0 ml water

Normal developing times with continuous rotation in a JOBO Expert Drum at 68F/20C:

Film	*El*	*Time*
FP4+	100	6.0
HP5+	400	6.5
BPF 200	200	6.0
T-Max 100	100	6.5

FORMULA #56

Two-Solution Pyro Developer (1950)

(F. Bürki; thanks to Lawrence Cooper)

SOLUTION A

Pyrogallol, 15.0 g
Sodium bisulfite, 15.0 g
Water to make 250.0 ml

SOLUTION B

Sodium carbonate, monohydrate, 100.0 g
Water to make 4.0 liters

Mix 1 part of Solution A to 19 parts of B or, as a percentage solution, use 5% A to 95% B to make the total volume (e.g., to make 1.0 liter of working solution, add 50.0 ml of A to 950.0 ml of B).

	Time	*Agitation*
T-Max 400 (EI 320)	6 minutes	5 inversions every 30 seconds
T-Max 100 (EI 100)	7 minutes	5 inversions every 30 seconds
Tri-X (EI 400)	7 minutes	5 inversions every 60 seconds

FORMULA #57

WD2H+ (2003)

(John Wimberley)

SOLUTION A

Distilled water, 750.0 ml
*Benzotriazole, 0.2 g
Metol, 6.0 g
Pyrogallol, 60.0 g
EDTA tetrasodium salt, 5.0 g
Distilled water to make 1.0 liter

*For more accurate measurement, prepare a 1% solution by dissolving 1.0 gram of benzotriazole in 100.0 ml of distilled water. Use 20.0 ml in place of 0.2 grams dry chemical.

SOLUTION B

Distilled water, 750.0 ml
Sodium carbonate, monohydrate, 110.0 g
Distilled water to make 1.0 liter

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 68F/20C. 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.

Pyrocatechin Developers

FORMULA #58

Hypercat

(Jay DeFehr)

STOCK SOLUTION A

Propylene glycol, 75.0 ml
Ascorbic acid, 0.5 g
Pyrocatechin, 10.0 g
Propylene glycol to make 100.0 ml

Add the dry chemicals to the glycol at room temperature, heat in a microwave, conventional oven, or on a stovetop with continuous stirring until all of the chemicals have dissolved, then top up to the final volume.

STOCK SOLUTION B

Distilled water, 750.0 ml
Sodium carbonate, 200.0 g
Distilled water to make 1.0 liter

The standard dilution is 1+10+100. The formula may be diluted up to 1+20+500 for longer development times, and increased edge effects. Starting development time is 5 to 7 minutes at 70F/21C.

NOTE: Glycol concentrates are easily measured with a measuring syringe. A 3.0, 6.0, or 25.0 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 #59

Pyrocat-HD

(Sandy King)

SOLUTION A

Distilled water, 750.0 ml
Sodium metabisulfite, 10 g
Pyrocatechin, 50.0 g
*Phenidone, 2.0 g
Potassium bromide, 1.0 g
Distilled water to make 1.0 liter

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

SOLUTION B

Distilled water, 700.0 ml
Potassium carbonate, 750 g
Distilled water to make 1.0 liter

For negatives intended for printing with silver gelatin papers mix 1 part A with 1 part B with 100 parts water. For negatives intended for printing with platinum/palladium (pt/pd) and most other alternative processes mix 2 parts A with 2 parts B with 100 parts water.

Superfine-grain Developers

FORMULA #60

DuPont No. 3

(V.B. Sease)
This formula is reputed to give the finest possible grain.

Water at 125F/52C, 750.0 ml
p-Phenylenediamine, base, 10.0 g
Glycin, 8.0 g

Sodium sulfite, 90.0 g
Water to make 1.0 liter

Dissolve the chemicals separately and then mix. The glycin will slowly dissolve after mixing. Filter the solution through a damp linen cloth.

Development time, undiluted, is between 20 to 25 minutes at 68F/20C.

NOTE 1: This formula results in at least a one stop loss in speed. By increasing the glycin to as much as 12.0 grams, film sensitivity can be increased, but the fine-grain effect decreases.

NOTE 2: Any gray coating remaining on the film after development can be removed by a 3% solution of glacial acetic acid.

FORMULA #61

Edwal No. 12

Water, 750.0 ml
Metol, 6.2 g
Sodium sulfite, 90.0 g
p-Phenylenediamine, base, 10.4 g
Glycin, 5.1 g
Water to make 1.0 liter

Use undiluted. Develop slow speed films for 11–16 minutes at 68F/20C.

FORMULA #62

FX 10 (1961)

(Geoffrey Crawley)
This formula is reputed to be the only true superfine-grain developer known not to cause a loss of emulsion speed. It is very sensitive to overexposure and overdevelopment. This developer may very well prove useful with tabular grain films. Try diluting it 1:3.

Sodium sulfite, 100.0 g
*Kodak CD-2, 7.5 g
Hydroquinone, 6.0 g
Borax, 4.0 g
Boric acid, crystalline, 4.0 g
Water to make 1.0 liter

* Kodak CD-2 is *N*,*N*-diethyl-2-methyl-p-phenylenediamine, monohydrochloride; this is a *p*-phenylenediamine derivative used in color developers.

Develop films for approximately 5 to 11 minutes at 68F/20C.

If the fine-grain effect is found to be too great and dichroic fog results, the sulfite content can be lowered. Alternatively, the amount of boric acid could be reduced, the borax increased, or both. Development times would be shorter.

If an even finer-grained effect is desired, with an inevitable loss in film speed, increase the acid and extend the development time. This would also increase the chance of dichroic fog.

NOTE: This formula was meant to be reused without replenishment to develop 6 to 7 rolls per liter. However, development time should be extended by about 5% each time it is used.

FORMULA #63

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 125F/52C, 750.0 ml
Sodium sulfite, 88 g
p-Phenylenediamine, 7.0 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 liter

*Do not use the monohydrate of trisodium phosphate.

Presoak the film in water or a 5% solution of sodium sulfite for 2 to 3 minutes to remove the film's anti-halation coating which may restrain development.

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 68F/20C:

Film	*ISO Time*
Up to 80	10–12 minutes
100 to 320	13–15 minutes
400+	18–20 minutes

NOTE: A characteristic of this developer is that the emulsion side will have a high sheen making it difficult to distinguish from the base side.

FORMULA #64

Windisch Superfine-Grain Developer

(Hans Windisch)

Water at 125F/52C, 750.0 ml
o-Phenylenediamine, 12.0 g

Metol, 12.0 g
Sodium sulfite, 90.0 g
*Sodium metabisulfite, 10.0 g
Water to make 1.0 liter

*The formula as originally published calls for 10.0 grams of potassium metabisulfite, crystalline.

Develop film for 12 to 13 minutes at 68F/20C.

Tropical Developers

For High-Temperature Processing

FORMULA #65

Agfa 16

Water at 125F/52C, 750.0 ml
Metol, 6.0 g
Sodium sulfite, 100.0 g
*Sodium carbonate, monohydrate, 12.0 g
Potassium bromide, 3.0 g

*10.0 grams sodium carbonate, anhydrous.

Add slowly to avoid caking:

Sodium sulfate, anhydrous, 40.0 g
Water to make 1.0 liter

Developing times:

Temperature	*Time*
65F/18C	9 to 11 minutes
75F/24C	6 minutes
85F/29C	3 minutes

FORMULA #66

Kodak DK-15

This is a non-blistering tropical developer.

Water at 125F/52C, 750.0 ml
Metol, 5.7 g
Sodium sulfite, 90.0 g
Balanced alkali, 22.5 g
Potassium bromide, 2.0 g

Add slowly to avoid caking:

*Sodium sulfate, anhydrous, 45.0 g
Water to make 1.0 liter

*If crystalline sodium sulfate is used, use 105.0 grams per liter.

Developing times:

Temperature	*Tank Development (Intermittent Agitation)*	*Tray Development (Constant Agitation)*
65F/18C	12½ minutes	10 minutes
70F/21C	10 minutes	8 minutes
75F/24C	8¼ minutes	6½ minutes
80F/27C	6¼ minutes	5 minutes
85F/29C	4¾ minutes	3¾ minutes
90F/32C	3¼ minutes	2½ minutes

Greater or lesser contrast may be obtained by developing for longer or shorter times than those specified.

NOTE 1: When development is completed, rinse the film in water for 1 or 2 seconds only and then immerse in Kodak SB-4 Tropical Hardener Bath for 3 minutes (omit the water rinse if the film tends to soften). Then fix for at least 10 minutes in an acid-hardening fixing bath, such as Kodak F-5 Hardening Fixer, and wash for 10 minutes in water at not over 95F/35C.

NOTE 2: When working below 75/24C, you may omit the sulfate for faster developing. Development time without the sulfate is 6 minutes at 68F/20C. Develop about 20% less for tray use.

NOTE 3: When working above 95F/35C use Kodak SH-5 Prehardener.

FORMULA #67

Kodak DK-15a

This is a low-contrast version of DK-15.

Water at 125F/52C, 750.0 ml
Metol, 5.5 g
Sodium sulfite, 90.0 g
Balanced alkali, 5.0 g
Potassium bromide, 2.0 g
Add slowly to avoid caking:
*Sodium sulfate, anhydrous, 45.0 g
Water to make 1.0 liter

*If crystalline sodium sulfate is used, then 105.0 grams per liter should be used.

Developing time and procedures are identical to those given for DK-15.

NOTE: When working above 95F/35C use Kodak SH-5 Prehardener.

PAPER DEVELOPERS

Paper-Developing Agents

The primary developing agents often have a major effect on print color and gradation. Pyrocatechin is often used for warm tones. Glycin is favored for neutral tones and subtle gradations. Amidol is often used in cold-tone formulas. However, as can be seen from the following formulas, there are no hard and fast rules. Agfa 108 is compounded with pyrocatechin, yet the addition of bromide, usually for warmer tones, causes it to become neutral to cold. Amidol is found in many neutral-tone formulas, and glycin is often used for warm tones.

Development Time

Paper may be developed over a wide range of times with varying results. Up to a point, the longer paper is developed, the richer the gradation and overall print quality. Exposure and dilution 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, even though they can at times make a difference.

Unless otherwise specified standard development time for all the paper developers are 1½ minutes for RC (i.e., 1 minute 20 seconds with a 10 second drain) and 2 minutes for fiber-base (1 minutes 50 seconds with a 10 second drain). You can extend or shorten the time to suit individual images.

Methods of Manipulating Print Developers

None of the paper developers in this section is written in stone. Many of them were created by photographers, not unlike you, who were experimenting with various proportions of developing agents and alkali. Feel free to alter any of the formulas. If your new brew gives you the tone/color, 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 compare and modify working solutions, not stock solutions. The following is a brief synopsis of some of the methods outlined in Chapters 3 and 8.

Cold Tones with MQ Developers

- Reduce the amount of bromide.
- Reduce the amount of bromide and add benzotriazole.

NOTE: Eliminating the bromide entirely, without replacing it by an antifoggant, may cause paper fog. To maintain an equivalent amount of fog reduction, substitute 0.2 grams of benzotriazole for every 1.0 gram of bromide. The easiest way to accomplish this is by converting both amounts into percentage solutions. Mix a 2% solution of benzotriazole (2.0 grams per 100.0 ml) and a 10% solution of bromide (10.0 grams per 100.0 ml). Then, substituting 10.0 ml of 2% benzotriazole will give the same results as 1.0 ml of 10% bromide.

Cold Tones with PQ Developers

- Eliminate the bromide and replace it entirely with a 1% benzotriazole solution.
- Increase the benzotriazole content up to 15.0 ml of 1% solution per liter.
- Substitute Phenidone and benzotriazole for metol and bromide.

NOTE: The more benzotriazole used, the bluer the tone is likely to be. However, if there is too much benzotriazole, paper development will be entirely suppressed.

Neutral Tones

- Eliminate or reduce the amount of bromide and/or substitute benzotriazole or Edwal's Liquid Orthazite.

Warm Tones

- 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 30.0 ml to 120.0 ml. After that, increase by 30.0 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. The best results are obtained from negatives of good contrast and printing density.

Cold-Tone Developers

FORMULA #68

Ansco 103

(Thanks to John J. Cahill)

Water at 125F/52C, 750.0 ml
Metol, 3.5 g
Sodium sulfite, anhydrous, 45.0 g
Hydroquinone, 11.5 g
Sodium carbonate, monohydrate, 78.0 g
*Potassium bromide, 1.2 g
Water to make 1.0 liter

*For coldest tones, use 0.6 grams of bromide (6.0 ml of a 10% bromide solution) and add 25.0 ml of a 1% benzotriazole solution. The small amount of bromide will help maintain consistent print color.

Dilute 1:2.

FORMULA #69

Blue-Black Developer

(Maxim Muir)
This formula gives either blue-blacks or rich, neutral tones, depending upon the paper. It works best with bromide papers.

