The Permanence and Care of Color Photographs:

Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures

Cecil W. Stoughton – August 14, 1963 (Courtesy of the John Fitzgerald Kennedy Library)

Henry Wilhelm

with contributing author

Carol Brower

Unfaded print made with Fujicolor SFA3 paper available at the end of 1992.

Fujicolor SFA3 color print after the equivalent of 50 years of display.

Fujicolor SFA3 print after 240 days in an accelerated dark fading/staining test.

Unfaded print made with Kodak Ektacolor paper available at the end of 1992.

Kodak Ektacolor print after the equivalent of 50 years of display.

Kodak Ektacolor print after 240 days in an accelerated dark fading/staining test.

Some color photographs last far longer than others. Some fade when exposed to light on display but are very stable when stored in the dark. Several new color print processes, which employ high-stability pigments instead of organic dyes to form the color image, will probably last for hundreds of years, both when displayed under normal conditions in a home, office, or museum and when kept in dark storage.

But most color films and papers on the market today gradually fade and develop overall yellowish stain when they are exposed to light or when they are stored in the dark. In most cases there are no differences in image stability between the color prints sold by professional portrait and wedding photographers — most of whose prints are made with Kodak Ektacolor "professional" paper and may sell for many hundreds of dollars — and the 35¢ Ektacolor prints available through the local drugstore. Worse still, because most professional portraits have been retouched and lacquered, they may deteriorate even *faster* than amateur color snapshots.

The result of more than 20 years of research, this is the first major book to evaluate the light fading and dark fading/yellowing characteristics of color transparency films, color negative films, and color papers. Recommendations are given for the longest-lasting products. High-resolution ink jet, dye-sublimation, color electrophotographic, and other digital imaging technologies are discussed.

The humidity-controlled cold storage facilities for the long-term preservation of color photographs and motion pictures at the John F. Kennedy Library, NASA, the Art Institute of Chicago, Paramount Pictures, Turner Entertainment, and Warner Bros. are described. Also discussed are conservation matting, mount boards, framing, slide pages, negative and print enclosures, storage boxes, densitometric monitoring of black-and-white and color prints in museum and archive collections, the discoloration and cracking of black-and-white RC prints, the care of color slide collections, the permanent preservation of color motion pictures, the historic Technicolor print process, the preservation of cellulose nitrate films, and many other topics.

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Wilhelm
and
Brower

The Permanence and Care of Color Photographs:

Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures

Preservation Publishing Company

A publication of THE CENTER FOR THE IMAGE.ORG *in association with* WILHELM IMAGING RESEARCH, INC.

About the Offset-Printed, PDF, and PDF/A Digital Editions of This Book

This publication was originally published as a high-quality offset-printed Smyth sown hardbound book on June 16, 1993. Printed at Arcata Graphics in Kingsport, Tennessee, the press run was 13,000 copies and the book has long been out of print.

A high-resolution Acrobat PDF of the complete book and each of its twenty chapters was posted on the Wilhelm Imaging Research, Inc. website <www.wilhelm-research.com> on June 6, 2003. Available without charge, more than one-half million copies of the PDF edition of the book have been downloaded worldwide since it was posted in 2003.

Henry Wilhelm and Carol Brower wrote, edited, and designed the page layout for the entire book using Aldus PageMaker software running on Apple Macintosh computers (Aldus Corporation merged with Adobe Systems, Inc. in 1994). PageMaker allowed for the export of a PostScript version of the page layout and, with all of the photographs rescanned, sized, and placed in the layout, it later became possible to produce a compact, authentic PDF file of the entire book, complete with searchable, vector-mapped type, and with high-resolution color and black-and-white photographs.

In order to produce the first PDF edition – a complex task that was undertaken fully ten years after the book was originally published in 1993 – it was necessary to preserve and maintain in operational condition the original Macintosh computers, Mac OS 7.1, the original Aldus PageMaker 4.2 software and associated files, all of the original Bitstream and Monotype digital type fonts used for the book (none of which are now commercially available), as well as the original PageMaker 4.2 text and page layout files, monochrome and color PPD and preference files, and sets of kerning and hyphenation tables for each of the twenty chapters, the book's cover and introduction materials. All of the original color and black-and-white photographs reproduced in the book have also been carefully preserved in humidity-controlled freezer storage at minus 20°C (4 below zero degrees F).

Migrating the original PDF files prepared in 2003 to the PDF/A-1b format [ISO 19005-1 Level B Conformance] was also difficult, and it proved necessary to reconstruct PostScript files for the entire book and to make changes in the color management scheme in order to comply with the file structure requirements of PDF/A-1b while at the same time preserving the original color and density of the color and black-and-white photographs in the book. PDF/A is standardized within the International Organization for Standardization (ISO), headquartered in Geneva, Switzerland < http://www.iso.org/iso/home.html>. Adobe states: "PDF/A stands for PDF for Archiving. It is a set of ISO Standards (ISO 19005) using a subset of the PDF format that leave out PDF features not suited for long-term preservation." PDF/A is designed for long-term digital preservation and access in archives, libraries, museums, universities, colleges, and other collections <http://en.wikipedia.org/wiki/PDF/A> and <http://www.adobe.com/enterprise/standards/pdfa/> and < http://www.adobe.com/enterprise/pdfs/pdfaforAcrobat.pdf>.

Posted on <www.wilhelm-research.com> on March 18, 2013, the new PDF/A edition of the complete book – and separately, each of the book's twenty chapters – replaces the original security-protected 2003 PDF edition and it continues to be available worldwide without charge. Historically, it is of interest to note that Adobe released the first version of Acrobat software and Acrobat PDF on June 15, 1993, just one day before this book was originally published on paper on June 16, 1993. Only six weeks earlier, on April 30, 1993, the underlying technology of the network that posted the world's first Web page was put into the public domain and made free and open to all. Designed by British computer scientist Tim Berners-Lee and a team of physicists and engineers working at CERN (the European Organization for Nuclear Research) in Geneva, Switzerland, Berners-Lee named the new network the "World Wide Web" (www). The first sentence of the first web page read: "The World Wide Web [aims] to give universal access to a large universe of documents."

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Reviewers Write About the World's First and Only Book On The Preservation of Color Photographs and Motion Pictures

Since its publication in 1993, ***The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures***, by Henry Wilhelm and contributing author Carol Brower, has received critical acclaim in more than 100 reviews and articles in newspapers, photography magazines, and museum publications. In September 1994, the book was awarded a special commendation by the Society of American Archivists for ". . .writing of superior excellence and usefulness, which advances the theory and practice of preservation in archival institutions." Although this fully-illustrated 744-page hardbound book focuses on color photography, it also gives the most comprehensive set of recommendations ever published on the storage and display of black-and-white photographs, and is the first book published in the world on the stability and preservation of color photographs and motion pictures. A free high-resolution PDF digital edition of the complete book was posted on the Wilhelm Imaging Research, Inc. website <www.wilhelm-research.com> in June 2003, and since that time more than one-half million copies of the PDF book have been downloaded. A newly-prepared PDF/A edition of the book was posted on March 18, 2013.

- "The phrases 'instant classic,' 'definitive work' and 'standard reference work' may be somewhat abused these days but if they were ever appropriate it would be to describe the 740 plus pages of ***The Permanence and Care of Color Photographs*** . . . ."
  — Joseph Meehan (***Photo District News***, July 1994)
- " 'Finally,' sighs National Geographic Society's Robin Siegel, conservator of some 12 million photographs. 'We've been waiting for documentation like this from a reputable source.' Adds Peter Galassi, director of photography for New York's Museum of Modern Art: 'Henry's work has been enormously valuable to us for protecting our collection.' "
  — Wendy Bounds (***The Wall Street Journal***, August 9, 1994)
- "***The Permanence and Care of Color Photographs*** is the most significant photography book to be published in recent years. The book ties together the history of color photography, as well as the latest developments in digital imaging, providing a fascinating overview of where photography has been – and its projected future. As a resource book it is unsurpassed."
  — Scott Teaford (***Communication Arts – 1994 Photography Annual***, August 1994)
- "This book is a must for anyone concerned about archiving color images, and should be required reading for all stock agencies, picture libraries, and corporate archivists . . . ."
  — George Schaub (***Outdoor & Travel Photography***, November 1993)
- ". . . a front-line report on the fierce battle between the consumers of photographic materials – filmmakers, photographers, archivists, even the public – and the manufacturers, especially Eastman Kodak."
  — A. D. Coleman (***Photography in New York***, January/February 1994)
- "This is the most important book on the craft of photography to have been published in ages. I rank the significance of this book up there with Ansel Adams' books on basic photography."
  — Ctein (***Photo-Electronic Imaging***, September 1993)
- "I cannot imagine anyone responsible for a collection of color photographic images who will not be richly rewarded by having a copy of this book, for background information and ready reference. I know of no other such comprehensive survey of this whole field, all its information scrupulously researched, clearly and attractively presented."
  — Daniel W. Jones, Jr. (**Peabody Museum, Harvard University**, September 1993)
- "Mr. Wilhelm's work is a valuable guide for everyone who uses a camera seriously. It is packed with tips on what color film to use, how to find the right processing [labs] and how to mount and store pictures."
  — John Durniak (***The New York Times***, July 18, 1993)
- "With 20 years of intensive research behind it . . . ***The Permanence and Care of Color Photographs*** reads more like an encyclopedia than a general textbook on the care of color photographs. It is not just about color photography. This book is really the definitive reference book on the preservation of 20th-century photographic materials, and it tells an intriguing story. It does not flinch from identifying the aging characteristics of specific brand names, and in doing so, Wilhelm has helped the photographic community set higher standards for image permanence. This book is also important because it will greatly serve future historians as they examine the transitional years from the dominance of photography based on silver halide chemistry to the emergence and eventual succession of digital electronic imaging."
  — Mark H. McCormick-Goodhart (***Journal of the American Institute for Conservation***, Spring, 1996)

THE NEW YORK TIMES, SUNDAY, JULY 18, 1993

CAMERA

John Durniak

Making Color Last: An Expert Speaks

NOT many photographers walk into a photo shop and ask, "Will the film you're selling me and the prints you make last a hundred years?"

But Henry Wilhelm has spent most of his life in the world of photography testing how long photographic films and prints — both black-and-white and color — can last, and what can be done to make them last longer.

He has just written a book on the subject, "The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides and Motion Pictures." It has long been awaited in the field and is a welcome guide to quality and permanence of photographic and electronic images.

The author is well known as a tester of film and equipment. He was a founding member of the American National Standards Institute subcommittee that created testing methods for measuring the stability of color photographs. He was also a founding member of the photographic materials group of the American Institute for Conservation.

Mr. Wilhelm thinks the transition from black-and-white to color photography has been a rough one. "The change to color," he writes, "resulted in the loss of the essentially permanent images provided by black-and-white photography that had long been taken for granted by photographers and the general public alike."

The major problem with color is that it fades. Just as clothes, car finishes, flags and paint fade, so does color in photographs. The main villains are heat, moisture and light,

In the photographic industry, fading is a major problem, more whispered about than discussed openly. But it is a serious matter for the consumer who sees images growing dim in their frames and for museum curators who must care for perishable treasures. Increasing stability is a high priority in the development, manufacturing and marketing of photographic color films, color papers and processing systems.

The scope of the book is encyclopedic. Its 20 chapters cover the past, present and future of knowledge of image deterioration and stability. There are over 2,600 items in the index, and 543 pictures, including many examples of just how color fades. (The book covers products and tests through late 1992.)

Mr. Wilhelm's work is a valuable guide for everyone who uses a camera seriously. It is packed with tips on what color film to use, how to find the right processing centers and how to mount and store pictures.

Carol Brower, his wife, also an expert on preserving images, is listed as a contributing author. She wrote a chapter on the handling, presentation and conservation matting of photographs, a subject of great importance since the chemicals in some mounting materials contribute to image deterioration.

Generously scattered throughout the 744 pages are large, boxed-off blocks of text in which the author names names, describing faults and praising strengths in films, papers, storage systems and processes.

In one such box, he answers one of the most frequently asked questions: What are the overall longest-lasting color transparency films?

Four of the answers come from Fujichrome: the company's professional, Velvia professional, amateur and CDU duplicating films. If projection can be avoided (for example, by showing duplicates instead), Kodachrome professional and amateur films will last just as long. He gives similar information for color negative films in four speeds and for paper to be used in making prints.

These sections, "Recommendations," are the parts most photographers will probably read first.

It may take all summer to get through this large, detail-packed book. But the time to think about lasting quality of color and lasting images is *before* shooting and processing film.

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"The Permanence and Care of Color Photographs" costs $69.95, plus $4.95 for shipping and handling, from Preservation Publishing Company, Box 567, 719 State Street, Grinnell, Iowa 50112; telephone (800) 335-6647; fax: (515) 236-0800.

John Durniak is a freelance writer, editor and consultant on photography.

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Reviews

Henry Wilhelm with Carol Brower, contributing author, *The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures*. Grinnell, Iowa: Preservation Publishing Company, 1993. ISBN: 0-911515-00-3. (744 pp) $69.95.

Reviewed by M. Susan Barger

Dr. Barger is at the University of New Mexico's Department of Earth and Planetary Sciences, in Albuquerque, NM 87131. She is perhaps best known for her research on daguerreotypes.

Nineteen years ago, when I was a graduate student in photographic science, a small group of us put in our order for a dozen copies of Henry Wilhelm's upcoming book on the stability of color photographs. At the prepublication price of around $2.00, how could we go wrong?

There is no question that Henry Wilhelm is largely responsible for initiating the rising consciousness of the importance of photographic image stability that we have seen over the last twenty-five years. Many of us still have yellowing copies of his first book, *Procedures for Processing and Storing Black and White Photographs for Maximum Possible Permanence,* which was first published in 1969. It was printed on newsprint and sold for the grand sum of 50¢. That small book is, as far as I have been able to tell, the first publication for a lay audience that directly addressed photographic processing for maximum permanence. There are older publications on good processing practice, but none of them ties processing to image permanence in such a direct way.

Anyone who has been paying attention to photography during the last twenty-five years knows that, in many ways, Henry Wilhelm has been the David to the photo industry's Goliath. Tweaks from Wilhelm's direction have pushed the photo industry to address the problem of image stability, particularly color image stability, in a much more public and active way than they had done previously.

Indeed, the Image Permanence Institute at Rochester Institute of Technology was established by the Society of Photographic Scientists and Engineers and members of the photo industry partly because of concerns raised by Wilhelm about industrial bias and secrecy. Thus, the Institute, as a nonindustrial center, would address issues of photographic image stability. Further, because Wilhelm was working away in Grinnell, Iowa on color stability, those working in other areas of photographic conservation were able to say with some authority that although color was an almost insurmountable problem, the information that curators, collectors, and archivists needed in order to care for these ephemeral objects would finally be available when Wilhelm's book was published. The book was coming any minute.

Long ago, we gave up waiting for the book, but I was very pleased to see that this past fall Wilhelm's great work was finally published. The question that needs to be asked here is, "Was it worth the wait?"

The Permanence and Care of Color Photographs is full of information, much of which has never been available or has never been gathered together in one place. The research described in the book is ongoing and the results are current to the end of 1992, the time the book went to press. For those that find the book overwhelming, it is possible to get the "take-home message" by reading just the Recommendations found in most of the chapters. The items that have grabbed the most press attention in the wake of the book's appearance are from the list in Chapter 1 of recommended products for obtaining the most stable photographic images. Wilhelm names names and spares no company in his critical evaluations of the stability of various color photographic products. While he may seem heavy-handed towards Kodak, this probably has more to do with the dominant market position that Kodak has enjoyed, especially in the United States. There is also a measure of glee that we take when the veil of industrial secrecy is pierced and we see that an industrial giant did not always operate in the most honest way. For instance, in his history of modern color imaging materials (i.e., Kodachrome® and subsequent products), Wilhelm points out that Kodak has issued products knowing that they were not stable and has deliberately replaced more stable products with less stable products. The situation was amplified by advertising rhetoric that calls us to preserve our precious moments on film. Several chapters, especially the one on wedding and portrait photographers, point out the often poignant and tragic loss that occurs when photographic images have faded away. This loss is emphasized in many of the illustrations throughout the book.

If the reader is interested in how Wilhelm arrived at his product recommendations, the first third of the book provides detailed descriptions of his tests and testing procedures. I found the delineation of his approach to testing imaging stability absorbing and quite pertinent to both the common use of photographs and to how we see. The section on accelerated aging procedures for color materials is very detailed and brings up issues that should be considered by anyone who uses accelerated aging testing for any type of materials. Wilhelm provides a good history of image stability testing and carefully describes the contributions made by the entire photo industry, especially Kodak, in this area.

There are two chapters devoted to the color films used in the motion picture industry. This includes recommendations for preserving what is now in archives and describes the best available current products for the production of new films. One entire chapter is devoted to Technicolor®, its history and properties.

Finally, the last ten chapters of the book are devoted to the care, storage, and display not only of color photographic materials of all types, but also of black and white materials. There are lengthy discussions of adhesives and mounting, marking methods, conservation matting, mat boards, storage envelopes, sleeves, boxes, and the like. This portion of the book brings together much of the work on the care and conservation of photographic materials which has evolved over the last twenty-five years and puts it in one place for the reader.

This book, in spite of its mostly positive qualities, should have been edited for continuity. The book was obviously written at different times, because much of the same information is repeated over and over again in the various sections. As persistent readers approach the back of the book, they may become confused and think they are reading some previous section. A good editor could have made the book more compact and easier to read and would have enhanced access to the valuable information and message that this book carries. I was also struck by a comment made by a photo curator when I said I was writing a review of this book. He said that the book looked so much like a chemistry text that although it is a "must-have" addition to any photo library, it was probably too difficult for him to attempt to read. This is not a chemistry book, for there is little or no information that could be called chemistry. Despite its appearance and technical content, this book can be profitably read by anyone with an interest in photographic preservation.

This book will not be widely available through your local bookstore, so those interested in purchasing it should contact the publisher directly. The address is: Preservation Publishing Co., 719 State St., Grinnell, Iowa 50112-0567. The cost is $69.95 per copy plus $4.95 shipping.

The Permanence and Care of Color Photographs:

Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures

Cecil W. Stoughton – August 14, 1963 (Courtesy of the John F. Kennedy Library)

President John F. Kennedy and his family at their summer home on Squaw Island, near Hyannis Port, Massachusetts.

The John Fitzgerald Kennedy Library in Boston, Massachusetts. The Library is administered by the National Archives.

April 1988 (2)

Library, in one of the Library's cold storage vaults examining the original color negative from the Kennedy family photograph. Since 1980, this negative and many of the other 18,000 color negatives in the collection have been stored at 55°F (12.8°C) and 30% RH. The Library plans to move the negatives to the 0°F (–18°C), 30% RH vault as soon as an improved image-reference system is implemented.

About the Cover

The photograph of President John Fitzgerald Kennedy, his wife Jacqueline Bouvier Kennedy, and their children Caroline B. Kennedy and John F. Kennedy Jr., on the cover of this book was taken on August 14, 1963 at the Kennedys' summer home on Squaw Island, near Hyannis Port, Massachusetts. The photographer, Cecil W. Stoughton, was an officer in the U.S. Army Signal Corps and served as a White House photographer. The photograph was made with Ektacolor color negative film in a Hasselblad camera.

Allan B. Goodrich, audiovisual archivist at the John Fitzgerald Kennedy Library in Boston, related the following about the picture: "John Jr. was approaching 3 years of age in 1963; Caroline would turn 6 years old in November. The dogs all belonged to the Kennedy family — JFK always liked dogs. The pups were the offspring of Charlie (the dog with Caroline) and Pushinka, which was the dog that Chairman Nikita Khrushchev of the Soviet Union gave to President Kennedy in 1961. John Jr. has his arm draped around Shannon. The shepherd's name was Clipper; the Irish Wolfhound was called Wolf."

On November 22, 1963 — exactly 100 days after this picture was taken — President Kennedy was assassinated in Dallas, Texas while campaigning for re-election.

It was during the 1960's that the historic shift from black-and-white to color photography began in earnest. Kennedy, who was inaugurated in 1961, was the first president to be photographed primarily in color. The Kennedy Library preserves these color photographs in 0°F (–18°C) and 55°F (12.8°C) cold storage vaults that are maintained at 30% relative humidity. When the Kennedy Library opened in 1979, it was the first collecting institution in the world to provide such a facility (see Chapter 20).

The Kodak Ektacolor and Kodacolor-X color negative films in the White House collection at the Kennedy Library have very poor image stability. According to unpublished Kodak data, these films are expected to suffer a 10% loss of density of the least stable image dye in less than 6 years when stored at normal room temperature (see **Table 5.14** on page 204). After President Kennedy's death, the White House color negatives were stored for more than 15 years under non-refrigerated conditions until the Library building was completed in 1979 and the negatives were placed in cold storage.

The photograph on the cover was reproduced from a Kodak Dye Transfer print that was made in 1975 from the original color negative (using an Ektacolor Print Film interpositive). In the course of making the Dye Transfer print, adjustments were made to correct for curve imbalances and loss of contrast in the original negative.

The Permanence and Care of Color Photographs:

Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures

by

Henry Wilhelm

with contributing author
Carol Brower

All of the photographs in this book were taken by Henry Wilhelm, except where noted.

PRESERVATION PUBLISHING COMPANY

GRINNELL, IOWA

U.S.A

This book is dedicated to
Sarah, David, and Charles Wilhelm,
and all the children of the world,
past, present, and future . . .

Henry Wilhelm – July 1986

Sarah
7½ years old

Henry Wilhelm – July 1986

David
5 years old

Carol Brower Wilhelm – April 1993

Charles
9½ months old

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This book was written and designed with Aldus PageMaker software on Apple Macintosh computers. Jim Powers, publications art director at Grinnell College, educated the authors about the nuances of PageMaker. Imagesetter output was produced by Waddell's Computer Graphic Center in Des Moines, Iowa. Color separations, black-and-white halftones, printing, and binding were provided by Arcata Graphics Company in Kingsport, Tennessee. Black-and-white lab work was done by the authors and by The Fine Print and North-Light custom labs in Minneapolis, Minnesota. The index was prepared by Rus Caughron for Carlisle Publishers Services in Dubuque, Iowa.

Henry Wilhelm and Carol Brower give presentations on the preservation of black-and-white and color photographs at the Visual Studies Workshop in Rochester, New York. The week-long workshop, which took place in August 1978, also featured as speakers Klaus B. Hendriks of the National Archives of Canada, Frank McLaughlin of Eastman Kodak, and Guenther Cartwright of the Rochester Institute of Technology.

About the Authors

Henry Wilhelm is one of the founding members of the American National Standards Institute subcommittee established in 1978 to write the now-completed ANSI IT9.9-1990 Standard on test methods for measuring the stability of color photographs. For the past 6 years he has served as secretary of that group. Wilhelm is also a member of the ANSI subcommittees on test methods for evaluating the stability of black-and-white films and prints, and is a founding member of the Photographic Materials Group of the American Institute for Conservation.

In 1980, Wilhelm served as a volunteer technical advisor to film director Martin Scorsese and his staff (Scorsese is the director of *Taxi Driver* [1976], *Cape Fear* [1991], *The Age of Innocence* [1993], and other films) in their successful effort to persuade Eastman Kodak and Fuji Photo Film Co. Ltd. to increase the stability of their color motion picture films.

In 1981, Wilhelm received a one-year fellowship from the John Simon Guggenheim Memorial Foundation of New York City for a long-term study of color print fading and staining under low-level tungsten illumination that simulates museum display conditions. In 1982, Grinnell, Iowa businessman and entrepreneur Sharp Lannom IV and Wilhelm established Preservation Publishing Company, which published this book.

Wilhelm has been involved with photography since childhood. In 1961–62, while attending high school in Arlington, Virginia, he was a part-time photographer for the *Washington Daily News* and also had a summer job at Hunter Associates Laboratory, Inc. assembling electronic instruments for measuring color and whiteness. Wilhelm became interested in the preservation of photographs in 1963 while working in the hot and humid jungles of Bolivia as a member of the Peace Corps.

In the mid-1960's, as a student interested in fine art and documentary photography, he and several of his friends at Grinnell College spent much of their time photographing news events for the college newspaper and other publications. They traveled to Selma, Alabama; Chicago; Washington, D.C.; and other cities to photograph the civil rights struggle and the emerging protests against the Vietnam war.

Wilhelm and fellow student John Phillips photographed, designed, and wrote *Grinnell College – 1966*, which was seized and banned by the college after it had been delivered to the printer. Twenty years later, under a new president, the college finally published this controversial yearbook.

In 1966, Wilhelm served as an assistant to Ansel Adams during one of Adams's photography workshops in Yosemite National Park in California. Discussions with Adams further increased Wilhelm's interest in the preservation of photographs. In 1967, Wilhelm established the East Street Gallery in Grinnell to exhibit the work of Midwestern fine art photographers.

In 1972, Wilhelm received the first of two U.S. patents for the design of archival print washers for black-and-white fiber-base prints; he produced the print washers for a number of years under the East Street Gallery name. In 1969, Wilhelm published a 26-page booklet entitled *Procedures for Processing and Storing Black and White Photographs for Maximum Possible Permanence*. Research which began with that publication led to the writing of this book.

Carol Brower, an artist, became actively interested in the subject of preservation as an undergraduate student in the School of Art and Design, Department of Fine Arts, at Pratt Institute in New York City (1969–1974). Her concerns regarding the longevity of drawing papers, pencils, inks, and paints used in her own work led to her working for galleries where a high priority was placed on conservation.

In 1972, Brower began to investigate and promote the proper handling and conservation matting of photographs; she is best known for her matting of photographic prints for many of the major museums and galleries in New York City, including Castelli Graphics, Laurence Miller Gallery, Life Picture Gallery, Light Gallery, Pace/MacGill Gallery, and others. During the past 20 years, Brower has worked with many photographers, curators, and private collectors, and has matted a wide variety of photographs made by a broad spectrum of photographers, ranging from the little-known to the historically prominent. She has been a member of the Photographic Materials Group of the American Institute for Conservation since 1982, and a member of the Professional Picture Framers Association since 1985.

As contributing author to this book, Brower wrote Chapter 12, which discusses the handling, presentation, and conservation matting of fine photographic prints. With Wilhelm, she co-authored Chapter 13 on the composition and stability of mount boards. Brower assists Wilhelm in various aspects of his research and writing, and she took many of the photographs in this book. In addition to her work at Preservation Publishing Company, Brower continues to do conservation matting for clients in New York City and elsewhere.

Brower and Wilhelm became acquainted in 1978 when Brower's concern about possible adverse effects of alkaline-buffered boards and papers on color photographs led her to contact Wilhelm. Brower moved to Grinnell from New York in 1990. Wilhelm and Brower were married in 1991.

Introduction: Looking Toward the Future

Since the modern era of color photography began with the introduction of Kodachrome and Agfacolor transparency films in 1935–36, there has never been a more exciting time in the fields of still and motion picture photography. Or, taking into account the rapid emergence of "photo-realistic" digital imaging, recording, and high-resolution color printing technologies, it would be more appropriate to say that there has never been a more exciting time in the history of color *imaging!*

Many more ways are now available to make color still photographs and moving images than at any time in the past, and there are more ways to make color prints than ever before. Photographs can be originated on traditional color film and scanned to produce a digital image file for input to a personal computer or workstation running Adobe Photoshop or other image-processing software. The computer-corrected/enhanced/manipulated color image can be written back to color negative or transparency film with a high-resolution film recorder, creating what is called a "second-generation original," which in turn can be used to make prints in a darkroom with traditional color papers from Kodak, Fuji, Konica, Agfa, or Ilford.

Or the digital file can be output directly on plain paper with an Iris high-resolution ink jet printer; or to a Kodak XL 7700-series printer to produce an Ektatherm thermal dye-transfer (dye-sublimation) print; or to an imagesetter to generate separation negatives for making an UltraStable pigment color print; or to a Canon Color Laser Copier or other color copier with a digital signal interface to produce a low-cost, plain-paper print; or to a large-format Xerox Versatec liquid-toner electrostatic color printer; or to an imagesetter to make separation negatives for high-quality 4-color (or 7-color, or 10-color) printing by offset lithography or other process; or printed with . . . ?

Or the digital image file can be output with a Metrum Foto-Printer to directly expose a Fujicolor, Ektacolor, Konica Color, or Agfacolor print; or output to an Ilford Digital Imager to create an Ilfochrome silver dye-bleach print; or output to a . . . ?

The digital image file may be stored on a magnetic hard disc, a rewritable magneto-optical disc, a writable CD (e.g., a Kodak Photo CD), magnetic tape; or stored on . . . ?

The digital image file may be transmitted to the other side of the world and be recorded and/or immediately output using any of the above color imaging systems. (Some daunting hardware and software problems must be solved, however, before it is certain that these digital image files will still be usable 15, or 25, or 100 years from now — and beyond.)

The merging of traditional photography with computer image processing, viewing, data recording, and image data-base technology; graphic arts electronic prepress systems; television (which will accelerate with the adoption of digital HDTV systems during the remainder of the decade); and telecommunications networks — including direct satellite broadcast and high-capacity wire and fiber-optic cable TV systems — has greatly expanded the options available in color imaging, storage, printing, and transmission. Indeed, among the most promising technologies for producing highly stable color prints at reasonable cost are the high-resolution liquid-toner electrophotographic systems (e.g., 3M Digital Matchprint) and ink-jet printing systems (e.g., Iris Graphics printers) that have been developed for the graphic arts proofing field.

The potentially extremely long-lasting UltraStable, EverColor, and Polaroid Permanent-Color pigment color prints, which are printed with separation negatives produced from digital files generated on high-resolution graphic arts scanners, are examples of the merging of old and new imaging technologies.

(At the time of this writing, Charles Berger, the inventor of the UltraStable process, was preparing UltraStable prints of photographer William Coupon's portraits of the six living United States presidents: Clinton, Bush, Reagan, Carter, Ford, and Nixon. Produced under contract for Time Inc. in New York City, a set of these six prints is to be given to the National Portrait Gallery in Washington, D.C. The UltraStable prints will last far longer than the very faded Kodak Ektacolor and Dye Transfer portraits of five presidents in the collection of the Lyndon Baines Johnson Library and Museum in Austin, Texas, which are reproduced on page 36.)

Multimedia systems, which in various ways combine still images, moving images, and sound, are finally bringing together the previously separate fields of still photography and motion picture and television moving-picture imaging.

More than 20 years ago, when this author began the image stability research reported in this book, there were fewer color films and papers to contend with. Electronic systems for still photography — which had achieved considerable sophistication in space exploration, military intelligence-gathering, and certain scientific fields — had not yet appeared in the general marketplace. In recent years, however, with increased international competition among the world's four principal manufacturers of color films and papers — Kodak, Fuji, Agfa, and Konica — the pace of new product introduction has accelerated greatly. Most color negative films are now on the market for only 2 or 3 years before they are replaced by new products. Improved color papers are being introduced almost as frequently. New "photo-realistic" digital color printing (color hardcopy) systems are announced almost monthly.

While it appears that traditional color films will continue to be the primary means of taking still photographs until well into the next century, alternative methods of making color prints will become increasingly important in many segments of the photography market.

