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PERIMENT IN ASSESSING LOR SEPARATION TECHNIQUES FOR IDENTIFYING SMALL DENSITY VARIATIONS IN TIRES

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16. Abstract

An experimental color system was tested as an adjunct to the X-ray fluoroscopy system already in use. Shades of gray were translated into various colors as a means of enhancing small defects normally observed with difficulty, and to provide for more rapid identification of gross defects.

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PREFACE

The experiment described in this report was conducted as a part of the Nondestructive Tire Testing Program sponsored by the National Highway Traffic Safety Administration. The principle objective of this experiment was to enhance the ability to analyze tire defects using standard X-ray flouroscopy techniques.

Sincere gratitude is extended to Mr. John Newett of Antech Inc., Maynard, Mass. who assisted TSC personnel in conducting this experiment.

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1.0 INTRODUCTION

Probably the most common nondestructive inspection technique currently in use in the tire industry is X-ray fluoroscopy. Its extensive use is dictated by the need to rigorously monitor the effectiveness of the hand labor used in assembling a tire. Most of the formulation and curing operations can be maintained within tolerance limits by batch and process control, but the tire builder is still responsible for proper layup and location of the various component parts. X-ray has been found to be an efficient means of determining the quality of the workmanship.

However, in order to inspect a worthwhile sampling of a day's production, it is necessary to inspect about 250 tires per 8 hour shift. At that rate, the ability to resolve even moderately severe defects is marginal. Moreover, if X-ray is to become useful in identifying more subtle types of flaws, a method of quantifying energy density in the image must be discovered.

The experiment described herein is an attempt to solve the twofold problem of providing more rapid identification of gross defects and more positive identification of less blatant defects such as thin sections and separations.

2.0 METHOD OF APPROACH

The X-ray fluoroscope for tires is an imaging system in which image brightness is a function of the thickness and density of the intervening medium. It is conventional to quantify an image of this character by assigning a gray scale to it having a number of steps equivalent to the eye's ability to resolve differences between adacent grays. (Usually between 8 and 10 levels.) However, optical photodensitometers can divide film and picture density into as many as 1000 levels, and the use of electrical processing in video images offers attractive alternatives. One approach is to separate light and dark into a number of levels and assign a color to each level. (See Figure 2-1) Assuming there are 10 electrical levels on the display tube between full bright and full dark, colors may be assigned as shown in the bottom scale of Figure 2-1. Instrumentation is available which can assign colors in the manner indicated; high resolution spreads all eight colors between only three or four gray levels at any degree of brightness.