Water at 125F/52C, 750.0 ml
Sodium sulfite, 180.0 g
Hydroquinone, 53.0 g
Phenidone, 2.2 g
Benzotriazole, 1.5 g

A white precipitate will form when the aforementioned ingredients are dissolved in the order shown. This is normal. This is normal. Allow to cool to about 75F/24C, and then slowly add the following while stirring:

Sodium hydroxide, 35.0 g

This will clear or almost clear the solution. Then add:

Water to make 1.0 liter

Dilute stock 1:5 with water. For less dramatic cool tones, dilute 1:10 or 1:15. The image will appear almost immediately after the print is put into the tray. Do not prematurely pull the print; develop for the full 2 minutes.

NOTE 1: The sodium hydroxide is not buffered and the solution will lose activity after 10–15 prints. However, the stock solution will keep for a month or more in a well-stoppered, amber glass bottle. A good way to make use of this formula is to mix up 1.0 liter, then dilute 250.0 ml of the stock with 1250.0 ml of water, make 10 prints, mix a fresh batch, and so on. Forty or more prints can be made in one session in this way.

NOTE 2: Altering the amount of benzotriazole will affect the level of fog and print tone.

FORMULA #70

Cold-Tone Developer

(Bürki and Jenny)
Similar to Kodak D-72 and Defender 54-D, this formula produces a more pronounced blue-black on some papers.

STOCK SOLUTION A

Water at 110F/43C, 750.0 ml
Metol, 3.0 g
Sodium sulfite, 40.0 g
Hydroquinone, 12.0 g
Sodium carbonate, monohydrate, 75.0 g
Potassium bromide, 0.8 g
Water to make 1.0 liter

STOCK SOLUTION B

Benzotriazole, 1% solution

Dilute 1:2 and add between 6.0 ml and 15.0 ml of Stock Solution B per each liter of Stock Solution A used. The more benzotriazole the greater the blue density.

FORMULA #71

Defender 54-D

The effects of this formula on paper color are subtle with most modern emulsions.

Water at 110F/43C, 750.0 ml
Metol, 2.7 g
Sodium sulfite, 40.0 g
Hydroquinone, 10.6 g
*Sodium carbonate, anhydrous, 75.0 g
Potassium bromide, 0.8 g
Water to make 1.0 liter

*Sodium carbonate, monohydrate, 88.0 g.

Dilute 1:2.

FORMULA #72

W130B

(John Wimberley)
According to some photographers Ansco 130 gives an unmatched tonal richness. By changing the restrainer 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 125/52C, 750.0 ml
Metol, 2.2 g
Sodium sulfite, anhydrous, 50.0 g
Hydroquinone, 11.0 g
Sodium carbonate, monohydrate, 78.0 g

Benzotriazole, 0.2 g
Glycin, 11.0 g
Water to make 1.0 liter

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

FORMULA #73

Agfa 108

Water at 125F/52C, 500.0 ml
Metol, 5.0 g
Sodium sulfite, 40.0 g
Hydroquinone, 6.0 g
Sodium carbonate, monohydrate, 40.0 g
Potassium bromide, 2.0 g
Water to make 1.0 liter

Use undiluted with a normal development time of 2 minutes. Longer development will increase the contrast even more.

NOTE: Potassium bromide, in this formula, will cause a slight green cast with some papers. 20.0 ml of Edwal's Liquid Orthazite can be substituted for the bromide.

FORMULA #74

Edwal 120

SOLUTION A

Water at 125F/52C, 500.0 ml
Pyrocatechol, 20.0 g
Sodium sulfite, 40.0 g
Water to make 1.0 liter

SOLUTION B

Water at 125F/52C, 750.0 ml
*Potassium carbonate, anhydrous, 120.0 g
+Potassium bromide, 1.0 to 3.0 g
Water to make 1.0 liter

* 134.0 grams of sodium carbonate monohydrate 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.

Low-Contrast Developers

FORMULA #75

Agfa 105

Water at 125F/52C, 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 liter

Use undiluted with a normal development time of 1½ minutes.

FORMULA #76

Ansco 120

Soft-Working Paper Developer

Water at 125F/52C, 750.0 ml
Metol, 12.3 g
Sodium sulfite, 36.0 g
Sodium carbonate, monohydrate, 36.0 g
Potassium bromide, 1.8 g
Water to make 1.0 liter

Dilute 1:1. 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.

FORMULA #77

Defender 59-D

Soft-Working Developer
This developer is for prints from high-contrast negatives.

Water at 125F/52C, 500.0 ml
Metol, 3.0 g
Sodium sulfite, 36.0 g
Sodium carbonate, monohydrate, 21.0 g
Potassium bromide, 4.0 g
Water to make 1.0 liter

Dilute 1:3. Develop for 3 to 4 minutes at 68F/20C.

FORMULA #78

Gevaert G.253

Soft-Portrait Paper Developer

Water at 125F/52C, 750.0 ml
Metol, 3.0 g
Sodium sulfite, 20.0 g
Sodium carbonate, monohydrate, 23.0 g
*Potassium bromide, 1.0 g
Water to make 1.0 liter

* Warmer tones may be obtained with the addition of up to 4.0 grams of potassium bromide.

Use undiluted or 1:1 and use developing times from 1 to 3 minutes.

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 #79

Agfa 100

Water at 125F/52C, 750.0 ml
Metol, 3.0 g
Sodium sulfite, 39.0 g
Hydroquinone, 9.0 g
Sodium carbonate, monohydrate, 90.0 g
Potassium bromide, 3.0–4.5 g
Water to make 1.0 liter

Dilute 1:2. Develop 1 to 2 minutes.

FORMULA #80

Agfa 125

Water, 500.0 ml
Metol, 3.0 g
Sodium sulfite, 44.0 g
Hydroquinone, 12.0 g
Sodium carbonate, monohydrate, 65.0 g
Potassium bromide, 2.0 g
Water to make 1.0 liter

Develop prints for 2 minutes.

FORMULA #81

Ansco 130

This is a versatile developer that is capable of beautiful gradation. The tone will vary, depending upon the paper and adjustments made to the chemistry.

Water at 125F/52C, 750.0 ml
Metol, 2.2 g
Sodium sulfite, 50.0 g
Hydroquinone, 11.0 g
Sodium carbonate, monohydrate, 78.0 g
Potassium bromide, 5.5 g
Glycin, 11.0 g
Water to make 1.0 liter

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 to 6 minutes. With chlorobromide papers it is 1½ to 3 minutes.

NOTE: The prepared stock solution is clear but slightly colored. The coloration does not indicate the developer has deteriorated.

FORMULA #82

Ansco 130, Ansel Adams' 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 below). 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 125F/52C, 750.0 ml
Metol, 2.2 g
Sodium sulfite, 35.0 g
Sodium carbonate, monohydrate, 78.0 g
Glycin, 11.0 g
Water to make 1.0 liter

Hydroquinone Solution

Water at 125F/52C, 750.0 ml
Sodium sulfite, 25.0 g

Hydroquinone, 10.0 g
Water to make 1.0 liter

Add the hydroquinone solution as needed to the stock solution.

NOTE: Maxim Muir recommends adding 5.0 grams of sodium bisulfite to buffer the hydroquinone solution.

FORMULA #83

Dassonville D-1

Charcoal Black Paper Developer

Water, 500.0 ml
Metol, 3.0 g
Sodium sulfite, 43.0 g
Hydroquinone, 11.0 g
Sodium carbonate, monohydrate, 35.0 g
Potassium bromide, 2.0 g
Water to make 1.0 liter

Dilute 1:1.

FORMULA #84

E-72

(Chris Patton)
"Environmentally friendly" Dektol-type developer.

Water at 125F/52C, 750.0 ml
*Phenidone, 0.3 g
Sodium sulfite, anhydrous, 45.0 g
Ascorbic acid, 19.0 g
Sodium carbonate, monohydrate, 90.0 g
Potassium bromide, 1.9 g
Water to make 1.0 liter

*3.0 grams of metol may be substituted for the Phenidone.

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.

FORMULA #85

Ilford ID-20

For neutral blacks with bromide paper.

Water, 500.0 ml
Metol, 3.0 g
Sodium sulfite, anhydrous, 50.0 g
Hydroquinone, 12.0 g
Sodium carbonate, anhydous, 60.0 g
Potassium bromide, 4.0 g
Water to make 1.0 liter

Dilute 1:1 to 1:3.

FORMULA #86

Kodak D-72

This developer is similar to Kodak Dektol.

Water at 125F/52C, 750.0 ml
Metol, 3.0 g
Sodium sulfite, 45.0 g
Hydroquinone, 12.0 g
Sodium carbonate, monohydrate, 80.0 g
Potassium bromide, 2.0 g
Water to make 1.0 liter

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 8.0 ml of 10% potassium bromide per liter. For higher contrast with bromide papers, dilute 1:1 and add 1.0 ml of 10% bromide per liter.

Development times are from 1½ to 3 minutes.

Toning Developers

FORMULA #87

Dassonville D-3

Autotoning Developer
This formula is the same as Edwal 106 and Ansco 115.

Water at 125F/52C, 500.0 ml
Sodium sulfite, 82.5 g

Sodium carbonate, monohydrate, 138.0 g
Glycin, 26.5 g
Hydroquinone, 8.5 g
Potassium bromide, 3.7 g
Water to make 1.0 liter

For warm black tones with bromide papers dilute 1:3.

For brown blacks dilute 1:7 and develop for 2 to 3 minutes and 4 to 6 minutes with slow chlorobromide papers.

At a dilution of 1:15, Dassonville D-3 produces tones known as "gravurebrown." At this dilution, develop for 3 to 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 predominate tones are lighter than middle gray. With fast chlorobromide papers, it produces delicate tones that are also exceptional for high-key images.

FORMULA #88

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 125F/52C, 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 liter

*For slightly less warm tones, 81.0 grams of sodium carbonate, monohydrate, 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.

NOTE: Some papers will react in unusual and inconsistent ways to this developer.

FORMULA #89

Toning Developer (1943)

(Bürki and Jenny)
Produces tones varying from brown to red on chlorobromide papers.

SOLUTION A

Water at 70F/21C, 750.0 ml
Pyrocatechol, 20.0 g
Sodium sulfite, 100.0 g
Potassium carbonate, 100.0 g
Potassium bromide, 2.0 g
Water to make 1.0 liter

SOLUTION B

Ammonium sulfate, 2% solution
Normal working solution
Solution A: 200.0 ml
Solution 250.0 ml
Water: 250.0 ml

Expose the print so the desired density is reached in 2½ minutes at 68F/20C. To increase red-brown tones take equal parts of A and B. To increase cold brown tones decrease B, and for red tones increase B.

Variable Contrast Developer

FORMULA #90

Beers Two-Solution Variable Contrast Developer

(Dr. Roland F. Beers)

SOLUTION A

Water at 125F/52C, 750.0 ml
Metol, 8.0 g
Sodium sulfite, 23.0 g
*Potassium carbonate, 21.0 g
Potassium bromide, 10% solution, 11.0 ml
Water to make 1.0 liter

SOLUTION B

Water at 125F/52C, 750.0 ml
Hydroquinone, 8.0 g

Sodium sulfite, 23.0 g
*Potassium carbonate, 28.4 g
Potassium bromide, 10% solution, 22.0 ml
Water to make 1.0 liter

*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 monohydrate in place of the potassium salt.

Mix the stock solutions in the following proportions to give a progressive range of contrasts.

Contrast	*Low*		*Normal*			*High*	
Solution No.	*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 to 3 minutes but with less agitation.

Warm-Tone Developers

FORMULA #91

Agfa 120

Brown-Tone Paper Developer

This developer will produce a variety of brown to warm black tones on various papers, depending on dilution and exposure time.

Water at 125F/52C, 750.0 g
Sodium sulfite, 60.0 g
Hydroquinone, 24.0 g
Potassium carbonate, 80.0 g
Water to make 1.0 liter

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

FORMULA #92

Ansco 110

Direct Brown-Black Paper Developer

Water at 125F/52C, 750.0 ml
Sodium sulfite, 57.0 g
Hydroquinone, 22.5 g
Sodium carbonate, monohydrate, 75.0 g
Potassium bromide, 2.75 g
Water to make 1.0 liter

Dilute 1:5. Give 3 to 4 times normal exposure and develop for 5 to 7 minutes at 68F/20C.

FORMULA #93

Catechol Copper-Tone Developer

Water at 110F/43C, 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 liter

Use 1:1 and develop between 1 and 2 minutes at 70F/21C. The shorter the development time, the warmer the tone (Chapter 8: Paper Development, Image Color: Print Tone vs. Tint, Manipulating Paper Tones).

FORMULA #94

Catechol Warm-Tone Developer

Water at 110F/43C, 750.0 ml
Pyrocatechin, 4.0 g
Potassium carbonate, 45.0 g
Potassium bromide, 0.4 g
Water to make 1.0 liter

The developer should be used full strength at 100F/38C with exposure times reduced from those used with normal developers. After development the print is cooled in a water bath and then processed following normal procedures. This process works particularly well with Photographers' Formulary Fixer TF-4, which does not require an acid stop bath.