When exposed to light during display, or when stored in the dark, some color materials last far longer than others. Evaluating the image stability characteristics of a color film or paper takes time. Once samples of a new product are obtained,

Henry Wilhelm examining color print samples in a low-level, 1.35 klux incandescent tungsten light fading test that had been in progress for more than 10 years at the time this book went to press in 1992. Similar 1.35 klux tests are conducted with fluorescent illumination. Data obtained from these long-term tests allow predictions to be made for permissible display periods for various types of color prints when displayed in museums and archives.

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up to a year or more is required to conduct meaningful tests. The recommendations for the longest-lasting color films and papers given in Chapter 1 on pages 3 to 6 were based on this author's tests together with the often incomplete but nonetheless very valuable accelerated dark fading data supplied by the manufacturers. Most of this information has not previously been available.

It was this author's goal that these recommendations be *current* at the time this book went to press at the end of 1992, and all of those involved with this book can take satisfaction in the fact that this goal was, for the most part, achieved.

In making a recommendation for a particular type of color film or paper — the longest-lasting color slide film, for example — it is of course necessary to test all the different products on the market. In recommending Fujichrome films as, overall, the longest-lasting transparency films available, this was done. At the Photokina trade show in Germany in September 1992, however, Kodak announced that new Ektachrome films would be introduced in 1993. Samples of these films — Ektachrome Lumiere professional films and Ektachrome Elite amateur films — were not available in time to include test data on these products in this book. Is the projector-fading and dark storage stability (including rates of yellowish stain formation) of these new films better than that of previous Ektachrome films? Are they more stable than the Fujichrome films listed in the recommendations on page 3? At the time this book went to press, Kodak had declined to disclose the results of its stability tests with these new films.

(In recent years, Kodak has been very reluctant to make stability data available; for example, Kodak has not released image stability data for *any* of its Process RA-4 Ektacolor papers, the first of which, Ektacolor 2001 paper, was introduced in 1986. Likewise, no stability data have been disclosed for Ektachrome Radiance paper for printing color transparencies, or for the Ektatherm electronic print paper used in Kodak's XL 7700-series digital thermal dye-transfer printers.)

As with other new products, tests with the new Ektachrome Lumiere and Elite films will be started by this author as soon as production samples of the films can be obtained in 1993. Meaningful stability data should become available in the months that follow. This research — which will incorporate new digital imaging materials as soon as they appear on the market — is an ongoing effort, and it is hoped that a way will be found to publish stability test results and product recommendations on a regular basis.

To assure continued independence in this research, it is this author's firm policy not to accept paid consulting work from any manufacturer of traditional photographic films and papers or from any manufacturer of electronic imaging systems. Although this author has frequently voiced his opinions about the merits — or lack thereof — of various products with their respective manufacturers, this has been done without financial compensation.

The coming years look highly promising for image preservation. Color materials are, overall, much more stable than they were at the beginning of the 1980's. The Fujicolor SFA3 color papers introduced in 1992, for example, last far longer when exposed to light on display, and when stored in the dark, than any previous color paper for printing color negatives. Increasing numbers of museums and motion picture studios are providing cold storage facilities to preserve their collections. Digital image data-base systems are providing greatly increased access to collections while avoiding handling and physical damage to irreplaceable photographic originals.

Acknowledgments

Throughout the past 20 years during which this book was created, many individuals, collecting institutions, and companies in the United States, Japan, Germany, Switzerland, Canada, and other countries have contributed information, image-stability data, samples of color films, papers, electronically produced color prints, and other materials that were vital to the completion of this book and to the research upon which it is based. For all of these contributions, both large and small, I am extremely grateful.

This book would not exist were it not for the long-standing support and encouragement of Sharp Lannom IV, a Grinnell businessman and a friend. Endowed with a keen intellect, Sharp has wide-ranging interests and an acute appreciation of the importance of history. Many years of research were required to develop the accelerated light fading tests described in Chapter 2, and to establish their validity as meaningful image-life predictors for various types of color prints when they are displayed in homes, offices, museums, and archives. Sharp became involved in this work in 1981, and his patience and comprehension of the problems inherent in long-term image-stability testing will forever be appreciated. Without his firm but understanding guidance, the writing of this book would not have been completed. Sharp has made an immeasurable contribution to the preservation of the world's photographic and motion picture heritage.

I also express my appreciation to William, Thomas, and Charles Lannom for their contributions to this effort. In addition, I thank Mark Bjorndal, who has handled the business affairs of this project since it began.

No one is more familiar with my work than John Wolf, a science writer, editor, and long-time friend from Madison, Wisconsin. John read and edited the countless revisions of my manuscript during the past 15 years, and he deserves particular thanks for his dedication to this book. John is the most intelligent editor I have ever worked with.

June Clearman, a mathematician and computer programmer working at the Robert Noyce computer center at Grinnell College, volunteered countless hours over a period of more than 5 years to write the computer programs used to record, stain-correct, and analyze the well over one million individual densitometric readings generated during the course of the stability tests reported in this book. Without June's computer programs, the image-life predictions for displayed prints listed in Chapter 3 would not have been possible.

I also give special thanks to Klaus B. Hendriks, the director of conservation research at the National Archives of Canada, for his contributions and friendship over the years; to Bob Schwalberg, whose support and humor helped Carol Brower and me get through both happy and difficult times, and who will always be a trusted friend and colleague; to Jane Gilmer Wilhelm, my exceptional mother, who contributed to this book in many important ways; to Sarah Wilhelm, my 14-year old daughter, whose gentle skepticism ("I will believe it when I see it") encouraged me to work a little harder; to David Wilhelm, my 11-year old son, who has always somehow understood the difficulties of my tasks; to Carol Brower Wilhelm, my best friend and wife, whose strength, determination, and sensitivity brought this long project to completion; and to Charles Wilhelm, our infant son, who waited so patiently, day after day, night after night, throughout his first year of life, while his mother and father completed this book.

Henry Wilhelm

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1. Traditional and Digital Color Prints, Color Negatives, and Color Slides: Which Products Last Longest?

The Hidden Problem: Simply Looking at a Beautiful Color Photograph Provides Absolutely No Indication of How Long It Will Retain Its Original Brilliance — Whether Exposed to Light on Display or Stored in the Dark

From its earliest period of conception in the 19th century, photography depended on two inextricably interwoven processes: making the image appear and keeping the image from disappearing, so the history of photography is strewn with the skeletons of inventors who did not take seriously, from the first concept, the ecology of permanence.[1]

Edwin H. Land (1909–1991)
Founder of the Polaroid Corporation

A Gregory Heisler photo of New York City Mayor Edward I. Koch may wind up as Koch's official portrait in City Hall. Unlike the Mayor's predecessors, whose portraits are both painted and formal, Koch is looking rather relaxed and candid in this color photo. The photo, taken for the June 11, 1989, *New York Times Sunday Magazine*, was Heisler's first assignment to shoot Koch. The Art Commission, which decides on all art works in city buildings, still must approve the photo. "I'm excited," says Heisler, who thinks the concern of the Art Commission is that of archival quality — whether a photograph will last as long as a painting.[2]

"PDNews" by Susan Roman
Photo District News
New York City – 1989

. . . part of the reason the Cabinet project was done with photographs instead of the traditional oil paintings was that Smith was able to convince White House officials that the photographic papers such as Kodak Ektacolor Professional Paper offer improved image stability. In addition, photography offers quick results at a fraction of the cost of oil painting. So a 30" x 40" photograph taken by Smith and printed on Kodak Ektacolor Professional Paper now hangs at the entry of every Cabinet member's office on Capitol Hill.[3]

From a 1986 interview with
photographer Merrett T. Smith
in *Kodak Studio Light* magazine

When I came into Fehrenbach Studios I was angry. My son's graduation portrait had faded so badly that I brought it in to see what they would do about it. The picture was only seven years old! They said it was printed on Kodak paper and they thought it would last but it didn't. They said it wasn't their fault that it faded and they could replace it for half price. I wasn't satisfied with that so I left and wrote to Kodak and told them that I thought Kodak should replace the print. Kodak said it wasn't their fault and it wasn't the studio's fault.

I had a picture that wasn't any good and I knew it wasn't *my* fault! We never had a problem before — we have all our own baby pictures and they lasted forever. If these were taken in black-and-white, would they have faded? All the ads I've seen in the newspapers say that photographs live forever . . . . It sort of takes you by surprise when you've never seen it happen before. It's such a gradual thing you don't notice it at first.[4]

Mrs. Lloyd Karstetter
Reedsburg, Wisconsin – 1980

January 1981

The worldwide shift from black-and-white photography to color photography — which got under way rather slowly with the introductions of Kodachrome and Agfachrome transparency films in 1935 and 1936, Kodacolor color negative film in 1942, and Eastman Color motion picture films in 1950 — began to proceed in earnest in the 1960's and is now essentially complete in all but a few segments of the still photography and motion picture fields. Unfortunately, as gradually became apparent, the change to color resulted in the loss of the essentially permanent images provided by black-and-white photography that had long been taken for granted by photographers and the general public alike. Shown here in 1981 are Bernice and Robert Fehrenbach of Fehrenbach Studios in Reedsburg, Wisconsin with some of the faded and cracked Kodak Ektacolor prints made between 1969 and 1976 that were brought back to the studio by angry customers asking for replacements. The highly unstable Ektacolor RC paper of this period was one of the most memorable low points in the often-troubled history of permanence in the color photography field.

The Organic Dye Images of Color Films and Prints versus the Metallic Silver Images of Black-and-White Photographs

Black-and-white photographs have images made of metallic silver — the images appear black because the filamentary structure of the tiny grains of silver absorb, rather than reflect, light. These silver images are unaffected by prolonged exposure to light and are also essentially permanent when stored in the dark (at least this is true with correctly processed fiber-base prints; as discussed in Chapter 17, black-and-white RC prints, with their sometimes self-destructing images, are another matter altogether). Many people have black-and-white photographs of their ancestors that have remained in good condition for 50 to 100 years — or even longer. Museum collections have significant numbers of black-and-white photographs from the late 1800's and early 1900's that are still in excellent condition.

Unlike the usually very long-lasting silver images of black-and-white photographs, most color photographs have images formed of cyan, magenta, and yellow organic dyes that fade when exposed to light on display. The brighter the light, the faster they fade. Kodak Ektacolor prints and most other types of color photographs also gradually fade and form yellowish stain when stored in the dark; the slow but inexorable image deterioration begins the moment processing is completed. High temperatures and/or high humidity in storage accelerate the deterioration process.

The Longest-Lasting Color Films and Color Print Materials

Recommendations for the most stable, longest-lasting color materials are given in the next four pages. These recommendations, which cover color materials that were available at the time this book went to press in late 1992, are based on extensive accelerated light fading tests and accelerated dark fading/staining tests — conducted by this author over a period of more than 15 years and reported in Chapters 2 through 6 — together with often incomplete but nonetheless vitally important accelerated dark fading data made available by Agfa, Fuji, Ilford, Kodak, Konica, and 3M (reported in Chapters 5 and 9).

As existing products are improved and new products are introduced — and as procedures for predicting color image fading and staining become more sophisticated — it is certain that the product recommendations given in this book will change. Further improvements in image stability

(text continued on page 7 . . .)

Recommendations

Longest-Lasting Color Transparency Films:

Longest-Lasting Overall:

Fujichrome Professional Films

Fujichrome Velvia Professional Film (ISO 50)

Fujichrome "Amateur" Films

Fujichrome CDU Duplicating Films

Longest-Lasting if Projection Can Be Avoided:

Kodachrome Professional Films

Kodachrome "Amateur" Films

For a photographer who prefers Process E-6 films, Fujichrome films are clearly the best choice. Fujichrome's resistance to fading during projection is the best of all slide films — for a given amount of fading, Fujichrome slides can be projected twice as long as Ektachrome slides. However, when yellowish stain that occurs over time in storage is considered, Fujichrome's stability in dark storage is roughly equal to that of Ektachrome films. Fujichrome Velvia Professional film, a very sharp, extremely fine-grain 50-speed film introduced by Fuji in 1990, is not quite as stable as the other Fujichrome films when projected, but Velvia nevertheless has better projector-fading stability than Ektachrome. Velvia lasts far longer under projection than Kodachrome film, Velvia's principal competitor.

Kodachrome has the best dark storage dye stability of any color film, and Kodachrome, as a result of its unique, external-coupler processing method, is the only color transparency film that remains completely free from yellowish stain formation during prolonged storage in the dark. Unfortunately, however, Kodachrome has the worst projector-fading stability of any color slide film on the market. Kodachrome film is a very good choice if projection can be avoided, but if originals sometimes must be projected, and time or money prevents routine duplication of originals, Fujichrome is the better choice. There are no stability differences between the "amateur" and "professional" transparency films of a given type (e.g., Fujichrome, Ektachrome, Kodachrome, and Agfachrome).

Longest-Lasting Color Negative Films:

Very Low Speed (ISO 25–50):

Kodak Ektar 25 Film

Kodak Ektar 25 Professional Film

Konica Color Impresa 50 Professional Film

Low Speed (ISO 100):

Kodak Ektar 100 Film

3M ScotchColor 100 Film

Fujicolor Super G 100 Film

Fujicolor Reala Film (ISO 100)

Medium Speed (ISO 160–200):

Kodak Vericolor III Professional Film Type S
(called Ektacolor Gold 160 Professional Film in Europe and Asia)

Fujicolor 160 Professional Film Type L

Fujicolor Super G 200 Film

Konica Color Super SR 200 Film

Konica Color Super SR 200 Professional Film

3M ScotchColor 200 Film

Polaroid OneFilm Color Print Film (ISO 200)
(made for Polaroid by the 3M Company in Italy)

High Speed (ISO 400):

Kodak Vericolor 400 Professional Film
(called Ektacolor Gold 400 Professional Film in Europe and Asia)

Kodak Ektapress Gold 400 Film

Kodak Gold Plus 400 Film

Fujicolor HG 400 Professional Film

Fujicolor Super G 400 Film

3M ScotchColor 400 Film

Very High Speed (ISO 1000–3200):

Kodak Ektar 1000 Film

Kodak Ektapress Gold 1600 Film

Kodak Gold 1600 Film

Fujicolor Super HG 1600 Film

Among the color negative films included in the five ISO speed-range groups are films intended for a variety of applications, and the films judged to be the most stable products of each type have been listed. While a photographer may, of course, decide to select a film with lower stability to gain some other advantage, it is best to stay away from the very worst products, such as Kodak Vericolor II Professional Film Type L and Agfacolor XRS 1000 Professional Film.

In the Medium Speed group (ISO 160–200), for example, Kodak Vericolor III Professional Film Type S is a daylight/electronic-flash film of moderate contrast and color saturation intended primarily for professional portrait and wedding photography. Fujicolor 160 Professional Film Type L is a tungsten-balanced color negative film generally used for product and commercial photography; this film is considerably more stable than Kodak's equivalent tungsten-balanced color-negative film, Vericolor II Professional Film Type L. Fujicolor Super G 200 Film, 3M ScotchColor 200 Film, Polaroid OneFilm (ISO 200), and the pleasingly lower-contrast Konica Super SR 200 Film are daylight color negative films intended for the general amateur market.

The 3M ScotchColor 200 and Polaroid OneFilm recommended here are the "improved stability" types introduced in late 1990 (Polaroid OneFilm is made in Italy by the 3M Company for Polaroid and is essentially identical to 3M ScotchColor 200 film). Pre-1990 versions of these 3M and Polaroid films had very poor dark fading stability.

The recommendations for color negative films given here are based on Arrhenius accelerated test data supplied by the various manufacturers and on single-temperature accelerated dark fading tests conducted by this author. These recommendations were based on the best information available at the time this book went to press in 1992. Because of differences in test conditions and methods of evaluation, however, the available data did not in every case permit a precise comparison of the stability of one film with another.

Longest-Lasting Color Internegative Film:

Fujicolor Internegative Film IT-N

Color internegative films are used by labs for making color internegatives from transparencies. Fujicolor Internegative Film IT-N has considerably better dark fading stability than Kodak Vericolor Internegative 6011 and 4114 films (stability data for Vericolor Commercial Internegative Film, to be introduced in 1993, were not available at the time this book went to press).

Longest-Lasting Papers for Printing Color Negatives:

Longest-Lasting Overall (RA-4 Compatible Papers):

Fujicolor Paper Super FA Type 3

Fujicolor Supreme Paper SFA3

Fujicolor SFA3 Professional Portrait Paper

Fujicolor Professional Paper SFA3 Type C

Fujiflex SFA3 Super-Gloss Printing Material

Second Longest-Lasting (RA-4 Compatible Papers):

Konica Color QA Paper Type A5

Konica Color QA Paper Type A3

Konica Color QA Paper Professional Type X2

Konica Color QA Super Glossy Print Material Type A3

Introduced in 1992, Fujicolor SFA3 papers are **by far** the best of the fast-processing RA-4 compatible color negative papers. In fact, considering the Fujicolor papers' greatly superior light fading and dark fading stability, combined with their very low rate of yellowish stain formation in dark storage, these are without question the finest chromogenic color papers ever made. On display, the Fujicolor SFA3 papers will last **more than four times longer** than Ektacolor papers. The color, tone reproduction, and image sharpness of the Fujicolor papers are also outstanding. Fujicolor Professional Paper SFA3 Type C and its lower-contrast counterpart, Fujicolor SFA3 Professional Portrait Paper (tentative name), are particularly recommended for portrait, wedding, commercial display, and fine art photography — markets where long-lasting color prints are a must.

Longest-Lasting Process EP-2 Compatible Papers:

Konica Color Paper Type SR

Konica Color Paper Professional Type EX

Konica Color Paper Type SR (SG)

By the beginning of 1990, Process RA-4 compatible papers had largely replaced the older EP-2 papers in minilabs, and by the end of 1991 RA-4 papers had become standard in most large photofinishing and commercial labs. Among the Process EP-2 compatible papers, Konica Color Paper Type SR and its lower-contrast counterpart, Konica Color Professional Paper Type EX, are recommended. These papers have better long-term light fading and dark fading stability than Kodak Ektacolor Plus or Ektacolor Professional papers.

In a given manufacturer's line of color papers, there are no significant stability differences between papers intended for professional markets and those sold to photofinishers catering to amateurs. For example, all current Kodak Ektacolor RA-4 papers have essentially the same image stability characteristics — there are no significant light fading stability differences between Ektacolor Portra II Paper, a "professional" paper used in the upscale portrait and wedding field where a single large print may sell for $1,000 or more, and Ektacolor Edge paper, an "amateur" paper used by minilabs and large-volume, low-cost photofinishers for their 35-cent prints.

Longest-Lasting Papers for Printing Color Transparencies:

Longest-Lasting Overall:

Ilford Ilfochrome Classic print materials

Ilford Ilfochrome Rapid print materials

(for best stability, high-gloss, polyester-base versions of Ilfochrome [formerly called Cibachrome] are recommended)

Longest-Lasting Process R-3 Compatible Papers:

Fujichrome Paper Type 35

Fujichrome Paper Type 35-H

Fujichrome Super-Gloss Printing Material

Although subject to light fading, Ilford Ilfochrome prints can be considered absolutely permanent (with essentially zero stain levels) in normal, room-temperature dark storage; this property makes Ilfochrome unique among conventional, easy-to-process color print materials. When kept in the dark in normal storage conditions, Ilfochrome polyester-base prints should last much longer than most black-and-white photographs. Here we see the great advantage of the Ilfochrome preformed dye (silver dye-bleach) system compared with the less stable and generally yellowish-stain-prone chromogenic processes.

It would be a major advance for photography if Ilford would offer a negative-printing version of Ilfochrome (with improved light fading stability) for color negative users. Ilford has long had the technology to produce such a material — in 1963 a color negative version of Cibachrome (now called Ilfochrome) named Cibacolor was actually shown at the Photokina trade show in Germany, but, unfortunately, it was never marketed. Such a new "Ilfocolor" print material would be a fabulously successful product in the portrait, wedding, and fine art fields.

Among Process R-3 compatible print materials, Fujichrome Paper Type 35 is by far the best choice; Type 35 paper has much better light fading and dark storage stability (with much lower rates of yellowish stain formation) than Kodak Ektachrome Radiance Paper and polyester-base Ektachrome Radiance Select Paper. It should be noted, however, that when exposed to light on display, neither Fujichrome Type 35 nor Ilfochrome is as stable as Fujicolor SFA3 color negative paper.

(**Recommendations** *continued on next page . . .*)

Recommendations *(continued from previous page)*

Longest-Lasting Translucent and Transparent Color Display Materials:

Longest-Lasting Overall:

Ilford Ilfochrome Display Film (translucent base)
Ilford Ilfochrome Display Film (transparent base)

Longest-Lasting RA-4 Compatible Materials:

Fujitrans SFA3 Display Material (translucent base)
Fujiclear SFA3 Display Material (transparent base)

Although this author did not conduct comparative tests with display materials (they will be tested in the future), the fact that these products have the same dye sets as their corresponding reflection-print materials (e.g., Kodak Duratrans RA and Ektatrans RA display materials have the same dye set as Ektacolor Supra and other Ektacolor RA-4 papers) allows a meaningful comparison to be made. In tests, Ilford Ilfochrome materials had reduced rates of light fading under the moderately heated, low-humidity conditions associated with backlit displays, and this gives Ilfochrome an added advantage over chromogenic materials such as Duratrans RA.

Fujitrans and Fujiclear SFA3 Display materials, expected to be introduced in 1993, will employ the same emulsion technology used in Fujicolor SFA3 papers, and in demanding backlit display applications, Fujitrans and Fujiclear will probably last on the order of four times as long as Kodak Duratrans RA, Duraclear RA, and Ektatrans RA. Only long-term tests will show whether or not Fujitrans and Fujiclear SFA3 materials will outlast Ilfochrome display materials in backlit display applications.

Longest-Lasting, Most Stable Color Photographs of Any Type:

UltraStable Permanent Color Prints (tentative)
Polaroid Permanent-Color Prints (tentative)
EverColor Pigment Color Prints (tentative)
Fuji-Inax Photocera Ceramic Color Photographs

On long-term display — perhaps going on even for centuries — UltraStable Permanent Color Prints (made with the improved-stability yellow pigment to be introduced in early 1993) and Polaroid Permanent-Color Prints are in a class by themselves. Accelerated test data from prototype materials indicate that in normal display situations the prints should last 500 years or more without significant fading or staining. The prints should last as long as (or quite possibly even longer than) the best "archivally" processed and toned fiber-base black-and-white prints. These are the Rolls Royce's of the color photography field — materials against which all others must be compared. Unlike conventional color prints in which the image is formed with organic dyes, the prints use color pigments that have truly extraordinary light fading stability.

EverColor Pigment Color Prints, to be introduced in early 1993 by the California-based EverColor Corporation, are produced with a high-stability version of the AgfaProof process. Samples were not available for testing at the time this book went to press in 1992, but it is expected that EverColor prints will have very good light fading and dark storage stability.

The recommendations given here for UltraStable, Polaroid Permanent Color, and EverColor prints are listed as "tentative," pending the results of stability tests with production materials.

All three of these processes employ digitally produced separation negatives and may be used to make prints from color transparencies, color negatives, existing color prints, computer-generated images, Photo CD's, and other digital sources.

Fuji-Inax Photocera Ceramic color photographs, which are available only in Japan, use inorganic pigments to form images on ceramic plates which are fired at high temperatures. The resulting "photographic ceramic tiles" are claimed by Fuji to be unaffected by light, rain, seawater, and fire.

Systems for Printing Digital Color Images from Computers, CD-ROM's, Photo CD's, Electronic Still Cameras, and Video Sources:

An ever-increasing number of methods are available for producing color prints ("hardcopy") from digital image sources. Included are "photorealistic" thermal dye transfer printers (also called dye-sublimation printers, the Kodak XL7700-series printers and the Tektronix Phaser IISD are examples); "photorealistic" ink jet printers (i.e., Iris Graphics ink jet color printers); and digital printers using traditional color photographic materials (e.g., Metrum FotoPrint Digital Printers, Agfa Digital Printing Systems, and Kodak LVT Digital Image Recorders, all of which can print high-quality digital images on standard process RA-4 compatible color negative papers). The 3M Color Laser Imager is a digital printer using a special EP-2 color paper made by 3M (stability data not available). Fuji (Fujix) Pictrography Digital Printers use a unique photographic-thermal-transfer process.

Producing lower-quality color images — which are nevertheless adequate for many business applications, proofs, and publication layouts — are digital electrophotographic color copier/printers (e.g., the Canon Color Laser Copier 500 and other color electrophotographic plain-paper copier/printers equipped with digital interfaces). Liquid-toner electrostatic color printers such as the Xerox/Versatec 8900-series digital plotter/printers (making prints up to 54 inches wide by 15 feet or more in length, the printers are used in the Cactus Digital Color Printing System) provide a method for making pleasing — if not quite "photorealistic" — color prints in large sizes and at low cost.

This author has not had an opportunity to test the image stability of all of the many digital color printing materials in the important and rapidly expanding "color hardcopy" and graphic arts proofing field; however, among those printing devices whose output was evaluated, the following deserve particular note:

Metrum FotoPrint Digital Printers (RA-4 color prints)
Agfa Digital Printing Systems (RA-4 color prints)
Bremson Laser Color Recorders (RA-4 color prints)
Kodak LVT Digital Image Recorders (RA-4 color prints)
Ilford Digital Imagers (Ilfochrome color prints)
Kodak XL 7700-series Digital Printers (Ektatherm prints)
Fuji Pictrography Digital Printers (Pictrography prints)
Cactus Digital Color Printers (electrostatic color "prints")
Canon Color Laser copier/printers (plain-paper "prints")
Kodak ColorEdge copier/printers (plain-paper "prints")

Of the available methods for making high-quality, "photo-realistic" color prints from digital sources, printers using RA-4 compatible Fujicolor SFA3 color papers or Ilfochrome materials produce the longest-lasting prints; color prints made with these devices are inexpensive and their overall image quality can be as good or better than prints exposed with an optical enlarger.

The overall image quality of Kodak Ektatherm prints and other types of thermal dye transfer color prints can approach that of prints made with conventional color negative papers. In the United States, Kodak Ektatherm prints were initially the only type of print available from Kodak Photo CD images when the Photo CD system was introduced in the summer of 1992.

The recommendations for Fuji Pictrography prints and Cactus digital prints are tentative, pending completion of stability tests.

Iris ink jet printers are capable of producing high-quality, large-format color images from digital sources. At the time this book went to press in 1992, the light fading stability of Iris prints was very poor. However, Iris Graphics, Inc. (a Scitex company), the maker of the printers, has said that inks of greatly increased stability would be introduced before the end of 1993.

Longest-Lasting Polaroid "Instant" Color Prints:

Longest-Lasting Overall:

Polaroid Polacolor ER, 64T, 100, and Pro 100 Prints

Polaroid "peel-apart" instant prints have inferior light fading stability compared with chromogenic color papers such as Fujicolor and Ektacolor; because Polacolor prints are unique images with no usable negatives from which additional prints can be made, the prints should be displayed with caution.

Because of excessive yellowish stain that occurs over time in normal, room-temperature dark storage, and because of poor light fading stability, Polaroid "Vision 95" prints, Spectra HD ("Image" in Europe), Polaroid 600 Plus, and Polaroid SX-70 prints available at the time this book went to press in 1992 were not recommended for other than short-term applications.

Photo CD's, CD-ROM's, and Other Optical Disk and Magnetic-Media-Based Systems Are Not Recommended for the Long-Term Preservation of Photographically Originated Images:

The suitability of Kodak Photo CD's and other types of digital optical disk and magnetic systems for the long-term storage of photographically originated color images involves three distinct considerations. To use the Kodak Photo CD as an example of a laser-read optical disk image storage medium, the first consideration is the long-term stability (readability) of the Photo CD itself. The second consideration is what assurance there is that compatible hardware for reading Photo CD's will still be available in 25, 50, or 100 years (or more) from now. The third consideration is what assurance there is that software for decompressing and reading Photo CD images will be available for the vastly different computer and electronic imaging systems that will be in use in 25, 50 or 100 years (or more) from now. To rely on the Photo CD as a long-term image storage medium, all three of these considerations must be satisfied. At the time this book went to press in 1992, none of them was. The continuing rapid technological change and the consequent obsolescence of hardware, software, and data storage media in the computer and video industries make it questionable that today's Photo CD's will be usable even 25 years from now (recall the Sony Betamax camcorders and VCR's of the 1980's?). Although Photo CD's and other CD-ROM's — and other optical disk and magnetic digital image storage systems — have tremendous utility for the rapid access and distribution of color images, color photographic originals must be carefully preserved for long-term image preservation.

Longest-Lasting Color Microfilm and Microfiche Products:

Ilford Ilfochrome Micrographic Films

Because they are essentially permanent in dark storage at normal room temperature, polyester-base Ilford Ilfochrome Micrographic films are the only color microfilm/microfiche materials suitable for long-term museum and archive applications. Kodachrome film and motion picture print films such as Eastman Color and Fujicolor do not even approach the outstanding dark storage stability of Ilfochrome Micrographic films. The image stability of Ilfochrome Micrographic films is so good, in fact, that this author believes that under normal storage conditions, these films likely will outlast conventionally processed silver-image black-and-white microfilms on polyester base.

Longest-Lasting Motion Picture Color Negative and Color Print Films:

Longest-Lasting Color Negative Films:

Fujicolor Negative Film F-64, 8510 and 8610
Fujicolor Negative Film F-64D, 8520 and 8620
Fujicolor Negative Film F-125, 8530 and 8630
Fujicolor Negative Film F-250, 8550 and 8650
Fujicolor Negative Film F-250D, 8560 and 8660
Fujicolor Negative Film F-500, 8570 and 8670
Eastman Color Negative Film 7291
Eastman EXR 500T Color Negative Film 5296 and 7296

Longest-Lasting Color Intermediate Film:

Fujicolor Intermediate Film, 8213 and 8223

Longest-Lasting Color Print Films:

Fujicolor Positive Film LP, 8816 and 8826

These recommendations for color motion picture negative and print films are based on Arrhenius accelerated dark fading data supplied by the manufacturers: Fuji Photo Film Co., Ltd., Eastman Kodak Company, and Agfa-Gevaert AG (refer to Chapter 9 for further information). Fuji's accelerated aging data indicate that the Fujicolor motion picture print films are not greatly affected by high humidities, and this can be particularly advantageous when films must be stored in less than ideal conditions. Agfa CP1 and CP2 color motion picture print films have poor image stability, and their use should be avoided.

will be made, and with Fuji, Kodak, Konica, and Agfa all trying hard to outdo each other, a color film or paper that was rated "longest-lasting" in its category at the time this book went to press will inevitably be eclipsed by an even better product in the future.

While the relative performance of films and papers processed, stored, and displayed in the wide variety of conditions that one might encounter in the real world may differ from that reported in this book, the image-life predictions and product recommendations presented here represent a concerted effort over a period of many years by this author to make sense out of a complex and constantly changing body of information. The assessments of the light fading stability of color print materials and the projector-caused fading of color slides deserve particular note, and the data presented in this book help fill major gaps in the information that has been published previously.