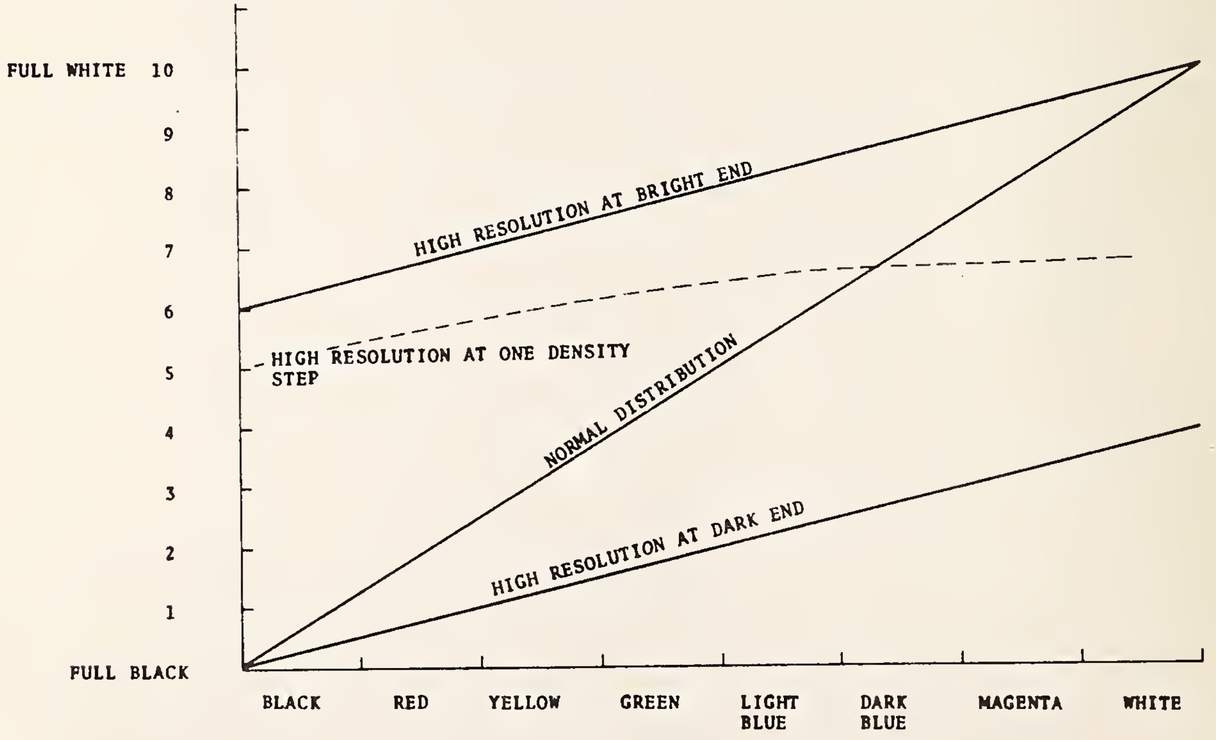


Figure 2-1. Schematic Chart of Assignment of Color to Levels of Light and Dark

The benefit of this technique is of course that the interval between two shades of gray barely distinguishable to the human eye, may be assigned to eight separate color segments thereby providing an elegent scheme for small density differential image enhancement.

3.0 INSTRUMENTATION

A Picker Corporation X-ray Machine described in Reference 1 is routinely used at TSC for tire inspection. The display is a conventional 525-line black and white 17 inch monitor. The task for the ensuing experiment was to provide level separation and color assignment. Two posibilities were available. The first was a fifteen level unit in which each color could be manually adjusted to the desired gray level and upper-to-lower limits assigned also manually. This was available from Colorado Video Corporation in Boulder, Colorado.

The second was an eight level unit in which color span could be compressed, expanded or placed anywhere from white to black. (See Figure 3-1) This unit was available from Antech Inc., Sudbury, Mass.

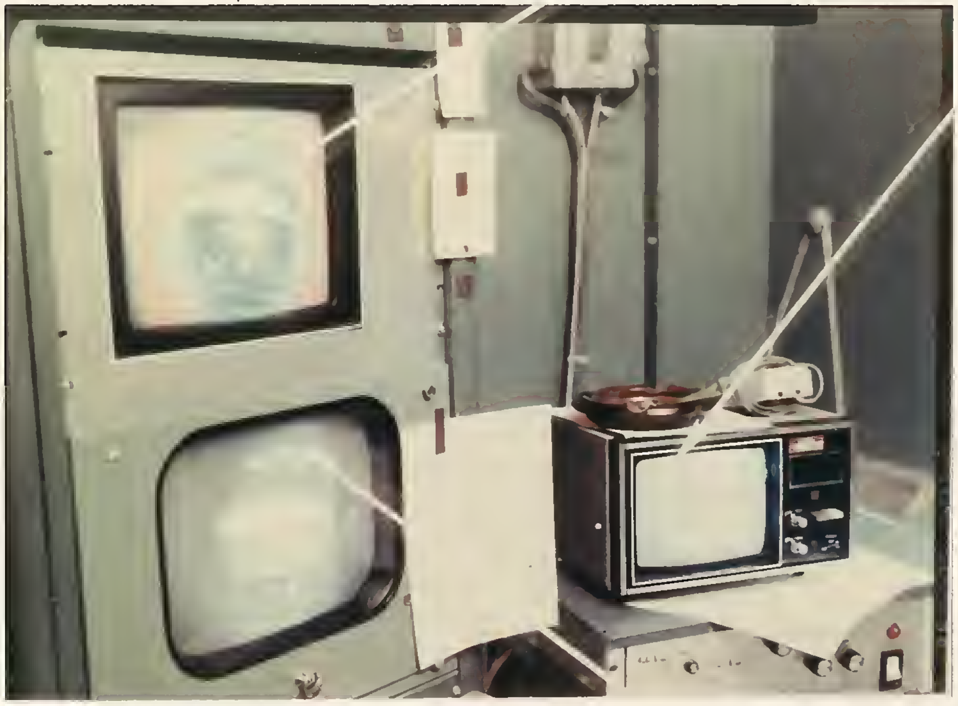


Figure 3-1. Picker Control Room with Antech Color Separator in Operation

For reasons of simplicity and cost the Antech unit was used, although as the conclusions point out, this might have been a mistake.