FORMULA #95

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 125F/52C, 500.0 ml
Metol, 2.5 g
Sodium sulfite, 37.5 g
Hydroquinone, 10.0 g
*Sodium carbonate, anhydrous, 37.5 g
+Potassium bromide, 13.0 g
Water to make 1.0 liter

*Sodium carbonate, monohydrate, 45.0 g.
+The liberal use of potassium bromide is recommended, even in excess of the quantity indicated in the formula.

Dilute 1:2. Exposure should be adjusted to produce the desired contrast and tone when developed from 1½ to 2 minutes at 68F/20C.

FORMULA #96

DuPont 51-D

For warm black tones on slow chlorobromide and chloride papers and neutral tones on bromide papers.

Water at 125F/52C, 500.0 ml
Metol, 1.5 g
Sodium sulfite, 22.5 g
Hydroquinone, 6.3 g
*Sodium carbonate, monohydrate, 17.5 g
Potassium bromide, 1.5 g
Water to make 1.0 liter

*Sodium carbonate, anhydrous, 15.0 g

To use, 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 68F/20C.

FORMULA #97

Gevaert G.261

Brown-Black Paper Developer

Water at 125F/52C, 750.0 ml
Sodium sulfite, 40.0 g
Glycin, 6.0 g
Hydroquinone, 6.0 g
Sodium carbonate, monohydrate, 35.0 g
Potassium bromide, 2.0 g
Water to make 1.0 liter

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 to 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 10.0 grams of sodium bicarbonate to each liter of the diluted developer.

FORMULA #98

Ilford ID-24

For Sepia to Bright Red Tones

Water at 125F/52C, 500.0 ml
Sodium sulfite, 31.3 g
Hydroquinone, 3.4 g
Sodium carbonate, monohydrate, 43.3 g
Potassium bromide, 0.3 g
Glycin, 3.4 g
Water to make 1.0 liter

With increased exposure, greater dilution of developer, and more potassium bromide, the color produced ranges from sepia to bright red, as indicated in the following table. Development can be up to 30 minutes, depending on the color desired. Using the solution at 80F/27C can speed up development.

Color	*Exposure*	*Dilution of Developer*	**Additonal 10% Potassium Bromide*	*Approximate Development Time*
Warm-black	Normal	Full strength	None	1½ minutes
Sepia	2× normal	5×	1.0 ml	5 minutes
Brown sepia	3× normal	10×	3.0 ml	10 minutes
Red-brown	4× normal	15×	5.0 ml	15 minutes
Red	5× normal	20×	6.0 ml	20 minutes

Normal exposure should be determined by first using Ilford ID-78 (next formula).

FORMULA #99

Ilford ID-78 (1960)

(Thanks to Ian Grant)
PQ developer for warm-black tones
ID-78 is a modern PQ warm tone developer which is very close in its formula to Ilford Neutol WA®. It works extremely well with modern papers.

Water at 125F/52C, 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 liter

Dilute 1:1 or 1:3.

NOTE 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.

NOTE 2: If a stock solution is made up with no bromide or benzotriazole it can be varied from a cold/blue black developer to a warm-tone developer with the addition of benzotriazole or bromide.

FORMULA #100

Kodak D-52

This formula is similar to the proprietary formula Kodak Selectol.

Water at 125F/52C, 500.0 ml
Metol, 1.5 g
Sodium sulfite, 22.5 g
Hydroquinone, 6.0 g
Sodium carbonate, monohydrate, 17.0 g
Potassium bromide, 1.5 g
Water to make 1.0 liter

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 #101

Kodak D-155

Brown-black to red-brown image tones.

Water at 125F/52C, 750.0 ml
Metol, 0.4 g
Sodium sulfite, 22.0 g
Hydroquinone, 4.0 g
Sodium carbonate, anhydrous, 18.0 g
Potassium bromide, 4.0 g
Glycin, 2.6 g
Water to make 1.0 liter

Dilute 1:1 to 1:4 for use.

FORMULA #102

Kodak D-166

Red-Brown Paper Developer

Water at 125F/52C, 750.0 ml
Metol, 0.6 g
Sodium sulfite, 12.5 g
Hydroquinone, 4.2 g
Sodium carbonate, anhydrous, 12.5 g
Potassium bromide, 6.2 g
Water to make 1.0 liter

Dilute 1:1 for use. Develop until the desired image tone is reached.

FORMULA #103

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, monohydrate, 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 #104

Sepia-Tone Paper Developer

(Jim Carbone)

Water at 125F/52C, 750.0 ml
Sodium sulfite, 60.0 g
Sodium carbonate, monohydrate, 90.0 g
Glycin, 25.0 g
Hydroquinone, 8.0 g
Potassium bromide, 2.0 g
Water to make 1.0 liter

Dilute 1 part stock to 2 parts of water. Develop for a full 2 minutes. For warmer tones increase the dilution.

Amidol Paper Developer

Notes on Amidol

- Amidol works without an accelerator (alkali).
- The pH of an amidol developer should be between 7 and 8. Benzotriazole should not be used with amidol as it is essentially inactive at this pH level.
- Use a 3 minute standard development time for amidol developers with bromide papers.
- Varying the amount of sodium sulfite affects the keeping qualities of the solution.
- The amount of bromide may be adjusted to ensure clear highlights without fogging.
- Amidol powder works best when it is fresh. Fresh amidol has a slight green cast. Old, oxidized amidol is gray or black. Old amidol will often be usable, but the results will be different from those obtained with a fresh batch, including longer development times. Old amidol also tends to more readily stain prints.
- 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.
- When mixing amidol formulas, use a mask, as the fine powder is easy to inhale.

FORMULA #105

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 liter

*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 to 4 minutes.

FORMULA #106

Amidol Paper Developer No. 1

Sodium sulfite, 100.0 g
Amidol, 6.6 g
Potassium bromide, 10.0 g
Water to make 1.0 liter

This developer may be used in dilutions ranging from undiluted to 1:15, depending on the contrast desired. Developing times are from 1½ to 6 minutes.

NOTE: The sulfite and bromide can be mixed as a stock solution and the amidol added just before use.

FORMULA #107

Below's Amidol Paper Developer

This formula is claimed to have better keeping qualities in solution than other amidol formulas.

Metol, 1.0 g
Sodium sulfite, 30.0 g
Amidol, 6.0 g
Potassium bromide, 0.4 g
Water to make 1.0 liter

Dilute as needed to manipulate contrast. Develop for 2 to 4 minutes.

FORMULA #108

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.

NOTE: The sulfite and bromide can be mixed as a stock solution and the amidol added just before use.

FORMULA #109

Ansco 113

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 liter

Do not dilute. Develop for 1½ to 7 minutes.

NOTE: The sulfite and bromide can be mixed as a stock solution and the amidol added just before use.

FORMULA #110

Dassonville D-2

Water at room temperature, 750.0 ml
Sodium sulfite, 32.0 g
Amidol, 5.3 g
Potassium bromide, 0.5 g
Water to make 1.0 liter

Use at full strength.

NOTE: The sulfite and bromide can be mixed as a stock solution and the amidol added just before use.

The Weston Amidol Developers

All three of the famous Weston's—Edward, Brett, and Cole—used amidol paper developer formulae. Each had his own variation. All four of the following formulae are used undiluted and should be followed by running water or a citric acid stop bath.

FORMULA #111

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, 7.0 ml

FORMULA #112

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, 1800.0 ml

*Brett's handwritten formula specifies 60.0 oz, which equals approximately 1800.0 ml.

(circa 1982)

Water at room temperature, 3.5 liters
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"; the citric acid acts as an organic antifoggant, similar to benzotriazole. Use as needed.

FORMULA #113

Cole Weston's Amidol Paper Developer

Water at room temperature, 2.0 liters
Sodium sulfite, 54.0 g

Amidol, 16.0 g
10% potassium bromide, 12.0 ml
10% citric acid, 12.0 ml

FORMULA #114

DuPont BB Formula

(Thanks to John E. Quick)
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 will create 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, preferred cooler tones and may well have used BB while it was available.

DuPont ceased marketing photographic materials in the early 1970s.

Sodium sulfite, 85.0 g
Benzotriazole, 15.0 g
Water to make 1.0 liter

Add BB solution 10.0 to 15.0 ml at a time to neutral or cold tone print developers until the desired tone is achieved.

UNIVERSAL DEVELOPERS

FORMULA #115

Ilford ID-36

This is a "universal" developing formula for film or paper. It is also recommended as a redeveloper for bleached negatives or prints.

Water at 125F/52C, 750.0 ml
Metol, 2.0 g
Sodium Sulfite, anhydrous, 50.0 g
Hydroquinone, 12.5 g
Sodium Carbonate, anhydrous, 72.0 g
Potassium Bromide, 10% solution, 7.5 ml
Water to make 1.0 liter

FILM: For tray development dilute 1:3 and develop for 3 to 5 minutes at 68F/20C. For tank development dilute 1:7 and develop for 6 to 10 minutes at 68F/20C.

PAPER: Dilute 1:3. Develop for 1½ to 2 minutes.

FORMULA #116

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 125F/52C, 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 liter

FILM: Use without dilution. Develop roll film about 9 minutes in a tank of fresh developer at 68F/20C. Develop sheet film for about 6 minutes at 68F/20C. 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 68F/20C. For colder tones, double the quantity of balanced alkali; use without dilution and develop 1 to 2 minutes.

In either case, the tones produced by this developer are slightly warmer than the tones given produced by Kodak D-52 and Kodak D-72.

STOP AND HARDENING BATHS

FORMULA #117

Bisulfite Stop Bath

This stop bath is inexpensive and very gentle acting. It may be used in place of an acetic acid stop bath.

Water, 750.0 ml
Sodium bisulfite, 10.0 g
Water to make 1.0 liter

Use undiluted.

FORMULA #118

Indicator for Stop Baths

Bromcresol purple, 10% solution, 9.25 g
Sodium hydroxide, 1.0 g
Distilled water to make 250.0 ml

Add a sufficient amount of this solution to any amount of fresh 28% acetic acid to cause it to be clearly visible as yellow. When the pH of the acid becomes higher than 6.8 the bath will turn purple. Discard at the first signs of changing to purple or sooner.

An alternate method is to place 24.0 ml of stop bath to be tested in a container. Add 2 drops of the testing solution. If the stop bath remains yellow it is still good. If it turns purple time to deep six.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

FORMULA #119

Kodak SB-1

Nonhardening stop bath.

Water, 1.0 liter
*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 × 10″ prints per liter.

FORMULA #120

Kodak SB-4

Tropical hardener bath.
This solution is recommended for use with tropical developers when working above 75F/24C.

Water, 1.0 liter
Potassium alum, 30.0 g
Sodium sulfate, anhydrous, 60.0 g

After development, rinse the film in water for 1 second, then immerse in the SB-4 bath for 3 minutes. Above 85F/29C omit the water bath and transfer the film directly to the SB-4 bath. Agitate for 30 to 45 seconds immediately after immersing in the hardener or streaks will result.

The hardening bath is a violet blue color by tungsten light when freshly mixed but turns to yellow-green with use; it then ceases to harden and should be replaced with a fresh bath. The hardening bath should never be overworked. An unused bath will keep indefinitely, but a partially used bath will deteriorate rapidly within a few days.

FORMULA #121

Kodak SB-5

Non-swelling acid rinse bath.

Water, 500.0 ml
Acetic acid, 28% solution, 32.0 ml
Sodium sulfate, anhydrous, 45.0 ml
Water to make 1.0 liter

This bath is satisfactory up to 80F/27C. It should be replaced after processing about 12 rolls per liter. The bath should not be revived with acid.

When working at temperatures below 75F/24C the life of the acid rinse bath may be extended by giving films a few seconds rinse in running water prior to immersion in the acid rinse.

FORMULA #122

Kodak SB-8

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 liter

FIXERS

- Crystalline hypo, when mixed with water, produces a noticeable lowering of temperature. Always begin with water of at least 90F/32C 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.
- Dissolve the acid ingredients separately (e.g., boric acid) in a small volume of hot water, especially when a mixture of sodium sulfite and acetic acid is used.
- Removing the hardener from fixer will improve the gloss on paper.
- 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.
- When called for use boric acid, granular, as powdered boric acid is extremely difficult to dissolve in water. Boric acid is used as cockroach poison. Do not ingest.
- Excessive fixing times will promote adsorption or retention of the fixer complexes in gelatin, or more particularly on the fibers of paper base, and should be avoided. In addition, excessive fixing can bleach silver images, especially those on paper prints. Warm-tone images are particularly at risk.

FORMULA #123

Acid Hypo

(J. Ghislain Looten)

Water at 125F/52C, 2.0 liters
Sodium thiosulfate, 480.0 g
Sodium bisulfite, 45.0 g

Use undiluted. Unlike Plain Hypo this fixer can be saved and reused. It allows easy toning with direct toners, such as selenium.

FORMULA #124

Agfa 304

Rapid Fixer

This fixer makes use of sodium thiosulfate and ammonium chloride to form ammonium thiosulfate in solution.