The *Inherent* Dye Stability and Yellowish Staining Characteristics of a Color Material

The most important factors that will, ultimately, determine the useful life of a color film or color print are the *inherent* dye stability and resistance to yellowish stain formation that have been built into the product by its manufacturer. These are fundamental properties of each and every color film or color print material. The inherent light fading and dark storage stability properties differ greatly among current products — for any given storage or display situation, some materials will last far longer than others.

At present, when a photographer buys a roll of color film, no information is provided about how long the processed color images will last before noticeable changes take place. The photographer has no idea whether another film — made by the same or a different manufacturer — might last longer.

The sharpness, graininess, color, and tone-scale reproduction characteristics of a film can be examined immediately after processing, and if the photographer is not pleased with the results, he or she can try a different product. Indeed, Kodak, Fuji, and the other major manufacturers routinely publish image-quality data for their films, including RMS granularity values, resolving power values, modulation transfer functions (MTF), characteristic curves, spectral sensitivity curves, and spectral dye density curves. Missing, in most cases, has been even the most basic information about the image stability characteristics of the film. Looking at a processed color film or print will tell you nothing about how long it will last.

Since the introduction of Kodachrome in 1935 and Agfacolor-Neu transparency film in 1936 — the first modern color films — the major manufacturers have conducted extensive image stability tests with their color films and papers. In years past, however, the results of these tests were for the most part kept secret. For photographers and the general public alike, image stability has remained a hidden characteristic — one that manifests itself only years after a product is purchased. And by then, of course, it is too late.

Most manufacturers of color materials have long included a fading warranty disclaimer on every package of color film and paper to help protect themselves from upset customers once the inevitable has occurred and color prints and films have faded to the point that they are no longer acceptable.

The wording of Kodak's disclaimer is typical:

> Since color dyes may change over time, this product will not be replaced for, or otherwise warranted against, any change in color.

Similarly, Fuji states on its packages:

> Since color dyes may change in time, no warranty against or liability for any color change is expressed or implied.

Agfa includes the following on its color film boxes:

> As all color dyes may in time change, there is no warranty against, or any liability for, any change in color.

For the most part, the above disclaimers have been the only information supplied to the general public concerning the longevity of color films and color print materials they use. It is hoped, however, that in the future basic image stability information will be routinely included in the technical data sheets that Kodak, Fuji, and the other manufacturers publish for each of their color films and papers.

Image Permanence Is an Important Consideration When Selecting a Color Film or Color Paper

Although a photographer must consider many factors when selecting a color film or print material for a particular purpose, it is only prudent to choose the most stable products available from those that otherwise meet the photographer's requirements (e.g., color negative or color transparency; high-speed film or slow-speed film with sharp, fine-grain images; color negative or color reversal paper; and so forth).

Other factors being equal — and if there is a choice — almost every photographer will choose a longer-lasting film or paper over a less stable one. The same is true of the general public. If a portrait studio offers a customer a print on a color paper that when displayed would last four times longer than a print made on the "leading brand" color paper — and both prints cost the same and were essentially identical in appearance — which print would the customer prefer?

With the Photography Industry Undergoing a Fundamental Restructuring, Eastman Kodak is No Longer the Unchallenged Leader

Although the Eastman Kodak Company, with 1992 revenues in excess of $20 billion, is still the world's largest photographic manufacturer, the company no longer dominates the photographic industry as it once did. Competition among the world's seven principal manufacturers of color films and papers — Kodak, Fuji, Agfa, Konica, 3M, Ilford, and Polaroid — has greatly intensified since the mid-1980's.

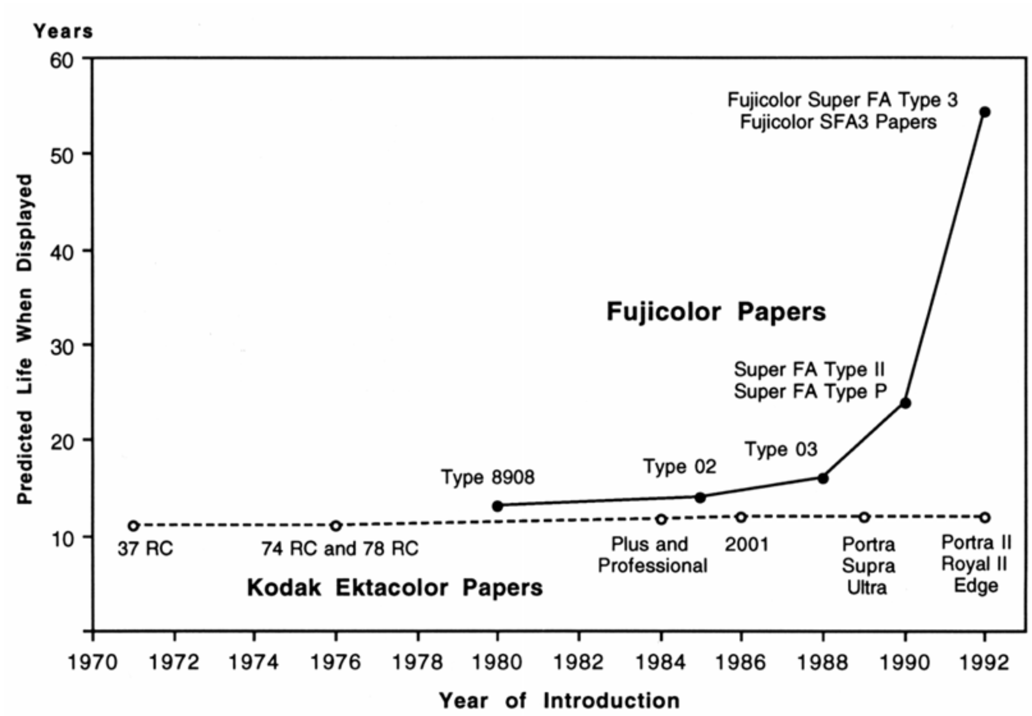


Figure 1.1 Beginning in 1980, successive generations of Fujicolor EP-2 and RA-4 compatible papers have exhibited steadily increasing light fading stability, with current Fujicolor SFA3 papers having an estimated display life of more than 50 years according to this author's tests. Kodak's Ektacolor papers, on the other hand, have shown negligible improvements in light fading stability since the introduction of Ektacolor 37 RC Paper more than 20 years ago in 1971. When exposed to light on display, Fujicolor SFA3 papers last more than **four times longer** than current Ektacolor papers (e.g., Ektacolor Portra II Paper).

The increased worldwide competition, together with the threats to the traditional photography companies posed by the rapid advances in television, computer imaging systems, desktop publishing, electronic biomedical imaging, electronic document management systems, and other electronic imaging systems that increasingly are displacing silver-halide-based photography, have all contributed to confusion and uncertainty in the photography industry.

A prime example of the changes taking place in the photography industry is the complete destruction of the once huge television newsfilm and home movie markets in the span of only a few years by the introduction of portable ENG (electronic news gathering) video cameras and the now-ubiquitous amateur camcorder.

New technologies for making high-quality color prints from digital sources — including ink jet printing, dry- and liquid-toner electrophotographic printing, and thermal dye transfer printing — offer the hope that in the future highly stable color prints will become available at reasonable cost. In the entire history of photography, there have never been as many ways to make color prints as there are now. The color imaging field has finally opened up to competitors from outside the traditional photography industry.

These forces have put the entire photography industry into a state of unprecedented upheaval. Kodak, Fuji, and the other photographic manufacturers are now not only fighting each other for market share, but are also trying to respond to the often unclear needs of a rapidly changing marketplace. Because of these pressures, the manufacturers have sharply increased their research and development efforts, and the rate of new product introductions has accelerated dramatically during the past few years.

Image permanence — and the long-overdue recognition that it is a key aspect of overall product quality — has in the past decade been receiving increased attention by almost every manufacturer. With the Japanese manufacturers Fuji Photo Film Co., Ltd. and Konica Corporation making ever-improving image permanence a primary corporate objective, color stability has finally become a major competitive issue in the marketplace.

In recent years, Fuji has achieved substantial improvements in the stability of its color negative papers, and Fujicolor papers now have far better light fading and dark fading stability than Kodak's corresponding Ektacolor papers (see Chapter 3 and Chapter 5). In dark storage, the Fujicolor papers also have better dye stability and much lower rates of objectionable yellowish stain formation than the Kodak papers. The stability of color papers has been a weak area for Kodak, and at the time this book went to press in late 1992, Kodak's papers fell short in almost every respect when compared with the image stability of all of its competitors' papers.

On display, Fujicolor SFA3 papers for printing color negatives are more than *four times more stable* than Ektacolor Portra II Paper and the other Ektacolor papers that were available at the time this book went to press in late 1992.

In fact, as shown above in **Figure 1.1**, this author's tests have revealed that the light fading stability of Ektacolor papers has seen almost no improvement since Ektacolor 37 RC Paper was introduced in 1971 (see Chapter 3). In that period of more than 20 years, the only significant advance made by Kodak in the image stability of Ektacolor paper was the introduction of a more dark-stable cyan dye in August 1984.

(Konica had introduced an improved-stability cyan dye in its Konica Color Type SR color negative paper several months earlier in April 1984, and at the time this book went to press, Konica continued to maintain superiority over Kodak in the overall image stability of its Konica Color process RA-4 and EP-2 compatible papers.)

Comparative Light Fading of Fujicolor SFA3 Papers and Kodak Ektacolor Papers

The dramatic improvements made in the light fading stability of Fujicolor SFA3 papers, introduced in 1992, are clearly evident in these illustrations.

The prints were subjected to accelerated fluorescent light fading tests conducted at 21.5 klux for accumulated light exposures equivalent to those which the prints would receive during the listed years of display (at 450 lux for 12 hours a day). The prints were covered with glass during the tests.

As reported in Chapter 3, this author's predicted display life for Fujicolor SFA3 prints is 54 years, based on this author's "home and commercial" display conditions. Current Ektacolor prints, on the other hand, have a predicted display life of only a little over 12 years.

Current Ektacolor, Fujicolor, Konica Color, and Agfacolor color negative and color reversal papers all incorporate UV absorbing emulsion overcoats, and in most indoor display situations it makes little difference in fading rates whether or not the illumination source contains UV-radiation. Most of the fading that occurs with these papers is caused by visible light — and *not* by UV radiation. Framing with Plexiglas UF-3 or other UV filters is of little if any benefit. Ilford Ilfochrome prints, Kodak Dye Transfer prints, and Kodak Ektatherm digital prints do not have UV-absorbing overcoats, however, and the stability of these prints can be greatly impaired when UV radiation from bare-bulb fluorescent lamps is present.

The Fujicolor test prints were made on Fujicolor SFA3 Professional Paper Type C, and the Ektacolor prints were made on Kodak Ektacolor Supra Paper. Supra paper, which is one of Kodak's Ektacolor "professional" papers, was chosen as the best contrast match for Fujicolor Type C paper.

All of the Ektacolor papers available at the time this book went to press in late 1992 had essentially identical light fading characteristics (these papers included Ektacolor Edge Paper, Ektacolor Royal II Paper, Ektacolor Supra Paper, Ektacolor Portra II Paper, Ektacolor Ultra Paper, and Duraflex RA Print Material). The light fading stability of Ektacolor 74 RC paper, in use from 1977 until 1986, is similar to that of current Ektacolor papers.

Unfaded print made with Fujicolor SFA3 paper available at end of 1992.

Fujicolor SFA3 color print after the equivalent of 10 years of display.

Unfaded print made with Kodak Ektacolor paper available at end of 1992.

Kodak Ektacolor print after the equivalent of 10 years of display.

Unfaded print made with Kodak Ektacolor 74 RC paper (1977–1986).

Kodak Ektacolor 74 RC print after the equivalent of 10 years of display.

Fujicolor SFA3 color print after the equivalent of 15 years of display.

Fujicolor SFA3 color print after the equivalent of 30 years of display.

Fujicolor SFA3 color print after the equivalent of 50 years of display.

Kodak Ektacolor print after the equivalent of 15 years of display.

Kodak Ektacolor print after the equivalent of 30 years of display.

Kodak Ektacolor print after the equivalent of 50 years of display.

Kodak Ektacolor 74 RC print after the equivalent of 15 years of display.

Kodak Ektacolor 74 RC print after the equivalent of 30 years of display.

Kodak Ektacolor 74 RC print after the equivalent of 50 years of display.

Comparative Dark Fading and Yellowish Staining Behavior of Fujicolor SFA3 Papers and Kodak Ektacolor Papers

The superior dark storage stability of Fujicolor SFA3 papers, introduced in 1992, is clearly evident in these illustrations. In addition to having better *dye stability* in dark storage, the Fujicolor papers also have far lower rates of *yellowish stain formation* than the Ektacolor papers that were available at the time this book went to press in late 1992. With Ektacolor and most other current chromogenic papers, brilliance-robbing yellowish stain that occurs over time in dark storage is a more serious problem than is dye fading itself.

The prints were subjected to an accelerated dark fading/staining test conducted at 144°F (62°C) and 45% RH for the number of days listed. Results from this author's single-temperature comparative dark storage tests for color papers — and 20% dye fading predictions based on multi-temperature Arrhenius tests conducted by the major manufacturers — are listed in Chapter 5.

The Fujicolor test prints were made with Fujicolor SFA3 Professional Paper Type C, and the Ektacolor prints were made with Kodak Ektacolor Supra Paper. Supra paper, which is one of Kodak's Ektacolor "professional" papers, was chosen as the best contrast match for the Fujicolor Type C paper.

With the exception of Ektacolor Portra II Paper, all of the Ektacolor papers available at the time this book went to press in 1992 had essentially identical dark fading/staining stability (these included Ektacolor Edge Paper, Ektacolor Royal II Paper, Ektacolor Supra Paper, Ektacolor Ultra Paper, and Duraflex RA Print Material). Ektacolor Portra II Paper, introduced in 1992, has somewhat better dye stability in dark storage, but the poor yellowish stain behavior of the paper remains the same as that of the previous Portra paper (1989–92) and other Ektacolor papers.

Ektacolor 74 RC paper, in use from 1977 until 1986, employed a cyan dye with very poor dark fading stability; in addition, over time the papers developed high levels of yellowish stain in dark storage. (Konica PC Color Paper Type SR, introduced in 1984, was the first chromogenic paper to use a high-stability cyan dye, and this greatly improved the paper's overall stability.)

Unfaded print made with Fujicolor SFA3 paper available at end of 1992.

Fujicolor SFA3 print after 60 days in accelerated dark fading/staining test.

Unfaded print made with Kodak Ektacolor paper available at end of 1992.

Kodak Ektacolor print after 60 days in accelerated dark fading/staining test.

Unfaded print made with Kodak Ektacolor 74 RC paper (available from 1977 until 1986).

Kodak Ektacolor 74 RC print after 60 days in accelerated dark fading/dark staining test.

Fujicolor SFA3 print after 120 days in accelerated dark fading/staining test.

Fujicolor SFA3 print after 180 days in accelerated dark fading/staining test.

Fujicolor SFA3 print after 240 days in accelerated dark fading/staining test.

Kodak Ektacolor print after 120 days in accelerated dark fading/staining test.

Kodak Ektacolor print after 180 days in accelerated dark fading/staining test.

Kodak Ektacolor print after 240 days in accelerated dark fading/staining test.

Kodak Ektacolor 74 RC print after 120 days in accelerated dark fading/ dark staining test.

Kodak Ektacolor 74 RC print after 180 days in accelerated test — sample print not available.

Kodak Ektacolor 74 RC print after 240 days in accelerated dark fading/ dark staining test.

Comparative Dark Fading and Yellowish Staining Behavior of Color Papers Used to Print Color Transparencies

Among "easily processed" color print materials, Ilford Ilfochrome silver dye-bleach prints are the only type of color prints that are essentially permanent in normal, room-temperature dark storage. Polyester-base Ilfochrome prints, which can be made only from color transparencies, are expected to last 500 years or more without noticeable fading or staining when kept in the dark; no other type of conventional color print can even approach this level of stability. Kodak Dye Transfer prints, which are far more expensive than Ilfochrome prints, also have excellent dark storage stability. (Both Ilfochrome and Dye Transfer prints are subject to light fading, however.)

Among process R-3 compatible reversal papers, Fujichrome Paper Type 35 is by far the most stable material, both in dark storage and when exposed to light on display.

Unfaded Ilford Cibachrome II print (now called Ilfochrome Classic). Prints shown below made with other processes were similar in appearance prior to accelerated aging.

Kodak Dye Transfer fiber-base print after one year in the accelerated dark fading/staining test. The print showed almost no fading and suffered only slight staining. The one-year test period was twice as long as that used with the now-obsolete Ektachrome and Fujichrome papers below.

Ilford Cibachrome II (now called Ilfochrome Classic) print, made on a glossy polyester-base, after one year in the accelerated dark fading/staining test. The print showed no detectable fading or staining at the completion of the test (the prints are subject to light fading, however).

Kodak Ektachrome 22 RC print (initial type: 1984–90) after 6 months in the accelerated dark fading/staining test. Ektachrome Radiance paper (1991—) has greatly improved dye stability in dark storage, but over time the paper still develops high levels of yellowish stain.

Fujichrome Paper Type 34 RC print (1986–92) after 6 months in the accelerated dark fading/staining test. Fujichrome Paper Type 35 (1992—) has similar stability. Note the low yellowish stain level and the much better cyan dye stability compared with Ektachrome 22 paper.

UltraStable and Other Pigment Color Prints May Have a Display Life of More Than 500 Years

The only way to make truly long-lasting color photographs that can safely be displayed for hundreds of years is to form the color images with high-stability color pigments instead of the far less light-stable organic dyes used with Fujicolor, Ektacolor, and most other color processes.

Currently available high-stability pigment color prints include UltraStable Permanent Color prints (see description on page 49) and prints made with Polaroid Permanent-Color materials, both invented by California photographer Charles Berger, and EverColor Pigment Color Prints made with a high-stability modification of the AgfaProof graphic arts proofing system and planned for introduction in 1993 by the EverColor Corporation (see description on page 122 and the suppliers list on page 293).

At the time this book went to press in late 1992, production samples of prints made with these three processes were not yet available, and it was not known which of the three produced the most stable prints — nor which was capable of the best color and tone reproduction. This author will start long-term stability tests with these processes as soon as verified production samples are obtained.

Unfaded pigment print made with Polaroid Permanent-Color materials. The color of the pink dress in this early prototype print is exaggerated because the digital laser scanner used to make the separations had not been properly adjusted for the process.

Polaroid Permanent-Color print after light exposure in an accelerated test equivalent to 575 years of display. Some magenta fading occurred, but the print remains in good condition. (The print was exposed to 21.5 klux fluorescent illumination for 6 years.)

Polaroid Permanent-Color print after 6 years in an accelerated dark fading/staining test. No fading or staining of the image or polyester base material could be observed. (The accelerated test was conducted at 144°F [62°C] and 45% RH.)

Unfaded print made on Kodak Ektacolor Plus Paper in 1985. Ektacolor Professional Paper and the Process RA-4 Ektacolor papers available at the time this book went press in 1992 have similar image stability.

Kodak Ektacolor Plus print after light exposure in an accelerated test equivalent to 250 years of display. (The print was exposed to 21.5 klux glass-filtered fluorescent illumination for 2.7 years [75°F and 60% RH].)

Kodak Ektacolor Plus print after one year in an accelerated dark fading/staining test. Note the severe, overall yellowish staining of the image. (The accelerated test was conducted at 144°F [62°C] and 45% RH.)

Color Photographic Images Are Composed of Cyan, Magenta, Yellow, and Sometimes Black Layers

Most color films and prints have images composed of organic cyan, magenta, and yellow (the subtractive primary colors) dyes residing in very thin gelatin layers that are coated on transparent film base, polyethylene-coated RC paper base, or white polyester base. At any given point in an image, the color is determined by the relative concentration of the three dyes. No dye is present in white areas, and black areas have a maximum concentration of all three dyes. Some types of color prints, including the UltraStable Permanent Color print reproduced at the right, employ high-stability pigments instead of generally much less light-stable organic dyes to form the image.

UltraStable prints, EverColor pigment prints, Iris and Stork ink jet prints, some types of thermal dye transfer prints, and offset-printed color illustrations such as those in this book utilize a "black printer" in addition to cyan, magenta, and yellow image layers used with traditional color photographs in order to obtain the required densities in dark areas and to increase apparent sharpness. Color copier-printers such as the Canon Color Laser Copier, Xerox 5775 Digital Copier, and Kodak Color Edge Copier also employ a black image in addition to cyan, magenta, and yellow.

Unlike Ektacolor prints and most other current types of color photographs, the color image layers of UltraStable prints are prepared individually. Examples of these layers (and various combinations of layers) are reproduced below.

UltraStable print and color image layers courtesy of Charles Berger

UltraStable Permanent Color print with an image composed of cyan, magenta, yellow, and black pigment layers. The print was made from a 6x7-cm transparency supplied by Fuji as an aid for setting up graphic arts color scanners.

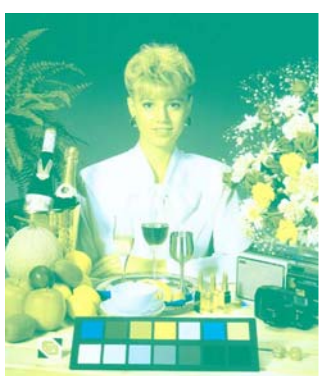
Cyan image.

Magenta image.

Yellow image.

Black image.

Cyan and magenta without yellow or black images.



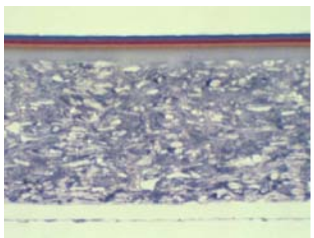
Cyan and yellow without magenta or black images.

Magenta and yellow without cyan or black images.

Cyan, magenta, and yellow without black image.

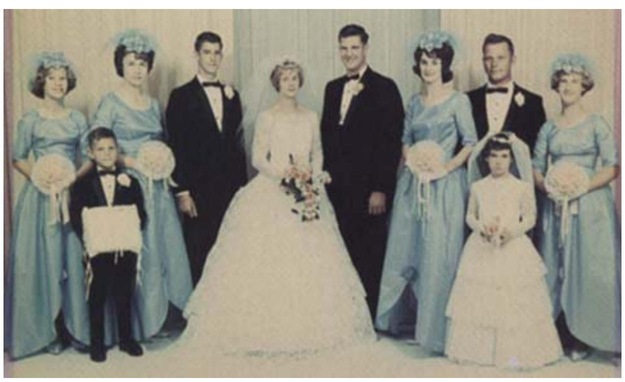
How Color Photographs Can Look After They Fade and Stain in Normal Display and Dark Storage

When color prints and films fade, the three image dyes (and black image, if present) rarely fade at the same rate, and the result is a progressive shift in color balance. Light fading characteristically results in a partial or total loss of highlight and low-density detail as well as a color-balance change that is visually most apparent in low- and medium-density portions of an image. Fading that occurs in dark storage with Ektacolor and other chromogenic color prints is usually characterized by an overall change in color balance and ever more objectionable yellowish stain. Fujicolor SFA3 and Fujichrome Type 35 papers, introduced in 1992, have greatly reduced rates of yellowish stain formation.



A magnified cross-section of an Ektacolor 74 RC print, with the cyan, magenta, and yellow dyes that were formed during processing. Beneath the print emulsion is a polyethylene plastic (RC) layer containing a white titanium dioxide pigment, followed by a core of fiber-base photographic paper. At the bottom is a layer of clear polyethylene.

This 1971 Kodak Ektacolor RC print was framed behind an oval mat. After 7 years of home display, the image suffered severe magenta dye fading and developed yellowish stain.



Displayed 1968 Ektacolor print with severe magenta dye fading and loss of detail in skin tones and in the bride's dress while the groom's black tuxedo appears unaffected.

1950 Kodacolor print kept in the dark (note stain).

1980 Agfacolor print kept in the dark (note cyan fade).

1970 Ektacolor RC print after 10 years of display.

1970 Ektacolor RC print after 10 years of display.

1973 Ektacolor RC print after 8 years of display.

1969 Ektacolor RC print after 13 years of display.

Color Photography Has Now Largely Replaced Black-and-White Photography

Long before Louis Daguerre publicly revealed his daguerreotype process in France in 1839, he and another Frenchman, Joseph Nicephore Niepce, had been experimenting with various materials which they hoped could be used to produce color images. In 1816, Niepce wrote to his brother Claude:

> The experiments I have thus far made lead me to believe that my process will succeed as far as the principal effect is concerned, but I must succeed in fixing the colors; this is what occupies me at the moment, and it is the most difficult.

While neither Daguerre nor Niepce succeeded in producing a workable color process, the desire to make photographs in color persisted, and it was not long before many photographers began to hand-color their daguerreotypes. Often the coloring consisted of nothing more than adding a little rosy color to the cheeks of people in the portraits; sometimes rather elaborate work was done in an attempt to simulate the full range of colors in the original scene.

It is interesting to speculate about what place black-and-white pictures would have had in the history of photography if practical color processes had been invented before black-and-white systems had become widespread. Assuming equal costs and ease of use of both black-and-white and color, it is not unlikely that black-and-white photography would have been considered something of a curiosity, perhaps desirable only for certain scientific or artistic applications. The principal achievement of photography has always been to record events, people, and scenes; color is almost always an important part of this reality.

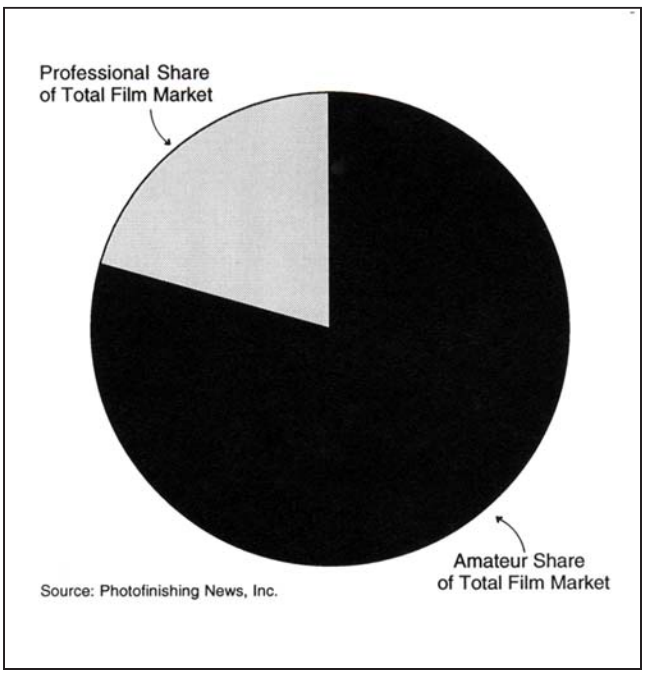


Figure 1.2 Beginning in the mid-1960's, amateur photography in the United States embarked on a major shift toward color negative films and color prints — and away from the previously popular black-and-white films and color slide films. By 1990, approximately 90% of all amateur photographs were made with color negative films and printed on color negative papers.

When portrait and wedding photographers made the virtually total shift from black-and-white to color photography during the 10 years from 1965 to 1975, there was very little realization on their part that in abandoning black-and-white photography, they were also giving up the long-term stability of the metallic silver images that they had come to take almost for granted.

The ability to make a portrait — to "Take A Moment Out Of Time . . . And Make It Last Forever," as a 1980 Kodak color portrait advertising slogan[5] put it — and know that the photograph could be displayed without worry for many generations to come was a very important part of the appeal of portrait photography ever since highly stable silver-gelatin materials (the ordinary black-and-white print) came into general use around 1900.

Despite their great stability advantages, black-and-white photographs are missing one crucial element, and that is color. We see in color; and the general public has shown an overwhelming preference for color images, whether they be color photographs, color television, color motion pictures, or color illustrations in newspapers, magazines, books, and advertisements. At their best, color photographs are stunningly beautiful in a way that is very different from the monochromatic images of carefully made black-and-white photographs. Color photographs offer a much more complete depiction of reality and provide much more visual information than do black-and-white photographs.

Joel Meyerowitz, a New York City fine art and commercial photographer who started his career in 1962 with black-and-white films and became an accomplished black-and-white printmaker, said this about color photography in an interview with Bruce K. MacDonald in *Cape Light,* his celebrated book of color photographs taken on Cape Cod which also served as the catalogue for a 1978 exhibition of the same name at the Museum of Fine Arts in Boston:

> . . . Color film appears to be responsive to the full spectrum of visible light while black and white reduces the spectrum to a very narrow wavelength. This stimulates in the user of each material a different set of responses.
>
> . . . Color is always a part of experience. Grass is green, not gray; flesh is color, not gray. Black and white is a very cultivated response.
>
> . . . [Color] makes everything more interesting. Color suggests more things to look at, new subjects for me. Color suggests that light itself is a subject. . . . Black and white taught me about a lot of interesting things: life in the streets, crazy behavior in America, shooting out of a car. Black and white shows how things look when they're stripped of their color. We've accepted that that's the way things are in a photograph for a long time because that's all we could get. That's changed now. We have color and it tells us more. There's more content! The form for the content is more complex, more interesting to work with.[6]

A 1963 Kodak ad that appeared on the back cover of the company's **Studio Light** magazine encouraged photographers to give up black-and-white photography and switch to color. The ad suggested that the Ektacolor prints of the time would "last a lifetime," which proved not to be true. When portrait and wedding photographers switched to color during the 1960's and early 1970's, most had no realization that in giving up black-and-white photography, they were also giving up a highly stable medium that could indeed last a lifetime. Properly processed black-and-white fiber-base prints can potentially be displayed for hundreds of years under normal conditions without significant change.

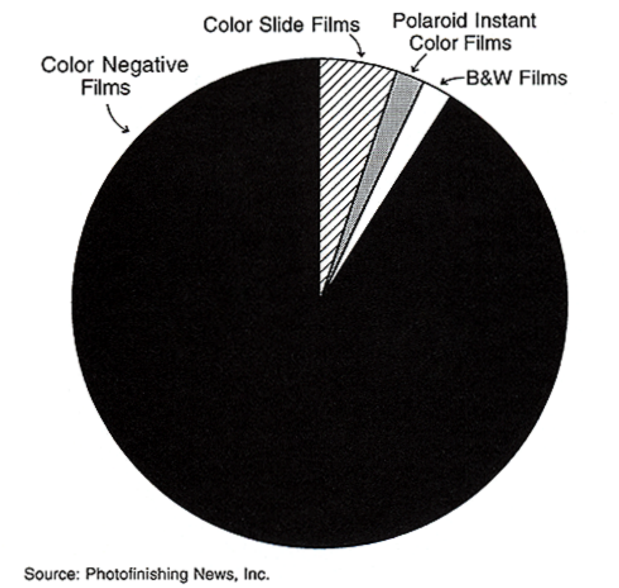


Figure 1.3 In terms of the total number of still camera exposures made in the United States, amateur photographers have by far the largest share of the market. In 1990, professionals made only about 20% of the total exposures, while amateurs — mostly using color negative films — contributed about 80%. Color negative films and papers designed for the amateur market have become the core of the worldwide photographic industry.