The Antech unit consisted of a color separator with gain, span and level adjustments as well as a mode control which permitted single color assignment in a probe mode, and a white suppress position to provide image enhancement.

Interface problems were minimal. The coaxial input to the black and white monitor was teed and a signal was fed directly to the Antech unit. Figure 3-1 shows the results.

4.0 THE EXPERIMENT

The number of tires with known defects was scanned and shown in Figures 4-1 through 4-5. The tires used were in poor condition and while the photographs are dramatic the defects were substantial. Subtle flaws could be identified as in Figure 4-6, only after a moderate amount of adjustment.

Two conditions militated against better color discrimination. The first was the Lambertian character of the intensity distribution at the image. The center of the display was much brighter than the periphery and therefore an image without structure would always have a separation of concentric rings of color. The second problem was that the tire has a range of density levels which requires constant intensity adjustment of the X-ray to obtain a good image. Such a procedure defies quantification by constant level color separation techniques.

Neither problem was completely insurmountable. For instance, a level compensation system could be introduced at the system interface which would normalize brightness over the display face. The reasons for not solving these problems were not technical.

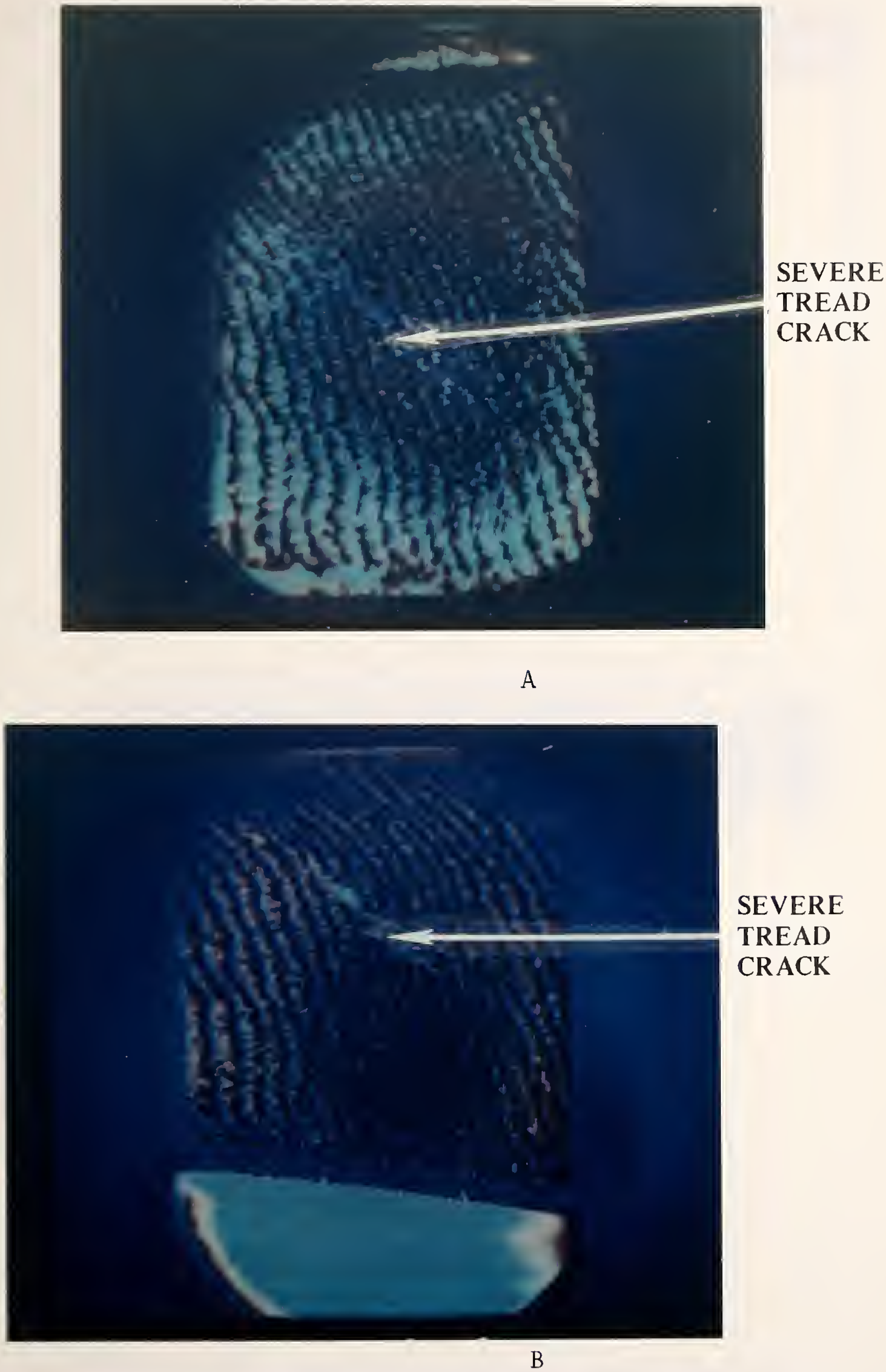


Figure 4-1. Tread Area Showing Severe Tread Crack (Glass Belted Polyester Tire)-Two Level Adjustments.