Water at 125F/5 2C, 750.0 ml
Sodium thiosulfate, 200.0 g
Ammonium chloride, 50.0 g
Potassium metabisulfite, 20.0 g
Water to make 1.0 liter

Use undiluted. Fix paper for 3 to 5 minutes. Film should be fixed for three times the clearing time.

FORMULA #125

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

Add the acetic acid slowly with stirring. Dissolve the boric acid separately in a little hot water and add this last.

Optional Hardener

Aluminum chloride, hexahydrate, 50.0 g
Water to make 100.0 ml

The stock solution is to make 1.0 liter of concentrate.

FILM: Dilute 1:3. If hardening is desired add 25.0 ml of the hardener to each liter of working solution. The hardener should be added slowly with stirring. Films should be fully fixed in approximately 5 minutes.

PAPER: Dilute 1:7. Prints will be fixed in 3 minutes. Do not leave prints in this fixer for more than 10 minutes.

FORMULA #126

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 125F/52C, 600.0 ml
*Ammonium thiosulfate, 60% solution, 333.0 ml
Sodium sulfite, 15.0 g
Acetic acid, 28% solution, 55.0 ml
+Boric acid, granular, 7.5 g
Potassium alum, 15.0 g
Add water to make 1.0 liter

*200.0 grams of ammonium thiosulfate, crystalline can be used.
+Dissolve the boric acid separately in a little hot water and add this last.

FILM: Use undiluted. With a fresh bath, clearing time should be approximately 1 to 2 minutes. Film should be completely fixed in 4 to 5 minutes. The bath can be used until clearing time exceeds 7 minutes.

PAPER: Dilute 1:1. Immerse fiber-base paper for 3 minutes, RC paper for 1½ minutes. If two baths are used, give 3-and-3, or 1½- and-1½ minutes in each bath for fiber-base and RC paper, respectively.

FORMULA #127

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 125F/52C, 600.0 ml
Potassium thiocyanate, 100.0 g
Potassium alum, 50.0 g
Add water to make 1.0 liter

When the above is thoroughly dissolved, add:

Acetic acid, glacial, 25.0–35.0 ml

At room temperatures of 65F/18C or higher, fixing will take place in 20 seconds. At −23F/−30C fixing will take place in 4 minutes (1 hour with ordinary fixers). This fixer will not freeze at temperatures above −28F/−33C.

Use 25.0 ml of acetic acid for rapid fixing and 35.0 ml for low temperatures.

Caution: Potassium thiocyanate is a mild skin irritant. Wear gloves and wash off any that splashes onto your skin.

FORMULA #128

Kodak F-1a

Acid Hardener

Water at 125F/52C, 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 liter

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 250.0 ml of hardener to 1.0 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.

To make a pre-hardening bath dilute 250.0 ml of the stock hardener solution in 1.0 liter of water. Harden film or paper for 1 minute prior to fixing.

FORMULA #129

Kodak F-5

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 125F/52C, 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 liter

FILM: Film should be clear in 5 minutes and fully fixed in 10. Discard when the clearing time is close to 10 minutes. The hardener can be mixed separately as a stock solution (see the following formula).

PAPER: Use the two-bath method, 5 minutes in each bath. Do not use hardener in this fixer if you intend to tone the print.

FORMULA #130

Kodak F-5a

Hardener

Water at 125F/52C, 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 liter

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 250.0 ml of hardener to 1.0 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 pre-hardening bath dilute 250.0 ml of the stock hardener solution in 1.0 liter of water. Harden film or paper for 1 minute prior to fixing.

FORMULA #131

Kodak F-6

Odorless Acid-Hardening Fixer
Most fixers have strong odors caused by sulfur dioxide. The substitution of balanced alkali for boric acid in the F-6 formula eliminates the odor almost entirely.

Water at 125F/52C, 600.0 ml
Sodium thiosulfate, 240.0 g
Sodium sulfite, 15.0 g
Acetic acid, 28% solution, 48.0 ml
*Balanced alkali, 15.0 g
Potassium alum, 15.0 g
Water to make 1.0 liter

*Sodium metaborate may be used as a substitute.

To prevent sulfurization mix the alum separately in a small amount of hot water. Add this solution last with rapid stirring.

FILM: Film should be clear in 5 minutes and fully fixed in 10. Discard when the clearing time is close to 10 minutes.

PAPER: Use the two-bath method, 5 minutes in each bath. 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 #132

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 125F/52C, 500.0 ml
Sodium thiosulfate, 240.0 g
Sodium sulfite, 10.0 g
*Sodium bisulfite, 25.0 g
Water to make 1.0 liter

*Substituting 22.0 grams of citric acid for the bisulfite will eliminate much of the odor associated with fixers.

FILM: Film should be clear in 5 minutes and fully fixed in 10. Discard when the clearing time is close to 10 minutes.

PAPER: Use the 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 #133

Plain Hypo

Use 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 be used to 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 125F/52C, 2.0 liters
Sodium thiosulfate, 480.0 g

Use fresh and undiluted.

FORMULA #134

TF-2

Alkaline Fixer
(Bill Troop)

Due to its alkalinity, this fixer will wash out of negative and print materials more rapidly than will an acid fixer. This fixer 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 liter

Use undiluted for either film or paper. Follow development by a 60-second plain water rinse or a minimum of 5 full changes of water. Fix films for 3 times the clearing time, or a minimum of 5 minutes, agitating for a full 30 seconds during each minute. Fix paper for 10 full minutes with occasional agitation.

The capacity of TF-2 is twenty 8 × 10″ prints or films per liter.

FORMULA #135

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.

This formula is similar to Photographers' Formulary TF-4. However, TF-4 is more concentrated and slightly less alkaline. The greater concentration of Formulary TF-4 increases the fixing capacity to fifty 8 × 10″ prints or films per liter; the slightly lower alkalinity of TF-4 decreases the ammonium odor.

Ammonium thiosulfate, 57–60% solution, 800.0 ml
Sodium sulfite, 60.0 g
Sodium metaborate, 5.0 g
Water to make 1.0 liter

Dilute 1:4 for either film or paper. Follow development by a 60-second plain water rinse or a minimum of 5 full changes of water. Fix films for 3 minutes, agitating for a full 30 seconds during each minute. Fix paper for 1 full minute with continuous 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 non-hardening fixer. If a print has been previously hardened, use 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 (Appendix 1: Safety in Handling Photographic Chemicals), there should be no more danger than in any other process. 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 lights 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 #136

Ansco 241

Iron Blue Toner
This formula is suitable for bromide and fast chlorobromide papers.

Distilled water at 125F/52C, 500.0 ml
Ferric ammonium citrate, 8.0 g
Potassium ferricyanide, 8.0 g
Acetic acid, 28% solution, 265.0 ml
Distilled water to make 1.0 liter

Prints for toning should be fixed in plain, non-hardening hypo at a temperature of 68F/20C 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.

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 #137

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 125F/52C, 750.0 ml
*Ammonium thiocyanate, 105.0 g
Gold chloride, 1% solution, 60.0 ml
Water to make 1.0 liter

* 110.0 grams of sodium thiocyanate or 135.0 grams of potassium thiocyanate may be substituted.

After fixing and thorough washing tone the prints for 10 to 20 minutes with occasional agitation. The prints should then be washed and dried.

FORMULA #138

Dassonville T-6

Gold Chloride
For gray-blue tones.

SOLUTION A

Thiocarbamide, 16.0 g
Water to make 1.0 liter

SOLUTION B

Gold chloride, 4.0 g
Distilled water, 1.0 liter

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 75F/24C. 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 non-hardening fixer and thoroughly washed. Two-bath fixing is recommended, the second being a plain hypo bath without hardener.

NOTE 1: Stains are caused by incomplete washing between fixing and toning.

NOTE 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.

NOTE 3: The stock solutions will keep indefinitely, but the mixed toner will not keep for more than a few days.

FORMULA #139

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
*Thiocarbamide, 3.5 g

*If thiocyanate is substituted for thiocarbamide more purplish tones will appear.

SOLUTION B

Water, 250.0 ml
Citric acid, 3.5 g

SOLUTION C

Water, 250.0 ml
Gold chloride, 1.0 g

Take 30.0 ml of each stock solution and add 300.0 ml of water. Fix the print in a plain hypo bath and wash for 10 to 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.

NOTE 1: Slight intensification will take place with some papers, particularly chloride and chlorobromide emulsions.

NOTE 2: This quantity of toner can be used for two to four 11 × 14″ prints. The mixed solution will keep for several hours.

FORMULA #140

Kodak T-12

Iron-Toning Bath
This toner produces blue tones.

Ferric ammonium citrate, green, 4.0 g
Oxalic acid, crystals, 4.0 g
Potassium ferricyanide, 4.0 g
Water to make 1.0 liter

To use, immerse the well-washed print in the toning bath for 10 to 15 minutes until the desired tone is obtained. Then wash until the highlights are clear.

NOTE: Dissolve each chemical separately and filter before mixing together.

FORMULA #141

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 125F/52C, 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, anhydrous, 15.0 g

Continue to stir until all the chemicals are dissolved.

The range of toning times is 8 to 45 minutes at 68F/20C. Increasing the temperature to between 100F/38C and 105F/40C 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 × 10″ prints per liter.

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 #142

Ansco 221

Sepia toner for warm-brown tones
Bleach:

Water at 125F/52C, 750.0 ml
Potassium ferricyanide, 50.0 g
Potassium bromide, 10.0 g
Sodium carbonate, monohydrate, 20.0 g
Water to make 1.0 liter

Redeveloper:

Water, 300.0 ml
*Sodium sulfide, anhydrous, 45.0 g
Water to make 500.0 ml

*Be sure to use sodium sulfide, not sodium sulfite.

To use, 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 to 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.

NOTE 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.

NOTE 2: Use plastic trays, especially with the bleaching bath. Otherwise, blue spots may form on the print.

FORMULA #143

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 add Solution C. Finally add 105.0 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 to 60 minutes at 110F/43C to 125F/52C. Agitate prints occasionally until toning is complete.

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 #144

Formulary Thiourea Toner

(William M. Wilson)
This formula is similar to Ansco 221 Sepia Toner, without the rotten egg smell associated with sulfide toners.

Bleach:
Water at 125F/52C, 750.0 ml
Potassium ferricyanide, 50.0 g
Potassium bromide, 10.0 g
Sodium carbonate, monohydrate, 20.0 g
Water to make 1.0 liter

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

Sodium hydroxide, 10.0 g
Cold water to make 100.0 ml

SOLUTION B

Thiourea, 5.0 g
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.

To use the redeveloper, mix 1 part A and 1 part B with 16 parts water.

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 liter

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 to 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: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

FORMULA #145

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 125F/52C, 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 68F/20C, 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, add cold water to bring the total volume to 1.0 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 120F/50C 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 to 20 minutes and use a wet cotton ball to wipe any scum off the print surface.

FORMULA #146

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 liter

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in Pharmacopoeia.

SOLUTION B

Hydrochloric acid, concentrate, 100.0 ml
Water to make 1 liter

Make up bleach from: 2 parts A and 10 parts B with 40 parts water.

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, anhydrous, 15.0 g
Water to make 1.0 liter

Develop to completion.

NOTE: the developer should be fresh and discarded once it turns green.

Caution: Add the acid to the water never add the water to the acid.

FORMULA #147

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 160F/70C, 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 liters

*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 120F/50C. Bring the toner to this temperature. At this temperature prints will tone in 12 to 15 minutes, depending on the type of paper. Never use the solution above 120F/50C because blisters and stains may result. Toning should not be continued longer than 20 minutes at 120F/50C.

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 to 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.

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.

FORMULA #148

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, 2.0 liters

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 to make 1.0 liter

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 mid-tones 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 to 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 65F/18C to 75F/24C.

FORMULA #149

Kodak T-8

Polysulfide Toner
For sepia tones.
This toner creates slightly darker brown tones than Kodak T-7a on warm-tone papers. It has the further advantage over hypo-alum formulas of not requiring heating, although raising the temperature to 100F/38C will reduce the toning time.

Water, 750.0 ml
*Polysulfide, 7.5 g
Sodium carbonate, monohydrate, 2.5 g
Water to make 1.0 liter

*Also known as sulfurated potash, liver of sulfur, and potassa sulfurated.

Immerse the well-washed print in the bath and agitate for 15 to 20 minutes at 68F/20C or for 3 or 4 minutes at 100F/38C.

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 70F/21C.

FORMULA #150

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.

SOLUTION A, PART 1

Distilled water at 125F/52C, 750.0 ml
Sodium thiosulfate, 240.0 g
Ammonium persulfate, 30.0 g
Water to make 1.0 liter

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 110F/43C for use. Maintain the temperature between 100F/38C and 110F/43C while toning. If necessary, place a smaller tray containing the toner inside a larger tray of running water at 110F/43C.

Toning takes from 5 to 20 minutes depending on the desired hue. After all the prints have been toned, re-fix for 5 minutes then wash for one 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.

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.

Copper Toners

FORMULA #151

Dassonville T-5

Copper Toner
For purple-brown to chalk-red tones.