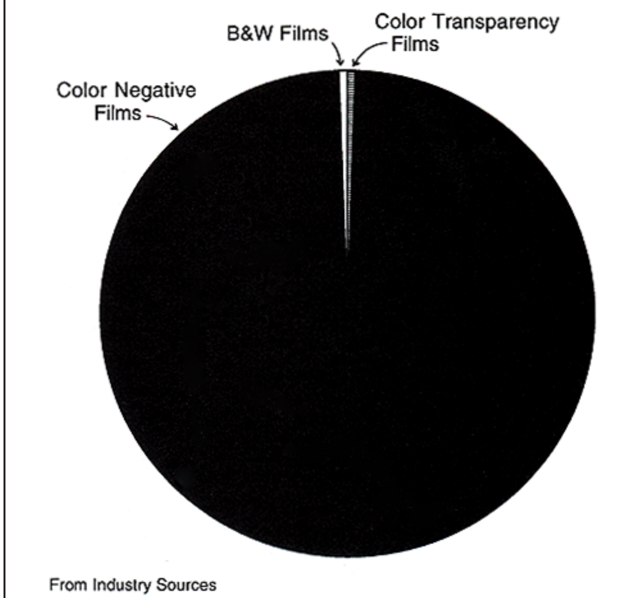


Figure 1.4 Professional portrait and wedding photographers have converted almost entirely to color negative films and papers (the Ektacolor papers used by many professional labs have the same image stability as their amateur "35-cent drugstore print" Ektacolor counterparts). In 1992, it was estimated that portraits and wedding photographs made with color transparency films and B&W films amounted to less than one percent of the total.

The Desire for Color Led to the Colorization of B&W Movies and Television Productions

The desire for color on the part of the general public is so strong that in the mid-1980's — over the heated objections of many movie directors and film curators — Turner Broadcasting System, through its Turner Entertainment Company subsidiary, and others began releasing "colorized" video versions of old black-and-white movies such as *It's a Wonderful Life* and *Yankee Doodle Dandy*. The colorized films are being broadcast over television and, in many cases, released on videocassette.

The colorization process is done with computers — with human operators making determinations about appropriate colors for each scene — and is output on videotape.[7] The movies themselves are not harmed and remain in their original black-and-white form. The computer-aided colorization of movies has become a flourishing industry, and many hundreds of films and early black-and-white television programs have been colorized for sale and rental in the global broadcast, cable, and videocassette markets.

Colorizing a film costs $2,500 to $3,000 a minute, with the costs for a feature-length film sometimes amounting to more than $350,000. Turner, which holds some 3,300 theatrical motion pictures in its library along with about 2,000 shorts and cartoons and more than 2,000 hours of television programs,[8] is by far the biggest customer of the colorizing business. At the time this book went to press in 1992, Turner had colorized several hundred films and had spent many millions of dollars on the effort.

Said Wilson Markle, president of Colorization Inc., a Toronto-based company that pioneered the colorization of black-and-white films: "People don't like black and white. They do like color, and when we color it, they buy it."[9]

According to Earl Glick, chairman of Hal Roach Studios, a Hollywood studio with many classic black-and-white movies in its archives:

> People who buy the movies for distribution and sale — television stations, networks, cable television and so on — always classify the black-and-white movie as a lesser picture, and therefore don't pay as much as they would pay for a color picture. Every time we went to sell something to them they'd say, "Well, this is only worth so much, because it's black and white." So we thought, well, if these pictures were in color, they'd command a much bigger price.[10]

An audience survey commissioned by the studio showed that "85 percent of people would watch something only if it were in color. In the age group under 20, nobody wants to watch anything in black and white." Glick went on to say: "We've sold more color cassettes of 'Way Out West' in six months than the black and white has sold in 10 years — and at a higher price."

Ironically, perhaps, at the present time the entertainment film industry is spending more money *adding* color to black-and-white films than it is spending to prevent color from fading away in existing color movies.

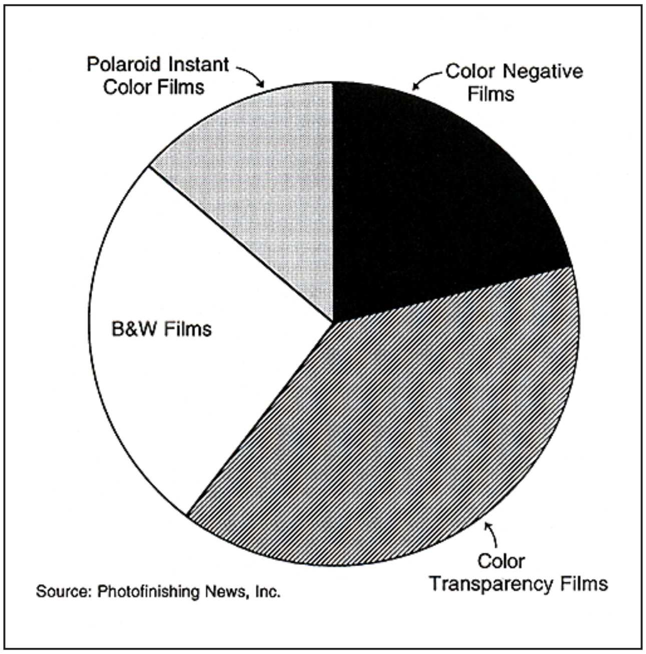


Figure 1.5 It is among photographers working in photojournalism, stock photography, fine art photography, and in commercial, industrial, educational, and scientific fields that color transparency films, black-and-white films, and Polaroid instant photographs are still widely used. But even these branches of photography are increasingly employing color negative films for their work.

The Modern Era of Color Photography Began in 1935–36 with the Introduction of Kodachrome and Agfacolor Neu Color Transparency Films

Although a number of color processes were available in the early 1900's, such as the additive screen Autochrome plates introduced by the Lumiere brothers in France in 1907, and dye-transfer and tricolor carbro prints made from glass-plate separation negatives photographed sequentially through red, green, and blue filters — or in complex "one-shot" cameras that exposed all three separation negatives with a single exposure — all of these early color processes saw only limited use. They were either so cumbersome and time-consuming that only the most dedicated photographers would consider using them, or, in the case of Autochrome plates and the other additive screen processes of the time, they lacked the resolution necessary to produce satisfactory results in any but large-format cameras, and making good-quality prints from the additive screen images was difficult and time-consuming.

With the introduction of Kodak Kodachrome transparency film in 1935 and Agfa Agfacolor Neu transparency film in 1936, high-quality color photography suddenly became accessible to everyone. These films, which formed images by a process known as *chromogenic development,* were the first successful integral tripack color films.

Kodachrome film was first marketed in 1935 as a 16mm amateur movie film. Kodachrome for 35mm color slides was introduced in 1936; the film had an ASA speed of 10. Kodachrome sheet films in sizes up to 8x10 inches were supplied for the professional market from 1938 until 1951.

Beginning in 1941, Kodak supplied the amateur market with prints made with the Kodachrome process under the Minicolor name; the prints, which had rounded corners, were made with a white pigmented acetate base. From 1946 until 1955, the acetate-base prints were sold under the Kodachrome Print name. The Kodachrome Print name continued to be used for many years after 1955 to signify any print made from a Kodachrome or Ektachrome transparency by Kodak Processing Laboratories. Most of these prints were printed on Kodak fiber-base or RC-base color negative papers with an internegative made from the transparency. In later years, many "Kodachrome Prints" were made with Ektachrome RC reversal papers.

Kodachrome process acetate-base prints supplied to the professional market were called Kotavachrome Prints from 1941 until 1946; from 1946 until 1956, the prints were sold under the Kodachrome Professional Print name. All Kodachrome process prints have very good dark storage stability — their dark stability is much better, in fact, than that of any current Kodak color negative or reversal paper.

Kodachrome grew out of the research of Leopold D. Mannes and Leo Godowsky, Jr., who were professional musicians and avid amateur photographers. Interested in the work of the two inventors, Kodak coated a number of experimental plates for Mannes and Godowsky beginning about 1922, and in 1930 Mannes and Godowsky accepted an invitation to join the staff of the Kodak Research Laboratories and work with other Kodak personnel in perfecting their new process. From 1935 to 1938 Kodachrome was designed to be processed using what was known as the controlled-diffusion bleach method; this was a very complex 28-step, 3½-hour process requiring three separate processing machines. The dark-storage stability of this first version of Kodachrome was relatively poor, and most examples have by now suffered nearly total loss of yellow dye.

In 1938 the processing of Kodachrome — as well as some aspects of the film itself — was changed to the selective re-exposure method, and the use of controlled-diffusion bleach baths was abandoned.

February 1989

The Kodachrome processing machine at The Color Place in Dallas, Texas (the line was closed at the end of 1992). Kodachrome has suffered a considerable loss of market share in recent years in favor of the much easier to process E-6 Fujichrome and Ektachrome films. At the time this book went to press in 1992, only two independent professional labs in the U.S. still processed Kodachrome.

Russell Lee for the Farm Security Administration – 1939 (Courtesy of the Library of Congress)

The initial "controlled-diffusion bleach" Kodachrome film and processing procedure was in use from 1935 until around 1940. As can be seen in this 35mm Kodachrome photograph taken in Oklahoma in 1939 by Russell Lee for the Farm Security Administration, the dark fading stability of Kodachrome film from this early period was poor.

Beginning with the improved film and processing procedure introduced in 1938, Kodachrome has had very good dark fading stability. Kodachrome film is still the only transparency film that remains totally free of yellowish stain formation during long-term storage.

Kodachrome processing continues to be a very complex procedure and can be done only with large, continuous processors. The three separate color developers and the two precisely controlled colored light re-exposure steps make it impractical for the user to process the film.

Agfacolor Neu Transparency Film Was the First Incorporated-Coupler Color Film

Agfacolor Neu film, introduced by Agfa in Germany in 1936, one year after Kodachrome film became available, was probably more significant than Kodachrome in that the basic incorporated-coupler design of Agfacolor Neu is now used in all chromogenic materials except Kodachrome. Because the color couplers were incorporated into the emulsion layers during manufacture, only one color developer

Russell Lee – 1940 (Library of Congress)

In 1938 Kodachrome film was modified and the processing procedure changed to the selective re-exposure reversal method that is still in use today. The excellent dark fading stability and freedom from yellowish stain of the improved Kodachrome process are evident in this 1940 photograph of a depression-era New Mexico family eating dinner.

was required and processing was greatly simplified compared with that required with Kodachrome film.

Although the technique Agfa devised to prevent color couplers in Agfacolor Neu film from migrating from one emulsion layer to another when the emulsion was wet and swollen during manufacturing and processing has been replaced by other methods (e.g., the "protected" or oil-encapsulated couplers invented by Kodak in the early 1940's and the latex "L-couplers" employed by Fuji in recent years), the incorporated-coupler concept pioneered by Agfa is now used with all color negative films, color negative papers, and with all Process E-6 compatible transparency films.

Formation of Color Image Dyes in Film and Print Emulsion Layers with Chromogenic Development

Chromogenic development (coupling color development) was first disclosed by the German chemist Rudolf Fischer in patents, and in articles written with his co-worker, Hans Siegrist, that were published between 1912 and 1914. In simple terms, the process of chromogenic development can be described as follows:

When a silver halide emulsion is developed with certain types of developers, oxidation products that are produced in the course of development of the silver image can be used to react with, or couple with, special types of chemical compounds known as *color couplers* to form colored dye images.[11] Thus, during processing, the dyes are chemically synthesized in the thin emulsion layers where they remain in place after they are formed.

With the exceptions of the special color-correcting "masking" couplers used with modern color negative films, the couplers themselves are colorless; it is the chemical reaction between the couplers and the developer oxidation products that forms the colored dyes. It can be seen that where there has been no light exposure and no development takes place, developer oxidation products are not produced and even though color couplers are present, no dye will be formed. Thus, the density of the dye image corresponds to the density of the silver image — which in turn is deter-

Courtesy of Klaus B. Hendriks

As illustrated by this 1938 Agfacolor transparency, the dark storage stability of early Agfacolor films was poor. The photograph is of Klaus B. Hendriks, the director of the Conservation Research Division of the National Archives of Canada, at the age of 10 months in Germany.

mined by the amount of light exposure received by the emulsion at each point in the image. After chromogenic development is completed, both a silver image and a colored dye image are present at the same locations in the emulsion; the silver image is later removed by converting it back into a silver halide (chemical bleaching) and then removing the silver halide with a fixer.

The great virtue of the chromogenic process is that it permits the same extremely light-sensitive silver halides employed in black-and-white films to be used to form high-resolution color images. Modern color photography is often referred to as "silver-based photography" or "silver halide photography" even though — unlike black-and-white photography — there is no silver left in color films or prints at the completion of processing.

In 1913, the year after he first described color couplers and suitable developers for producing color images, Fischer obtained a patent for the design of an integral tripack color film containing incorporated couplers that would form yellow, magenta, and cyan dyes in the three emulsion layers. Fischer was unable to make a usable color material based on his ideas, however. His main difficulty was in finding a way to prevent the couplers from wandering from their assigned layer into another layer of the emulsion while it was wet during manufacture or processing. If, for example, a magenta coupler diffuses out of the green sensitive emulsion layer into the red sensitive layer, magenta dye will be formed where there should be only a cyan dye image — thus preventing proper color reproduction.

Application of the original Fischer process was finally achieved by Agfa in the Agfacolor Neu transparency film introduced in 1936. In early 1939, Agfa introduced the world's first incorporated-coupler motion picture color negative film and a companion color print film. These products were the forerunners of all current still camera and motion picture color negative films, as well as motion picture print films and papers for printing color negatives.

Many thousands of different couplers have been formulated to date; new couplers are constantly being produced in the course of research and development by the manufacturers of color materials. Of course, only a relatively small number of couplers have actually been used in commercially available film and print materials. Among the properties of a coupler that determine its suitability for use in a particular emulsion layer are the following:

1. The color (and color purity) of the dye formed by the coupler. Couplers can be formulated to form dyes of almost any color, but in color photography, cyan, magenta, and yellow dyes are of primary interest. (A perfect magenta dye, for example, would absorb only green light and would be fully transparent to both red and blue light. In color photography, "perfect" dyes do not yet exist, and this degrades color reproduction.)

2. The color of the unreacted coupler. (Except with color negative films, couplers must be colorless.)

3. The coupler's reaction characteristics with the oxidation products that result from development of the particular silver halide used in an emulsion with the color developer at the time and temperature specified by the process (e.g., E-6, C-41, RA-4, R-3, and EP-2).

4. The light fading stability of the dye formed by the coupler. (Various chemical "stabilizers" may be incorporated in an emulsion during manufacture to reduce the harmful effects of light exposure. In addition, Ektacolor, Fujicolor, and all other *current* chromogenic print materials employ UV-absorbing emulsion overcoats that essentially eliminate UV radiation as a cause of fading in prints displayed under normal indoor conditions.)

5. The dark fading stability of the dye formed by the coupler. (Unreacted couplers that remain in the emulsion may have a significant deleterious effect on the dark fading stability of a dye.)

6. The tendency of unreacted couplers, which remain in the emulsion after processing, to produce stain over time. Such stain, which is almost always yellowish or brownish in color, is particularly noticeable in whites and other low-density areas of color prints. Yellowish stain can occur in dark storage, or it can be caused by exposure to light and ultraviolet radiation. With the Kodak Ektacolor papers available at the time this book went to press in 1992, yellowish stain formation in dark storage — caused primarily by the gradual discoloration of the initially colorless magenta couplers that remain in the print following processing — was a more serious problem than the dark fading of the image dyes themselves. Fujicolor SFA3 color negative paper and Fujichrome Type 35 reversal paper employ new types of "low-stain" magenta couplers that have greatly reduced rates of yellowish stain formation.

7. Whether or not the coupler is protected by a patent held by a competitor and, if it is, whether or not it can be licensed on acceptable terms.

Selection of a particular dye-forming coupler always involves a compromise of these and many other properties. Unless accelerated light fading and dark fading tests are performed, the stability characteristics of the dye formed by a particular coupler generally are not apparent until many months or years after processing.

From a manufacturer's point of view, the single most important characteristic of a color coupler is the color purity of the cyan, magenta, or yellow dye that it produces. The color purity of these dyes has a direct bearing on the color reproduction, color saturation, and other aspects of image quality that are apparent immediately after processing is completed. It is not surprising, then, that in the marketplace coupler characteristics relating to the visual quality of the dyes that make up the color image have *tended* to have priority over the long-term stability characteristics of a particular color dye.

Among Available Dyes and Pigments, Chromogenic Dyes Are Virtually Unique in Terms of Their Instability in Dark Storage

Among the available color processes, chromogenic films and prints as a group have the distinct limitation of being relatively unstable in dark storage. While most classes of dyes are subject to light fading, chromogenic dyes are almost unique among commercially available dyes in that many of them also have poor stability when stored in the dark unless kept at refrigerated temperatures.

While many of the dyes and pigments intended for use with fabrics, printing, watercolors, and other purposes have less than adequate light fading stability, nearly all of these colorants have very good stability when kept in the dark. For example, although the 4-color process inks used in offset printing typically have poor light fading stability (the magenta and yellow inks are generally much less stable than the cyan and black inks when exposed to light), the dark storage stability of these inks appears generally to be excellent. When a book of color photographs is printed on good-quality, long-lasting paper and is protected from undue exposure to light, the printed reproductions will probably far outlast the original color prints.

In the Years Following the Introduction of Kodachrome Film, There Have Been Tremendous Differences in the Permanence of the Many Types of Color Films and Prints That Have Been Marketed

While Kodachrome films and prints were successful products for Kodak, the company, which from its very beginnings has always been oriented toward the mass market, believed that the Kodachrome system had several serious shortcomings. First, in common with all color transparency films designed to be viewed by projection, Kodachrome films had a very narrow exposure latitude, which meant that the film was unusable in the simple, fixed-exposure box cameras of the day. This limitation alone effectively closed Kodak out of the bulk of the potentially huge market for amateur color snapshots. Kodak was well aware of the fact that although advanced amateur photographers were for the most part satisfied with putting on family slide shows to view their color photographs, most people preferred to have color prints which could be displayed, sent to friends and relatives, kept in wallets and purses, and arranged in carefully inscribed and dated albums.

With the Kodacolor process, introduced in 1942, Kodak believed that it had solved most of the marketing limitations of Kodachrome. Kodacolor was a wide-latitude chromogenic color negative film designed for use in fixed-exposure box cameras; both the film and prints were relatively simple to process. Kodacolor prints were made with a low-cost fiber-base paper support (it was many years later, in 1968, before a low-cost polyethylene resin-coated RC support was introduced as a substitute for the more expensive, non-absorbent acetate-base support of the type that was required with the Kodachrome print process).

Courtesy of Virginia Wolf

A 1944 Kodacolor print of John Wolf, the editor of this book, and his mother, Virginia Wolf. The severely stained print has been kept in an album and has not been displayed. All Kodacolor prints made from 1942 until 1953 now exhibit similar staining. Kodacolor prints from this period also have extremely poor light fading stability.

The Totally Lost Kodacolor Era of 1942–53

The fact that both Kodacolor films and prints were far less stable than Kodachrome films and prints — and of black-and-white films and prints — did not dissuade Kodak from marketing the products to an unsuspecting public. Consumers who made the unfortunate decision to use Kodacolor now have nothing left but unprintable negatives and faded, severely stained prints. In fact, this author does not know of a *single* Kodacolor print taken from 1942 until 1953 (the year that Kodak managed to significantly reduce the print staining problem) that survives today in reasonable condition; all have faded and developed an ugly, overall orange or yellow stain regardless of whether they

Printed reproductions such as this ad, which appeared on the back cover of the July 1950 issue of **Popular Photography** magazine, are the only record of what pre-1953 Kodacolor prints once looked like.

were exposed to light on display or kept in the dark in albums. The discoloration is caused by unstable magenta dye-forming color couplers that remain in the print after processing. These hundreds of millions — perhaps billions — of Kodacolor prints and negatives represent the first great era of color photography to be *totally* lost.

For Years the Permanence of Color Films and Prints Has Been Shrouded in Secrecy

It was during the early days of color photography that Kodak adopted a policy of strict secrecy on matters of color stability; the company concluded that it would not be in its best interests to let the public become aware of the extreme stability advantages of Kodachrome over Kodacolor. (Looking back on the history of color photography, it is difficult to find another pair of products offered by a manufacturer at the same time that had such an extreme difference in image stability.)

Kodak apparently feared that if the general public knew just how poor the stability of Kodacolor prints was — even if the prints were kept in an album in the dark — the market for Kodacolor would be seriously restricted. Most amateur photographers would simply continue to use black-and-white films. Color photography was much more profitable to Kodak than was black-and-white photography.

The decision not to disclose color stability information to the public meant that there was little incentive to introduce more stable color print processes. With stability data kept secret, Kodak could not advertise improvements in image stability, and over the years this has effectively doomed Kodak's interest in silver dye-bleach materials and other potentially long-lasting (and probably more expensive) color print processes for the general market.

As a result, during the early 1940's Kodak made a policy decision that was to have far-reaching consequences in terms of color permanence: the company decided that it should try to satisfy the requirements of nearly *every* branch of photography with one basic chromogenic color print material. This allowed considerable economies of production and a concentration of research and development activities. The design, processing speed, and cost requirements of this color print material were unfortunately dictated by its principal market: drugstore photofinishing. This is a hotly competitive market in which every fraction of a cent spent in producing a print is considered important.

Thus we have arrived at the present, with professional portrait and wedding photographers, fine art photographers, and photographers producing prints for historical documentation, all using a color print material whose every design aspect was dictated by the drugstore photofinishing and minilab business.

Very few people know that the most expensive color portrait or wedding photograph purchased from their local studio is printed on the *same type* of color paper that is used for the 35-cent prints they pick up at their local drugstore. In fact, as discussed in Chapter 8, because of the stability problems associated with the lacquering and retouching commonly done in the professional portrait field, there is a good possibility that the drugstore print, made on Ektacolor Edge Paper, is *more* stable than portrait and wedding photographs costing hundreds of dollars.

Kodak Continues to Keep Stability Data for Its Ektacolor and Ektachrome Papers Secret

Although Fuji, Konica, and Agfa have been routinely releasing basic image stability data for their color papers in recent years, Kodak has not disclosed stability data for any of its Process RA-4 Ektacolor papers, which date back to the introduction of Ektacolor 2001 Paper in 1986. At the time this book went to press in 1992, these papers included Ektacolor Edge, Royal II, Portra II, Supra, Ultra, and Duraflex. Likewise, Kodak had not released any stability data for Ektachrome Radiance or Radiance Select papers for printing color transparencies. Kodak also had not released stability data for Ektatherm thermal dye transfer paper, which is used in the Kodak XL 7700-series digital printers for making prints from Kodak Photo CD's and other digital sources. The index print ("contact print") accompanying every Kodak Photo CD is an Ektatherm print.

For a few years, beginning in the early 1980's, Kodak did publish dark fading and light fading data for its Ektacolor and Ektachrome papers. At that time the company also published stability data for its color negative, color transparency, and color motion picture films. A summation of Kodak's dark fading predictions is included in Chapter 5; data for motion picture films are included in Chapter 9.

At the time this book went to press in 1992, the most recent image stability data published by Kodak for its color papers dated back to February 1985 and were for Ektacolor Plus Paper,[12] a Process EP-2 paper that was introduced in 1984 as a replacement for Ektacolor 78 Paper.

Albert Wittmer – Courtesy of the International Museum of Photography (Gift of Walter Clark)

This 1941 Kodak Azochrome silver dye-bleach print is in the collection of the International Museum of Photography at George Eastman House in Rochester, New York. The print is believed to have been made from a 4x5-inch or 8x10-inch Kodachrome transparency. After more than 50 years of storage in the dark, the extremely sharp color image remains in excellent condition, with no apparent fading or staining. In dark storage, Azochrome was probably the most stable color print material ever developed by Kodak. In abandoning the high-stability silver dye-bleach process, Kodak embarked on a policy of focusing its color photography efforts on the high-volume, low-cost amateur snapshot market. Beginning with the introduction of Kodak Color Print Material Type C in 1955 (renamed Ektacolor Paper in 1958), there has been no significant difference in stability between Kodak's amateur and professional color papers — a situation that continues to exist today.

Kodak Almost Introduces Azochrome, a Highly Stable Silver Dye-Bleach Material, in 1941

In 1941, Eastman Kodak announced the Azochrome color print process, a high-stability silver dye-bleach direct positive process that Kodak had started work on in 1934.[13] (In the silver dye-bleach process — Ilfochrome is the only modern example — the image is made up of highly stable, fully formed dyes that are incorporated in the emulsion layers during manufacture. The dye layers are selectively bleached during processing to form the color image.)

The outbreak of World War II caused Kodak to postpone the marketing of Azochrome, and by the end of the war, Kodak had decided to abandon the Azochrome process and to concentrate its efforts on far less stable chromogenic materials such as Kodacolor for the general market and let the already existing Dye Transfer process satisfy the needs of the specialized, and small, advertising market.

A number of examples of early Azochrome prints examined by this author suggest that the process has excellent dark storage stability — certainly much better than any current Kodak chromogenic print material. If Kodak had actually gone ahead and introduced Azochrome in the early 1940's — and disclosed its superior stability characteristics — it is certain that the evolution of Kodak's color print materials would have proceeded much differently and that today the company would be producing far more stable color print materials for the professional market.

A high-stability, negative-printing version of Azochrome would have been extremely successful in the professional portrait and wedding market — and in the fine art field. Color microfilms and motion picture print films made with Azochrome technology would last *far longer* than Kodak's current chromogenic products for these applications.

Early Ektachrome Films Were Far Less Stable Than the Kodachrome Films They Replaced

When Kodak replaced large-format Kodachrome sheet films with Ektachrome films at the beginning of the 1950's, no one outside of the company was aware that these new films faded in the dark at least 20 times faster than the discontinued Kodachrome films. The large differences in image stability between these films was a closely held secret within Kodak. The unfortunate results of this product downgrading can be seen in the now severely faded Ekta-

An Ektachrome 120 transparency shot in 1959 by Norman Rothschild and stored in the dark in New York City under normal room-temperature conditions since it was taken. The severe cyan and yellow dye loss is characteristic of the Kodak Process E-1, E-2, and E-3 Ektachrome films in use from 1946 until 1976.

Above is a Kodachrome duplicate made in 1961 of the original Ektachrome transparency on the left. During the more than 30 years that have passed since the Kodachrome was made, it is estimated to have faded less than 10%. It not only shows what the original Ektachrome looked like but also illustrates the dramatic difference between the dark-storage stability of the two films.

chromes from the period in the collections of *Life* magazine (at Time Warner Inc.), *Vogue* magazine, the National Geographic Society, the Library of Congress, the International Museum of Photography at George Eastman House, and other institutions all over the world.

For example, the original 8x10-inch Process E-1 Ektachromes of the famous Marilyn Monroe calendar photographs taken by Los Angeles photographer Tom Kelly in 1947 have suffered severe fading. The images survive only because Dye Transfer and tricolor carbro (pigment) prints were made from the Ektachromes and because many photomechanical reproductions have been published in the years since the photographs were made.

During the period from 1959 to 1976, most professional commercial, advertising, and fashion photographers in the United States used Kodak Process E-3 Ektachrome films in sheet-film and roll-film formats. These films, and the E-3 duplicating films, had very poor dark fading stability and were far inferior to the then-available "amateur" 35mm Process E-4 Ektachrome films (1966–1977). Kodak has never explained why — for a 10-year period — professional photographers using Ektachrome were supplied with a far less stable product than were amateurs, a fact that was kept secret from professionals and amateurs alike. It was not until 1977, when all Ektachrome films were replaced by improved E-6 Ektachrome films, that the stability of the professional films finally equalled that of the amateur films.

The Eastman Color Motion Picture Process: A Major Problem for Film Studios and Archives

Color motion pictures, most of which are now made with a negative/positive color process that is in most respects similar to that used with still-camera color negatives and prints, have (with some exceptions) been significantly improved in terms of image stability since the mid-1980's. However, even the improved products require humidity-controlled cold storage for long-term preservation. Most motion picture color negatives and prints made after the introduction of the Eastman Color process in 1950 until about 1985 have by now suffered significant fading.[14] Nearly all Eastman Color prints made between 1950 and around 1970 have now lost most of the cyan dye component of their images (and usually much of the yellow dye as well), and all that remains is a ghastly reddish-magenta reminder of what once were brilliant, full-color images.

When the Technicolor Corporation abandoned its dye-imbibition motion picture print process in the mid-1970's, few people in the Hollywood movie industry realized that

75th ANNIVERSARY YEAR

VARIETY

PRICE $1

NEWSPAPER

OLD PIX DON'T DIE, THEY FADE AWAY

Pay-TV Pirates Put On Notice In House Bill

SCORSESE HELMS INDUSTRY PLEA TO KODAK

Brit. Equity Coin Keeps West End 'Chicago' Floating

The July 9, 1980 edition of **Variety**, the entertainment industry publication, featured a front-page story on the color film fading crisis. The article described film director Martin Scorsese's efforts to focus attention on the very poor image stability of the motion picture color negative and print films supplied by Kodak, Fuji, and Agfa.

As is vividly shown in this frame from the 1961 film **West Side Story**, starring Natalie Wood, Eastman Color Print Film from the period had extremely poor dark fading stability (the 70mm film clip containing this image was 30 years old at the time this book went to press). All Eastman Color Print Films dating from the introduction of the process in 1950 until 1982 have similarly poor image stability. Fortunately, in the case of **West Side Story**, black-and-white separation negatives were made from the camera color negative, and a new intermediate negative and release prints can be made from these separations.

Reproduced above is an actual frame from the 1935 Technicolor film **Becky Sharp**, which starred Miriam Hopkins and Alan Mowbray. **Becky Sharp** was the first feature-length movie filmed with Technicolor 3-strip cameras. The Technicolor dye-imbibition printing process produced color images that are essentially permanent in dark storage. Except for surface scratches, the cellulose nitrate film base of this 57-year old film clip, which has been kept in normal room-temperature storage in Hollywood, also remains in very good condition. A modern adaptation of the Technicolor imbibition printing process is currrently in use in China, but in the United States and Europe, the Technicolor imbibition process was replaced by the far less stable Eastman Color print process in the mid-1970's (see Chapter 10).

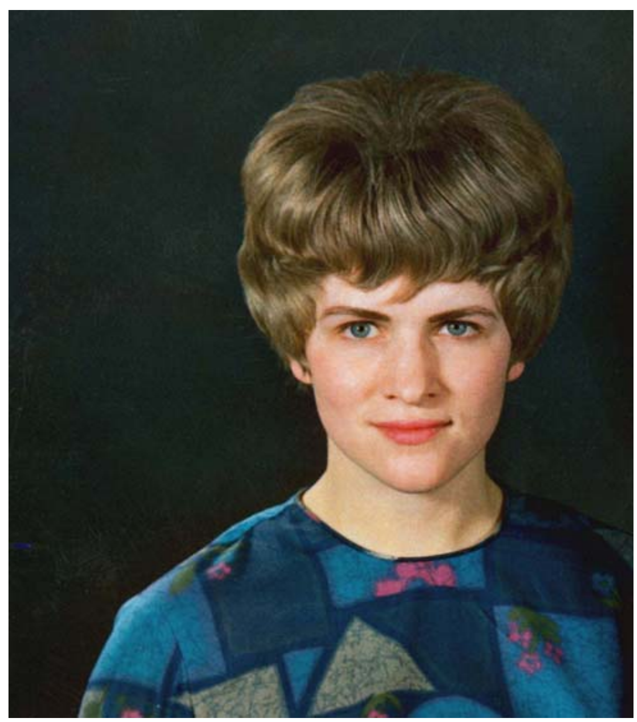
they were giving up permanent color motion pictures. Current Eastman Color Print Film 5384 is far less stable than prints made by the Technicolor dye-imbibition process.

