A High-Speed, Direct-Positive Photothermographic System

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Abstract

In a silver halide photothermographic system, all of the development products are confined in the coated layer and are not washed out. It has been found that these products of thermal development of a high-speed, negative working silver halide emulsion system can selectively inhibit image and fog formation when the system is heated beyond optimum negative development. Upon extended heating, negative development abruptly shuts down in the exposed areas and is followed by high-density fog development. The result is a high-speed, direct-positive photographic image with good image structure. The direct-positive photographic speeds can be as high as ISO 24.000 and are believed to be the highest yet reported for a silver halide recording system. This ultra high-speed system will be shown to result from a new, two-stage amplification mechanism.

Introduction

In the past there have been many attempts to use the products of silver halide development to amplify the original response of a negative working photographic system. These previous attempts include:

1. The use of released iodide ions released at the time of development to crack the shell of incorporated, internally fogged, silver halide grains and by developing these additional silver halide grains, amplifying the original photographic response [1].
2. Incorporating the colorless form of a spectral sensitizing dye into the silver halide emulsion which can be converted to a spectral sensitizing dye upon reaction with an oxidized developing agent. The sensitizing dye, which is created image wise, can migrate to neighboring grains and spectrally sensitize them. Subsequent exposure of the developing film, to the wavelength of the newly created sensitizing dye leads to a secondary amplification of the original photographic response [2,3].
3. Incorporating a desensitizing dye into a high-speed silver halide emulsion and developing the exposed film in a fogging developer leads to a considerable amplification of the original photographic response without fogging unexposed grains [4].

All of the known previous attempts, to use the products of development to produce higher photographic speeds have done so with an increase in negative working systems. Although significant speed increases in photographic speed could be shown, all of the previous attempts have also resulted in a significant increase in granularity, which limits their photographic utility.

It is the object of this paper to describe a new reversal system in which the products of development are used to inhibit the fogging development of an incorporated, very fine grain component, thus allowing a significant increase in photographic speed with less of a loss in image structure than with negative working systems.

The initial focus of this investigation was to take advantage of the photothermographic chemistry evolved for the creation of a photothermographic color system [5] and apply it to the creation of a photothermographic, black and white, negative system for X-ray recording. In a classic case of serendipity, this new, two-stage amplification system was discovered.

Experimental

Initially the chemical compositions of the silver halide coatings were similar to those described by House (5) but when a time of development series revealed a new high-speed reversal taking place, the coating format was adjusted to take better advantage of this newly discovered reversal. The details of the final coating compositions are described in two separate publications [6,7]. The basic elements of the high-speed reversal are:

1. A state of the art, silver halide tabular grain emulsion, optimally chemically and spectrally sensitized.
2. A thermal solvent dispersion of salicylanilide.
3. A dispersion of the silver salt of 1-phenyl-5-mercaptotetrazole.
4. A dispersion of a catachol developing agent.

Figures 1–5 show sensitometry, picture tests and electron micrographs of the phothermographic response of this new reversal system.

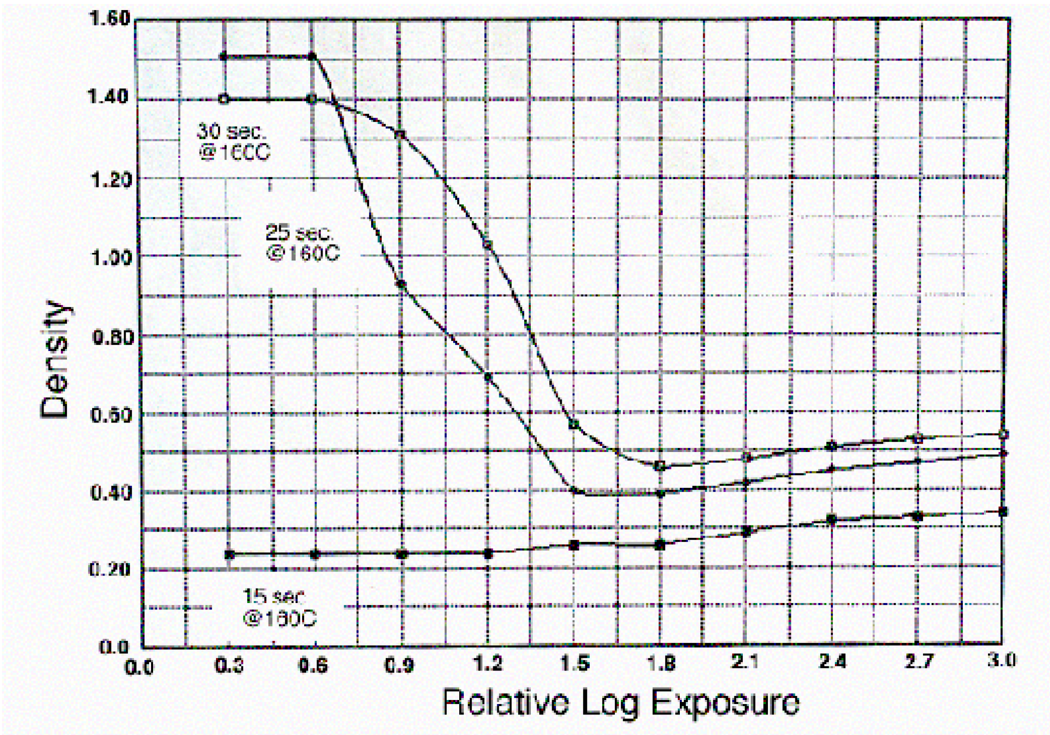

***Figure 1**. Effect of time of development on photothermal response.*

***Figure 2**. ISO 6400 test exposure with green sensitized photothermographic layer, fluorescent lighting with grayscale chart.*

