Optical Restoration of Faded 35mm Color Negative

By Peter Kuran

Since 1950, color negative film has become the standard on which millions of motion picture and television shows have been photographed. Since the early 1970s, it has become apparent that the color negative film stock on which these images were recorded was not entirely stable and was fading with time. Digital technology is beginning to offer solutions for saving these records but will continue to be unavailable for most of them due to cost. Optical (photochemical) restoration offers a cost-effective alternative to preserving many film records that might be lost by the time digital technology is affordable.

The 35mm Eastman Color Negative Film 5247 was introduced in 1949. This camera film quickly replaced the Technicolor three-strip camera system for the origination of high quality color motion pictures. Other companies, including Fujicolor and Agfacolor, have also produced color negative film.

Unlike black-and-white negative films, early color negative films kept under even ideal conditions demonstrate fading of their color dyes. Many of these color negative films, over 40 years in age, generally exhibit strong fading, but even films produced as recently as 20 years ago can exhibit signs of fading. Also, the older intermediate films and color reversal intermediate films (CRIs) exhibit different fading characteristics, causing opticals to stand out from original negatives that may not exhibit fading.

In the past, some studios have taken the precaution of protecting their original negative investment by making red, green, and blue separations. But even under the best conditions, many separations made in the 1950s and 1960s suffer from varying amounts of white dirt, dust, and scratches enhanced by optical systems before wet gating became possible. In addition, differential support shrinkage between the three separations can cause fringing problems when they are recombined.

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Symptoms of Faded Color Negative

During prolonged storage many factors affect the dye stability of color negative films, including the composition of the original film itself, storage temperature, humidity, tightness of winding, and the original processing of the color film. The yellow dye layer is particularly vulnerable to these factors. Computer analysis of the dynamic range of a faded color negative image (Fig. 1) generally shows significant loss in the yellow dye layer and, to a certain extent, the magenta layer. Yellow dye loss can be as much as 75%.

Upon visual inspection of the original color negative, there will appear to be a strong magenta cast to the emulsion. A standard laboratory aim density (LAD) print from this negative will yield an overall green appearance. Creating a timed print from the faded color negative will exhibit a "crossover" effect, i.e., strong blue shadows and yellow highlights.

Trying to correct for this condition on severely faded color negative utilizing standard printer timing corrections is essentially impossible. When one attempts to time out the yellow in the highlights, the shadow areas become even bluer and more unnatural. On the other hand, attempting to time out the blue in the shadows, the whites become even more yellow and sick looking.

Existing Techniques of Restoring Color

Other techniques that attempt to restore the color of faded color negative may yield results that range from good to unacceptable depending on the condition of the original. In situations where the negative has been well kept and preserved, and depending on the subject matter, a good film timer familiar with the problems of faded negative may time a new print to near-perfect acceptability. However, this will not work on severely faded negatives and demanding subject matter.

Making red, green, and blue separations and greatly increasing the gamma of the blue record (e.g., 4X in the case of 75% dye loss) through development, while excellent in theory, often results in a very grainy blue record unusable for recombining. If the original faded negative or best new print from this negative is telecined, current video technology is able to bring these crossover discrepancies into range, but these results are only at video resolution (less than one quarter the resolution of 35mm

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Before color restoration.