The 3M Company Announces, and Then Withdraws, Its Pioneering Electrocolor Process for Making Highly Stable Electrophotographic Color Prints

The 3M Electrocolor process, which was introduced in 1965, produced color prints from both color negatives and color transparencies using a liquid-toner electrophotographic process developed by Vsevolod Tulagin and his co-workers at the 3M Company in St. Paul, Minnesota. In this author's accelerated aging tests, the prints appeared to be essentially permanent in the dark and had much better light fading stability than the Kodak Ektacolor paper and other chromogenic color negative papers available at the time.

Although 3M used organic dyes to form the images of Electrocolor prints, patents for the process state that pigments could also be employed.[15] With the proper selection of pigments, the process would have been capable of producing prints that were essentially permanent both when exposed to light on display and when kept in the dark.

Had the stability advantages of Electrocolor prints been properly promoted, the process would have been very successful in the upper tier of the portrait and wedding photography business. In a classic example of limited vision and missed opportunity, 3M failed to exploit the potential of the process and withdrew it from the market only 2 years after it was introduced. The basic technology employed in the Electrocolor process reappeared in 1990 in the 3M Digital Matchprint graphic arts direct-digital proofing system. As discussed later in this chapter, the Digital Matchprint system has the potential to produce inexpensive, highly stable color prints of excellent quality.



Courtesy of Donald R. Hotchkiss

The 3M Electrocolor liquid-toner electrophotographic process, introduced in 1965 and abandoned by 3M shortly thereafter, had the potential of producing color prints with outstanding image stability. This portrait is from a 2-inch-wide section of an 8x10-inch Electrocolor test print.

In 1970 Agfa of Germany Introduces, but Soon Abandons, the World's Most Stable Conventionally Processed Color Print Material

One of the saddest legacies from the era of secrecy regarding color stability is that on a number of occasions, when a promising process was being actively researched, or, in a few cases, actually put on the market, the veil of secrecy prevented the manufacturer from exploiting the stability advantages of the process — resulting in the product's demise. For example, in 1970 Agfa started production of Agfachrome CU-410, a reversal silver dye-bleach material used for printing transparencies in Agfa's photofinishing plants. According to the noted German color photography historian Gert Koshofer, the silver dye-bleach process had been investigated by Agfa since 1927, with intensive work beginning in 1962 culminating with the introduction of Agfachrome CU-410.[16] Samples of CU-410 tested by this author proved to be essentially permanent in dark storage and to have very good light fading stability; in fact, the prints have much better light fading stability than current Ilford Ilfochrome and Kodak Dye Transfer prints.

To this author's knowledge, Agfa never advertised the stability advantages of these prints. Because the material was somewhat more costly and also more difficult to manufacture and process than chromogenic reversal materials, Agfa stopped producing the material in 1976, just as quietly as it had begun 6 years earlier. Koshofer reports that few Agfa customers who received these prints even realized that they were made by the silver dye-bleach process or were otherwise different from other prints. The chromogenic Agfachrome reversal paper with which Agfa replaced the CU-410 process was vastly inferior in both light fading and dark-storage stability. If Agfachrome CU-410 were on the market today, it would in an overall sense be the world's most stable color print product (excluding the complex and considerably more expensive pigment color print processes). As it was well within Agfa's capability to perfect a negative-printing version of CU-410, the company could also have achieved tremendous sales in the professional portrait and wedding markets (which use color negative materials almost exclusively), and in the fine art field.

Agfachrome CU-410, and improved versions that would have followed if work on the process had continued, would have without a doubt been commercially successful if Agfa had had the wisdom to depart from its policy at the time of maintaining strict secrecy on matters concerning color stability. Image stability — the principal advantage of CU-410 over the company's chromogenic materials — was never promoted and the product was considered a failure. Agfa apparently was reluctant to publicize the excellent stability of Agfachrome CU-410 because this would inevitably have led to requests for information on Agfa's chromogenic Agfachrome and Agfacolor papers, which, by comparison, had very poor stability.

Courtesy of Gert Koshofer and Klaus B. Hendriks

An Agfachrome CU-410 silver dye-bleach print made in 1970. Essentially permanent in dark storage, the light fading stability of the prints is far better than in any other print material ever made by Agfa. In light fading tests conducted by this author, CU-410 lasted approximately **three times longer** than current Ilfochrome silver dye-bleach materials. Like Kodak, Agfa failed to recognize the importance of the silver dye-bleach system and abandoned the technology in favor of the far less stable chromogenic negative and reversal print systems.

The Worst Color Paper in Modern Times: Agfacolor Paper Type 4 (1974–1982)

In 1974, as a replacement for its then popular Agfacolor fiber-base paper, Agfa-Gevaert introduced Agfacolor PE Paper Type 4, the firm's first RC color paper. As the lowest-cost color paper available, Type 4 paper enjoyed wide use, especially in the mass portrait business, from the mid-1970's until the paper was discontinued in 1982. The paper was also used by a significant number of photofinishing labs in Europe and the U.S. The cyan dye in Agfacolor Type 4 paper had unbelievably poor dark fading stability, with the prints in most cases suffering from near-total cyan dye fading in less than 6 years. Untold millions of portraits

1987

A very faded 1977 childhood portrait of 13-month-old Donald Wilhelm IV and his 7-year-old sister Donna Jo that was made with Agfacolor Type 4 paper sits on the center of Donald's coffin. In 1987, at age 11, Donald died of cancer. The portrait was taken by a discount store photographer and the original negative no longer exists.

1991

Some color photographs last much longer than others. Like many people, Betty J. Gerber of Walnut Creek, California, shown here with her mostly very faded collection of family photographs, did not learn this fact until it was too late. In the 1970's and early 1980's, she had the misfortune of sending her color negative film to a photofinisher that used Agfacolor Type 4 paper. Whether kept in the dark or exposed to light on display, every single one of the countless millions of prints made with this paper worldwide has now faded to an ugly reddish ghost of the original color image.

of children, adults, and families made with Type 4 paper by PCA International, Inc. of Matthews, North Carolina and other mass-market portrait labs are now worthless. Business losses resulting from the exceedingly poor stability of the paper led to the filing of a nationwide class-action suit in 1985 against Agfa-Gevaert on behalf of labs and photographers across the United States who had used Type 4 paper; the case was settled out of court for an undisclosed sum in 1987. It is almost certain that, had the extremely poor stability of the paper been known, not a single lab would have used the product.

The fiasco did have one beneficial outcome, however — Agfa began to make a serious effort to improve the stability of its color papers, and the Agfacolor Type 8 and Type 9 papers that were available at the time this book went to press in 1992 represent a vast improvement over Agfa's ill-fated Type 4 paper.

In 1963 Ciba-Geigy Announces the Cibacolor Silver Dye-Bleach Process for Printing Color Negatives — But Cibacolor Is Never Marketed

Cibachrome (renamed Ilfochrome in 1991) and other silver dye-bleach products are inherently direct positive materials and therefore have always been used for making prints from color transparencies. It is possible, however, to make silver dye-bleach prints from color negatives by means of a special reversal processing procedure, and Ciba-Geigy announced such a product under the Cibacolor name at the same time the firm introduced Cibachrome in 1963. For reasons that have never been understood by this author, Ciba-Geigy decided not to market Cibacolor.

Essentially permanent in dark storage, Cibacolor prints also had light fading stability that was *far* superior to that of Ektacolor and other chromogenic materials available at the time. This author believes that the demand for Cibacolor would have been far greater than the currently limited market for Ilfochrome materials and that Ciba-Geigy's failure to exploit the potential of Cibacolor was a major blunder. Cibacolor would have been extremely successful in the portrait and wedding fields, which, because they use color negative films almost exclusively, have never been able to benefit from the superior permanence of Cibachrome.

Courtesy of Armin Meyer

This Cibacolor print, made directly from a color negative, was one of the prints exhibited by the Swiss firm Ciba-Geigy at the Photokina trade show in Germany in 1963.

© 1968 and 1971 by Max Brown

The upper print, made in 1971 with Ektacolor RC paper, faded much more than the lower print, made in 1968 with fiber-base Ektacolor Professional Paper, even though the fiber-base print had been displayed for 3 years longer than the RC print when this picture of the two choir photographs was taken in 1980. Both prints were framed under glass and had been on display next to each other in a church under similar lighting conditions.

1982

Max Brown, an Iowa portrait and wedding photographer, is shown here in 1981 with a group of severely faded prints that were made from 1969 to 1974 with the then-new Ektacolor RC papers. The prints had been returned to Brown's studio by irate customers asking for free replacements (see Chapter 8 for an account of Brown's lawsuit against Kodak which was brought about by the very poor stability of the early Ektacolor RC papers).

Displayed Ektacolor RC Prints Made in the Late 1960's and Early 1970's Have Suffered from Very Rapid Fading and Severe Color Shifts

Most Kodak Ektacolor RC prints made between 1968 and 1977 now exhibit severe image fading and shifts in color balance if they have been displayed; framing of these prints under glass — usually a recommended practice — appears to have actually *contributed* to their rapid deterioration. The prints were made with the first RC color papers marketed by Kodak, and this author believes that the RC base used with these products was itself a major factor in the rapid light fading that occurred (see discussion of RC base-associated fading and staining on page 72).

The rapid deterioration of these RC papers, which were introduced by Kodak during the period when many photography studios made the switch from black-and-white to color, caused considerable difficulties for professional portrait and wedding photographers after disgruntled customers returned faded prints to their studios (see Chapter 8).

© 1968 and 1970 by Fehrenbach Studios

Displayed under similar lighting conditions in a home, the Ektacolor RC print on the left faded much more than the fiber-base Ektacolor Professional print on the right, even though the RC print had been displayed for a shorter period when this photograph was taken in 1981.

Courtesy of Thomas T. Hill

This Polaroid SX-70 print, made in 1972 only a few months after the SX-70 system was introduced, has developed an overall yellowish stain which is plainly evident in the once-white background of this photograph. Cracks can be seen over the whole area of the image; the cracks are located in the image-receiving layer, beneath the transparent polyester print cover sheet. The print has been kept in the dark under normal storage conditions.

Polaroid SX-70 Instant Color Prints Made In the 1970's Quickly Developed Objectionable Levels of Yellowish Stain — Many Prints from the Period Also Suffer from Internal Image-Layer Cracking

The Polaroid SX-70 camera and instant color prints were quite a sensation when they were introduced in 1972, but it soon became apparent that both the image stability and physical stability of the one-of-a-kind prints was very poor. Objectionable levels of yellowish stain were often reached after only a few months in dark storage (see page 174). In addition, with SX-70 prints from the 1970's, the image receiving layer, located beneath the transparent print cover sheet, is subject to catastrophic cracking (see page 125).

During the 1970's and 1980's, Polaroid ran many advertisements for the company's SX-70 and Polacolor peel-apart instant color films which claimed that the prints had outstanding stability. An ad entitled "This Polaroid SX-70 Photograph Is Part of the Collection of the Museum of Modern Art" appeared in *The New Yorker* and other magazines in 1977; it stated that SX-70 prints have ". . . remarkable clarity and definition of detail whose color is among the most stable and fade resistant in existence."[17]

Using a large-format version of its Polacolor ER peel-apart film, Polaroid has for some years offered for sale life-size replicas of paintings in the collection of the Museum of Fine Arts in Boston.[18] Prices for the replicas, which are framed and intended for display, range from $120 to more than $1,000. This author's tests show that the light fading stability of the prints is very poor (see Chapter 3).

Consumer Reports Publishes Article Saying Kodak's PR-10 Instant Color Prints Have Very Poor Light Fading Stability

In November 1976, *Consumer Reports* magazine published an article that compared the light fading stability of the newly introduced Kodak Instant Print Film PR-10 and Polaroid SX-70 prints.[19] The magazine used high-intensity light fading tests and concluded that the light fading stability of the Kodak product was far inferior to Polaroid SX-70 prints. This apparently caught Kodak quite by surprise because a test report like this had never before appeared in a general-circulation publication.

In spite of the fact that Kodak's own — secret — light-fading tests agreed in general with the conclusions reached by *Consumer Reports*, Kodak's public relations people denounced the article and said that the high-intensity light fading tests used by the magazine were not valid and that "the entire tone" of the article was "misleading and blown out of proportion." According to Kodak, "the stability of Kodak instant prints is entirely satisfactory when such prints are handled, displayed, or stored in the usual variety of home and office situations . . ."[20]

As shown on page 138 (see the last entry in Table 3.3), this author's low-level, long-term light fading tests revealed that displayed Kodak PR-10 Instant color prints had extremely poor light fading stability — by far the worst, in fact, of any color print material ever tested by this author. If anything, the *Consumer Reports* article understated just how poor the light fading stability of Kodak PR-10 instant prints actually was.

Kodak was forced to withdraw its ill-fated instant print films and cameras from the market in 1986 after losing a historic patent infringement suit brought against the company by Polaroid. In the end, Kodak was ordered to pay Polaroid a total of $924,526,554 — nearly $1 billion! — in damages and interest; Kodak's total losses from its foray into instant photography probably exceeded $2 billion.

The Museum World and the General Public Become More Aware of – And Alarmed by – the Poor Permanence of Color Prints and Films

In what can be viewed as a landmark event that helped alert the museum world to the magnitude of the color stability problem and the need to better care for their collections, the International Museum of Photography at George Eastman House, in Rochester, New York, presented a "Colloquium on the Collection and Preservation of Color Photographs" in 1975. This was the first event of its type in the United States (earlier, in 1973, a conference on color preservation sponsored by the Royal Photographic Society was held at the Victoria and Albert Museum in London).[21]

In a letter of invitation to those attending the meeting, which was not open to the public, William Jenkins, a George Eastman House staff member and the organizer of the conference, wrote:

> As you may know, the International Museum of Photography has been concerned for some time with the difficulty of collecting color photographs. We have collected dye transfer and

> carbro prints believing these to be relatively permanent, but our policy has been to refrain from acquiring the less stable materials such as "Type C" prints.[22] [Note: In current usage, "Type C print" is a generic term used to refer to a Kodak Ektacolor print or other chromogenic print made from a color negative.]

George Larson, a key figure in stability research at Eastman Kodak, and Charleton Bard, who, during the 1980's, became Kodak's regular speaker on the subject of color stability, represented Kodak at the conference. Larson and Bard, for the first time, gave some basic room-temperature dark-keeping stability data for the current Kodachrome and Ektachrome films. The meeting was marked by some strong denunciations of Kodak for its secrecy policies and for the very poor image stability of many of its color products. The renowned portrait photographer, Arnold Newman, said at the conference:[23]

> Millions and millions of people have taken color wedding pictures, vacation pictures, and family snapshots. What's going to happen to these pictures in 25 years? They're going to disappear.

Newman, who showed the group a selection of severely faded Ektachrome transparencies he had taken some years earlier of President John F. Kennedy, also expressed alarm about the fate of color portraits:

> These things are carefully hung on walls and they are expected to last. The great American public doesn't know it, but it is buying junk.
>
> They [Kodak and the other manufacturers] are going to find that the public is going to start getting angry in about 8 to 10 years from now when all these personal pictures begin to fade.

Eastman House later changed its policy of not collecting Kodak Ektacolor prints (a potentially embarrassing situation in light of the fact that this is by far the largest selling print material produced by Kodak, the museum's most important benefactor); the collection now includes a sizable number of recently acquired Ektacolor prints.

Refrigerated storage was one of the major recommendations to emerge from the 1975 conference. With the acquisition of the 3M-Sipley Collection in 1976, Eastman House possessed the most valuable collection of historical color processes in the United States. Many of these early color photographs have already seriously deteriorated because of improper storage in the past, and the damage is becoming worse with each passing year.

In spite of the immense value of these photographs, many of which were made by color processes of which examples exist in no other collection in the United States, Eastman House did not include a refrigerated vault in its new $7.4-million archive building completed in 1988. At the time this book went to press in 1992, Eastman House continued to store its priceless collection of color photographs and motion pictures under improper conditions, without refrigeration.

October 1975

New York City photographer Arnold Newman complaining about his severely faded Process E-1 Ektachrome transparencies at the "Colloquium on the Collection and Preservation of Color Photographs" sponsored by George Eastman House in Rochester, New York in October 1975. Listening to Newman's complaints is Charleton Bard (right), a Kodak research scientist who worked on color image stability problems for the company.

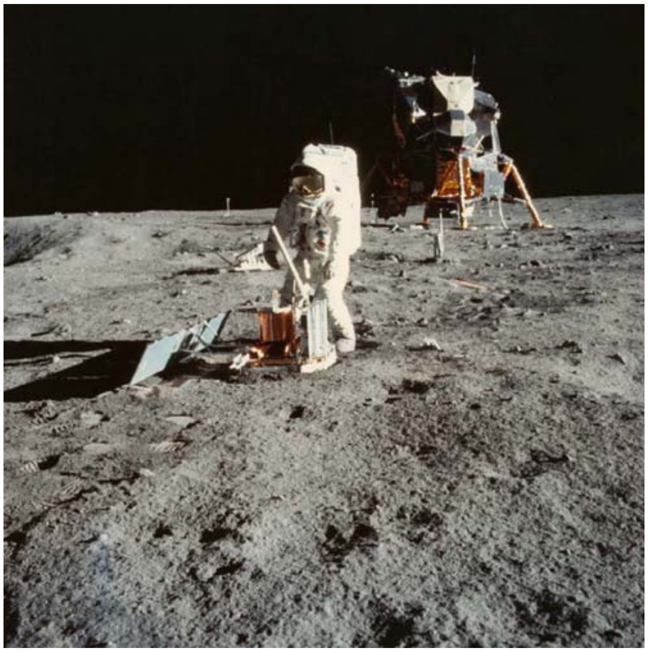
Neither Ilford, the manufacturer of Ilfochrome (then called Cibachrome and, at the time of the Eastman House Conference, the world's most stable color print material), nor Polaroid or Fuji was invited to attend the 1975 Eastman House conference.

Other Important Preservation Conferences Soon Followed

Concern about the instability of color materials and the desire to learn more about how to better care for collections of color photographs and motion pictures in museums and archives led to many other preservation conferences and symposia. Many of the articles on color stability and preservation published during the past 20 years were based on presentations given at these meetings.

The 1976 American Association for State and Local History Seminar in Madison, Wisconsin

In May 1976 the American Association for State and Local History (AASLH) sponsored a seminar on the "Use of Historical Photographs." Organized by George Talbot,



Courtesy of NASA (Photograph AS11-40-5947)

In this Ektachrome photograph by NASA astronaut Neil Armstrong, Edwin E. Aldrin, Jr. deploys a seismic experiment package on the surface of the moon during the historic July 1969 Apollo 11 mission. In the background is the lunar module in which the two astronauts descended from lunar orbit to a landing on the moon. The mission was the first time that human beings had set foot on the moon.

the meeting took place at the State Historical Society of Wisconsin in Madison, Wisconsin. This author and Klaus B. Hendriks of the National Archives of Canada were among the speakers; the processing and care of both black-and-white and color photographs in an institutional setting were discussed. The great increase in life afforded color photographs and motion pictures by humidity-controlled cold storage was emphasized.

Allan B. Goodrich, audiovisual archivist at the John Fitzgerald Kennedy Library in Boston, Massachusetts, was one of those attending the seminar; at that time, the Kennedy Library had not yet been completed and Goodrich had been thinking about how best to preserve the library's extensive collection of color materials from the Kennedy era. Goodrich had read a little-noticed 1970 article on color motion picture film storage by Peter Z. Adelstein and co-workers at Eastman Kodak entitled "Preservation of Motion Picture Color Films Having Permanent Value,"[24] which included a small graph that, for the first time, gave predictions for the number of years it would take for a 10% dye loss to occur with representative Kodak color motion picture films stored at temperatures down to 20°F (–6.7°C).

This article and the discussions about cold storage that took place at the AASLH seminar in Madison convinced Goodrich that it was indeed possible to preserve the Kennedy color negatives, color prints, and motion pictures indefinitely. At the time, the prevailing view among most museum curators and archivists was that "all color fades" and nothing could be done to stop it. Because of the image-stability problem, many curators and museum people had simply written off color photography altogether.

October 1987

The original Ektachrome EF and MS films used by the astronauts for photography on the historic Apollo mission to the moon on July 16–24, 1969, together with original color still photographs and motion pictures from other space missions, are permanently preserved at 0°F (–18°C) and 20% RH at NASA headquarters in Houston, Texas. As part of the most sophisticated color film preservation effort in the world, a complete set of color duplicates is stored in a second 0°F (20% RH) facility in Houston, and a third set is kept in a 0°F (20% RH) vault at White Sands, New Mexico.

In October 1979 the Kennedy Library began operation of a humidity-controlled cold storage vault maintained at 0°F (–18°C) and 30% RH to permanently preserve the Kennedy collection. This was the first humidity-controlled, 0°F photographic storage facility in the world, and it has helped encourage many other collecting institutions and motion picture studios to construct cold storage vaults to preserve their holdings (see Chapter 20).

The "Stability and Preservation of Photographic Materials" Session at the 1978 SPSE Annual Conference in Washington, D.C.

In an event that could be considered the beginning of the modern era of the photographic preservation field — in which scientific investigation of the complex deterioration processes affecting photographic materials over time came to the forefront — a special session on the "Stability and Preservation of Photographic Materials" was included in the program of the annual conference of the Society of Photographic Scientists and Engineers (now known as the Society for Imaging Science and Technology, or IS&T) in Washington, D.C. in May 1978.[25] This special session on preservation, which was the first of its kind at an SPSE meeting, was chaired by Klaus B. Hendriks of the National Archives of Canada.

The meeting included a presentation by Robert J. Tuite of Eastman Kodak on color image stability that contained significant new information about the stability of Kodak color materials and the accelerated test methods employed by Kodak.[26]

This author's presentation at the SPSE meeting included data which, for the first time, showed that there could be significant reciprocity failures with color print materials in accelerated light fading tests; in the talk, this author also proposed limits for dye loss, color imbalance, and stain formation in color print materials.[27] The meeting was an important first step by the photography industry toward becoming more open about the stability problems of color film and print materials.

Although most of Klaus Hendriks' research at the National Archives of Canada since he began his work there in 1975 has centered on the conservation of historical and modern black-and-white materials, his work in organizing numerous conferences and symposia for the Society of Imaging Science and Technology and other organizations has been an valuable contribution to the field of color preservation. Through internships in the conservation laboratories at the National Archives of Canada, Hendriks has helped train numerous individuals now working in the photographic conservation field.[28] Over a period of many years, Hendriks and his staff assembled *Phocus*, a bibliographic data base for photography conservation that is now the largest such on-line resource in the world. Hendriks is the author of the chapter on preservation in the 1989 book *Imaging Processes and Materials – Neblette's Eighth Edition*.[29]

The 1978 Conference on Color Permanence at the International Center of Photography in New York City

In May 1978, the International Center of Photography (ICP) in New York City sponsored a 2-day conference entitled "The Permanence of Color — Technology's Challenge, the Photographer's and Collector's Dilemma." The conference focused on color stability problems in fine art photography and in photojournalism; this author served as chairperson of the event. A number of experts in the field, including representatives of Polaroid and Ilford, gave presentations at the conference. Eastman Kodak was invited to take part but declined to attend.

Establishment of the Photographic Materials Group of the American Institute for Conservation in 1979

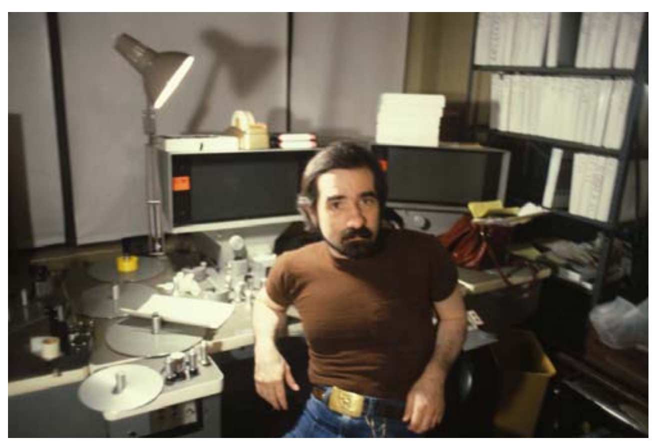
Since its founding in 1979, one of the most active organizations in the photographic conservation field has been the Photographic Materials Group of the American Institute for Conservation.[30] Usually meeting twice a year (the group sponsors a program at each annual conference of the American Institute for Conservation and also meets separately once a year at different locations around North America), the diverse membership of the Photographic Materials Group consists of practicing conservators, researchers in the conservation field, curators, and others responsible for the care of photographic collections.

The Photographic Materials Group (PMG) meetings have become a major venue for the exchange of conservation-related information, and each year the organization publishes a bound volume of collected papers that have been presented at the group's gatherings. A number of these papers are cited elsewhere in this book.

The 1980 American Film Institute and Library of Congress Cold Storage Conference

In 1980 the American Film Institute and the Library of Congress sponsored a conference in Washington, D.C. on "Cold Storage of Motion Picture Films" that helped increase awareness of the importance of low-temperature storage in the motion picture industry and in film archives.[31] Attending the conference on behalf of noted film director Martin Scorsese was Mark del Costello, who made an appeal for support of Scorsese's campaign to make improved color stability a high-priority goal for Kodak, Fuji, and Agfa-Gevaert.[32] Following the conference, this author began serving as a volunteer technical advisor on color stability-related issues to Scorsese and his staff.

At a meeting in Martin Scorsese's New York City apartment suite on July 14, 1980, Scorsese and his assistants Donna Gigliotti and Mark del Costello met with Ken Mason and Tony Bruno of Kodak's Motion Picture Division to discuss Scorsese's demands that Kodak (a) disclose the stability characteristics of its existing color motion picture



July 1980

Martin Scorsese, the director of **Cape Fear** (1991), **The Age of Innocence** (1993), and other noted films. Scorsese's film preservaton campaign helped to persuade Kodak and Fuji to develop the longer-lasting motion picture color negative and color print films that were introduced by both companies beginning in 1982. Scorsese has also encouraged the major Hollywood film studios to devote more time and money to film preservation — and to improve the storage conditions they provide for their film libraries (see discussion in Chapter 9 and Chapter 20).

The color film storage vault in the Paramount Pictures Film and Tape Archive, located on the Paramount studio lot on Melrose Avenue in Hollywood, California. The color film vault, one of nine vaults in the high-security building, is kept at 40°F (4.4°C) and 25% RH. The multi-million-dollar facility went into operation in 1990. Shown here in the color film vault, which is equipped with movable shelving to conserve space, is Robert McCracken, a supervisor in Archive Operations.

A roll of the original camera negative from Francis Ford Coppola's 1974 classic, **The Godfather, Part II**. The film, which won six Academy Awards, starred Robert DeNiro, Robert Duvall, Diane Keaton, and Al Pacino.

October 1992 (2)

films and (b) replace current films with longer-lasting products. With the weight of the entire entertainment motion picture industry behind him, Scorsese was able to convince Kodak that these issues had to be addressed.

In August 1980, only a month after the meeting, Kodak announced that color film and print stability data would be made public. The information became available in May 1981. In October 1981 Kodak announced that it was abandoning all of its existing motion picture print films and replacing them with Eastman Color Print Film 5384 (35mm) and 7384 (16mm); in dark storage these new films were about ten times more stable than the films they replaced. Fuji Photo Film Co., Ltd. soon followed with substantially more stable motion picture color negative and print films.

The 1982 *Fugitive Color* Exhibition and Symposium at the University of Michigan

In January 1982 the University of Michigan in Ann Arbor, Michigan sponsored a national invitational exhibition of contemporary color photography to focus attention on the shift from black-and-white to color photography in the fine art world and the resulting problem of "fugitive color." (As applied to works of art, the term "fugitive" means that a paint, watercolor, fabric dye, or other medium has poor stability, especially when exposed to light on display.) Most of the photographs in the exhibition were printed on Kodak Ektacolor 74 RC Paper.

This author contributed an essay to the *Fugitive Color* exhibition catalogue[33] entitled "The Problems of the Ektacolor Print System." The essay began with the statement:

> The problem with Kodak Ektacolor prints is simple: they fade. The prints not only fade when they are on display and exposed to light (one might even be tempted to forgive the product if this were its only fault); much worse, Ektacolor prints also fade in the *dark*. How fast they fade depends on the storage temperature and relative humidity.
>
> . . . In 25 to 30 years [of storage in the dark] the prints will have suffered a visible loss of contrast and a serious color shift toward red-yellow because of cyan dye fading; the whites in the prints will have significantly yellowed. And that is when the prints are kept in the *dark* except for occasional viewing; if the prints have the misfortune of being displayed for 25 to 30 years, the condition of the images could be far worse.
>
> . . . To be sure, there will still be recognizable images there, but they will not be the same images the artist had created. In the tradition of the art world, where one can find Rembrandts in pristine condition after hundreds of years of constant display, 25 to 30 years is not a very long time. In diverse medium collections such as that of the Museum of Modern Art, one would be unlikely to find *any* type of artistic media with worse dark keeping properties than Kodak Ektacolor RC prints. Even 18th-century watercolors, some of which fade quite rapidly on exposure to light, generally have very good dark keeping stability.

Accompanying the exhibition was a symposium on the stability problems of color prints and films. This author spoke on behalf of the exhibition organizers, and Charleton Bard, a color stability research scientist at Eastman Kodak, gave a presentation on the problem from Kodak's perspective. Sitting in the symposium audience was reporter

Marty Killeen, who was working on a feature on color fading for the CBS-TV show *Walter Cronkite's Universe*. The show was broadcast nationwide on August 31, 1982. Charleton Bard, this author, and Iowa portrait and wedding photographer Max Brown, who was plagued by irate customers bringing faded Ektacolor RC prints back to his studio demanding free reprints (see Chapter 8), appeared on the program to present their disparate views on the color fading problem.

Seminars on the Preservation of Photographs at the Rochester Institute of Technology

In September 1977 the Rochester Institute of Technology (RIT) in Rochester, New York sponsored the first of its semi-annual seminars on the "Restoration and Preservation of Photographic Images." Not only were these seminars popular among people in museums, archives, and industry who were responsible for the care and management of photographic collections, but they also served as an ad hoc twice-a-year gathering for many of the speakers, including this author, who were active in the newly emerging field of photographic preservation. The early RIT seminars were much-anticipated events and featured a free and enthusiastic exchange of information and viewpoints between the seminar speakers themselves and the always-interesting attendees.