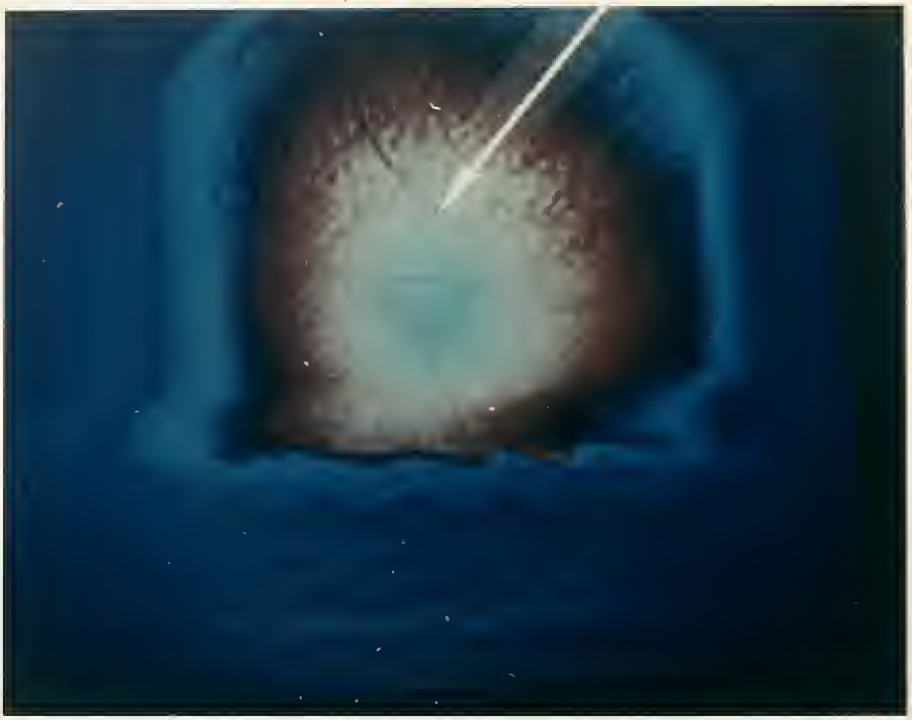


Figure 4-2. Sidewall Area Showing Stray Cord