SOLUTION A

Copper sulfate, 6.5 g
Potassium citrate, neutral, 24.8 g
Water to make 1.0 liter

SOLUTION B

Potassium ferricyanide, 5.5 g
Potassium citrate, neutral, 24.8 g
Water to make 1.0 liter

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 liter

Prints should be washed another ½ hour after using this solution. Fresh solution should always be used.

FORMULA #152

GT-15

Copper Red Toner

SOLUTION A

Potassium citrate, neutral, 100.0 g
Water at 68F/20C, 500.0 ml

SOLUTION B

Copper sulfate, 7.5 g
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.

NOTE: GT-15 bleaches the print. Compensate by extending the printing time as much as 50%.

Dye Toners

FORMULA #153

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 liter

*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 68F/20C is from 3 to 9 minutes.

FORMULA #154

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 liter

*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 liter

*Thoroughly dissolve the dye in hot water, filter, add the acid, and dilute to 1.0 liter. For methyl violet dye, use 0.05 grams.
+ 1 part glacial acetic acid slowly added to 9 parts water.

Place the print in the mordant for 1 to 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 to 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 60.0 ml of glacial acetic acid in 1.0 liter of water. An alternate method is to use 10.0 ml of household bleach to 1.0 liter of water.

Green Toners

FORMULA #155

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 liter
Ammonia (25% to 29% solution), 15.0 ml

SOLUTION B

Ferric ammonium citrate, 17.0 g
Water, 1.0 liter
Hydrochloric acid, concentrate, 40.0 ml

SOLUTION C

Sodium sulfide, 2.0 g
Water, 1.0 liter
*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 to 6 minutes excessive washing being 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 to 30 minutes in neutral or slightly acidified wash water and should be dried. Avoid belt and heat-drying machines for drying.

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.

Caution: Add the acid to the water, never add the water to the acid.

Caution: 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 #156

GT-16

Indirect Green Toner
This formula is most effective on warm-tone papers. Give 10 to 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.

To use, 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 Hypo Clearing Agent (HCA) and give 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 68F/20C, 285.0 ml

This should be done before treating the print with a washing aid and giving the final wash.

Caution: Add the acid to the water, never add the water to the acid.

Protective Toners

FORMULA #157

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 liter

*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.

+An equal weight of potassium thiocyanate may be substituted.

Add the gold chloride 1% stock solution to 750.0 ml of water. Dissolve the thiocyanate separately in 125.0 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 68F/20C 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.

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.

Caution: Work in a well-ventilated room and wear protective gloves when mixing and using.

FORMULA #158

Kodak GP-2

(Thanks to Jonathan Bailey)
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, anhydrous, 15.0 g
Water to make 1.0 liter

Tone for about 1 minute with continuous agitation at 80F/27C. Wash the toned print for 10 minutes.

FORMULA #159

Kodak GP-2R

Replenisher for GP-2

(Thanks to Jonathan Bailey)
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, anhydrous, 18.0 g
Water to make 1.0 liter

The replenishment rate is 11.0 ml per 80^2 inches of film processed.

Red Toners

FORMULA #160

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 90.0 grams of the crushed salt to 300.0 ml of cold water; shake as often as possible for several days.

Any precipitate that forms when the copper is added will be re-dissolved. 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 re-fixed and then washed.

Any pink stains in the whites can be removed by treating with a 1% solution of ammonia water.

FORMULA #161

Crimson Toner

For 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

Gold chloride, 1.0 g
Water, 450.0 ml

SOLUTION B

Potassium thiocyanate (sulfocyanide), 6.0 g
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 30.0 grams of sodium chloride in 1.0 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 900.0 ml will tone about eighteen 8 × 10″ prints.

Selenium Toners

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 powder, whether in powder or solution. Read the additional cautions in Appendix 1: Safety in Handling Photographic Chemicals.

FORMULA #162

Dassonville T-55

Direct Selenium Toner

(Courtesy of Judy Seigel)
This toner produces rich plum-purple to brown tones.

*Sodium sulfite, 25.0 g
Selenium powder, 1.0 g

* *Sulfite* not sulfide.

Dissolve the sodium sulfite in 100.0 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 to 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 #163

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 liter

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 liter

Dissolve the sodium sulfide in 100.0 ml of warm water. Add the selenium powder and slowly heat until dissolved. Allow to cool.

Dilute 1:10 with water. Tone the bleached prints for 3 to 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 to 2 minutes in the selenium-sulfide stock solution prior to bleaching. A small amount of thiourea can also be added to vary the tone.

NOTE 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.

NOTE 2: This formula deteriorates rapidly once diluted; dilute only enough for immediate use.

FORMULA #164

Dassonville T-56

Bleach and Redevelop Selenium Toner
(Courtesy of Judy Seigel)
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 liter

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 liter

Dissolve the sodium sulfide in 100.0 ml of warm water. Add the selenium powder and slowly heat until dissolved. Allow to cool.

Dilute 1:19. Tone the prints for 3 to 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 to 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 #165

Direct Selenium Toner

This toning formula works similarly to Kodak Rapid Selenium Toner.

Powdered selenium, 5.7 g
Sodium sulfide, 250.0 g
Water to make 1.0 liter

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 1.0 liter and allow to cool for use.

As with Kodak Rapid Selenium Toner, 1:9 will produce a color shift towards 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.

DuPont Toning System

FORMULA #166

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 (Chapter 10: DuPont 6-T Toning System).

Varigam toning bleach 6B-1:

Water, 750.0 ml
Potassium ferricyanide, 22.0 g
Potassium bromide, 25.0 g
Water to make 1.0 liter

Varigam toning bleach 6B-2:

Water, 750.0 ml
Potassium ferricyanide, 22.0 g
Potassium iodide, 10.0 g
Water to make 1.0 liter

Varigam 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 liter

Prints should be developed for 1½ minutes and fixed in a non-hardening fixing bath. Thoroughly wash the prints then bleach in one of the above 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.

Varigam toner 6T-1:

Water, 750.0 ml
Thiourea (thiocarbamide), 3.0 g
Sodium hydroxide, 6.0 g
Water to make 1.0 liter

Varigam toner 6T-2:

Water, 750.0 ml
Thiourea (thiocarbamide), 3.0 g
Sodium carbonate, 45.0 g
Water to make 1.0 liter

Varigam toner 6T-3:

Water, 750.0 ml
Thiourea (thiocarbamide), 3.0 g
Potassium carbonate, 48.0 g
Water to make 1.0 liter

Various combinations of bleach and toner will give different tones as shown by the following table:

Bleach in	*Tone in*	*Type of Tone Resulting*
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 liter

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 liter

After treatment in the chloride bath briefly rinse the prints and place in the gold solution. The effect of this bath is to replace the golden tint with a reddish one. Toning may be continued for from 2 to 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 non-hardening fixing bath. Thorough washing should follow.

The following table indicates the effect obtained by gold modification after toning in the various bleach–toner combinations.

Bleach in	*Tone in*	*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 less 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 above apply to the dried prints.

Caution: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

NEGATIVE REDUCERS

FORMULA #167

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 15.0 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 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 to 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 30.0 grams of citric acid, anhydrous.

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.

NOTE 1: Before reducing a negative or print clean thoroughly with film cleaner to remove any surface grease left from handling. To promote uniform reduction pre-wet the emulsion in a wetting agent such as Edwal's LFN.

NOTE 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 #168

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 bichromate, 10.0 g
Alum, 50.0 g
Water to make 1.0 liter

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in 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, and never add the water to the acid.

FORMULA #169

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 liter

Bleach the negative in this solution and after thorough washing redevelop to 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 #170

Kodak R-4a

Farmer's Cutting Reducer

For overexposed negatives.

STOCK SOLUTION A

Potassium ferricyanide, 37.5 g
Water to make 500.0 ml

STOCK SOLUTION B

Sodium thiosulfate, 480.0 g
Water to make 2.0 liters

Immediately before use take 30.0 ml of A, add 120.0 ml of B, and add water to make 1.0 liter. 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 to 15 parts water, depending on the desired rate of reduction.

FORMULA #171

Kodak R-4b

Farmer's Proportional Reducer

For overdeveloped negatives.

STOCK SOLUTION A

Potassium ferricyanide, 7.5 g
Water to make 1.0 liter

STOCK SOLUTION B

Sodium thiosulfate, 200.0 g
Water to make 1.0 liter

These are working solutions. The ferricyanide will keep indefinitely if shielded from strong daylight.

Place the dry film in Solution A for 1 to 4 minutes at 68F/20C. 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 #172

Kodak R-15

Super Proportional Reducer

For extreme overdevelopment.

STOCK SOLUTION A

Potassium persulfate, 30.0 g
Water to make 1.0 liter

STOCK SOLUTION B

Water, 250.0 ml
*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 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.

Caution: Add the concentrated sulfuric acid *slowly* with constant stirring to the *cold* water. To prepare a 10% solution of sulfuric acid, take 1 part sulfuric acid and add it slowly to 9 parts of water with stirring. Never add the water to the acid.

PRINT REDUCERS

FORMULA #173

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 180.0 ml of Solution B, and add 1500.0 ml of water. The amount of Solution A may be increased or decreased to control the time of reduction.
- 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 200.0 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.
- Spot reduction, mix 1 part A to 2 parts B without adding water.

For instructions on bleaching see Chapter 11: Photographic Reduction and Intensification.

FORMULA #174

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 non-staining 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 liter

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 #175

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 (Chapter 8, Printing Methods and Techniques: Redevelopment Method). After rehalogenating, any toning developer, warm or cold, can be used to give the purest tones possible.

Potassium ferricyanide, 8.0 g
Potassium bromide, 12.0 g
Water to make 1.0 liter

1. Develop, fix, and wash a print in the usual manner. Use a neutral tone developer such as Kodak D-72.
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. If not otherwise specified, wash RC prints for 5 to 15 minutes and fiber-based prints for 30 minutes.

NEGATIVE INTENSIFIERS

FORMULA #176

Chromium Intensifier #1

*Potassium bichromate, 10% , 12.5 ml
Hydrochloric acid, concentrated, 0.3 ml
Water to make 100.0 ml

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in Pharmacopoeia.

For instructions on chromium intensification see Chapter 11, Photographic Reduction and Intensification.

Caution: Always add the hydrochloric acid to the water slowly, stirring constantly, and never add the water to the acid.

FORMULA #177

Chromium Intensifier #2

*Potassium bichromate, 10%, 12.5 ml
Hydrochloric acid, concentrated, 1.2 ml
Water to make 100.0 ml

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in Pharmacopoeia.

For instructions on chromium intensification see Chapter 11, Photographic Reduction and Intensification.

Caution: Always add the hydrochloric acid to the water slowly, stirring constantly, and never add the water to the acid.

FORMULA #178

Ilford In-3

Chromium Intensifier

Bichromate stock solution:

*Potassium bichromate, 100.0 g
Distilled water to make 1.0 liter

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in Pharmacopoeia.

BLEACHING SOLUTION A

Bichromate stock solution, 100.0 ml
Hydrochloric acid, concentrate, 2.4 ml
Distilled water to make 1.0 liter

BLEACHING SOLUTION B

Bichromate stock solution, 100.0 ml
Hydrochloric acid, concentrated, 12.0 ml
Distilled water to make 1.0 liter

The bleaching solution should be made fresh each time. 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 negative developer such as Ilford ID-36. Wash thoroughly.

NOTE 1: The bichromate stock solution keeps indefinitely.

NOTE 2: Solution A gives more intensification than Solution B.

Caution: Always add the hydrochloric acid to the water slowly, stirring constantly, and never add the water to the acid.

FORMULA #179

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

*Store in a brown glass bottle.

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

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 68F/20C.

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 up to 25 minutes. If you do over intensify use two-solution Farmer's Reducer R-4b to reduce or eliminate the silver.

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 #180

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, it 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 fixing baths or in wash water contaminated with fixing bath. Kodak In-6 Intensifier is not suitable for fine-grain materials or for use when only moderate intensification is desired.

SOLUTION A

Distilled water at 68F/20C, 750.0 ml
Sulfuric acid, concentrate, 30.0 ml
Potassium bichromate, anhydrous, 22.5 g
Water to make 1.0 liter

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in Pharmacopoeia.

SOLUTION B

Distilled water at 68F/20C, 750.0 ml
Sodium bisulfite, anhydrous 3.8 g
Hydroquinone, 15.0 g
Kodak Photo-Flo 200, undiluted, 3.8 ml
Water to make 1.0 liter

SOLUTION C

Distilled water at 68F/20C, 750.0 ml
Sodium thiosulfate, pentahydrate, 22.5 g
Water to make 1.0 liter

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.

To intensify negatives, first wash the negatives to be treated for 5 to 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 68F/20C. 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 to 20 minutes and dry as usual.

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: Add the concentrated sulfuric acid *slowly* with constant stirring to the *cold* solution of the bichromate.

PAPER INTENSIFIERS

FORMULA #181

Chromium Intensifier for Prints

SOLUTION A

*Potassium bichromate, 30.0 g
Water to make 500.0 ml

*Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in Pharmacopoeia.