The seminars were cancelled amid controversy in 1981 after it was revealed that Kodak had secretly pressured RIT to cancel this author's invitation to speak on the stability and preservation of color photographs at a seminar scheduled to take place in August 1980.[34] Kodak was displeased with this author's critical comments concerning the image stability of its color films and print materials, especially Kodak's extremely unstable PR-10 instant print film. (Kodak's instant print films and cameras were withdrawn from the market in 1986 after a federal court ruled that Kodak had infringed on Polaroid patents; Kodak was ordered to pay Polaroid $925 million in damages.)

The last of the seminars took place in March 1981. Several years later the seminars resumed — with the discussions at first restricted to black-and-white photography. This author has not been invited back to speak at RIT.

The Image Permanence Institute Is Established at the Rochester Institute of Technology

One positive outgrowth of the RIT preservation seminars was the establishment in 1986 of the Image Permanence Institute (IPI) at the Rochester Institute of Technology.[35] Directed by James M. Reilly, the Institute is jointly sponsored by RIT and the Society for Imaging Science and Technology (IS&T). Reilly had been a regular speaker at the RIT preservation seminars and, initially working on his own, had become the world's leading authority on the technological history and preservation of albumen prints and other 19th-century processes. Reilly's book, *Care and Identification of 19th-Century Photographic Prints*, published by Eastman Kodak in 1986, is the definitive reference on the subject.[36]

IPI's research on protective polysulfide treatments for the silver images in microfilms and other types of black-

Treasured Ektacolor portraits of U.S. presidents fade too. Shown above as they appeared in 1979 in an exhibit at the Lyndon Baines Johnson Library and Museum in Austin, Texas, these very faded, personally inscribed portraits had been given to President Johnson by five former presidents: Herbert Hoover, Dwight D. Eisenhower, John F. Kennedy, Franklin D. Roosevelt, and Harry S. Truman. The framed group of photographs had been displayed in a small conference room next to the Oval Office in the White House from 1963 until 1969, during Johnson's term in office. The five portraits are said to have been among Johnson's most treasured possessions. The Johnson Library installed the exhibit in 1974; it was removed in 1981, and the faded portraits are now in room-temperature storage. Johnson died in 1973.

November 1979 (2)

Examination of the very faded portrait of Herbert Hoover at the upper left indicates that the print was made with fiber-base Ektacolor paper. The center portrait of Eisenhower is a Kodak Dye Transfer print; the image has suffered from considerable yellow dye fading. The portrait of Kennedy, at the upper right, is another Ektacolor print. At the lower left is a hand-tinted black-and-white print of Roosevelt. The portrait of Truman at the lower right appears to have been made with an Ektachrome paper, although this identification is not certain.

May 1982

Color as Form: A History of Color Photography exhibition at the Corcoran Gallery of Art in Washington, D.C. in 1982. Organized by the International Museum of Photography at George Eastman House, this was the first major exhibition of color photography to be densitometrically monitored to quantify fading or staining that might have occurred during the course of the exhibition. Copy transparencies were used for Autochrome plates and certain other fragile items in the exhibition.

and-white materials and its investigations of the stability of polyester, cellulose triacetate, cellulose nitrate, and other cellulose ester film-base materials when stored at various temperatures and relative humidities have been of major importance in the preservation field. IPI has built upon earlier research to better understand the relationship between relative humidity in storage and the deterioration of silver images and film base materials. IPI's findings have placed renewed emphasis on the substantial increases in longevity of these materials afforded by low-temperature and low-humidity storage. IPI also has an ongoing research program to investigate the effects of air pollutants on the stability of black-and-white and color materials.

James Reilly, Peter Adelstein, Douglas Nishimura, and others on the staff of IPI have been active participants in the work of a number of American National Standards Institute (ANSI) subcommittees concerned with stability testing and preservation. Adelstein, who retired from Eastman Kodak in 1987, presently serves as chairman of ANSI Subcommittee IT9, which has jurisdiction over all of the ANSI standards related to the permanence of imaging materials and systems, including magnetic tape, magnetic disk, and optical disk image-storage systems.

Most of IPI's initial funding was provided by Eastman Kodak and other companies in the photographic industry, although at the present time, grants from institutional and government sources constitute the primary support for IPI's activities. IPI also conducts materials testing for private companies under contract.

Policy for the Image Permanence Institute is set by the Board of Advisors, which is made up of representatives from the funding companies in the photographic industry, RIT, a number of collecting institutions, IS&T, and several private firms that supply storage and display materials. As a matter of policy, IPI does not publish comparative evaluations of the stability of commercial products (e.g., color films and papers), nor does it permit companies that contract its services to use IPI test data for such comparisons.

Fine Art Museums Begin to Respond to the Problems Posed by Color Photographs

Almost immediately after the fine art photography world had finally embraced color photography as an art form in its own right in the late 1970's, museum curators, private collectors, and a new generation of photographers working in color began asking questions about how long color prints could safely be displayed.

Some wondered if Kodak Ektacolor color prints actually faded in the dark. Others would collect nothing but Kodak Dye Transfer prints, hearing that they would last forever. Some museum curators and collectors, fearing that their investments would depreciate as the prints faded, would not collect color photographs at all. (The tenor of the time was nicely captured in Nancy Stevens' essay "The Perils and Pleasures of Collecting Color," which appeared in the May 12, 1979 issue of the *Saturday Review* magazine.)

Among fine art museums, a three-part strategy to deal with the color print fading problem gradually emerged. The first step is to obtain from the photographer two identical copies of each color photograph chosen for acquisition. This approach provides an "expendable" copy for display purposes, for use as a study print, and for loan to other institutions for exhibition. The second "preservation copy" is kept in the dark under the best storage conditions available. A major benefit of the two-print approach is that the condition of the "expendable" print can easily be assessed at any point in time by a simple side-by-side visual comparison with the "preservation" print.

The Museum of Modern Art in New York City and the Art Institute of Chicago are among the museums that have instituted a two-print acquisition program. Both museums have found that photographers working in color are almost always supportive of the museums' efforts to preserve their work for posterity and are happy to provide the second copy at a sharply reduced "lab price" (the actual cost of making the print). The Museum of Modern Art, which is

The Art Institute of Chicago, which owns an extensive collection of color photographs, was the first fine art museum to implement an ongoing densitometric monitoring program for the color and black-and-white prints in its collection (see Chapter 7 for print monitoring procedures).

The Art Institute was also the first fine art museum to provide cold storage for its collection of color photographs. Shown here examining color prints in the vault, which was constructed in 1982, are David Travis, curator of photography, and Douglas G. Severson, conservator. When stored at normal room temperature, Ektacolor prints from the 1970's and early 1980's have poor dye stability and high rates of yellowish stain formation. With few fine art museums having cold storage facilities, many of the Ektacolor prints preserved in the Art Institute's vault are believed to be the **only** examples of these images existing anywhere in the world that look essentially the same today as they did when they were made.

generally credited with launching the modern era of fine art color photography with the 1976 exhibition of William Eggelston's color photographs curated by John Szarkowski, director of the Department of Photography, issued the statement reproduced below in 1984:

The Museum of Modern Art
New York

Statement to Photographers Who Work in Color

It is now well known that with a few exceptions color print materials show a noticeable fading or color shift within as little as ten to twenty years when stored under normal room temperature and humidity conditions, even in the dark. Most such works in the Museum's Collection, prints up to 20 x 24 inches, are now stored at about 30°F [–1.1°C] and 35% relative humidity. These conditions will substantially increase the life of the prints.

However, these same photographs also fade or change color when, on exhibition, they are exposed to light. Since it is our purpose not only to preserve but also to show the pictures we collect, we propose the following:

When we decide to purchase a color print in unstable materials, we will ask to buy two prints, one at the artist's price, the other at the presumably much lower "lab" price, or what it costs to make the print. The Museum will agree to regard the two prints as equivalent versions of a single work of art, and will so record them. Neither print ever will be sold. Both prints will be placed in cold low-humidity storage. One will be available for exhibition and loan; the other will be kept in effect as a back-up, until such time as the first is judged to have faded significantly. This solution is not perfect, but it will help to resolve the conflict between our goals of preserving the Collection and making it known through exhibition here and elsewhere.

The second preservation step being taken by enlightened fine art museums is to provide humidity-controlled cold storage for their color prints and other materials with problematic dark storage stability. In the case of the Museum of Modern Art, a low-humidity refrigerator is now employed (see Chapter 19). The Art Institute of Chicago constructed a large, two-part, humidity-controlled cold storage vault in 1982 for housing its entire photography collection; color materials are kept in the colder of the two vault sections. The National Gallery of Canada in Ottawa began operation of a cold storage vault for its extensive fine art collection in 1988 (see Chapter 20).

The third preservation step now being employed by fine art museums is the electronic monitoring of the fading and staining that may occur over time with the color and black-and-white prints in their collections (see Chapter 7). Periodically, an electronic densitometer is used to measure the red, green, and blue densities at selected locations on each print. A measurement location map is prepared for each print, and records are kept of all density readings.

These procedures allow detection of any significant fading or staining that occurs over time, and if the changes exceed certain predetermined limits, the print in question is taken off display and is retired to the cold storage vault. Both the Art Institute of Chicago and the National Gallery of Canada have instituted monitoring programs for their collections. Monitoring is particularly important for prints that have no second "preservation copy" in cold storage.

This three-part preservation strategy allows fine art museums to collect color photographs made with virtually any color material — no matter how unstable it may be — and preserve the prints in essentially unchanged condition for the far distant future.

Former President Dwight D. Eisenhower speaking at a press conference at Grinnell College in Grinnell, Iowa in May 1965. As with other U.S. news events of the time, television crews filmed the press conference with Eastman Ektachrome Video News Film, a 16mm reversal film. Eisenhower, who served as president of the United States from 1953 until 1961, died in 1969.

May 13, 1965 (2)

Scenes such as the above were soon to end. By the close of the 1970's, the motion picture camera had all but disappeared in the television news field, replaced by compact ENG (electronic news gathering) television cameras made by Sony and other manufacturers. This was the first major market in which electronic systems totally replaced traditional color photography.

With the Invention of Television in the 1920's, Image Making Has Been Gradually Shifting from Traditional Photography to Electronic Systems

Beginning in 1956, with the introduction by the Ampex Corporation of the 2-inch quadruplex video tape recorder, the first practical video tape recorder for television,[37] traditional silver-halide-based black-and-white and color photography began a steady transition toward electronic systems for recording and preserving moving images.

For the advent of electronic *origination* of images, one must go back another 50 years — to the early 1900's — when a number of farsighted inventors in Europe and the United States involved themselves in trying to solve the vexing problems of "photographing" and transmitting images electrically — an exciting new concept that was called "television" (a word that has been credited to a Frenchman named Perskyi, who used the French word "télévision" in documents prepared for the 1900 Congres Internationale d'Electricité).[38]

By the mid-1920's, the time had come for the introduction of television to the general public. The following is excerpted from an account of the history of television by Richard S. O'Brian and Robert B. Monroe that was published in the *SMPTE Journal* in July 1976:[39]

> Stimulated by the ready public acceptance of radio broadcasting, it was inevitable that work would be undertaken to develop a working television system. Two inventive individuals, independently, but more or less simultaneously, undertook this mission: John Logie Baird, a Scottish engineer, in England, and C. Francis Jenkins, an independent inventor, in the U.S.A. Jenkins had achieved success in designing the first practical projector for motion-picture film in the 1890's and had made numerous contributions to motion-picture equipment design and to later development of still-picture transmission (wire or radio photos) technology. His approach to television was as a means of extending the motion picture into the home or conversely of enabling wired or wireless transmission to theaters from a central production location.
>
> . . . Both Baird and Jenkins appear to have succeeded in transmitting small, silhouette images contemporaneously, in 1925, [with] Jenkins actually making the world's first radio transmission of moving "shadow graphs" across the Anacostia River near Washington, D.C. on 13 June 1925. Baird had achieved silhouette picture transmission just a few weeks earlier, giving public demonstrations in a London department store during April 1925. The January 1926 demonstration by Baird is, however, generally recognized as the first in which gradations of tone scale in the moving

Carol Brower – June 1987

Amateur home movies, most of which were made with 8mm reversal color film, became the second major market in which traditional silver-halide-based photography was totally displaced by electronic systems. Exploding in popularity during the 1980's, the now-ubiquitous camcorder offers "instant" moving images with sound (and with no chemical processing) at far less cost and trouble than the earlier movie cameras and projectors. Shown here taping with their 8mm camcorder is the Clark and Teresa Winter family, at home in their New York City apartment.

> images made it possible to recognize facial features and expressions, despite the very coarse scanning structure used at the time. Line counts of 16, 24, 30, 48, 60, and in a few years, as high as 240, were subsequently used as refinement of mechanical and optical components was achieved.
>
> . . . Experimental television broadcasting, using mechanical scanning, soon began in the U.S. The first, and now barely remembered introduction of television broadcasting to the public was under way. The first license, W3XK, went to Jenkins in 1927 for a visual transmitter located near Washington, D.C.; other stations followed. In 1927, Dr. Ernst Alexanderson at General Electric began experimental television transmission over W2XAD, Schenectady. [By the next year, the pioneering Schenectady, New York TV station was broadcasting rather ambitious television productions that included television's first drama, *The Queen's Messenger*, a three-camera production, the sound portion of which was broadcast over sister-station WGY.]
>
> In 1928, RCA started operating an experimental 250-watt television station W2XBS, from 411 Fifth Avenue in New York City. By 1929, twenty-two experimental television licenses had been issued in the U.S. and portions of the radio spectrum between 2.0 and 2.95 MHz had been set aside for experimental transmissions.
>
> In Germany and in England, experimental television broadcasting was also under way. In 1929, arrangements were made between the BBC and the Baird Television Company for regular experimental transmission of television pictures from the London station. These early BBC television transmissions took place for one-half hour periods, five days a week, and had a definition of 30 lines and a frame repetition frequency of 12½ frames per second.
>
> In addition to this broadcasting schedule, Baird seemed intent on anticipating and exploring every possible television application. In May 1927 he demonstrated the transmission of television signals by telephone line between London and Glasgow. In February 1928, he transmitted the narrow-band television signals between London and New York, and to the S.S. Berengaria in mid-Atlantic, by shortwave radio. By 1930 Baird had demonstrated color television, 3-dimensional television, theater projection (of 30-line images!), infrared television pickup (called "Noctovision"), and had made television recordings on phonograph records. In June 1932 he transmitted the Derby from Epsom Downs on closed-circuit television to a capacity paying audience at the Metropole Cinema, Victoria, London, thus inaugurating theater pay-television!

It was the 1923 patent application for an all-electronic television system developed by Dr. Vladimir K. Zworykin, a Russian immigrant working for Westinghouse in the United States, that launched the modern era of television. Zworykin's system, which was demonstrated in 1924, employed an electronically scanned camera imaging tube (the Iconoscope) and a cathode-ray tube (CRT) for viewing in a TV receiver.

The Zworykin patent also covered the use of electronic flying-spot scanning for converting still-camera slides and motion pictures to television images. In 1929, Zworykin joined RCA to continue his work on advanced television systems and camera imaging tubes.

© 1967 by Robert Hodierne

Most network television coverage of the Vietnam war was done with 16mm motion picture cameras and Ektachrome color reversal film. In this scene, photographed in 1967 about 15 miles north of Saigon, television crews film the last words of a dying North Vietnamese soldier. The Ektachrome motion picture films of the time have poor image stability (which was often made worse by hurried processing and washing) and, with few exceptions, are steadily deteriorating in non-refrigerated storage in television news archives around the world.

By 1940 television had advanced to the point where nationwide commercial broadcasting was ready to begin. In May 1941 the Federal Communications Commission, acting on the recommendations of the National Television Systems Committee (NTSC), a group of 168 specialists from the radio and television industry, established a set of 22 standards that covered all technical aspects of monochrome television broadcasting, based on 525 picture-scanning lines.

Color Television Finally Gains Widespread Acceptance in the 1960's

In 1953 the FCC, acting on the recommendations of a second National Television Systems Committee, set standards for black-and-white compatible color television broadcasting; using 525 picture-scanning lines, this is the system that is still with us today. (PAL and SECAM, which are the primary German and French broadcast standards in Europe, are adaptations of the NTSC scheme but employ 625 picture-scanning lines.)

RCA began manufacturing color television receivers in 1954, and by the end of 1955 the company offered an extensive line of color television sets. The high cost of color television receivers, the limited amount of color programming available, and the notion held by many people that black-and-white television images were adequate served to discourage the public from buying the new color receivers. At the end of 1956, less than 1% of households in the United States had purchased color television sets.

It took another 10 years for color television to really catch on with the public. By 1967 CBS and ABC had joined NBC in converting all operations to color, and by 1970 the entire U.S. broadcasting industry had fully embraced color. Today, the vast majority of televisions sold are color units.

The Sony Betamax home video cassette recorder (VCR), introduced in 1974 (and obsolete by 1990, having lost out in

February 8, 1988

Julia and Julia, a historic 1987 Italian production starring Kathleen Turner and Sting, was the first full-length feature to be shot entirely with high-definition television cameras instead of with motion picture film. After editing, the video image was transferred to motion picture color negative film (via three electronically printed B&W intermediate films) and released on standard color motion picture print film for projection in theaters (shown above is the Varsity Theatre in Des Moines, Iowa). Sony HDTV cameras and video recorders were used for the production, which was "filmed" by cinematographer Giuseppe Rotunno.[40] At the time this book went to press in 1992, **Julia and Julia** remained the only major theatrical feature to have been originated in HDTV; a variety of practical problems, including lack of easily portable HDTV cameras and image resolution that is inferior to that of film, have discouraged more widespread use of HDTV in the theatrical entertainment industry.

February 7, 1988

An advertisement for **Julia and Julia** that appeared in the **New York Times** in 1988. Produced by RAI (Radiotelevisione Italiana), the "film" joins the 1935 Technicolor 3-strip film **Becky Sharp** and the 1951 Canadian Eastman Color film **Royal Journey** as the first feature-length theatrical productions to adopt a new technology marking an epochal change in the way color moving images are recorded.

the market to the competing VHS system) enabled consumers to record their favorite programs for later viewing and — in a little-anticipated development — launched the huge worldwide pre-recorded videocassette business.

High-Definition, All-Digital Television Broadcast Standards for the United States Are Expected to Be Issued by the FCC by the End of 1994

With a modest screen size — and viewed at normal distances — most people have come to accept the 525-line television picture, established more than 50 years ago in 1941, as having "adequate" image quality. With increasingly popular large-screen and projection television, however, the shortcomings of the 525-line picture (or the 625-line system used in Europe) are readily apparent.

A visually and aurally more sophisticated public, which quickly embraced the laser-read, non-contact optical audio CD because of its scratch-free, pristine sound and its claims of lasting "forever" without wearing out regardless of how many times it is played, has begun to expect better image quality in television as well. Magazines, books, and even newspapers are offering ever-better color reproduction. Color computer monitors now typically have far better image resolution than current 525-line television systems.

By the end of 1994, it is expected that the Federal Communications Commission will issue new regulations setting standards for an all-digital, high-definition television (HDTV) color broadcasting system for the United States. These new broadcast standards and the digital HDTV cameras and televisions, digital signal compression technology, HDTV videotape and laser-disk players and recorders, CD-ROM-based video game units, and the interactive, high-capacity wire and fiber-optic cable systems that will become available during the remainder of the decade are certain to accelerate adoption of electronic imaging and transmission systems in many areas of still photography.

September 1992

Sony HDTV analog television receivers drew large crowds at the Photokina trade show in Germany in 1992.

October 1992

Vast quantities of videotape from television productions are in storage around the world. Shown above is a section of the videotape library stored in the Paramount Pictures Film and Tape Archive in Hollywood, California. Paramount Pictures, which inspects all of its videotapes about every 4 years, has copied all of its analog videotapes onto digital videotape. Because of frequent videotape format changes and consequent equipment obsolescence, the long-term preservation of video materials presents far more difficult problems than is the case with the preservation of color motion picture films in cold storage.

The Merging of Still Photography with Digital Imaging Systems

For a variety of reasons, electronic imaging systems have been much slower to become accepted in still photography than has been the case in the moving-image field where film is now all but dead in most parts of the business.

When the Sony Mavica still video camera was introduced with great fanfare in 1981, there was considerable speculation that traditional silver-halide-based photography would soon be a thing of the past. But consumers were quick to realize that the pictorial quality of the 525-line images produced with the expensive camera was far inferior to that of traditional photography, and market acceptance of the Mavica was much less than Sony had expected. Most people have little interest in viewing silent still-camera images on a television set — a fact that Kodak faces in its effort to sell the Photo CD system in the amateur snapshot market.

Although the Mavica camera could produce small prints that were suitable for some applications, the poor resolution of the images meant that it was impossible to make satisfactory enlargements for display purposes. Cameras such as the $10,000 Kodak DCS 200 Digital Camera produce images that may be adequate for applications such as newspaper photography, but they still fall short of the image quality obtained with traditional cameras and films. (A single 35mm ISO 100 color negative frame may contain 18 megabytes or more of digital data — which is more data than the fully formatted text of this entire book — and to equal this level of image quality with an all-electronic camera at reasonable cost is well beyond the capability of current technology.)

The availability of high-resolution film scanners, increasingly powerful and affordable desktop computers, high capacity data storage systems (the Kodak Photo CD being a prominent example — see page 56), and software such as Adobe Photoshop has served to bring the many benefits of digital image processing and transmission to photographs originated with traditional color films. To many people, in fact, this combination of traditional photography and digital image processing has become the definition of "digital imaging."

During the remainder of the 1990's, the merging of traditional photography with digital image processing, storage, and transmission systems will rapidly expand, especially in publishing-related businesses (see page 46) and photo labs where digital imaging offers the greatest practical and economic benefits. At the same time, the use of digital still cameras will continue to increase in applications where they offer a compelling advantage. It is expected that when improved digital cameras become available in the mid-1990's, newspaper photography will be the first major branch of the field to abandon traditional silver-halide-based photography.

February 17, 1982

The Sony Mavica, the first still video camera, was announced in Japan in late 1981. Shown here holding a Mavica during a demonstration at the SPSE Photofinishing Symposium in Las Vegas, Nevada in February 1982 is Klaus B. Hendriks, director of conservation research at the National Archives of Canada. The Mavica camera produces color images in the standard 525-line analog television format.

September 1992

The Kodak Professional DCS 200 Digital Camera is built around a Nikon 35mm autofocus camera body. Instead of film, the camera uses a CCD (charge-coupled device) image sensor; the images are recorded on a small hard disk drive in the base of the camera. Introduced in 1992, the $10,000 camera is shown here being demonstrated at the Photokina trade show in Germany.

© 1992 by Bob and Lois Schlowsky — Schlowsky Photography and Computer Imagery, Weston, Massachusetts

This high-resolution, all-electronic photograph was made by Bob and Lois Schlowsky with a Hasselblad 553ELX camera equipped with a Leaf Digital Studio Camera back. Made by Leaf Systems, Inc. (a subsidiary of Scitex Corporation, Ltd.), the digital back costs about $36,000. The image is captured with a 1.2 x 1.2-inch CCD (charge-coupled device) area array with 2048 x 2048 pixels producing a 12.6 megabyte color file. The camera is connected by cable to a Macintosh computer with 64 MB of RAM; the image files are down-loaded to the computer after each exposure. The separations used to print the image on this page were made directly from a copy of the original digital file supplied on a SyQuest removable hard disk. To achieve maximum resolution, a monochrome CCD is used in the Leaf Digital Camera back; color photographs are produced with sequential exposures through red, green, and blue filters. Because of this, the system can be used only for still-life color photographs. Bob and Lois Schlowsky, who operate a commercial studio in Weston, Massachusetts, use the digital camera and computer system for nearly 90 percent of their studio work.[41]

Matthew R. Elman

Lois and Bob Schlowsky in their digital studio.

In an Age of Digital Imaging and Electronic Printmaking, What Constitutes a "Photograph"?

While there has never been a truly precise definition of what is — and what is not — a photograph, it has traditionally been accepted that a photograph: a) has an image that is formed on a material as a direct consequence of exposure to light and b) has a continuous-tone image structure. By this definition, images that are printed by offset lithography, such as the 175-line screen illustrations in this book, for example, do not qualify as photographs. Rather, they are considered to be *reproductions* of photographs. Notions of limited quantity also enter into people's thinking about the subject: a 35mm color slide, a black-and-white negative, or a color negative is usually a one-of-a-kind object, and only a small number of prints are generally made from a specific negative or transparency.

The introduction in recent years of thermal dye-transfer prints (e.g., Kodak Ektatherm prints) and other high-quality, "photorealistic" digital color printing methods has challenged the traditional concepts of what a photograph is. High-resolution electronic still cameras, such as the Leaf Digital camera discussed on the previous page, further cloud the issue. Upon close examination, the traditional definitions of what constitutes a photograph were actually never very adequate. Kodak Dye Transfer prints, for example, are *not* made as a consequence of direct exposure to light (Dye Transfer paper is not light-sensitive, and the prints are made under bright room illumination). Yet Dye Transfer prints have long been accepted as being among the highest-quality color photographs.

Traditional silver-halide-based photographic images are not truly "continuous tone." Instead, they have a random, irregular grain structure. (In fact, an ordered screen pattern is often much less noticeable than an irregular grain structure.) To cite an extreme example, if one compares the unsharp and grainy color prints from a 1980's Kodak Disc camera with the high resolution images from a Leaf Digital camera and printed by the extremely sharp UltraStable and Iris ink jet processes (see pages 49–54), it becomes very difficult indeed to maintain that blurry Disc camera 8x10-inch Ektacolor prints are legitimate photographs while the exquisitely sharp and beautiful 20x20-inch UltraStable and Iris color prints are not.

It is time to set the whole issue aside and instead think in terms of *visual image quality* and *image permanence*. How an image was made should be a secondary consideration.

September 1992 (2)

Metrum FotoPrint digital color printers produce 300 dpi "continuous-tone" prints with traditional RA-4 color papers.

Kodak Ektatherm XL 7700-series digital printers, one of which is shown here at the Photokina trade show in Germany in 1992, produce "continuous-tone" 200 dpi "photorealistic" thermal dye-transfer color prints from digital image files. Thermal dye-transfer (dye-sublimation) printers supplied by Kodak and other manufacturers cost between $10,000 and $25,000.

December 1979

Kodak Dye Transfer prints are made by successively rolling three "matrix films" (which have been soaked in acidified cyan, magenta, and yellow dye solutions) into contact with the print surface. The matrix films have a gelatin layer that varies in thickness according to image density — the thicker the gelatin, the more dye it carries and transfers to the print.

1992 – Courtesy of Fuji Photo Film Co., Ltd.

The images of Fuji-Inax Photocera photographs have a screen pattern that can be observed under magnification. Made with a ceramic support, Photocera photographs are fired at high temperatures to fuse the pigment image to the base. Fuji claims the photographs are permanent, even when displayed for many years outdoors in sunlight and rain.

The Linn Photo wholesale lab near Cedar Rapids, Iowa receiving its first batch of film of the night. With overnight processing and delivery for all of Iowa, the lab's operations begin in the afternoon and continue until early the next morning. Linn Photo was acquired by Qualex Inc. in 1992.

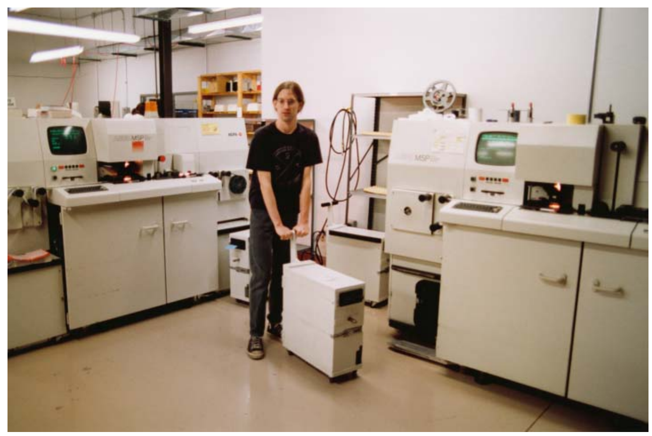
October 1991 (6)

Of the thousands of rolls of film received by the lab each night, about 95 percent are Kodak, Fuji, and other C-41 compatible color negative films in the 35mm and, to a much lesser extent, 110 and 126 formats (Kodak Disc film has almost disappeared from the market). The film is spliced together in long rolls for processing in the machines shown above.

At Least Until the Year 2010, Amateur Photography Will Probably Change Very Little, and Traditional Color Films and Papers Will Continue To Be Used

There is no technology on the horizon — even the distant horizon — that can provide the image quality of color prints made with 35mm autofocus cameras and color negative films which could even approach the low cost of this system. For as long as people want to have prints to look at, to send to friends and relatives, and to display in homes and offices, traditional photography will continue to be popular.

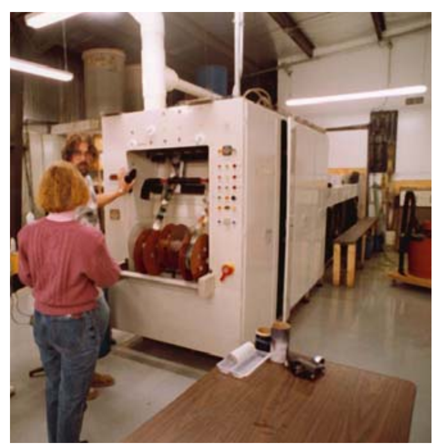
In recent years, Kodak, Fuji, and Konica have all been acquiring independent labs to protect their color paper markets. Qualex Inc., a joint venture of Kodak and Fuqua Industries Inc., is now the world's largest photofinisher. When Qualex acquired Linn Photo in 1992, Agfacolor paper was promptly replaced with Ektacolor paper. The only other change most customers noticed was that Qualex stopped returning negatives in the protective, high-density polyethylene sleeves that Linn had supplied for a number of years.



After processing, the spliced rolls of film are printed with Agfa MSP printers. Density and color-balance settings are determined by the computerized printers, each of which can expose between 15,000 and 20,000 prints per hour.

The self-contained minilabs now common in shopping malls and other locations are used in this wholesale lab for remakes and reprint orders.

With many millions of color prints produced each year, a tremendous amount of paper is used. These pallets contain hundreds of rolls of Agfacolor paper.



Rolls of exposed paper are processed in a six-strand Agfa RA-4 processor. After cutting, the prints and their negatives are put in customers' envelopes.

'X-Rated': the Mitchell brothers' legal battles with The City

San Francisco Examiner

Boom! 49ers blast Falcons

China shake-up favors reformers

DAY THE HILLS BURNED

The fury, sound of the firestorm

Colombia rocked by 2 quakes, eruption

Union City father stabbed to death

Contractor hid Hubble problems, NASA says

DISABLED PROTEST IN S.F.

Real issues competing with the sleaze

CAMPAIGN '92

The October 19, 1992 issue of the **San Francisco Examiner**. The newspaper usually runs 10 to 20 color pictures and 40 to 50 B&W photographs in its five daily editions.

October 1992 (3)

Staff photographer Kim Komenich (left) and reporter Greg Lewis edit film from a week-long assignment in Los Angeles for a follow-up story on the riot that erupted in April 1992 following the acquittal of four white Los Angeles police officers who had been charged with beating black motorist Rodney G. King. As with most other metropolitan newspapers, color negative film is used almost exclusively.