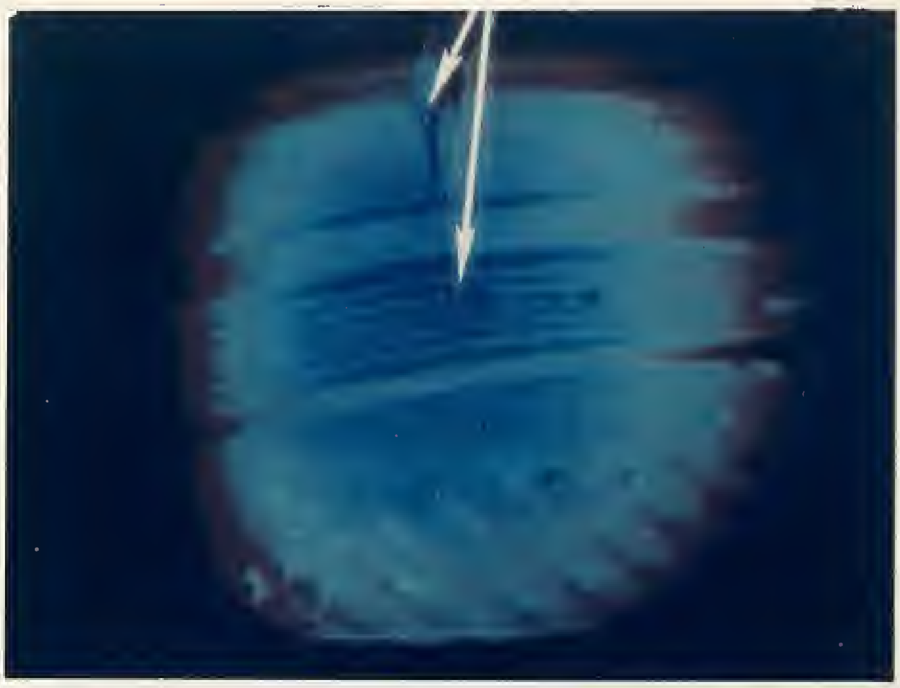
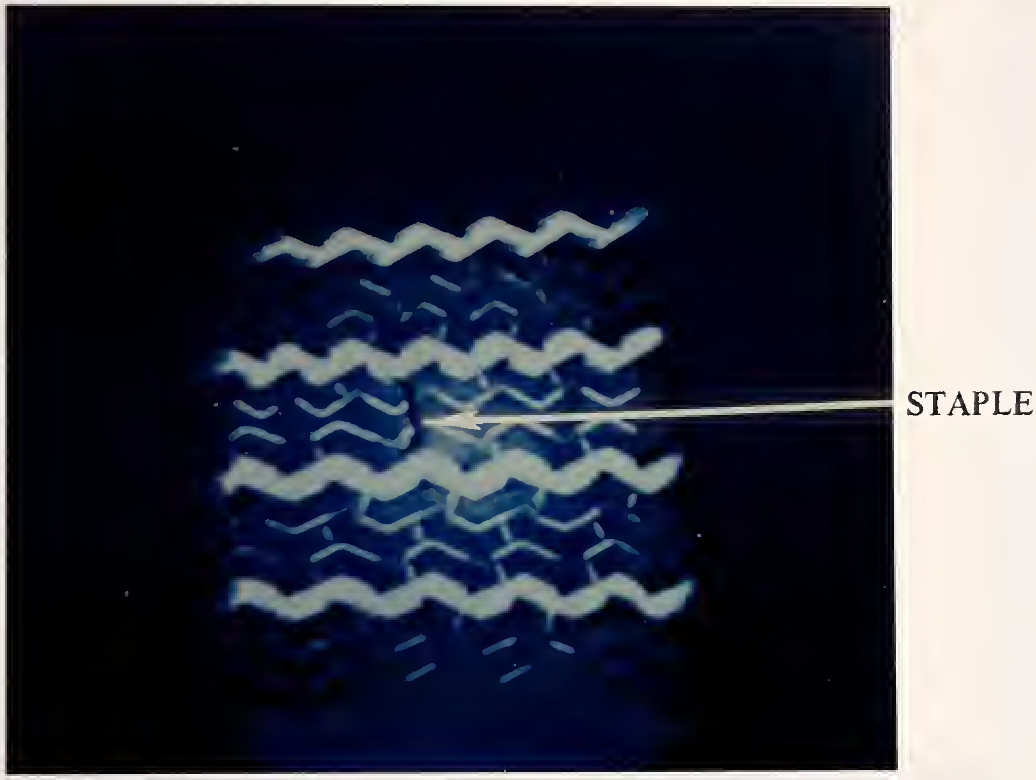