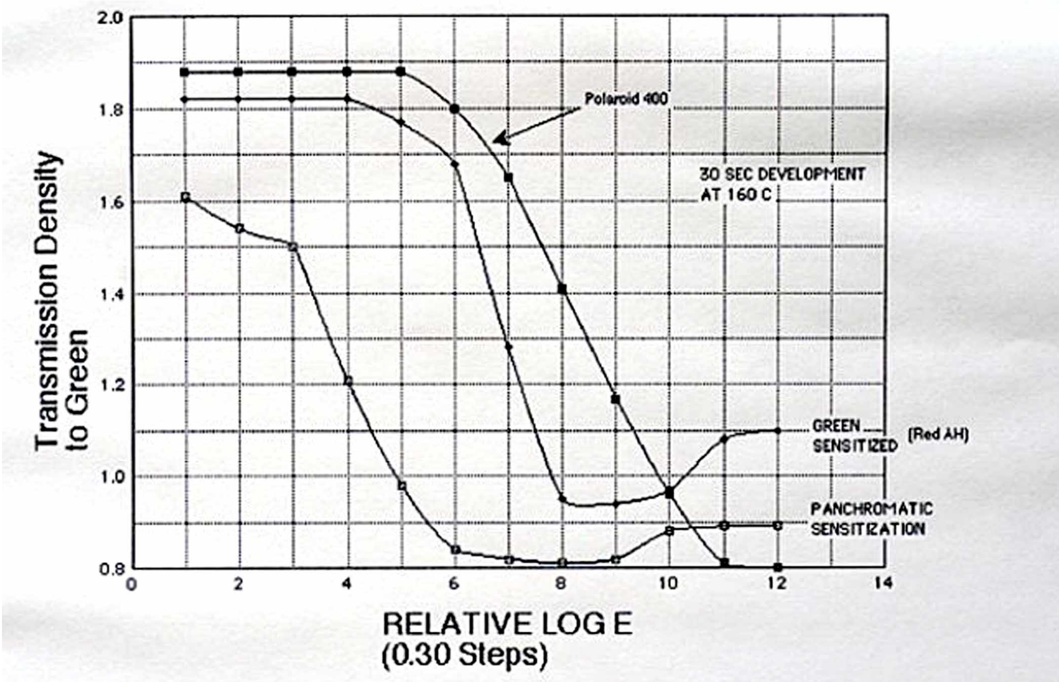

Figure 3. Comparison of sensitometric responses of Polaroid 400 with green sensitized and panchromatically sensitized, photothermographic reversal experiments.