With Its 100-Year-Old Darkrooms Replaced by a Fuji Minilab, a Nikon Film Scanner, and Six Macintosh Computers Running Adobe Photoshop Software, the *San Francisco Examiner* Entered the Digital Age

In October 1989, using Apple Macintosh computers and an early version of Adobe Photoshop color image-editing software that had been written by the now-legendary programmers, brothers Tom and John Knoll, the *San Francisco Examiner* became the first large metropolitan newspaper in the United States where the photographers not only took pictures but also learned to scan color negatives to create digital image files for loading into the networked Macintosh computers; to perform sophisticated corrections of the color balance, contrast, and color saturation of their images; and to output color separation files which are used in preparing the cyan, magenta, yellow, and black printing plates for the paper's presses.

Pictures and caption information are reviewed on computer screens by the newspaper's editors, and selected photographs are electronically sized, cropped, and placed in position together with text and graphic elements in pages composed electronically on the newspaper's more than 20 networked computers with Quark XPress software. Color prints are no longer needed.

According to photo editor Chris Gulker, a technology-oriented individual who was responsible for the early implementation of film scanners and image-processing computers at the *Examiner*, it is now possible to get on press with color pictures of late-breaking news events in as little as 40 minutes after exposed film arrives in the *Examiner's* photo department.

The changes at the *Examiner* since 1989 in the way images from color negatives get to the printed page dramatically illustrate the rapidly expanding role of digital systems throughout the worldwide publishing industry.

Photo editor Chris Gulker processes color negative film with the **Examiner's** washless Fuji minilab. The total dry-to-dry processing time is about 12 minutes.

Photo editor Chris Gulker scans color negatives into the **Examiner's** Macintosh computer network with a Kodak Film Scanner. The **Examiner** also uses Nikon scanners. Once a negative has been scanned, it is put into storage.

Gulker discusses a story with photographer Fran Ortiz while Ortiz adjusts color balance, density, saturation, and contrast and eliminates dust spots on an image with Adobe Photoshop software. The **Examiner's** photographers are responsible for handling their own photographs on the computers to prepare them for publication.

Fully composed digital pages with photographs in place are output to separation film on Linotronic and Autologic imagesetters. The films are used to make flexographic printing plates for the newspaper's high-speed presses.

October 1992 (4)

Like most other major newspapers, the **Examiner** receives photographs from all over the world via satellite; the photographs are downloaded into the Associated Press Leafdesk Digital Darkroom image-processing computer system, shown here. The Leafdesk is manufactured by Leaf Systems, Inc.

With film scanners and digital image-processing systems in place, it becomes possible to transmit publication-resolution color images anywhere in the world via satellite links, fiber-optic networks, computer data links, and even with cellular telephones. Photographers working in the field can process film locally and transmit scanned color images and caption information to their newspapers. (Many of the photographs published in newspapers and magazines during the 1992 Summer Olympics in Barcelona, Spain were processed in on-site minilabs and transmitted to publications around the world by photographers equipped with portable film scanners and Apple PowerBook computers.)

At the *Examiner* and at most other newspapers, the last step remaining before an all-electronic system is achieved is the origination of the picture itself. With computer systems already in use, electronic still cameras such as the Kodak DCS 200 digital camera, which has a CCD sensor in place of film and is built around a conventional Nikon camera body, provide direct digital input of color images that *can* be of surprisingly good quality. Use of electronic cameras eliminates the processing and scanning steps required for color film; in addition, pictures taken with electronic cameras can be transmitted directly to the newspaper from remote locations over phone lines or with cellular phones.

At the time this book went to press in late 1992, however, *Examiner* photographers were not making regular use of electronic cameras. Using the Kodak DCS 200 as an example of a state-of-the-art digital camera, photo editor Gulker cited a number of reasons why photographers were reluctant to give up traditional cameras and film.[42]

Among the drawbacks of the DCS 200 are: a) it is unable to take pictures faster than once every 2½ seconds, which is much too slow for most newspaper photography; b)its CCD array is smaller than a 35mm frame, and this increases the effective focal length of the camera's standard Nikon lenses by a factor of 2.5X, which can make wide-angle photography difficult; c) with a maximum capacity of 50 images on its internal hard disk, the camera must frequently be downloaded to a computer, which requires much more time and trouble than changing rolls of film with a conventional camera; d) the resolution and overall picture

Kim Komenich – April 1992 (Courtesy of the *San Francisco Examiner*/Hearst Corporation)

A photograph taken during the Los Angeles riots in April 1992 by Kim Komenich. The violence began immediately after the acquittal in a California state court of four white Los Angeles police officers who had been accused of using excessive force in the March 3, 1991 arrest of Rodney G. King, a black motorist who had been stopped for speeding. The brutal beating was captured on videotape with a Sony 8mm camcorder by an amateur who witnessed the event; the tape has been repeatedly broadcast around the world. For this book, the photograph above was reproduced from 4-color separations generated from a digital file supplied by the **Examiner**. From the moment the original 35mm color negative was scanned in the **Examiner's** photo department, the entire reproduction chain to the point of exposing the printing plates for this book at the printer in Kingsport, Tennessee was entirely digital; a traditional color print was never made.

quality of the images do not match traditional 35mm color negative film; e) long-term archiving of the digital images is a problem; and f) at a cost of about $10,000, the DCS 200 digital camera is a major budget item.

Most newspaper photographers value the image resolution of 35mm film, knowing that they can make high-quality enlargements of their most important photographs even if the reproduction quality of newspaper printing could in most cases be satisfied with lower-resolution images.

Digital cameras are certain to become better, faster, and less expensive, however, and Gulker predicts that "by 1995 or 1996, film may well be dead at the *Examiner* and other major newspapers."

In 1989, when photographers became familiar with how easy it was to manipulate images with Photoshop, some expressed ethical concerns about the new technology. Like most other newspapers, however, the *Examiner* has implemented a policy that strictly forbids doing anything to an image that alters its content and accuracy. Only routine dust-spotting; correction of color balance, contrast, and saturation; and minor dodging and burning are permitted. Distracting elements in a picture, such as intruding power lines or birds in the background, may not be removed.

October 1992

Komenich prepares to make an Ektatherm print of a photograph from his personal stock file of former Philippines president Ferdinand Marcos and his wife Imelda. Fully dust-spotted and corrected with Photoshop, the images, along with caption information, are stored on a rewritable 600 MB optical disk and can easily be printed when requested. Komenich won a Pulitzer prize in 1987 for his coverage of the Philippines revolution that forced Marcos from office.

An UltraStable Permanent Color print of a family group portrait by the noted photographer David B. LaClaire of LaClaire Portraiture in Grand Rapids, Michigan. Lasting far longer than conventional color prints, UltraStable Permanent Color prints are expected to become widely used in the upper end of the portrait, wedding, and fine art markets. The prints not only have appeal as family heirloom portraits but will also be used for portraits of presidents, prime ministers, and other government officials, as well as for photographs of writers, artists, movie stars, and other culturally and historically important individuals.

The UltraStable Permanent Color Process for Making Extremely Long-Lasting Pigment Prints

To a greater or lesser extent, all of the organic dyes used to form the images in conventional color films and prints gradually fade when exposed to light. Even Ilford Ilfochrome and Kodak Dye Transfer prints, which are exceedingly stable when stored in the dark, will fade to an objectionable degree after relatively few years of display. In long-term display, no current color material with a dye image can even approach the stability of the silver image of a carefully processed black-and-white photograph made on fiber-base paper (only fiber-base prints can be included in this comparison because, for the reasons discussed in Chapter 17, the life of displayed black-and-white RC prints may fall considerably short of that of fiber-base prints).

So how can a truly permanent color print be made? The answer is to do what Louis Ducos du Hauron, the French pioneer of color photography, did when he made the first real color prints in the 1870's, and that is to form the color image with *pigments* instead of dyes. Ducos du Hauron used a three-color adaptation of the then well-known carbon process to make his color prints. In those days, long before the

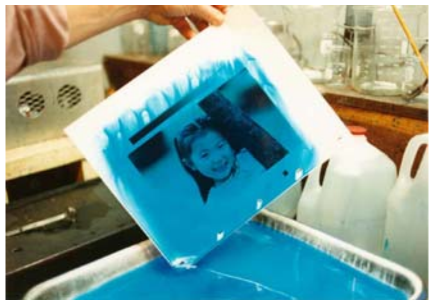
This 1877 photograph of Agen, France by the prolific French inventor and photographer Louis Ducos du Hauron is one of the first photographic color prints ever made. Using separate pigmented-gelatin layers to form the image, the process is the historical predecessor of the UltraStable process.

After exposure with separation negatives, the cyan, magenta, yellow, and black pigment layers are applied one at a time to a polyester or paper support.

Soaking the laminated pigment sheet.

Peeling off the plastic carrier sheet.

January 1991 (5)



Unhardened pigmented gelatin is removed in a warm-water bath.

With all four image layers applied, the finished print is rinsed with water.

development of the modern, easy-to-process chromogenic print (e.g., Ektacolor) with its lovely but all-too-fleeting organic dye image, making a print with separate pigmented-gelatin color layers was the only method available.

In the 1930's and 1940's, the tricolor carbro process (a variation of tricolor carbon) was frequently used for glamorous portraits of Hollywood stars, and lush tricolor carbro advertising photographs from this era can be found in the collections of George Eastman House, the Smithsonian, and other institutions. By the late 1950's, however, the color pigment processes had died out, first being replaced with the easier-to-manage Kodak Dye Transfer process, and later with Ektacolor, Cibachrome (now called Ilfochrome), and other inexpensive and conveniently processed materials.

But none of the modern color print materials were stable enough to satisfy Charles Berger. A fine art photographer who had published several books of photographs and whose work was in the permanent collection of the Museum of Modern Art in New York City, Berger was frustrated with the lack of anything available on the market with which he could make permanent color prints. By 1980, after several years of experimentation, Berger had developed a modern, pin-registered, high-resolution version of the classic tricolor carbon process. Berger not only made the process simpler to use — although the printmaking procedure remains a relatively complex task — but, more importantly, he came

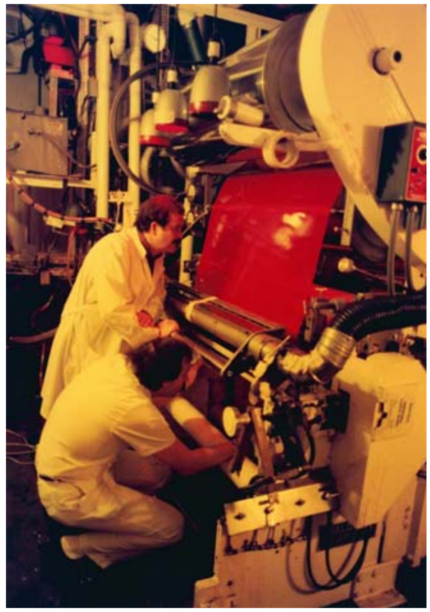
© 1976 by Charles Berger, courtesy of the photographer

An UltraStable print of poppies and azaleas photographed by Charles Berger in 1976. An accomplished artist and inventor who wanted long-lasting color prints for his own work, Berger made this print in 1992.

March 1991

Charles Berger mixing a pigmented-gelatin emulsion for a test coating at Kilborn Photo Products Inc. in Cedar Rapids, Iowa. Working with Berger is John DaSilva, an emulsion chemist who is director of research at Kilborn.

Emulsion technician Steve Hynek and Charles Berger mixing gelatin, magenta pigment, a chromium-free sensitizer, and other emulsion components.



Coating the magenta emulsion on a transparent polyester carrier sheet.

March 1991 (3)

The thick gelatin emulsion coatings are slowly dried in the dust-free, humidity- and temperature-controlled drying alley at Kilborn. Because the UltraStable emulsions are sensitive only to UV radiation, mixing, coating, and drying operations can be conducted under yellow safelights. The prints can also be made under UV-filtered illumination. Kilborn Photo Products, a little-known company that has been producing photographic products in Cedar Rapids, Iowa since 1895, is one of the oldest photographic manufacturers in the world.

up with cyan, magenta, yellow, and black pigments that had extremely good light fading stability. The pigments are similar to those used in automobile paints, which must be able to tolerate years of outdoor sun exposure under the harshest conditions. These materials were produced by the Polaroid Corporation under the Polaroid Permanent-Color name.[43] As shown by the accelerated test examples reproduced on page 14, the stability of these prints is extremely good.

When Polaroid declined to actively market the materials, Berger, living in Santa Cruz, California, joined forces with Richard N. Kauffman, a long-time environmentalist, photographer, and skilled tricolor carbro printer (Kauffman is the chairman of the California-based H. S. Crocker printing company), to work on easier-to-use, pre-sensitized materials employing non-toxic sensitizers and pigments. UltraStable Permanent Color materials, which can produce prints with outstanding color reproduction and extraordinary sharpness, are the result of this collaboration.[44]

The image stability of UltraStable prints is discussed in Chapter 3, beginning on page 121. The initial UltraStable materials, introduced in 1991, used a non-toxic organic yellow pigment that proved to be significantly less stable in light fading tests than expected, based on data supplied by the pigment's manufacturer. New materials made with a more stable, lead-free, metal-type yellow pigment were introduced in late 1992, but test results for the new pigment were not available at the time this book went to press.

Making UltraStable prints requires full-size, high-resolution, screened separation negatives, and the cost of the separations is the principal expense in making a print. Exclusive of separations, the costs of materials are quite low: materials for a 16x20-inch print total less than $25. Having prints (and the required separations) made by a lab can be expensive, however, with a 16x20-inch UltraStable print costing $500 or more (duplicate prints cost much less). Labs that offer UltraStable prints are listed on page 293.

© William Eggleston – Courtesy of the photographer and the Robert Miller Gallery

A photograph of novelist Eudora Welty by William Eggleston. The UltraStable print was made by Robert Liles. An exhibition of 50 of Eggleston's UltraStable prints is to be shown at the Robert Miller Gallery in New York City in October 1993.


February 1992

A pioneer in the use of high-resolution color ink jet printers in the fine art field is Nash Editions. Located near Los Angeles in Manhattan Beach, California, Nash Editions was founded by British-born Graham Nash of the legendary 1960's rock group Crosby, Stills, Nash & Young. An accomplished photographer and collector, Nash was drawn to the ink jet process as a means of printing images that he had worked on with Adobe Photoshop software on his Apple Macintosh computer. Shown here are Nash Editions staff members (left to right) Jack Duganne, R. Mac Holbert, and Graham Nash.

High-Resolution Ink Jet Color Prints Produced from Scanned Photographic Originals, Computer-Generated Images, and Other Digital Sources

One of the most promising of the rapidly advancing direct digital color printing technologies is high-resolution color ink jet printing. The best of the current generation of ink jet printers are the Iris printers manufactured by Iris Graphics, Inc. of Bedford, Massachusetts (Iris Graphics is a subsidiary of the Scitex Corporation Ltd., which is headquartered in Herzlia, Israel).

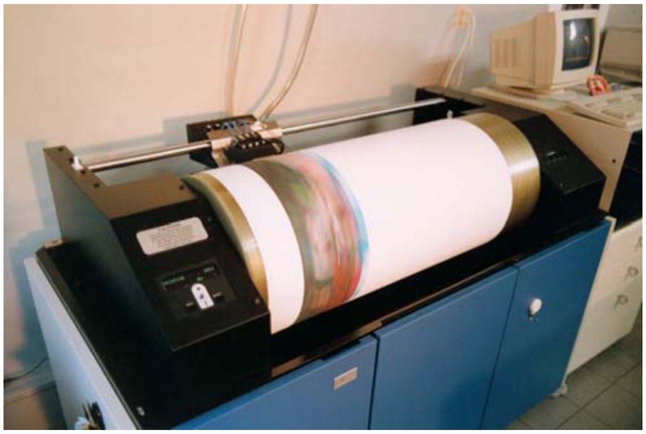
Capable of printing "photorealistic" color images on paper, polyester, cloth, and most other materials that will accept water-base inks, Iris printers have a resolution of 300 dpi (dots per inch). However, unlike most laser printers and low-cost desktop ink jet printers, the overlapping cyan, magenta, yellow, and black image dots laid down by an Iris printer are built up with from 0 to 31 microscopic droplets for each of the four colors. This unique 4-color variable-size dot structure (which does not have the rosette pattern usually found in 4-color printing) produces images that are far sharper and have much smoother tonal gradation than the images obtained from fixed-dot-size 300 dpi printers. Iris claims its printers have an "effective visual resolution of approximately 1,500 dpi."

When viewed without magnification, Iris ink jet images can have the appearance of traditional photographic color prints. In fact, because of the controls offered by Adobe Photoshop or other digital image processing software that is routinely used prior to printing, Iris ink jet prints are often qualitatively *better* than traditional color prints. Digital images scanned from photographic originals can easily be adjusted for contrast, color saturation, and color balance. Curve imbalances are simple to correct. (In a practical sense, alteration of contrast, color saturation, and curve balance is not possible with traditional color printing. Digital images can also be dodged, burned-in, dust-spotted, and have scratches filled in with a finesse that is absolutely impossible with traditional darkroom color printing.)

Although the Iris printers are expensive — the Model 4012, which makes prints in sizes up to 10x17 inches, costs $39,000 and the Model 3047, which makes prints in sizes up to 34x46 inches, sells for $123,000 — the materials costs for a print are less than for any other high-resolution color imaging process. The cost of the ink and paper for a 34x46-inch print can be as little as $12 (printing time of about 45 minutes). The cost of the ink and paper for an 8.5x11-inch print can be less than $1 (printing time of about 4 minutes).

Unfortunately, at the time this book went to press in late 1992, the ink sets available from Iris had very poor light fading stability. Even when protected with a sharp-cutting ultraviolet filter, the prints had a predicted display life of less than 3 years when evaluated with this author's standard test procedures (see **Table 3.3** on page 138 in Chapter 3). The Iris prints proved to be far less stable than Ilfochrome, Ektacolor, and other traditional color prints.

Iris Graphics has not made any claims for the light fading stability of prints made with the standard ink sets that were available at the time this book went to press in 1992, saying that the company would commit only to a display



Iris ink jet printers lay down the cyan, magenta, yellow, and black images in a single pass with the print material attached to a rapidly rotating drum. The leading band of the image printed by the cyan ink jet, which slowly moves across the image from left to right, is clearly visible.

Graham Nash and Jack Duganne detach a completed monochrome print from one of the Iris 3047 ink jet printers at Nash Editions. This particular image is a black-and-white self-portrait of Nash which was made during the period when he performed with Crosby, Stills, Nash & Young.

Bottles of the water-base inks employed in the Iris ink jet printers. Initially designed for graphic arts proofing, the standard Iris inks have very poor light fading stability. High-stability inks for fine art and other display applications are expected to become available by the end of 1993.

Duganne and Holbert work on an image with Photoshop running on a Macintosh computer with visiting New York City fashion photographer George Holz. Prints can be made from scanned transparencies and negatives or directly from a variety of Macintosh and IBM file formats.

A high-resolution flatbed CCD scanner custom-built by Photometrics, Ltd. is used by Nash Editions to input images from color prints, paintings, and other art work. The scanner can accommodate originals of up to 4x4 feet.

Nash Editions is located in this picturesque building not far from the Los Angeles International Airport.

An Iris ink jet print of movie actress Marilyn Monroe. Photographed by silent screen star Harold Lloyd, this previously unpublished picture was taken in 1952 while Monroe was visiting Lloyd's lavish Green Acres estate for a screen test. Monroe died from an overdose of sleeping pills in 1962 at the age of 36. Printed by Nash Editions, the Iris ink jet print was made from one side of a Kodachrome transparency stereo-pair that was scanned with a high-resolution scanner to produce a digital file for the Iris printer. Contrast adjustments and elimination of dust spots were done with Adobe Photoshop software on a Macintosh computer system. As would be expected, based on data obtained in accelerated dark fading tests with Kodachrome film, the transparency was still in excellent condition — after 40 years of storage — at the time this print was made. The image, which was free of yellowish stain, had brilliant highlights and minimal fading.

© The Harold Lloyd Trust (Courtesy of the Harold Lloyd Trust/First Interstate Bank of California)

life of "one to two years, with incidental, interior lighting."[45] When stored in the dark, however, the color images are essentially permanent; this author's tests indicate that the prints, when made on 100% cotton fiber paper or other stable material, have very little tendency to form yellowish stain over time. Because the inks used in Iris printers are water-soluble, a number of coatings are available for protecting the images from water damage.

Since their introduction in the late 1980's, the Iris printers have been employed primarily for graphic arts proofing, where image stability is generally not an important consideration. With the selection of suitable ink colorants, however, the ink jet process has the potential of producing highly stable color prints. In theory, any colorant that has the dielectric properties required by the Iris imaging system — and that can pass through the extremely narrow, 10-micron diameter ink jet nozzles employed in the Iris printers — could be used in an ink formulation.

After the highly publicized 1991 introduction of Iris prints in the fine art photography field by Nash Editions, Iris Graphics realized that there was a potentially large market for their printers outside of the traditional graphic arts proofing area, and the company set about developing a much longer-lasting ink set for fine art and other long-term display applications. Iris plans to introduce the new high-stability inks by the end of 1993.

Having Iris prints made is not inexpensive, although the cost of the prints can vary greatly depending on the supplier,[46] the size of the print, the type of paper desired, whether a protective coating is applied to the print, and the amount of computer time required for making alterations and corrections of the digital image. At the time this book went to press, Nash Editions charged $0.70 per square inch with a minimum cost of $400 (up to 24x24-inches) and a maximum of $700 for a 34x46-inch print (additional prints are about 50% less). Some firms offer straight prints from customer-supplied digital files at moderate cost: Image Transform Ltd. of Ankeny, Iowa produces 34x46-inch Iris prints on various papers, including Arches or Rives 100% cotton fiber watercolor papers, for $175 for the first print.

A large-format print emerging from a Xerox/Versatec liquid-toner electrostatic color printer. Used in the Cactus and Onyx Graphics digital printing systems, the Versatec units produce low-cost color prints in sizes up to 54 inches wide and 15 feet or more in length.

Color Electrophotography Is One of the Most Promising Technologies for Making Long-Lasting, High-Quality Color Prints at Moderate Cost

Liquid-toner and dry-toner electrophotographic color printers can utilize a wide variety of colorants to form images and, with respect to color stability, this gives these systems a considerable — if not yet fully realized — advantage over the traditional chromogenic and silver dye-bleach color print processes.

Color prints made with Canon Color Laser copier/printers, for example, are approximately twice as stable as Kodak Ektacolor prints according to this author's accelerated light fading tests with glass-filtered fluorescent illumination (see **Table 3.3** on page 137). A Canon color print typically costs only $3 to $5.

Although the image quality of prints made with Canon Color Laser copiers does not equal that of traditional color prints, the Canon prints are often satisfactory for proofing and are also suitable for many business and commercial applications.

Xerox/Versatec color printer/plotters, which serve as the output devices for the Cactus (Fairfield, New Jersey) and Onyx Graphics (Salt Lake City, Utah) digital printing systems, have become popular for producing large-format color prints for commercial display and advertising purposes. Although the image quality of these prints also does not equal that of traditional color photographs, the prints nevertheless are suitable for many purposes. Preliminary tests with "standard" Cactus prints indicate that the prints have fairly good light fading stability; prints made with the special toner set supplied by Cactus for outdoor display are probably much longer lasting.

The 3M Digital Matchprint liquid-toner electrophotographic graphic arts proofing system provides a prototype for a high-quality, high-stability digital color printmaking system. The $300,000 device can produce an 18x27-inch color print at 2,540 dpi on most types of paper in 30 minutes or less from a digital image file (the cost of materials for a print is low). Small prints can be output much more quickly. Although currently available toners were formulated to match graphic arts printing inks, and permanence was not an important consideration, high-stability toners could easily be developed for the system (see the discussion of the mid-1960's 3M Electrocolor process on page 27).

September 1992 (2)

Xerox/Versatec color printer in a system supplied by Onyx Graphics (note containers of liquid toners in base).

1992 – Courtesy of 3M Company

If high-stability colorants were to become available for the 3M Digital Matchprint graphic arts color proofing system, this process would be suitable for producing long-lasting color prints of excellent quality at low cost.

Despite Their Great Practical Utility, Photo CD's, CD-ROM's, and Magnetic Digital Image Storage Systems Are Not Recommended for the Long-Term Preservation of Photographically Originated Images

The September 1990 announcement of the Kodak Photo CD system, which was placed on the market in the summer of 1992, marked a historic turning point in the evolution of photography and, for the first time in the general market, raised questions about the long-term usability of photographic images stored in digital form. The Photo CD system, in which digitized images are stored on low-cost, write-once optical discs of the same physical format as the popular audio compact disc (CD), includes several components: a) high-speed CCD scanners which digitize images on color negative films, transparencies, and prints; b) computer workstations which convert the digitized data to Kodak's Photo YCC color space, make adjustments in color balance and density, and create an image file using a hierarchical file format and data-compression scheme developed by Kodak; and c) a laser disc writer developed by the Netherlands-based electronics giant Philips which writes the image file to a CD (a complete Kodak system costs $100,000 or more).

Kodak Photo CD Portfolio authoring software to be released in 1993 will allow individuals using a variety of scanners and computers to write image files in the Kodak Photo CD format using a Kodak CD disc writer (about $6,000).

The number of images that can be recorded on a Photo CD depends on the maximum image resolution selected; typically, each image requires about 4.5 Mbytes of disc space so approximately 100 images can be stored on a single disc (at present, the optical CD is the only viable, low-cost storage medium available that can accommodate the huge size of high-resolution color image data files). The ingenious hierarchical file structure allows images to be accessed in a number of different resolutions (e.g., low resolution for viewing on an ordinary color television and high resolution for printing in magazines and books) without the need to store redundant data for each of the available image resolutions. The discs can be read by a CD-ROM XA multi-session drive and can be viewed on a television with a Kodak or other Photo CD-compatible disc player. The Photo CD system is not the only way to record images on CD's (or other media), but it is the first system to bring together all of the components in a unified manner. The proprietary Kodak Photo CD file format and associated software are the heart of the system. Kodak has licensed the Photo CD system to other manufacturers including Fuji, Konica, and Agfa.

The Photo CD system is initially being directed at both the amateur snapshot market and a wide variety of professional applications in desktop and high-end publishing, stock photography, and medical imaging. Although there is considerable doubt that the Photo CD will be successful in the amateur field (having negatives routinely transferred to Photo CD's at a cost of more than $20 a roll is prohibitively expensive for most people, and for looking at family images on television, it is generally much more satisfying and certainly far less expensive to use a video camcorder and enjoy moving images complete with sound), the availability of high-resolution scans of color negative and transparency images for between $2 and $5 each is a revolution in the publishing field. Photo CD images can be imported into a computer running Adobe Photoshop or other image-processing software and, after color and density corrections and image retouching are completed, separation files can be output to an imagesetter to produce fully corrected separations at a previously unheard-of low cost. The images can also be output to a film recorder to create photographic "second originals," employed in multimedia applications, transmitted to remote locations, or used to make high-quality color prints with thermal dye transfer, high-resolution ink jet, electrophotographic, or traditional color photographic papers.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James H. Wallace, Jr., director and curator of Photographic Services at the Smithsonian Institution in Washington, D.C., describes the department's computer and digital imaging equipment to visitors from the ANSI subcommittee on the stability of color images. The Photographic Services department distributes hundreds of images on CompuServe, America Online, GEnie, and Internet on-line computer information services. At the time this book went to press in 1992, more than 30,000 downloads had occurred since the department began offering the no-cost service in November 1990. The digital images are scanned from color transparencies and color negatives; the originals are preserved in a cold storage vault maintained at 40°F (4.4°C) and 27% RH (see photograph on page 633).

Photo CD's and other types of optical disc and magnetic image storage systems can enable commercial and museum collections to reduce or eliminate handling and shipping of precious photographic originals.[47] A copy of the digital image file can be stored in a separate location to provide a backup should the originals be destroyed by fire or other catastrophe. Creating an electronic visual data base makes it possible for an institution to place photographic originals in cold storage while at the same time maintaining visual access to the images. The Photographic Services department at the Smithsonian Institution has implemented a comprehensive image access and preservation program for its collection that can serve as a model for others.[48]

Although using Photo CD's or other optical or magnetic media for the long-term preservation of photographically originated images may seem appealing, there are at present serious, unresolved problems related to the continued reliability of such systems in the future (see page 6). These concerns include the stability of the actual media (at the time this book went to press, Kodak had released only limited data about the long-term readability of its Photo CD's[49]) and, more importantly, the complete lack of assurance of future availability of hardware and software necessary to read, decompress, and access images on Photo CD's, CD-ROM's, and other types of optical and magnetic media.[50–52]

Notes and References

1. Edwin H. Land, "Selected Letters to Shareholders," a chapter in **Selected Papers on Industry**, Polaroid Corporation, Cambridge, Massachusetts, 1983, p. 27. The quotation is part of a letter from Land to Polaroid shareholders that originally appeared in the **1976 Polaroid Corporation Annual Report**. Land, who died in 1991, was the founder and chairman of the board of Polaroid.
2. Susan Roman, "PDNews," **Photo District News**, Vol. IX, Issue XIV, December 1989, p. 18.
3. Eastman Kodak Company, "Merrett T. Smith," **Kodak Studio Light**, Issue No. 1, 1986, p. 7. Published by Eastman Kodak Company, 343 State Street, Rochester, New York 14650.
4. Mrs. Lloyd Karstetter, interview with this author, Reedsburg, Wisconsin, February 19, 1980. Karstetter came to this author's attention after she had returned a number of very faded Ektacolor prints to Fehrenbach Studios in Reedsburg and asked the studio to replace the prints at no cost. Fehrenbach Studios believed that because of misleading advertising and poor product quality, Eastman Kodak bore the responsibility for the cost of replacing the faded prints. Citing the disclaimer concerning color dye fading that appears on every box of Kodak color film and paper, Kodak refused to cover the replacement costs. In 1982, after complaints to the Wisconsin Attorney General's office and the Federal Trade Commission in Washington, D.C. brought no results, Fehrenbach Studios and another Wisconsin professional photographer filed a $3.7-million lawsuit against Kodak. The lawsuit never reached trial (see Chapter 8).
5. Eastman Kodak Company, **Gift Certificate Program — Radio Spots,** Kodak Publication PP10-8H. In 1982, responding to a request from the Wisconsin Attorney General's office, which had informed Kodak that advertisements and publications such as this were in probable violation of Wisconsin's consumer fraud laws, Kodak changed the wording in this ad from "Take A Moment Out Of Time . . . And Make It Last Forever," to "Take A Moment Out Of Time . . . And Make It Last For Years To Come." The Kodak publication number for the ad copy remained the same; neither the original nor revised version is dated.
6. Joel Meyerowitz, **Cape Light**, Museum of Fine Arts, Boston, and Little, Brown and Company, Boston, Massachusetts, 1978. See also: Joel Meyerowitz, **A Summer's Day**, Times Books in Association with Floyd A. Yearout, New York, New York, 1985.
7. Mark A. Fischetti, "The Silver Screen Blossoms Into Color" (Special Report on Video Processing), **IEEE Spectrum**, Vol. 24, No. 8, August 1987, pp. 50–55 (published by the Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, New York 10017; telephone: 212-705-7555).
8. Peter Hay, **MGM: When the Lion Roars**, Turner Publishing, Inc., One CNN Center, Atlanta, Georgia 30348, 1991, p. 327. By the end of 1990, Turner Broadcasting System had spent more than $1 billion for the black-and-white and color motion pictures that make up its film library. According to Hay, Ted Turner ". . .ended up with what he always wanted — the richest film library in the world, including its crown jewel, **Gone With the Wind**. Told repeatedly that he had paid far too much for old movies, the owner of Turner Broadcasting System once explained his decision to a reporter: 'How can you go broke, buying the Rembrandts of the programming business when you are a programmer?'"
9. Leslie Bennetts, "'Colorizing' Film Classics: A Boon or a Bane?", **The New York Times**, August 5, 1986, pp. 1 and 21.
10. Leslie Bennetts, see Note No. 9.
11. For a concise description of the chromogenic process and other traditional photographic methods of color image formation, see: Peter Krause, "Color Photography," Chapter 4 in **Imaging Processes and Materials – Neblette's Eighth Edition** (edited by John M. Sturge, Vivian Walworth, and Allan Shepp), Van Nostrand Reinhold Company, New York, New York, 1989.
12. Eastman Kodak Company, **Evaluating Dye Stability of Kodak Color Prints – Prints on Kodak Ektacolor Plus Paper**, Kodak Publication CIS No. 50–4, Eastman Kodak Company, Rochester, New York, February 1985.
13. Gert Koshofer, **Farb Fotografie – Book 1**, Verlag Laterna magica, Munich, Germany, 1981, p. 171. Koshofer reports that Kodak described the Azochrome silver dye-bleach color print process and showed sample Azochrome prints made from Kodachrome transparencies in Chicago in August 1941.