After color restoration. ***Cover Photo.***

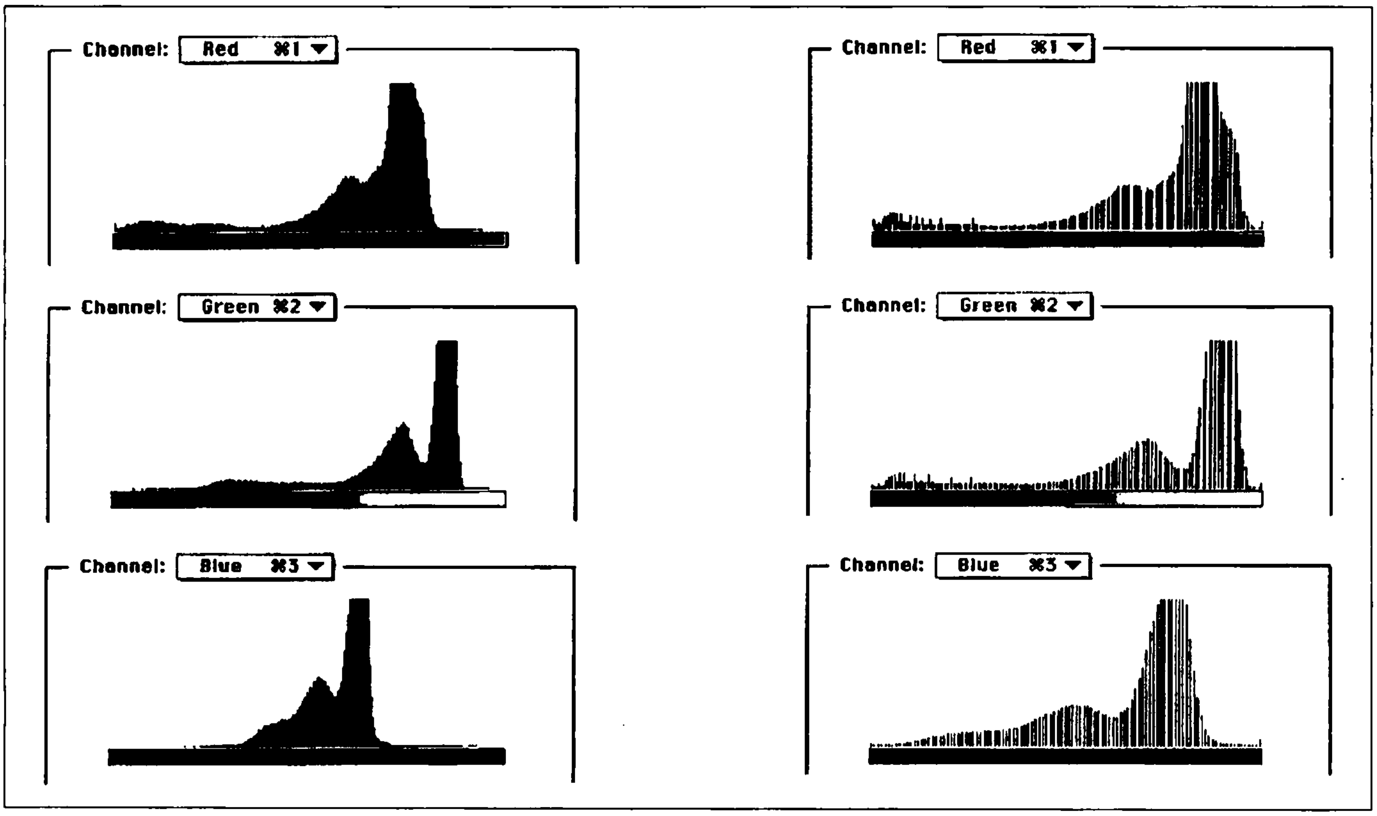

Figure 1. Histogram of information created by sampling a faded color negative frame scan using Photoshop (left column). The right column displays the corresponding histogram with the data stretched into the proper values. Each square reveals the dark-to-light values of the negative. The histogram shows the fading especially noticeable in the blue (yellow) channel.

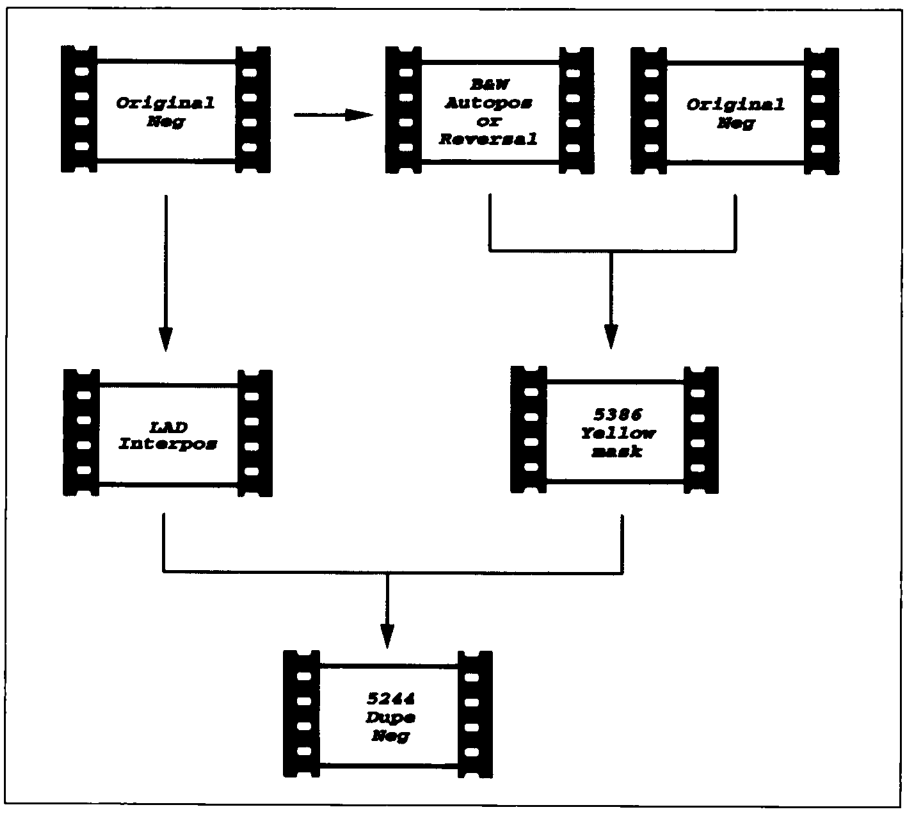

Figure 2. Restored color image process.

motion picture film) and do not address the long-term solution of restoring the material back to a film master with a higher resolution.