Figure 4-3. Sidewall Area (Radial Tire) Showing Cord Breaks Near Shoulder



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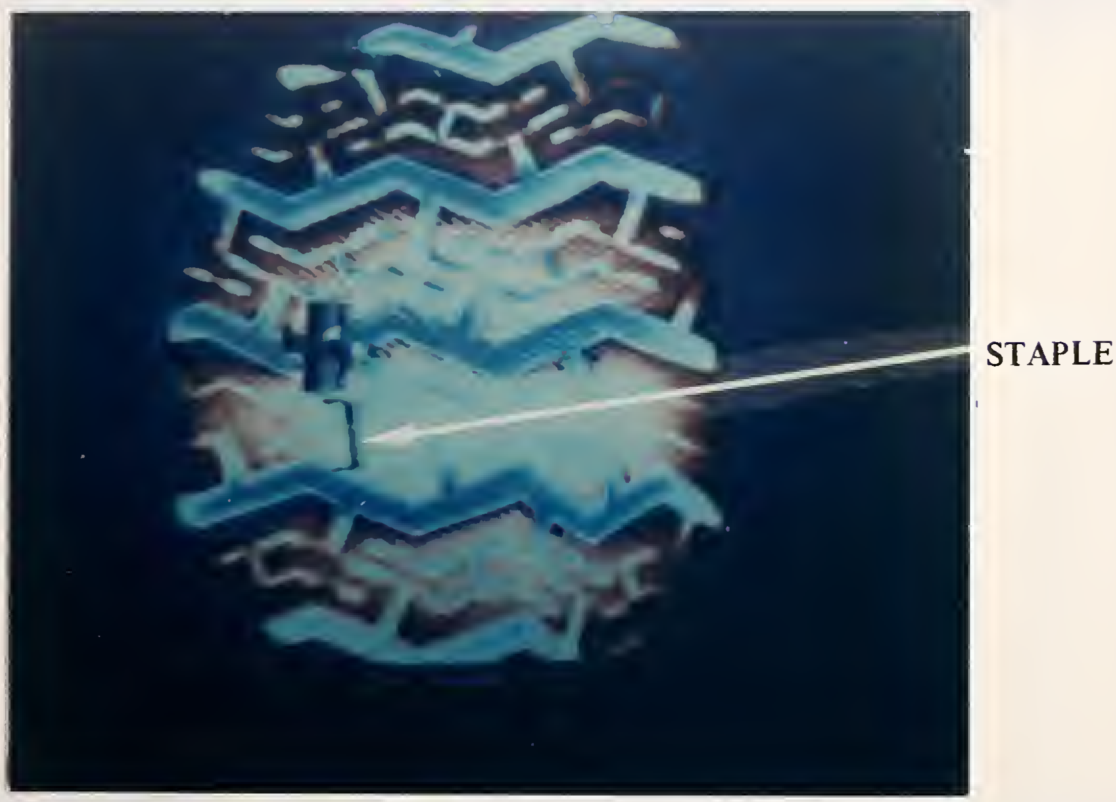

B

Figure 4-4. Different Level Settings Showing the Same Artifact (a Staple on the Outside of the Tire)