    The 1941 Azochrome print by Albert Wittmer from the collection of the International Museum of Photography at George Eastman House that is reproduced in this book on page 25 was included in the exhibition **Color As Form – A History of Color Photography** that opened at the Corcoran Gallery of Art in Washington, D.C. on April 10, 1982 (see page 17 of the exhibition catalogue published by George Eastman House in 1982). Later shown at Eastman House in Rochester, the exhibition was organized by George Eastman House, with John Upton serving as guest curator.
14. Paul C. Spehr, "Fading, Fading, Faded – The Color Film Crisis," **American Film**, Vol. V, No. 2, November 1979, pp. 56–61. See also: Bill O'Connell, "Fade Out – Remember the Glorious Color of Films Gone By? It May Soon Be Only a Memory – For the Prints Are Fading Fast," **Film Comment**, Vol. 15, No. 5, September–October 1979, pp. 11–18. See also: Harlan Jacobson, "Old Pix Don't Die, They Fade Away – Scorsese Helms Industry Plea to Kodak," **Variety**, Vol. 299, No. 10, July 9, 1980, pp. 1, 28–29. See also: Richard Patterson, "The Preservation of Color Films – Part I," **American Cinematographer**, Vol. 62, No. 7, July 1981, pp. 694ff; and Richard Patterson, "The Preservation of Color Films – Part II," **American Cinematographer**, Vol. 62, No. 8, August 1981, pp. 792ff.
15. Vsevolod Tulagin, Robert F. Coles, and Richard Miller, **Permanent Reproductions**, United States Patent No. 3,172,827, granted March 9, 1965 (filed April 18, 1960), and **Photoconductography Employing Organic Onium Cation**, United States Patent No. 3,172,826, granted March 9, 1965 (filed April 18, 1960).
16. Gert Koshofer, **Farb Fotografie – Book 1**, Verlag Laterna magica, Munich, Germany, 1981, p. 173.
17. Polaroid Corporation, "This Polaroid SX-70 Photograph Is Part of the Collection of the Museum of Modern Art," 2-page advertisement in **The New Yorker**, May 1977. The ad was illustrated with an SX-70 photograph by Lucas Samaras; the donation of the print to the Museum by an obscure arts foundation was facilitated by the New York advertising agency that prepared the Polaroid ad. At the time the ad featuring the Samaras SX-70 print appeared, it is believed that the Museum had only one or two other SX-70 prints in its collection.
18. Anon., "Fine Art, Via Polaroid," **The New York Times**, February 15, 1990, p. C3.
19. **Consumer Reports** staff, "Instant-Picture Cameras," **Consumer Reports**, pp. 622–625, November 1976.
20. William S. Allen, general manager, Consumer Markets Division, Eastman Kodak Company, letter to Dealers in Kodak Products, November 9, 1976. The letter stated in part:

    "There have been published reports critical of the stability of prints made with Kodak instant cameras and film. Kodak considers these reports to be misleading. The company has stated repeatedly that the stability of Kodak instant prints is entirely satisfactory when such prints are handled, displayed, or stored in the usual variety of home and office situations. . . .

    "It should be noted that the performance of a color print exposed to direct sunlight or to high-intensity fluorescent light is *not* indicative of its performance when the print is displayed or stored in the usual way by amateur picture-takers."

    When Allen wrote the letter, Kodak had extensive light fading data on PR-10 and was well aware that the prints were far less stable than any other color print material on the market; the company also knew that, under typical display conditions in the home or office, the prints would fade significantly in less than a year's time and that in most cases, the prints would become severely deteriorated after only 4 or 5 years of display. See: John Stewart, "Kodak Finds Its Instant Prints Fade More," **Democrat and Chronicle**, Rochester, New York, June 3, 1977. See also: John Stewart, "Expert's Tests Show Light Fades Color Photos — Don't Hang Them on the Wall," **Democrat and Chronicle**, Rochester, New York, March 22, 1979.
21. The Colour Group of the Royal Photographic Society sponsored a symposium on **The Conservation of Colour Photographic Records** at the Victoria and Albert Museum, London, England, September 20, 1973. Among the presentations were: "The Keeping Properties of Some Colour Photographs," by C. H. Giles and R. Haslam [University of Strathclyde]; "On the Resistance to Fading of Silver-Dye-Bleach Transparencies," by R. Bermane [Ciba-Geigy Photochemie Ltd.]; and "The Light Stability of New Polaroid Colour Prints," by H. G. Rogers, M. Idelson, R. F. W. Cieciuch, and S. M. Bloom [Polaroid Corporation]. Eastman Kodak did not take part in this important early conference. Proceedings of the symposium were published in 1974 by the Royal Photographic Society, and a number of the presentations later appeared as articles in the Society's journals.
22. William Jenkins, assistant curator for 20th Century Photography, International Museum of Photography at George Eastman House, letter dated September 9, 1975 to attendees of the October 17, 1975 "Colloquium on the Collection and Preservation of Color Photographs." Participation at the meeting by Kodak apparently convinced the company to include, for the first time, at least some information on the stability of color transparency and color negative films in **Storage and Care of Kodak Color Films**, Kodak Publication No. E-30, January 1976. Little of the often-heated discussion that took place at the conference ever became public because Arthur Goldsmith and Ed Meyers from **Popular Photography**, Ed Scully of

Modern Photography, and other members of the press who attended the event were asked to withhold publication of stories about the meeting until the official **Proceedings** of the conference were released by George Eastman House. The promised **Proceedings** were never published and, as a result, this early and important conference was never covered in the press. Since its founding in 1947, Eastman House has received a substantial portion of its funding from the Eastman Kodak Company, either directly or through the Eastman Charitable Trust. The yearly contribution from the Trust alone has often amounted to more than $1 million.

23. Dan Meinwald, "Color Photographs: Must They Always Fade?", **Afterimage**, November 1975 (published by the Visual Studies Workshop in Rochester, New York).
24. Peter Z. Adelstein, C. Loren Graham, and Lloyd E. West [Eastman Kodak Company], "Preservation of Motion-Picture Color Films Having Permanent Value," **Journal of the SMPTE**, Vol. 79, No. 11, November 1970, pp. 1011–1018. This article contained a graph showing predicted times for a 10% density loss of the cyan dyes of two unidentified Kodak motion picture color negative and print films stored at a wide range of temperatures. This small graph was the first public acknowledgment by Kodak that it had developed the now well-established Arrhenius multiple-temperature accelerated test method with which predictions for dark fading and dark staining rates of color films and prints can be obtained for normal room temperatures, cold storage temperatures, or any other desired temperature. This was a major breakthrough in the evaluation and preservation of color films and prints (see Chapter 2). The Arrhenius dark storage test method is also specified in American National Standards Institute, Inc., **ANSI IT9.9-1990, American National Standard for Imaging Media – Stability of Color Photographic Images – Methods for Measuring**, American National Standards Institute, Inc., New York, New York, 1991. Copies of the Standard may be purchased from the American National Standards Institute, Inc., 11 West 42nd Street, New York, New York 10036; telephone: 212-642-4900 (Fax: 212-398-0023).
25. Klaus B. Hendriks, chairperson, session on the **Stability and Preservation of Photographic Materials**, at the annual conference of the Society of Photographic Scientists and Engineers, Washington, D.C., May 1, 1978. Presentations were given by Klaus B. Hendriks [Public Archives of Canada], "The Challenge of Preserving Photographic Records"; Timothy F. Parsons [Eastman Kodak], "To RC or Not To RC"; Robert J. Tuite [Eastman Kodak], "Image Stability in Color Photography"; Martin Idelson [Polaroid], "Polacolor, Polacolor 2, and SX-70 Prints"; Henry Wilhelm [East Street Gallery], "Light Fading Characteristics of Reflection Color Print Materials"; and Stanton Clay [Ilford], "Light Fading Stability of Cibachrome."

    Hendriks also served as chairperson of the **International Symposium: The Stability and Preservation of Photographic Images**, Public Archives of Canada (renamed the National Archives of Canada in 1987), Ottawa, Ontario, August 29 — September 1, 1982, sponsored by the Society of Photographic Scientists and Engineers. Among the presentations were: Robert F. W. Cieciuch, "Stability of Polaroid Integral Color Film Images" and "Light Stability of Polacolor 2 and Polacolor ER Images and Its Maximization"; Henry Wilhelm, "Tungsten Light Fading of Reflection Color Prints"; and Charleton C. Bard and Paul M. Ness, "The Effects of Post Processing Handling on the Image Stability of Kodak Ektacolor Prints."

    In addition, Hendriks served as chairperson of the **Second International Symposium: The Stability and Preservation of Photographic Images**, Public Archives of Canada, Ottawa, Ontario, August 25–28, 1985, sponsored by the Society of Photographic Scientists and Engineers. Among the papers presented at the conference was: Kotaro Nakamura, Makoto Umemoto, Nobuo Sakai, and Yoshio Seoka [Fuji Photo Film Co., Ltd.], "Dark Stability of Photographic Color Print from the Viewpoint of Stain Formation." This important paper described the "low-stain" magenta couplers invented by Fuji and first used in Fujicolor Paper Type 12 (Process EP-2) introduced in 1985.
26. Robert J. Tuite [Eastman Kodak Company], "Image Stability in Color Photography," **Journal of Applied Photographic Engineering,** Vol. 5, No. 4, Fall 1979, pp. 200–207.
27. Henry Wilhelm, "Light Fading Characteristics of Reflection Color Print Materials," abstract in the 31st SPSE Annual Conference Program [abstracts], **Journal of Applied Photographic Engineering**, Vol. 4, No. 2, Spring 1978, p. 54A.
28. Klaus B. Hendriks, together with Brian Thurgood, Joe Iraci, Brian Lesser, and Greg Hill of the National Archives of Canada staff, is the author of **Fundamentals of Photographic Conservation: A Study Guide**, published by Lugus Publications in cooperation with the National Archives of Canada and the Canada Communication Group, 1991. Available from Lugus Productions Ltd., 48 Falcon Street, Toronto, Ontario, Canada M4S 2P5; telephone: 416-322-5113; Fax: 416-484-9512.
29. Klaus B. Hendriks, "The Stability and Preservation of Recorded Images," Chapter 20 in **Imaging Processes and Materials – Neblette's Eighth Edition** (edited by John M. Sturge, Vivian Walworth, and Allan Shepp), Van Nostrand Reinhold Company, New York, New York, 1989.
30. The Photographic Materials Group of the American Institute for Conservation (AIC) was founded in 1979. The first meeting, organized by Jose Orraca, was held at the University of Delaware in Newark, Delaware, August 20, 1979; the charter members of the group were Gary E. Albright, David E. Kolody, Jose Orraca, Mary Kay Porter, Siegfried Rempel, James Reilly, Henry Wilhelm, and Chris Young. For further information contact: American Institute for Conservation, Suite 340, 1400 16th Street, N.W., Washington, D.C. 20036; telephone: 202-232-6636.
31. Lawrence F. Karr, ed., **Proceedings – Conference on the Cold Storage of Motion Picture Films,** American Film Institute and Library of Congress, Washington, D.C., April 21–23, 1980.
32. See: Harlan Jacobson, "Old Pix Don't Die, They Fade Away — Scorsese Helms Industry Plea to Kodak," **Variety**, Vol. 299, No. 10, July 9, 1980, pp. 1, 28–29. This was a major article on the poor image stability of Kodak motion picture color negative and print films; the writer described film director Martin Scorsese's campaign to pressure Kodak into producing improved film stocks. See also: "Signers of No Fade Petition to Kodak Span All Industry Ranks," **Variety**, Vol. 299, No. 10, July 9, 1980, p. 29. See also: Robert Lindsey, "Martin Scorsese's Campaign to Save a Film Heritage," **The New York Times**, October 5, 1980, pp. 19ff. See also: Patricia O'Brian [Knight News Service], "Movies (and Snapshots) Are Losing Their Color," **San Francisco Chronicle**, May 11, 1980. This article also appeared under various titles in many other newspapers. See also: Jack Garner, "Films Fade – Director Protests; Kodak's 'Working on It'," **Democrat and Chronicle**, Rochester, New York, May 13, 1980, pp. 1C, 2C. See also: Richard Harrington, "Old Movies Never Die – They're Just Fading Away," **The Washington Post**, July 20, 1980.
33. David Litschel, editor, **Fugitive Color** (exhibition catalogue with essays by Diane Kirkpatrick and Henry Wilhelm, with an introduction by David Litschel), University of Michigan, Ann Arbor, Michigan, 1982. This author's essay was entitled "The Problems of the Kodak Ektacolor Print System." Published by the School of Art, University of Michigan, Ann Arbor, Michigan 48109.
34. On July 22, 1980 Herbert Phillips, director of the Graphic Arts Research Center at the Rochester Institute of Technology, telephoned this author to retract a previously extended invitation to speak at the "Preservation and Restoration of Photographic Images" seminar scheduled to take place August 25–27, 1980. This author had been a speaker on color photography at six previous RIT seminars on preservation and was listed as a speaker in the RIT brochure for the August 1980 seminar. Phillips informed this author that RIT "wanted some new material" for the program and had asked Kodak to give a presentation similar to the talk Kodak planned to present on August 12, 1980 at the Professional Photographers of America convention in Atlanta, Georgia.

    The actual reason for the cancellation of this author's invitation to speak was Kodak's displeasure with his presentations on color image stability at the previous six RIT seminars in which Kodak's policy of keeping image stability data secret was criticized; criticisms were leveled at Kodak's extremely unstable PR-10 instant print film; and advertisements by Kodak and Polaroid in which misleading claims were made about color image stability were also discussed. This author had obtained, from an anonymous source in Rochester, an internal Kodak memorandum dated May 13, 1980 which described a secret meeting between Allie C. Peed, Jr., director of Publications and Photo Information in Kodak's Consumer/Professional and Finishing Markets Division (at the time, on behalf of the Eastman Kodak Company, Peed was also serving as president of the Society of Photographic Scientists and Engineers), and Lothar K. Englemann, dean of Graphic Arts and Photography at RIT. The memorandum stated in part:

    ". . . Mr. Wilhelm will not be invited to be a program participant in future seminars. Mr. Hendrix [Dr. Klaus B. Hendriks of the Public Archives of Canada] will be invited, but, if he chooses not to come without Mr. Wilhelm, he will be dropped."

    Peed concluded his memorandum by saying ". . . if this one [the seminar] doesn't come off better than the previous one I think we have no alternative but to withdraw any Kodak support on the basis that we don't want our name associated with a poorly run seminar." In the August seminar, Kodak supplied seven out of the 19 speakers, at no cost to RIT. A front-page story by Richard Whitmire which appeared in the July 29, 1980 edition of Rochester's **Times-Union**

newspaper, entitled “Did Kodak Silence Critic? RIT Denies Pressure Led to Cancellation of Seminar Speaker,” included this account of the situation:

“Asked if he knew who sent the letter to Wilhelm, Peed said, ‘No, and I’d be glad to pay you if you could tell me. We have a bit of an internal investigation going on here to find out. We’re trying very hard to put a finger in the dike.’

“Peed did not hesitate to describe his unhappiness with Wilhelm. ‘Our difficulty with him is that he has assigned to himself a role of critic of Eastman Kodak products, for reasons unknown to us,’ he said.

“‘The question was whether we could continue to give support to an activity being used by someone to attack us.’

“But Peed denied Kodak was pressuring RIT to drop Wilhelm. When questioned about the last paragraph of his letter, Peed said, ‘Well, I guess it depends on your definition of pressure. I think we were just being pragmatic in describing a condition we find unacceptable.’

“Contacted yesterday, Englemann refused to discuss his conversation with Peed. ‘That is nobody’s business,’ he said.”

The matter received considerable press and television coverage in Rochester in the following weeks. An editorial entitled “Kodak, RIT and Academic Freedom” that was published in the July 31, 1980 issue of the **Times-Union** said, in part:

“In the matter of the disinvited seminar speaker, Eastman Kodak Co. seems to have challenged the concept of academic freedom and Rochester Institute of Technology seems to have submitted cravenly.

“. . . It’s good of Kodak to interest itself in RIT’s seminars, and wise of RIT to seek Kodak’s advice. But the interests of Kodak are not the same as the interests of photo specialists who are drawn to an academic seminar.

“Kodak ought to answer its critics, not try to silence them. RIT ought to serve students as best it can, and jealously guard its academic independence. Both ought to understand and respect the role of the other.”

On August 15, after this author traveled to Rochester and retained an attorney with the intention of suing both RIT and Kodak in addition to seeking an injunction which would force RIT to reinstate the speaking invitation, RIT agreed — out of court — to permit this author to speak at the seminar. The agreement was reached 3 days after Kodak announced in Atlanta, Georgia that the company would be making color stability information public for its current and future products.

For an account of the RIT incident, see: Richard Whitmire, “Did Kodak Silence Critic? — RIT Denies Pressure Led to Cancellation of Seminar Speaker,” **Times-Union**, Rochester, New York, July 29, 1980, p. A1; Anne Tanner and Dick Mitchell, “Kodak Critic Ponders Legal Action After Canceled Talk,” **Democrat and Chronicle**, Rochester, New York, July 30, 1980, p. D8; “Kodak, RIT and Academic Freedom,” editorial, **Times-Union**, Rochester, New York, July 31, 1980, p. A6; Richard Whitmire, “Kodak Fight Won’t Fade — Wilhelm Demands Reinstatement as RIT Speaker,” **Times-Union**, Rochester, New York, August 8, 1980, p. B1. Richard Whitmire, “RIT Re-Invites Kodak Critic,” **Times-Union**, Rochester, New York, August 18, 1980; “Wilhelm to Speak,” **Democrat and Chronicle**, Rochester, New York, August 19, 1980; “RIT Makes Amends,” editorial, **Democrat and Chronicle**, Rochester, New York, August 20, 1980, p. A18; “Fade Out, Fade In,” part of “The Year That Was: 1980,” **Times-Union**, Rochester, New York, January 3, 1981, p. 5.

See also a series of articles by Anthony Bannon: “Part I: Priceless Prints Deteriorating — ‘Living Color’ Dying Out in Old Photos,” **The Buffalo News**, Buffalo, New York, August 16, 1980; Anthony Bannon, “Part II: Photography ‘Nader’ Fighting Film Industry,” **The Buffalo News**, Buffalo, New York, August 17, 1980; Anthony Bannon, “Part III: Kodak Defends Stability of Its Film,” **The Buffalo News**, Buffalo, New York, August 18, 1980; Anthony Bannon, “Part IV: Cold, Darkness Are Necessary to Preserve Photos,” **The Buffalo News**, Buffalo, New York, August 19, 1980; Anthony Bannon, “Kodak Program on Color Fading Is Announced,” **The Buffalo News**, Buffalo, New York, August 31, 1980, p. A9. See also: John Bremer, “Wilhelm Feuds with Kodak over Seminar,” **Grinnell Herald-Register**, Grinnell, Iowa, August 28, 1980, p. 1.

See also: Cindy Furlong and Adam Weinberg, “The Imperfect Miracle — Wilhelm Reinstated at RIT Seminar, Kodak Shifts on Color,” **Afterimage** (published by the Visual Studies Workshop, Rochester, New York), October 1980, p. 3.

See also: John Thompson, interview with Henry Wilhelm concerning Kodak’s involvement in the controversy surrounding Wilhelm’s cancellation and later reinstatement as a speaker at the Rochester Institute of Technology Seminar on the preservation of photographs. Segment aired on the evening news of **WHEC** television (CBS — Channel 10), Rochester, New York, August 26, 1980. See also: Marty Bucksbaum, interview with Henry Wilhelm concerning the problems of fading color prints and the controversy surrounding Wilhelm’s being dropped and later reinstated as a speaker at the Rochester Institute of Technology seminar on the preservation of photographs. The segment aired on **WXXI** television (PBS — Channel 21), Rochester, New York, August 28, 1980.

See also: Thom O’Connor, “Why Henry Wilhelm Took On Kodak,” **New York Photo District News**, Vol. III, Issue I, Sec. II, November 1982, pp. 1ff; and Thom O’Connor, “Print Permanence — How Long Is Forever?”, **New York Photo District News**, Vol. III, Issue I, Sec. II, November 1982, p. 66.

RIT has long cultivated ties between the school and the photographic and graphic arts industries and governmental agencies with a zeal that would embarrass most colleges and universities. The driving force behind these intertwining relationships has been the school’s often-stated desire to obtain lucrative contracts for research projects and other revenue-producing services.

In 1980, at the time of the cancellation incident, M. Richard Rose was serving as president of RIT. Rose took early retirement in 1992 “. . . in the wake of controversy last year over his, and the school’s, links with the Central Intelligence Agency.” (from an article by Jennifer Hyman, “RIT Picks Its Next President, **Democrat and Chronicle**, Rochester, New York, May 19, 1992, page 1). RIT’s new president is Albert J. Simone, formerly president of the University of Hawaii.

For an account of the RIT-CIA controversy, see the long series of articles by Jennifer Hyman that appeared in Rochester’s **Democrat and Chronicle** newspaper beginning on April 27, 1991, with a story entitled “RIT Students Protest President’s CIA Work,” (p. 1B–2B) and that ran through the remainder of 1991 and continued into 1992. Among the **Democrat and Chronicle** articles were: “RIT Advises CIA to Plan for Future – Report Espouses Economic Espionage” (May 19, 1991); “Secret RIT Study Bashes the Japanese” (May 24, 1991); “CIA Vein Runs Deep Inside RIT – ‘85 Memo Spelled Out Formal Ties” (June 2, 1991); “CIA Had a Free Hand: RIT Official – Agency Ran Its Own Shadow Management” (June 11, 1991); “Many Feel CIA Ties Taint RIT’s International Efforts – Foreign Educators Grow Wary of School” (June 30, 1991); “The RIT-CIA Connection” (June 30, 1991). See also: “CIA Report on Japan Economy Creates Furor at Institute,” **The New York Times**, June 5, 1991, p. B10. See also: William Glaberson, “Soul-Searching at a University Over C.I.A. Links,” **The New York Times**, June 20, 1991, p. A1 and A11. See also: M. Kathleen Wagner, “Wariness of the CIA Lingers at RIT Forum,” **Democrat and Chronicle**, Rochester, New York, September 23, 1992, pp. 1B–2B.

35. Image Permanence Institute, Rochester Institute of Technology, Frank E. Gannett Memorial Building, Post Office Box 9887, Rochester, New York 14623-0887; telephone: 716-475-5199 (Fax: 716-475-7230).
36. James M. Reilly, **Care and Identification of 19th-Century Photographic Prints**, Kodak Publication No. G-2S, Eastman Kodak Company, Rochester, New York, 1986. See also: James M. Reilly, **The Albumen & Salted Paper Book — The History and Practice of Photographic Printing 1840–1895**, Light Impressions Corporation, 439 Monroe Avenue, P.O. Box 940, Rochester, New York 14603-0940, 1980.
37. Hiroshi Sugaya, “The Past Quarter-Century and the Next Decade of Videotape Recording,” **SMPTE Journal**, Vol. 101, No. 1, January 1992, pp. 10–13.
38. Richard S. O’Brien and Robert B. Monroe, with contributions by Charles E. Anderson and Steven C. Runyon, “101 Years of Television Technology,” **SMPTE Journal**, July 1976 (reprinted in the **SMPTE Journal**, Vol. 100, No. 8, August 1991, pp. 606–629).
39. Richard S. O’Brien and Robert B. Monroe, with contributions by Charles E. Anderson and Steven C. Runyon, see Note No. 38, pp. 610–611.
40. Nora Lee, “HDTV: The Artists Speak” (Electronic Imagery), **American Cinematographer**, Vol. 68, No. 9, September 1987, pp. 85–90.
41. Lois Schlowsky, “Digital Vision: Birth of a Filmless Photography Studio,” **Photo-Electronic Imaging**, Vol. 35, No. 11, November 1992, pp. 31–33. (Schlowsky Photography and Computer Imagery, 73 Old Road, Weston, Massachusetts 02193; telephone: 617-899-5110; Fax: 617-647-1608.)
42. Chris Gulker, photo editor of the **San Francisco Examiner**, interviews with this author during August–November 1992. For a detailed description of how the **Examiner** uses Adobe Photoshop to prepare scanned color negative images for publication, see: Jane Hundertmark, “Picture Success,” **Publish**, Vol. 7, No. 7, July 1992, pp. 52–58.
43. The Polaroid Corporation began working with Charles Berger in early 1985, and pigment films were successfully coated in March of that year (see: Polaroid Corporation, “Color for Centuries,” **Instants**,

Vol. 4, No. 2, Polaroid Corporation, Cambridge, Massachusetts, 1986, p. 4). At the time, Berger's printmaking materials were known as the ArchivalColor materials. Development work continued and in February 1987, Polaroid announced that it would market the materials worldwide. In June 1987, however, Polaroid abruptly announced that development work had ceased and that the company had decided not to market the ArchivalColor materials. Later, Polaroid announced it would make the existing materials available on a contract basis, under the Polaroid Permanent-Color name, but that further development would not be undertaken. Ataraxia Studio, Inc., 3448 Progress Drive – Suite E, Bensalem, Pennsylvania 19020 (telephone: 215-343-3214) was established to make prints using the Polaroid-manufactured materials (see: Linda Tien, "Lasting Impressions – At Ataraxia Studio, Images Are Made to Stand the Test of Time," **Specialty Lab Update**, published by the Photo Marketing Association International, March 1992, pp. 1 and 4). At the time this book went to press in 1992, however, commercial production of prints at Ataraxia Studio had not begun, and production print samples were not available for image stability and physical stability testing.

44. A number of articles have been written about the UltraStable process. See, for example: John Durniak, "Color Almost Too Good To Be True," **The New York Times**, December 6, 1992, p. Y27; and: Mark Wilson, "A Color Process That Won't Fade Away," **The Boston Sunday Globe**, May 17, 1992. See also: Spencer Grant and Elizabeth Forst, "Carbro Printing: Back to the Future," **Photo District News**, Vol. XII, Issue II, February 1992, pp. 98–100; and: William Nordstrom, "In Search of Permanence: 500-Year-Life UltraStable Color Photographs," **Professional Photographer**, Vol. 119, No. 2159, April 1992, pp. 34–36; and: David B. LaClaire, "Marketing UltraStable Portrait Prints," **Professional Photographer**, Vol. 119, No. 2159, April 1992, p. 36.
45. Joe Matazzoni, "Outputting Fine Color From the Desktop – In the Tradition of Fine Arts Printers, A Handful of Color Houses Are Producing Limited Edition Iris Prints From Digital Files," **Step-By-Step Graphics**, Vol. 8, No. 5, September–October 1992. Donald R. Allred, Ink and Media manager at Iris Graphics, Inc., was quoted in the article concerning the light fading stability of Iris prints.
46. Firms offering high-resolution Iris ink jet prints produced from digital image files (and from photographic originals) for the fine art and commercial display markets include: **Nash Editions**, P.O. Box 637, 1201 Oak Avenue, Manhattan Beach, California 90266 (telephone: 310-545-4352; Fax: 310-545-8565); **Image Transform Ltd.**, 2309 West First Street, Ankeny, Iowa 50021 (telephone: 515-964-0436; Fax: 515-964-3914); **Harvest Productions**, 911 Champlain Circle, Anaheim Hills, California 92807 (telephone: 714-281-0844; Fax: 714-281-2920); and **DiGiColor**, 1300 Dexter Avenue North, Seattle, Washington 98109 (telephone: 206-284-2198; Fax: 206-285-9664).
47. Christine Heap, "Photo Negative Database at the U.K.'s National Railway Museum," **Advanced Imaging**, Vol. 8, No. 2, February 1993, pp. 36–39.
48. Jim Wallace, "Considerations Regarding the Long-Term Storage of Electronic Images, **Journal of Electronic Imaging**, Vol. 2, No. 1, January 1993, pp. 35–37.
49. Eastman Kodak Company, **Kodak Photo CD Permanence Questions and Answers**, Eastman Kodak Company, Communications and Public Affairs, December 18, 1991.
50. National Archives and Records Service, **Strategic Technology Considerations Relative to the Preservation and Storage of Human and Machine Readable Records** (White Paper prepared for the National Archives and Records Service by Subcommittee C of the Committee on Preservation), July 1984.
51. John C. Mallinson, "Archiving Human and Machine Readable Records for the Millenia," **Second International Symposium: The Stability and Preservation of Photographic Images** (Printing of Transcript Summaries), the Society of Photographic Scientists and Engineers, Springfield, Virginia, pp. 388–403, 1985. (The symposium was held August 25–28, 1985 in Ottawa at the National Archives of Canada.) See also: John C. Mallinson, "Preserving Machine-Readable Archival Records for the Millenia," **Archivaria**, No. 22, Summer 1986, pp. 147–152. See also: John C. Mallinson, "On the Preservation of Human- and Machine-Readable Records," **Information Technology and Libraries**, Vol. 7, No. 1, March 1988, pp. 19–23.
52. John C. Mallinson, "Magnetic Tape Recording: History, Evolution and Archival Considerations," chapter in **Proceedings of the International Symposium: Conservation in Archives**, pp. 181–190. The symposium was held May 10–12, 1988 in Ottawa and was sponsored by the National Archives of Canada and the International Council on Archives. The proceedings were published by the National Archives of Canada, 1989. Copies of the proceedings are available from the International Council on Archives, 60 rue des Francs-Bourgeois, 75003 Paris, France.

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