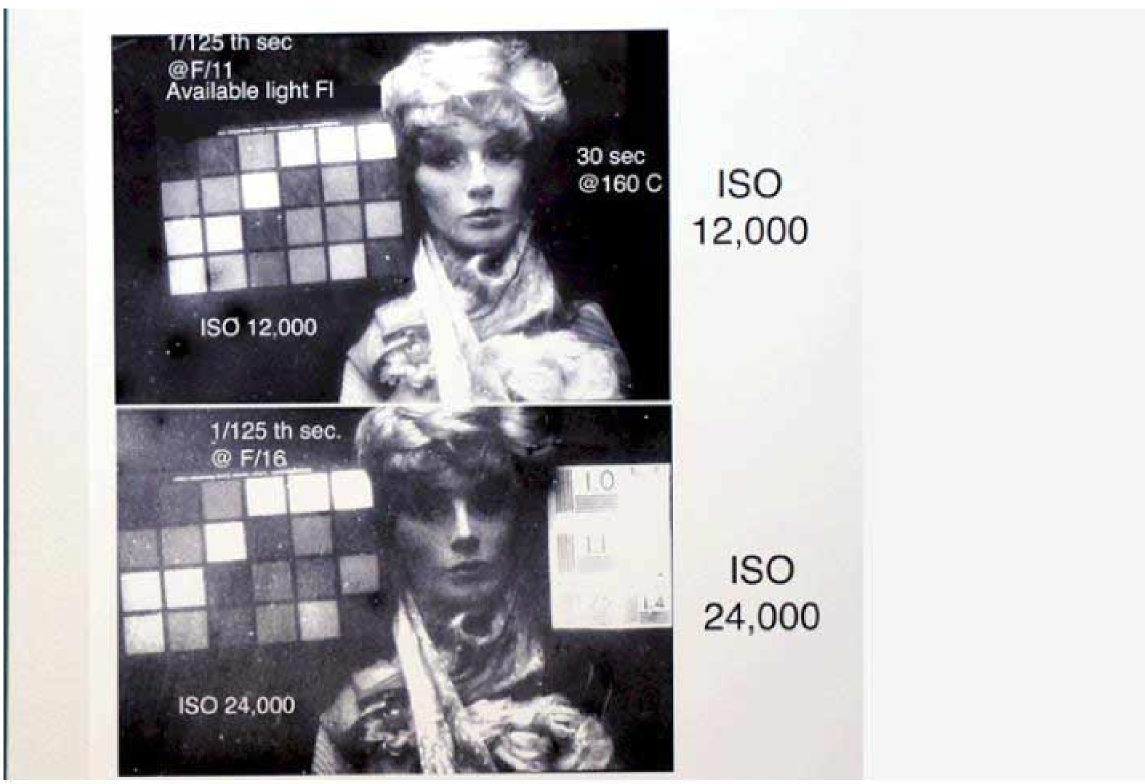

Figure 4. Picture tests of panchromatically sensitized coatings at ISO 12,000 and ISO 24,000.

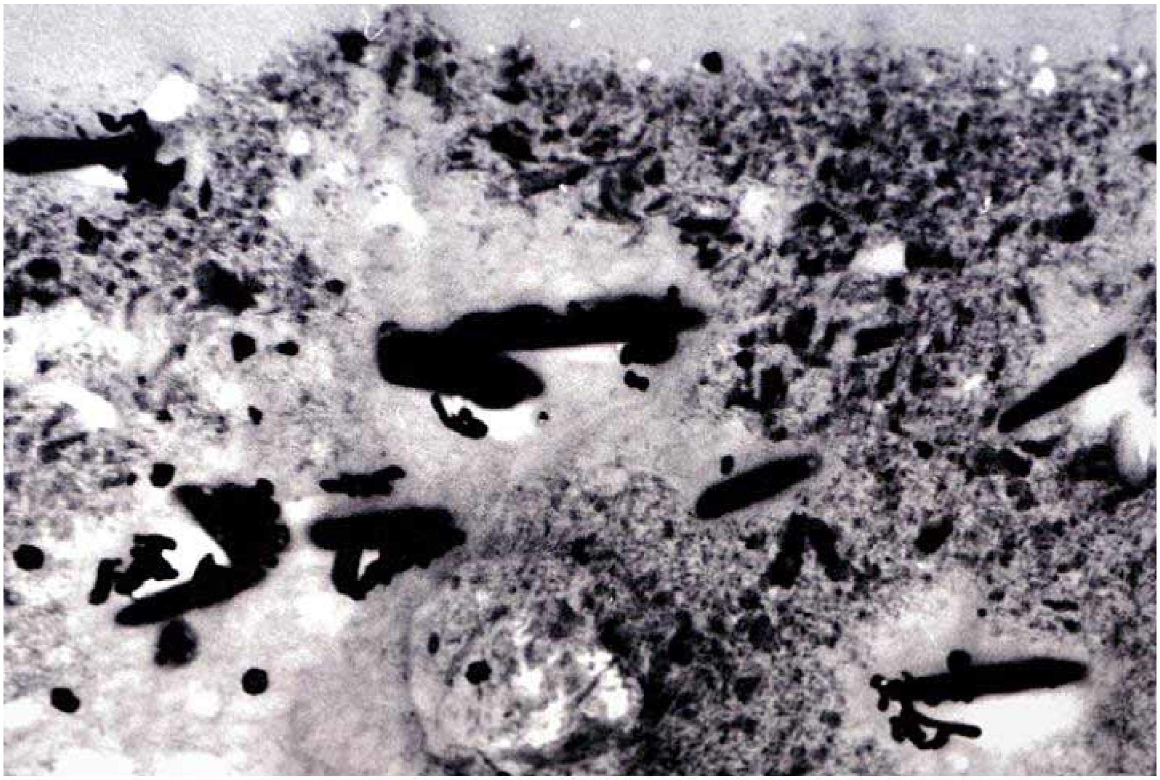

Figure 5. Electron micrograph of a photothermographic reversal system layer showing sphere of development inhibition resulting from the release of 1-phenyl mercaptotriazole as a function of physical development. This produces a second stage of chemical development amplification when the system is driven into fog by extended thermal development.

Conclusions

The main conclusions from this study are:

1. A silver halide photothermographic system has been demonstrated that can deliver useful photographic images with photographic speeds made at ISO 12,000 to 24,000 with dry-to-dry access times of 35 seconds.
2. By using a second stage of image amplification, it is possible to increase the effective photographic speeds of conventional negative working systems two to three stops.
3. The products of development can be used to inhibit the fogging development of an incorporated fine-grain component.

References

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[7] Michael R. Roberts, Paul B. Gilman, Donald L. Black and Kurt M. Schroder, US Patent Application Pub. No. US 2004/0259041 A1 (2004).