SOLUTION B

Hydrochloric acid, concentrate, 55.0 ml
Water to make 500.0 ml

Add 30.0 ml of Solution B to 30.0 ml of Solution A, plus 180.0 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.

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 minutes. If the print still does not react, or if spots or streaks appear, strengthen the bleach by using as much as 240.0 ml of A, 60.0 ml of B, and 180.0 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 70F/21C. 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 to 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 non-staining developer (e.g., Kodak D-72) for 2 to 5 minutes. The print should be washed for about ½ hour. Always use a fresh developer for print intensification.

After redevelopment, do not re-fix the print, 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.

NOTE 1: Prints for intensification should not be hardened. If they have been hardened, use Dehardener.

NOTE 2: The stock solutions will keep well in brown glass bottles.

Caution: Always add the hydrochloric acid to the water slowly, stirring constantly, and never add the water to the acid.

MISCELLANEOUS

FORMULA #182

Basic Scarlet N

For development by inspection with MQ developers

Chrysoidine, 1.0 g
*Phenosafranine, 1.0 g
Distilled water, 200.0 ml
Add: Alcohol, isopropyl, 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 to 15 seconds at 1-minute intervals.

NOTE 1: Basic Scarlet N tends to shorten development times by about 10%.

NOTE 2: A proprietary variation of Basic scarlet N, De-Tec, is available from Antec (Resources).

FORMULA #183

Dehardener

This solution should be used prior to toning prints that have been hardened during fixing. The formula will soften the emulsion so that the print will tone and spot more easily and washing will be more effective.

Water, 750.0 ml
Sodium carbonate, monohydrate, 30.0 g
Water to make 1.0 liter

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 #184

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, such as a shirttail.

FORMULA #185

Developer Stain Remover for Hands #1

This formula is similar to the one just given but with a slightly different dilution. It is generally considered to be safe for removing silver stains from hands.

SOLUTION A

Potassium permanganate, 7.3 g
Water, 1.0 liter

Keep hands in Solution A for a few minutes and then rinse in:

SOLUTION B

Sodium bisulfite, 90.0 g
Water, 1.0 liter

Wash thoroughly with soap and water.

FORMULA #186

Developer Stain Remover for Hands #2

This formula is generally considered to be safe for removing silver stains from hands.

SOLUTION A

Potassium ferricyanide, 30.0 g
Potassium bromide, 30.0 g
Water, 1.0 liter

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 #187

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 liter

Apply by wiping the film base gently with cotton, Photowipes®, or a soft microfiber photo cloth.

FORMULA #188

Fixer Test Solution

(Thanks to Manuel A. Garcia Maceda)

Water, 80.0 ml
Potassium iodide, 4.0–5.0 g
Water to make 100.0 ml

Add 10.0 ml of Fixer Test Solution to 100.0 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.

FORMULA #189

Hypo Clearing Agent

Water at 125F/52C, 750.0 ml
Sodium sulfite, 200.0 g
*Sodium bisulfite, 50.0 g
Water to make 1.0 liter

*The sodium bisulfite lowers the pH in order to prevent softening of the film emulsion. If paper is to be used, the bisulfite may be left out in order to improve the paper's gloss.

Dilute 1:9. After fixing rinse the print or film for 1 minute in running water then transfer to the HCA.

Papers	*Water Rinse After Fixer (optional)*	*HCA (with agitiation)*	*Final Running Water Wash*
SW	1 minute	2 minutes	10 minutes
DW	1 minute	3 minutes	20 minutes
Film	30 seconds	1 to 2 minutes	5 minutes

Capacity: Fifty 80^2 inch prints or forty 80^2 inches of film per liter.

FORMULA #190

Kodak Amidol Redeveloper

Water at room temperature, 750.0 ml
Sodium sulfite, 25.0 g
Amidol, 6.5 g
Water to make 1.0 liter

This developer can be used for redevelopment following the use of Kodak S-6 Stain Remover.

FORMULA #191

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

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 35mm frames (three frames of 120 or a single 4 × 5″ 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 125.0 ml of distilled water in a clear glass and add 1.0 ml of the test solution. Pour 15.0 ml of the diluted solution into a clear 30-ml glass container. Take six 4 × 5″ prints or equivalent from the wash water and allow them to drip for 30 seconds into the 15.0 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.

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: Dissolve the sodium hydroxide in a small volume of water in a separate container before adding it to the solution of the other constituents.

FORMULA #192

Kodak S-6

Stain Remover

This formula is used for developer or 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 liter

*Dissolve the permanganate completely, otherwise spots may appear on the negative.

STOCK SOLUTION B

Cold water, 500.0 ml
Sodium chloride, 75.0 g
Sulfuric acid, concentrate, 16.0 ml
Water to make 1.0 liter

STOCK SOLUTION C

Sodium bisulfite, 1% solution, 1.0 g
Water, 100.0 ml

Harden the film for 2 to 3 minutes in Kodak SH-1 Formalin Supplementary Hardener. After hardening, wash for 5 minutes. Bleach the negative for 3 to 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 non-staining developer such as Kodak D-72, diluted 1:2.

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.

Caution: Add the concentrated sulfuric acid *slowly* with constant stirring to the *cold* solution of sodium chloride.

FORMULA #193

Kodak SH-1

Formalin Supplementary Hardener

This formula is recommended for the treatment of negatives that would normally be softened considerably by chemical treatment during the removal of several types of stains, or by intensification or reduction techniques.

Water, 500.0 ml
Formaldehyde, 37% (formalin), 10.0 ml
Sodium carbonate, monohydrate, 6.0 g
Water to make 1.0 liter

After hardening for 3 minutes, negatives should be rinsed and immersed for 5 minutes in a fresh acid fixing bath and well washed before treatment.

Caution: Formaldehyde is highly toxic. Use in a well-ventilated area and exercise all handling precautions. Unless your mixing area has an effective fume hood it is highly recommended that you mix formaldehyde outdoors, and even then an appropriately rated fume mask should be used.

FORMULA #194

Kodak SH-5

Prehardener

For high-temperature processing

Water, 900.0 ml
*Kodak Anti-Fog No. 2, 0.5% solution 40.0 ml
Sodium sulfate, 50.0 g
Sodium carbonate, monohydrate, 12.0 g
Water to make 1.0 liter
Formaldehyde, 37% (formalin), 5.0 ml

*Kodak Anti-Fog #2 is 6-nitrobenzimidazole nitrate. To make a 0.5% solution, dissolve 1 gram in 200.0 ml of distilled water.

To use, soak the exposed film in the prehardener for 10 minutes with moderate agitation. Then drain the film for a few seconds, immerse in water for 30 seconds, drain thoroughly, and immerse in the developer. In general, developers such as Kodak D-76 may be used up to 95F/35C. Above 95F/35C it may be better to use developers specifically formulated for tropical developing (Tropical Developers High-Temperature Processing up to 105F/40C, above).

The following are developing time adjustments for use with a prehardener at temperatures between 75F/24C and 95F/35C:

75F/24 Use normal developing time recommended for processing without prehardener at 68F/20C
80F/27 Develop for 85% of time at 68F/20C
85F/29 Develop for 70% of time at 68F/20C
90F/32 Develop for 60% of time at 68F/20C
95F/35 Develop for 50% of time at 68F/20C

After development is complete rinse and fix in an acid-hardening fixing bath such as Kodak F-5. Wash and dry as usual.

At temperatures above 95F/35C, increase the 6-nitrobenzimidazole content of the prehardener up to double the normal formula concentration to control fog. Process as just described, using a low-activity developer to avoid short processing times. The average development time at 110F/43C, after prehardening, is 25% of the normal time at 68F/20C.

NOTE: The entire bath, with the exception of the formalin, may be kept as a stock solution. Just before use, add 5.0 ml of the formalin to each liter and mix thoroughly.

FORMULA #195

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 over-fixing in which previously dissolved silver is absorbed into the material.

Distilled water, 100.0 ml
*Sodium sulfide, anhydrous, 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.

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 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 re-fixing 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.

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 #196

Kodak TC-1

Tray Cleaner

Water, 1.0 liter
*Potassium bichromate, anhydrous, 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 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.

Caution: Add the concentrated sulfuric acid *slowly* with constant stirring to the *cold* solution of the bichromate.

FORMULA #197

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 liter

SOLUTION B

Water, 750.0 ml
Sodium bisulfite, anhydrous, 30.0 g
Sodium sulfite, 30.0 g
Water to make 1.0 liter

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 for cleaning 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 the hands.

NOTE: Store the solution in a stoppered glass bottle away from light.

Caution: Add the concentrated sulfuric acid *slowly* with constant stirring to the *cold* solution of the permanganate.

FORMULA #198

Print Flattener

Glycerin, 60.0 ml
Water to make 1.0 liter

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 glycerin to 3 parts of water before placing them under pressure will also ensure flatness and substantially eliminate their tendency to curl.

FORMULA #199

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 drops

Soak the film for 3 to 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.

REVERSAL DEVELOPMENT

(Chapter 13: Reversal Processing and Enlarged Negatives)

The following formulas are given in the order they are to be used, not alphabetically as are other formulas. Three possible first developers are given. D-67 will produce a higher contrast positive.

First Developer for High-Contrast Positives

FORMULA #200

Kodak D-67

(D-19 + Thiocyanate)

Distilled water at 125F/52C, 500.0 ml
Metol, 2.0 g
Sodium sulfite, anhydrous, 90.0 g
Hydroquinone, 8.0 g
*Sodium carbonate, monohydrate, 52.5 g
Potassium bromide, 5.0 g
+Sodium thiocyanate (liquid), 51%, 3.0 ml
Water to make 1.0 liter

*Sodium carbonate, anhydrous, 45.0 g.
+ 2.0 ml of potassium thiocyanate can be substituted. Reduce the carbonate to 44.5 grams. If liquid sodium thiocyanate is not available, use 2.0 grams of sodium thiocyanate.

Development time is 8–10 minutes at 68F/20C. The contrast of the positive cannot be appreciably changed by varying the development time. However, varying the amount of hydroquinone can be used to adjust the contrast.

FORMULA #201

Kodak D-67R

Replenisher for D-67
Distilled water at 125F/52C, 500.0 ml
Metol, 2.0 g
Sodium sulfite, anhydrous, 90.0 g
Hydroquinone, 8.0 g
Sodium carbonate, monohydrate, 52.5 g
*Sodium thiocyanate, 51%, 7.5 ml
Water to make 1.0 liter

*2.5 ml of potassium thiocyanate can be substituted. Reduce the carbonate to 37.5 grams.

The volume of the first developer needs to be kept constant by adding Kodak D-67R. Replenish the first developer with 18.5 ml per 80^2 inches. If only one roll of film is developed it is possible that less than 18.5 ml will be missing from the total volume. If this is the case then remove as much as necessary to reduce the volume by 18.5 ml and then add the replenisher.

First Developer for Normal Contrast Positives

FORMULA #202

Kodak D-11

Distilled water at 125F/52C, 500.0 ml
Metol, 1.0 g
Sodium sulfite, anhydrous, 75.0 g
Hydroquinone, 9.0 g
*Sodium carbonate, monohydrate, 30.0 g
Potassium bromide, 5.0 g
Water to make 1.0 liter

*Sodium carbonate, anhydrous, 26 g

For use as the first developer in reversal processing dilute 1:3 and develop for 12–15 minutes at 68F/20C.

FORMULA #203

Kodak D-76 + Thiosulfate

Distilled water at 125F/52C, 500.0 ml
Metol, 2.0 g
Sodium sulfite, 100.0 g
Hydroquinone, 5.0 g
Sodium carbonate, anhydrous, 60.0 g
Sodium thiosulfate, pentahydrate, 16.0 g
Potassium bromide, 4.0 g
Water to make 1.0 liter

Use a development time of 10 minutes at 68F/20C.

The contrast of the positive cannot be appreciably changed by varying the development time. However, varying the amount of thiosulfate can be used to create a first developer tailored for a specific emulsion. Increasing the thiosulfate reduces the maximum and minimum densities while decreasing the thiosulfate has the opposite effect.

Bleach and Clearing Baths

FORMULA #204

DW-1

Bleach Bath
(David Wood)

Potassium bichromate, anhydrous, 6.0 g
Water to make 1.0 liter
Sulfuric acid, concentrate, 12.0 ml

Caution: Add the concentrated sulfuric acid *slowly* with constant stirring to the *cold* solution of the bichromate.

Caution: Potassium bichromate is an allergen to some people and a suspected carcinogen. See precautions under potassium bichromate in Pharmacopoeia. If you are concerned about using bichromate use the permanganate bleach and metabisulfite clearing bath, below.
Bleach for 5 minutes at 68F/20C.

FORMULA #205

DW-2

Clearing Bath
(David Wood)

Water, 1.0 liter
Sodium sulfite, anhydrous, 30.0 g

Sodium metabisulfite, 10.0 g
Boric acid, crystalline, 1.0 g
Citric acid, 3.0 g

Clear for 3 minutes at 68F/20C. Discard after 12 rolls of 35-mm 36 exposure rolls of film or equivalent.