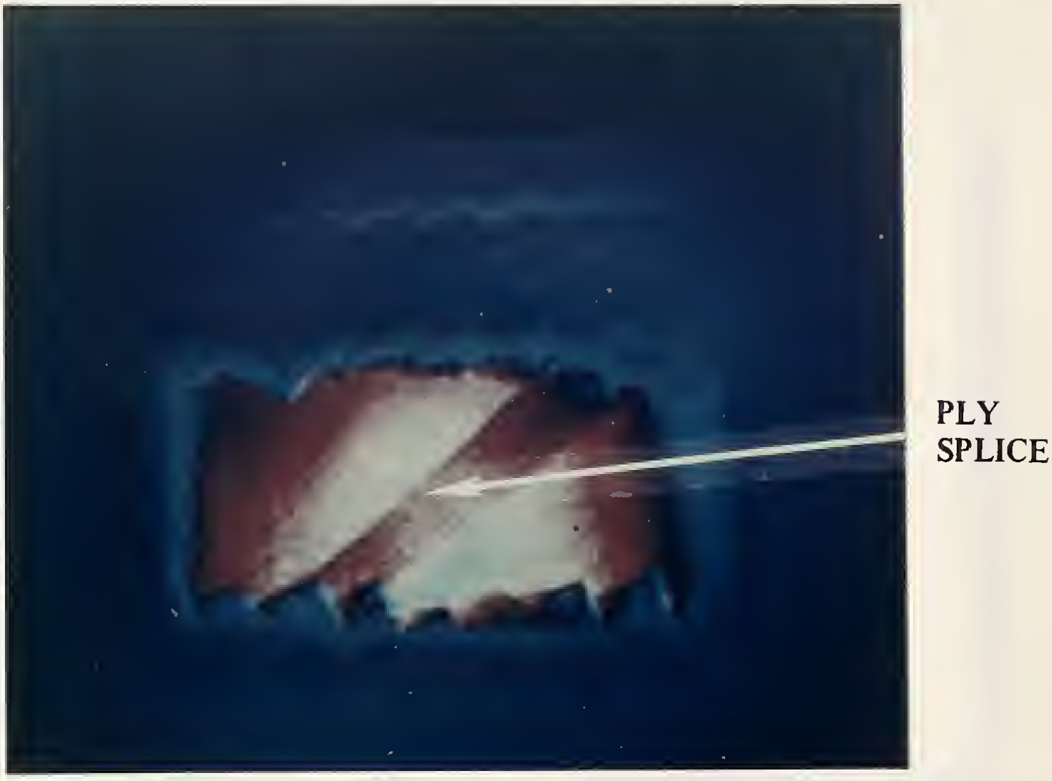

Figure 4-5. View of a Ply Splice Through a Chunked out Segment of Tire

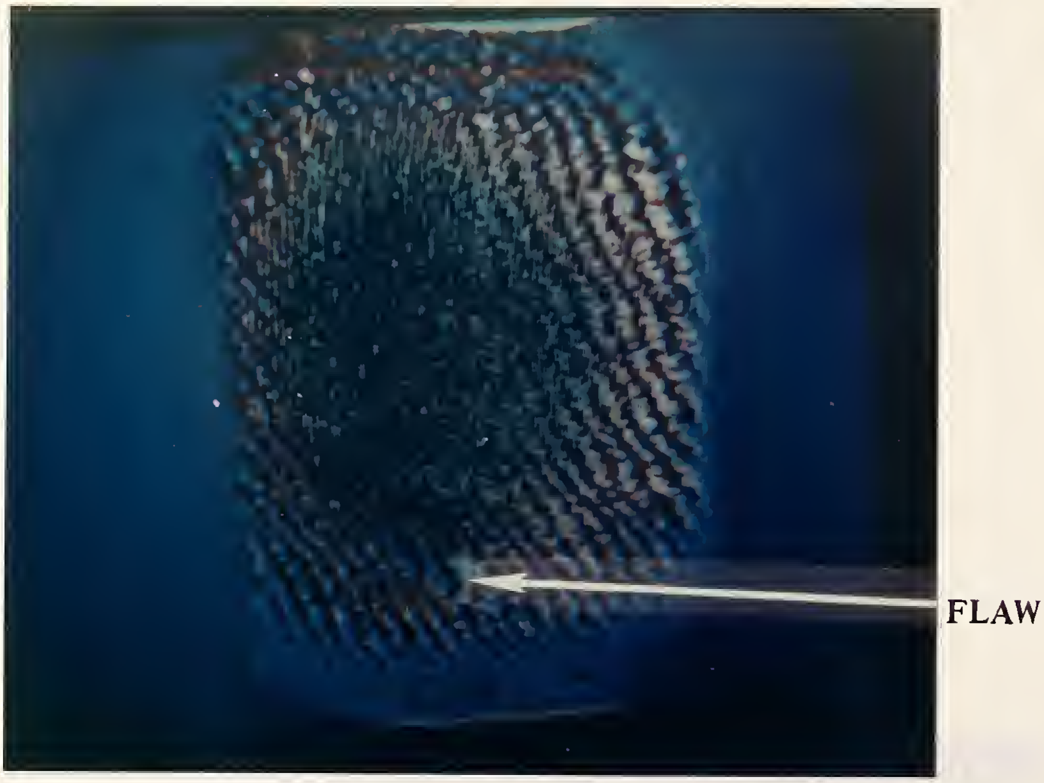

Figure 4-6. Flaw in Belt Area

5.0 CONCLUSIONS

Color separation as a tool in fluoroscopy has promise. Image noise in the form of artificial values of brightness reduced the ability to interpret the data; however this can be overcome.

A useful extension of the experiment would probably be the investigation of a fifteen level color separation unit with a means for normalizing the entire image brightness. Also by automatically monitoring and controling radiation level to a constant value through the tire, color separation could be related closely to tire density.

The project has been discontinued because the modifications to the equipment would not be cost effective for the intended use of the X-ray machine at TSC.