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Restored Color Image (RCI) Processes

The RCI process (Fig. 2) offers a choice of two different optical (photochemical) procedures. Each process utilizes intermediate elements generated from the original negative and then combined with the original negative to produce a matte, which is then combined with an interpositive to create a new internegative.

The most easily reproduced process utilizes existing standard film processes to restore color by creating a mask, which is combined with an interpositive to create a new internegative. This process is easily implemented because of the use of existing film processes and currently available off-the-shelf stocks.

The original negative is printed to an interpositive and an autopositive. The interpositive is made using Kodak LAD standards, and no attempt is made to correct the color at this stage. Attempts to correct the color on the interpositive appear to reduce the success of the final image at the final step.

The autopositive is generated from available film stock (such as Kodak 5360 Direct MP) and processed in conventional D-97 processing. The image created on the autopositive stock is very light and is used only to boost the contrast of the original color negative for the next intermediate step. This element is recombined on an optical printer with the original negative to create a yellowish color mask onto registered color print stock (B&H perf, 0.1866 pitch) such as Kodak's 5384 or 5386.

The resulting color print intermediate element is recombined on a two-projector head optical printer and fit against the interpositive to create a new internegative. The author's research shows that this intermediate mask needs incremental adjustment for scene-to-scene color correction when it is being made.

It is hoped that advances in color analyzing technology will follow this process and provide a special color analyzer to meet the requirements of this new technology and make the process extremely cost-effective. This process is successful about 70% of the time, depending on the contents of the scene. The results range from astonishing to mediocre; but when compared to a timed print taken from an extremely faded original negative, there is no question that the results are far superior for theatrical projection.

The problems with this process arise from the fact that the autopositive stock, which provides most of the objectives required (i.e., microfine grain and a direct reversal of the image) also provides a limitation in that it is sensitive only to green and blue (thus orthochromatic). This creates the appearance of a slight lowering of the saturation of the resulting balance of the green values.

The second procedure discussed here is the most reliable from the standpoint of accuracy of color reproduction but requires nonstandard processing of intermediate elements for it to work. The author's research has shown that to provide the most accurate color reproduction, the autopositive would have to be sensitive only to red or be panchromatic and exposed with a red seperation filter (such as a 29 or 70 red). Since it is impossible to manufacture a film stock that is sensitive only to red (let alone an autopositive film stock with microfine grain), the choice would have to be a panchromatic film stock that is exposed with red filtration. Currently researched black-and-white stocks would add additional grain to the resulting image.

Experimentation with an Ilford black-and-white stock has shown the most promising results, especially since it works well with reversal processing and therefore would replace the autopositive step. However, this is not a standard process and would require substantial investment by a film lab and additional work to modify a black-and-white film stock.

Conclusion

The results with the RCI process have been substantial. It was utilized primarily to fix the color of extremely faded Eastman color negative, originally shot in the 1950s, which was used in a recently released documentary film finished in the 35mm format entitled *Trinity and Beyond.* This footage was so faded that it otherwise could not have been used; it had also been classified until recently and would never have been seen by anyone.

Even with recently enhanced awareness that motion picture color negative is fading, only a chosen few films and records will be saved using expensive, state-of-the-art digital techniques to restore their images to near-perfect reproduction at film resolution. Others, not as fortunate but equally as important, whose value is judged solely against this expense, will continue to fade into obscurity and will be lost forever.

The RCI process provides the only optical (photochemical) technique able to restore color images at film resolution at costs well below those of current digital technology, making it possible to save these records for future generations before further deterioration occurs.

THE AUTHOR

Peter Kuran heads Visual Concept Engineering (VCE), an optical effects house he started at the age of 20. He began his career at George Lucas's Industrial Light & Magic, where he worked on such films as *Star Wars, Star Trek II and V, Robocop 1, 2, and 3, Addams Family, Addams Family Values, GhostBusters 2,* and *Beetlejuice.* Following *Star Wars,* he worked on ABC's "Battlestar Galactica" and the feature films *The Dark* and *Piranha,* among several others, before returning to ILM to begin effects on *The Empire Strikes Back.* He then returned to Los Angeles to develop his company full time, working on such films as *The Howling, Airplane, and Dragon Slayer.*

VCE was responsible for the visual effects for Oliver Stone's *Nixon* and Ed Zwick's *Courage Under Fire,* and is currently working on TriStar Pictures' *Starship Troopers.* Kuran has recently completed his own 92-minute documentary film, *Trinity and Beyond,* which uses previously classified government footage on the creation and testing of the atomic and hydrogen bombs over a 20-year period. Kuran used the RCI system to recreate and preserve original color negatives of the government film.