SALTED PAPER

(Chapter 14: Printing-Out Processes)

FORMULA #206

Gelatinochloride 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 to 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 to 3 minutes. Allow the paper to dry in the dark.

FORMULA #207

Warm-Tone Printing-Out Paper

Gelatin Sizing

Cold water, 1.0 liter
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 liter

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 #208

Borax Toning Bath

For warm tones

Water 100F/38C, 400.0 ml
Borax, 3.0 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, depending on the tone desired. The longer the toning, the colder the tone will be. Be aware that when the prints are dry, the tone becomes 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 #209

Thiocyanate Toning Bath

For cold tones

Water at 100F/38C, 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 to 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.

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

Direct Conversions from U.S. Customary to Metric Units

Direct equivalents							
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

(*Continued*)

Direct equivalents (Continued)

Grams to grains		*Grains to grams*		*Grains to ounces*		*Ounces to grains*	
grams	*grains*	*grains*	*grams*	*grains*	*ounces*	*ounces*	*grains*
1	15	1	0.06	30	.07	0.1	44
2	31	2	0.13	50	.11	0.2	88
3	46	3	0.19	60	.14	0.3	131
4	62	4	0.26	80	.18	0.4	175
5	77	5	0.32	90	.21	0.5	219
6	93	6	0.39	100	.23	0.6	262
7	108	7	0.45	150	.34	0.7	306
8	123	8	0.52	200	.46	0.8	350
9	139	9	0.58	250	.57	0.9	394
10	154	10	0.65	300	.69	1.0	438
15	231	15	0.97	400	.92	2.0	875
20	309	20	1.30	500	1.15	3.0	1313
25	386	25	1.62	750	1.72	4.0	1750
30	463	30	1.94	1000	2.29	5.0	2185
35	540	35	2.27	2000	4.58	6.0	2625
40	617	40	2.59	3000	6.88	7.0	3060
45	694	45	2.92	4000	9.16	8.0	3500
50	772	50	3.24	5000	11.45	9.0	3940
75	1157	75	4.86	6000	13.75	10.0	4375
100	1543	100	6.48	7000	16.00	16.0	7000
500	7716	500	32.40				
1000	15432	1000	64.80				

Grams to ounces		*Ounces to grams*		*Feet to meters*		*Meters to feet*	
grams	*ounces*	*ounces*	*grams*	*feet*	*meters*	*meters*	*feet (approx.)*
5	.18	1	28.3	3	.91	1	3′ 3″
10	.35	2	56.7	3½	1.07	1.25	4′ 1″
15	.53	3	85.0	5	1.52	1.5	4′ 11″
20	.71	4	113.4	6	1.83	1.75	5′ 9″
25	.88	5	141.7	7	2.13	2	6′ 7″
50	1.76	6	170.1	8	2.44	2.5	8′ 2″
100	3.53	7	198.4	9	2.74	3	9′ 10″
150	5.29	8	226.8	10	3.05	4	13′ 1″
200	7.05	9	255.1	12	3.66	5	16′ 5″
250	8.81	10	283.5	15	4.57	6	19′ 8″
300	10.58	11	311.8	20	6.10	7	23′ 0″
350	12.34	12	340.2	25	7.62	8	26′ 3″
400	14.10	13	368.5	30	9.14	9	29′ 6″
450	15.87	14	396.9	40	12.19	10	32′ 10″
500	17.63	15	425.2	50	15.24	15	49′ 3″
600	21.16	16	453.6	75	22.86	20	65′ 7″
800	28.21	24	680.4	100	30.48	30	98′ 5″
1000	35.27	32	907.2	150	45.72	50	164′ 0″

COMPOUND CONVERSIONS

Although 1.0 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 32.0 ounces (1.0 quart). This means that it takes 30.0 grams in 1.0 liter to make the same working strength solution as 1.0 ounce in 1.0 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 to 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 below.

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 100.0 grams of sodium sulfite and 101.0 grams is an error of 1%. The difference between 1.0 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
0.25 = 3.7
0.3 = 4.4
0.4 = 5.8
0.5 = 7.3
0.55 = 8
0.6 = 8.8

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
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 (1/8 oz)
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
5.5 = 80
5.6 = 81
5.7 = 83
5.75 = 84
5.8 = 85
5.9 = 86
6.0 = 88
6.1 = 89
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
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)
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 365grains
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
250 = 8 oz 146 grains
270 = 9 oz
275 = 9 oz 73 grains
300 = 10 oz
325 = 10 oz 365grains
330 = 11 oz
350 = 11 oz 292 grains
360 = 12 oz
375 = 12 oz 219 grains
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
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
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
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 = 330 oz 146 grains

Liquid Measure Compound Equivalents

Milliliters = Ounces
0.3 ml = 5 minims
1 ml = .032 fl oz (¼ fl dram)
1.1 ml = .035 fl oz
1.2 ml = .038 fl oz
1.3 ml = .042 fl oz
1.4 ml =-.045 fl oz
1.5 ml = .048 fl oz
1.6 ml = .051 fl oz
1.7 ml = .054 fl oz
1.8 ml = .058 fl oz
1.9 ml = .06 (½ fl dram)
2 ml = .064 fl oz.
2.25 ml = .072 fl oz
2.5 ml = .08 fl oz
2.75 ml = .088 fl oz
2.8 ml = .09 (¾ fl dram)
3 ml = .096 fl. oz
3.5 ml = .11 fl oz
3.75 ml = .12 fl oz
3.9 ml = ⅛ fl oz (1 fl dram)
4 ml = .128 fl oz
4.25 ml = .136 fl oz
4.5 ml = .144 fl oz
5 ml = .16 fl oz (1¼ fl drams)
5.5 ml = .176 fl oz
6 ml = .19 fl oz
6.5 ml = .2 fl oz
7 ml = .22 fl oz
7.5 ml = .24 fl oz
7.8 ml = ¼ fl oz (2 fl drams)
8 ml =.256 fl oz
8.5 ml = .27 fl oz
9 ml = .288 fl oz
9.5 ml = .3 fl oz
10 ml = .32 fl oz (2½ fl drams)
11 ml = .35 fl oz
11.7 ml = ⅜ fl oz (3 fl drams)
12 ml = .38 fl oz
13 ml = .416 fl oz
14 ml = .448 fl oz
15 ml = .48 fl oz
15.6 ml = ½ fl oz (4 fl drams)
16 ml = .51 fl oz
17 ml = .54 fl oz
18 ml = .576 fl oz
19 ml = 608 fl.oz.
19.5 ml = ⅝ fl oz (5 fl drams)
20 ml = .64 fl oz
23.5 ml = ¾ fl oz (6 fl drams)
25 ml = .8 fl oz
27.3 ml = ⅞ fl oz (7 fl drams)
30 ml = .96 fl oz
31.3 ml = 1 fl oz (8 fl drams)
35 ml = 1.12 oz
39 ml = 1¼ fl oz
40 ml = 1.28 fl oz
45 ml = 1.44 fl oz
46.9 ml = 1½ fl oz
50 ml = 1.6 fl oz
55 ml = 1¾ 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 = 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
87.5 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 = 10 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 = 16 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
950 ml = 30.4 fl oz
970 ml = 31 fl oz
975 ml = 31.2 fl oz
11 = 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.	Balanced Alkali or Sodium metaborate, octa.	1.70
Balanced Alkali or sodium metaborate, octahydrate	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

The formula specifies:	*You have:*	*Multiply by:*
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, anhy.	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

Sodium Carbonate Conversion Table

The following tables provide a listing of conversions for anhydrous to monohydrate and for crystal to monohydrate.

Anhydrous to Monohydrated

Metric		*U.S. Customary*			
Anhyd.	*Mono.*	*Anhyd.*		*Mono.*	
Grams ⟷	*Grams*	*Oz* ⟷	*Grains*	*Oz* ⟷	*Grains*
0.5	0.58	¼	…	…	128
1.0	1.17	…	145	…	170
1.5	1.73	…	165	…	193
2.0	2.34	…	175	…	205
3.0	3.51	½	…	…	256
4.0	4.68	…	265	…	310
5.0	5.85	…	300	…	351
6.0	7.02	¾	…	…	384
7.0	8.19	…	350	…	410
8.0	9.36	…	360	…	421
9.0	10.53	…	365	…	427
10.0	11.70	…	385	1	13
15.0	17.55	1	…	1	74
20.0	23.40	1¼	…	1	202
25.0	29.25	1½	…	1	330
30.0	35.10	1	260	1	378
35.0	40.95	1¾	…	2	20
40.0	46.80	2	…	2	149
45.0	52.65	2¼	…	2	278
50.0	58.50	2½	…	2	406
55.0	64.35	2¾	…	3	95
60.0	70.20	3	…	3	223
70.0	81.90	3¼	…	3	351
80.0	93.60	3½	…	4	42
90.0	105.30	4	…	4	298
100.0	117.00	5	…	5	372
110.0	128.70	6	…	7	9
120.0	140.40	7	…	8	83
130.0	152.10	8	…	9	193
140.0	163.80	9	…	10	228
150.0	175.50	10	…	11	306

Crystal to Monohydrated

Metric		*U.S. Customary*			
Cryst.	*Mono.*	*Cryst.*		*Mono.*	
Grams ⟷	*Grams*	*Oz* ⟷	*Grains*	*Oz* ⟷	*Grains*
1.0	.43	¼	…	…	47
2.0	.87	…	165	…	71
3.0	1.29	…	175	…	76
4.0	1.73	½	…	…	95
5.0	2.17	…	265	¼	6
6.0	2.60	…	300	¼	20
7.0	3.03	¾	…	¼	32
8.0	3.47	…	350	¼	41
9.0	3.89	…	360	¼	46
10.0	4.33	…	365	¼	49
15.0	6.40	…	385	¼	58
20.0	8.67	1	…	¼	79
25.0	10.83	1¼	…	¼	16
30.0	12.90	1½	…	¼	64
35.0	15.07	1	260	¼	82
40.0	17.34	1¾	…	¾	…
45.0	19.55	2	…	¾	47
50.0	21.67	2¼	…	¾	95
60.0	25.99	2½	…	1	33
70.0	30.34	3	…	1¼	18
80.0	34.67	3¼	…	1¼	65
90.0	38.90	3½	…	1½	4
100.0	43.34	4	…	1½	100
110.0	47.67	5	…	2	74
120.0	52.01	6	…	2½	43
130.0	56.24	7	…	3	13
140.0	60.67	8	…	3¼	96
150.0	65.01	9	…	3¼	61
160.0	69.33	10	…	4¼	36
175.0	75.84	15	…	6¼	66
200.0	86.68	20	…	8½	73

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.

	Dry Weight in Metric Grams	*Teaspoon Amount*
*Amidol	1.6 grams	1 teaspoon
*Ascorbic acid	4.4 grams	1 teaspoon
*Balanced Alkali	4.3 grams	1 teaspoon
*Benzotriazole	0.2 grams	⅛ teaspoon
*Borax	3.8 grams	1 teaspoon
Boric acid	4.1 grams	1 teaspoon
Chlorhydroquinone	3.4 grams	1 teaspoon
*Chrome alum	1.2 grams	¼ 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	21.0 grams	1 Tablespoon
*Thiourea	3.0 grams	1 teaspoon
Tri-sodium phosphate	4.5 grams	1 teaspoon

[*] Spoon measurements may differ slightly in weight each time. These 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 Ec.

TABLE 4 Comparison of Thermometer Scales

Basic conversion factors

To convert Fahrenheit into Centigrade:	To convert Centigrade into Fahrenheit:
Subtract 32; multiply by 5 and divide by 9. *Example: 125°F − 32 = 93 × 5 = 465 ÷ 9 = 51.67°C*	*Multiply by 9; divide by 5; add 32 to result,* *Example: 18°C × 9 = 162 ÷ 5 = 32.4 + 32 = 64.4°F.*

°C ⟷	°F	°C ⟷	°F	°C ⟷	°F	°C ⟷	°F	°C ⟷	°F	°C ⟷	°F
+100	+212										
99.44	211	74.44	166	49.44	121	24.44	76	−0.55	31	−25.55	−14
98.89	210	73.89	165	48.89	120	23.89	75	−1.11	30	−26.11	−15
98.33	209	73.33	164	48.33	119	23.33	74	−1.67	29	−26.67	−16
97.78	208	72.78	163	47.78	118	22.78	73	−2.22	28	−27.22	−17
97.22	207	72.22	162	47.22	117	22.22	72	−2.73	27	−27.78	−18
96.67	206	71.67	161	46.67	116	21.67	71	−3.33	26	−28.33	−19
96.11	205	71.11	160	46.11	115	21.11	70	−3.89	25	−28.89	−20
95.55	204	70.55	159	45.55	114	20.55	69	−4.44	24	−29.44	−21
95	203	70	158	45	113	20	68	−5	23	−30	−22
94.44	202	69.44	157	44.44	112	19.44	67	−5.55	22	−30.55	−23
93.89	201	68.89	156	43.89	111	18.89	66	−6.11	21	−31.11	−24
93.33	200	68.33	155	43.33	110	18.33	65	−6.67	20	−31.67	−25
92.78	199	67.78	154	42.78	109	17.78	64	−7.22	19	−32.22	−26
92.22	198	67.22	153	42.22	108	17.22	63	−7.78	18	−32.78	−27
91.67	197	66.67	152	41.67	107	16.67	62	−8.33	17	−33.33	−28
91.11	196	66.11	151	41.11	106	16.11	61	−8.89	16	−33.89	−29
90.55	195	65.56	150	40.55	105	15.55	60	−9.44	15	−34.44	−30
90	194	65	149	40	104	15	59	−10	14	−35	−31
89.44	193	64.44	148	39.44	103	14.44	58	−10.55	13	−35.55	−32
88.89	192	63.89	147	38.89	102	13.89	57	−11.11	12	−36.11	−33
88.33	191	63.33	146	38.33	101	13.33	56	−11.67	11	−36.67	−34
87.78	190	62.78	145	37.78	100	12.78	55	−12.22	10	−37.22	−35
87.22	189	62.22	144	37.22	99	12.22	54	−12.78	9	−37.78	−36
86.67	188	61.67	143	36.67	98	11.67	53	−13.33	8	−38.33	−37
86.11	187	61.11	142	36.11	97	11.11	52	−13.89	7	−38.89	−38
85.55	186	60.55	141	35.55	96	10.55	51	−14.44	6	−39.44	−39
85	185	60	140	35	95	10	50	−15	5	−40	−40
84.44	184	59.44	139	34.44	94	9.44	49	−15.55	4		
83.89	183	58.89	138	33.89	93	8.89	48	−16.11	3		
83.33	182	58.33	137	33.33	92	8.33	47	−16.67	2		
82.78	181	57.78	136	32.78	91	7.78	46	−17.22	1		
82.22	180	57.22	135	32.22	90	7.22	45	−17.78	0		
81.67	179	56.67	134	31.67	89	6.67	44	−18.33	−1		
81.11	178	56.11	133	31.11	88	6.11	43	−18.89	−2		
80.55	177	55.55	132	30.55	87	5.55	42	−19.44	−3		
80	176	55	131	30	86	5	41	−20	−4		
79.44	175	54.44	130	29.44	85	4.44	40	−20.55	−5		
78.89	174	53.89	129	28.89	84	3.89	39	−21.11	−6		
78.33	173	53.33	128	28.33	83	3.33	38	−21.67	−7		
77.78	172	52.78	127	27.78	82	2.78	37	−22.22	−8		
77.22	171	52.22	126	27.22	81	2.22	36	−22.78	−9		
76.67	170	51.67	125	26.67	80	1.67	35	−23.33	−10		
76.11	169	51.11	124	26.11	79	1.11	34	−23.39	−11		
75.55	168	50.55	123	25.55	78	0.55	33	−24.44	−12		
75	167	50	122	25	77	0	32	−25	−13		

TABLE 5 Film Development Temperature Conversion Chart

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	2.5	*	*
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
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)

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.

Material Sources

Not all chemical suppliers will sell directly to photographers.

ASIA AND THE PACIFIC

Vanbar (chemicals and darkroom supplies); www.vanbar.com.au.

Science Supply Australia (chemicals, lab supplies, educational material); t (03) 9873 2588; www.ssapl.com.au.

Sigma-Aldrich (bulk chemicals); www.sigmaaldrich.com.

EUROPE

ACROS (bulk chemicals); t +32 14 575 211; www.acros.be.

Atelier pH7 (alternative process supplies), 7, rue des Balkans 1180 Brussels, Belgium; www.permadocument.be.

Firstcall Photographic Limited (alternative process, chemicals, darkroom equipment), Cherry Grove Rise, West Monkton, Taunton, Somerset TA2 8LW United Kingdom, t +44 (0)1823 41 3007; www.firstcall-photographic.co.uk.

Fotoimpex (papers, chemistry, film, darkroom supplies), Alte Schönhauserstrasse 32b 10119 Berlin-Mitte, Germany; t 0049 (0)30 28 59 90 81; www.fotoimpex.de.

Fotomatica (chemicals, film), Via Quintavalle 20, 31030, Carbonera, Italy; t +49 (0)422 445 017; www.fotomatica.it.

Fotospeed (chemicals, equipment), Unit 6b, Park Lane Industrial Estate, Corsham, Wiltshire, SN13 9LG United Kingdom; t +44 (0)1249 714555; www.fotospeed.com.

JOBO AG (darkroom equipment manufacturers, including daylight development tanks for large format film), Kölner Straße 58, 51645, Gummersbach, Germany; t +49 (0)2261 545-0; www.jobo.com.

Lotus View Camera (Large format field cameras, photo chemicals), Ernsting 73, 5121 Ostermiething, Austria; t +43 (0) 62 78 79 325-25; www.lotusviewcamera.at.

Manuel Riesgo, S.A. (chemicals, alternative processes), Spain; t 917 953 012; www.manuelriesgo.com.

Paterson Photographic Limited (darkroom accessories), 2 Malthouse Road, Tipton, West Midlands, DY4 9AE, United Kingdom; t 0121 520 4830; www.patersonphotographic.com.

Retro Photographic Ltd (chemicals, alternative process, darkroom supplies), Hollybush Cottage Barn, Candy, Nr. Oswestry, Shropshire, SY10 9BA, United Kingdom; t +44 (0)8452 26 26 47; www.retrophotographic.com.

RH Designs (StopClock enlarger timers, Paper Flasher, analyzers), Mill Fosse House; Hawes; North Yorkshire; DL8 3QF United Kingdom; t 01969 667776; www.rhdesigns.co.uk.

Sigma-Aldrich (bulk chemicals); www.sigmaaldrich.com.

Silverprint Ltd (chemicals, darkroom supplies, equipment), 12 Valentine Place, London, SE1 8QH United Kingdom; t +44 (0)20 – 7620 0844; www.silverprint.co.uk.

NORTH AMERICA

AccuLab (digital electronic scales), 131 Heartland Boulevard, Edgewood, New York 11717; U.S./Canada t (800) 656-4400, International t (631) 254-4299; www.acculab.com.

Antec (bulk chemicals and De-tec film desensitizer), 721 Bergman Avenue, Louisville, Kentucky 40203; t (800) 448-2954, www.kyantec.com.

Artcraft Chemicals (bulk chemicals), P.O. Box 382, Altamont, New York 12009; t (800) 682-1730; www.artcraftchemicals.com.

Bostick & Sullivan (alternative process, chemicals), P.O. Box 16639, Santa Fe, New Mexico 87592; t (877) 817-4320; www.bostick-sullivan.com.

Calumet Photographic (darkroom equipment), 890 Supreme Drive, Bensenville, Illinois 60106; t (800) 225-8638; www.calumetphoto.com.

Canadawide Scientific Ltd (bulk chemicals, lab apparatus), 2300 Walkley Road, Ottawa, Ontario K1G 6B1 Canada; t (800) 267-2362; www. canadawide.ca.

Charles Beseler Company (enlargers, easels), 1560 N.W. Blvd, Vineland, New Jersey 08360; t (800) 237-3537; www.beselerphoto.com.

Cole-Parmer (International source for chemicals and lab supplies, including hard to find chlorohydroquinone), 625 East Bunker Court, Vernon Hills, Illinois 60061; t (800) 323-4340; www.coleparmer.com.

CPM, Inc. (Delta 1 darkroom equipment), 10830 Sanden Drive, Dallas, Texas 75238; t (214) 349-6886, www.cpmdelta1.com.

David Lewis, (Private Label soft-emulsion enlarging paper, bromoil chemical), 457 King Street, P.O. Box 254, Callander, Ontario P0H 1H0 Canada; t (705) 752-3029, www.bromoil.com.

D.F. Goldsmith Chemical & Metal Corp. (plt/pld), 909 Pitner Avenue, Evanston, Illinois 60202; t (847) 869-7800; www.dfgoldsmith.com.

Del Amo Chemical Company (bulk chemicals), 535 West 152nd Street, Gardena, California 90248; t (310) 532-9214; www.delamochemical.com.

Digitaltruth Photo Ltd. (Silvergrain photochemistry, bulk chemicals, equipment, darkroom supplies); 14781 Memorial Drive, Suite # 2342, Houston, Texas 77079; t (888) 391-8922; www.digitaltruth.com.

.dr5-Chrome Lab, (reversal processing of black and white film); 601 Galapago Street, Denver, Colorado 80204; t (303) 534-2375; www.dr5.com.

Edmund Scientific (scales, labware, and apparatus), 60 Pearce Avenue, Tonawanda, New York 14150; t (800) 728-6999; www.scientificsonline.com.

Eight Elm Photo-Video (bulk chemicals), 525 University Avenue, Toronto, Ontario M5G 2L3 Canada; t (416) 597-6638; www.eightelmphoto.com.

Film for Classics, (re-spooled film in discontinued sizes such as 620), Box 486, Honeoye Falls, New York 14472; t (585) 624-4945; www.filmforclassics.com.

Freestyle Photographic Supplies, (darkroom equipment and supplies), 5124 Sunset Boulevard, Los Angeles, California 90027; t (800) 292-6137; www.freestylephoto.biz.

Hanna Instruments (pH meters), 584 Park East Drive; Woonsocket, Rhode Island 02895; t (800) 426-6287; www.hannainst.com.

Hass Manufacturing (Intellifaucet water control monitors), 371 NY Highway 351, Averill Park, New York 12018; t (518) 674-8151; www.hassmfg.com.

JD Photochem (chemicals), P.O. Box 99009, Succ.Fatima, Longueuil, Quebec, J4G-2S6 Canada; t (450) 646-9650; www.jdphotochem.com.

Ohaus Balances & Scales, P.O. Box 2033, 19A Chapin Road, Pine Brook, New Jersey 07058; t (973) 377-9000; www.ohaus.com.

Omega/Satter (Berg toners, enlargers, easels, darkroom accessories, King Concept and JOBO processors), 1041 S Carroll St, Hampstead, Maryland 21074; t (410) 374-3250; www.omegasatter.com.

Pelouze Scale Company (Pelouze R-47 photographic balance beam, postage scales), Sanford, 2707 Butterfield Road, Oak Brook, Illinois 60523; t (877) 724-8324; www.pelouze.com.

Photographers' Formulary (chemicals and kits), P.O. Box 950, Condon, Montana 59806; t (800) 922-5255; formulary@blackfoot.net; www.photoformulary.com.

Print File, Inc, (negative preservers) P.O. Box 607638, Orlando, Florida 32860; t (800) 508-8539; www.printfile.com.

Regal Photo Products Inc (darkroom sinks, dryers, washers), 2769 South 34th Street, Milwaukee, Wisconsin 53215; t (800) 695-2055.

S.K. Grimes (Camera accessories, repairs, custom machining, and modifications), 32 mechanic Avenue, Unit 222 (P.O. Box 1724), Woonsocket, Rhode Island 02895, t (401) 762-0857; www.skgrimes.com.

Sciencelab.com, Inc. (International source for chemicals and lab supplies, including hard to find nickel ammonium sulfate), 14025 Smith Road, Houston, Texas 77396; U.S. t (800) 901-724; International t (281) 441.4400; www.sciencelab.com.

Spectrum Chemicals (bulk chemicals, lab apparatus) 14422 S San Pedro St., Gardena, California 90248; t (800) 342-6615; www.spectrumchemical.com.

Sprint Systems (Sprint proprietary darkroom chemicals), 100 Dexter Street, Pawtucket, Rhode Island 02860; t (800) 356-5073; www.sprintsystems.com.

Stouffer Industries (step-wedges), 922 S. Cleveland Street, Mishawaka, Indiana 46544; t (574) 252-5772; www.stouffer.net.

Tekniscience Inc. aka Biobar.ca, (chemicals and lab apparatus) 2425, Edouard-Michelin, Suite 200, Terrebonne, Quebec J6X 4P2 Canada; t (800) 267-9799; www.biobar.ca.

WEB SITES

Adox Film, www.adox.de
Alternative Photography, www.alternativephotography.com
Analog Photography Users Group, www.apug.org

Azo Forum, www.michaelandpaula.com/mp/AzoForum
Camera Arts, www.cameraarts.com
Classic Enlargers, www.classic-enlargers.com
Darkroom Automation, www.darkroomautomation.com
Digital Truth, www.digitaltruth.com
Large Format Photography, www.largeformatphotography.info
Mike Ware Alternative Photography, www.mikeware.co.uk
PhotoNet, www.photo.net
Phototakers Forum, www.phototakers.com
Silvergrain Research, www.silvergrain.org
The Classic Camera, www.cosmonet.org
The Contact Printers Guild, www.contactprintersguild.com
The Light Farm, www.thelightfarm.com
The Royal Photographic Society, www.rps.org
Unblinking Eye, www.unblinkingeye.com

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