# Misleading Results with a Bar Phantom Image

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***A bar phantom was imaged in an attempt to measure the resolution of a scintillation camera with a high energy collimator. The image obtained was actually a Moire pattern but it caused some confusion; it resembled a bar phantom image because it had the appearance of different sized bands in different quadrants. On closer examination the image was found to be due to interference patterns between the lead bars and the array of holes in the collimator.***

A Pho/Gamma V camera (Searle Radiographics, Des Plaines, IL) was noted to produce poor quality images, when used with a high energy parallel hole collimator for gallium scans, and compared with another camera of the same model using the same type of collimator. To find the cause of poor resolution we attempted to measure the extrinsic resolution of the system by imaging a bar phantom placed directly on the collimator. This particular bar phantom had 4.5-, 4.0-, 3.5-, and 3.0-mm lead bars.

The image obtained caused further confusion (Fig. 1). Little could be distinguished in the two quadrants on the right; the left quadrants exhibited light and dark bands of different sizes, which one would expect with a bar phantom image. Most surprising, however, was that the light and dark bands in these two quadrants were parallel, whereas the bars in adjacent quadrants of the bar phantom were perpendicular.

The bar phantom was imaged with another Pho/Gamma V camera with the same type of collimator; an identical image was obtained.

The phantom was rotated 45° counterclockwise and another image was obtained (Fig. 2). In this image the lines seen in adjacent quadrants were neither parallel nor perpendicular. Figures 3, 4, and 5 were obtained by rotating the phantom an additional 45°, 45°, and 15° counterclockwise, respectively. These pictures were equally puzzling. Some of the anomalies noted were that in Fig. 3 the lines in adjacent quadrants were again parallel as in Fig. 1, but in Fig. 4 they were not parallel; some of the lines in Fig. 3 appeared broken and interdigitated, rather than continuous; and in some but not all cases, a 45° rotation of the phantom caused a 90° or more change in the direction of the lines.

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The collimator was removed so that a flood field could be performed (Fig. 6) and an image was made of the phantom placed directly on top of the crystal (Fig. 7); both were normal.

### Results and Discussion

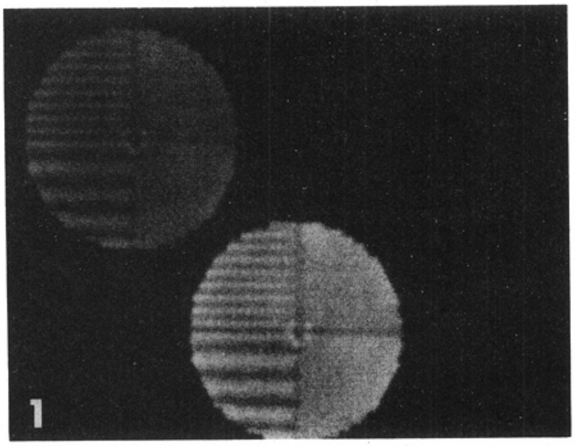
The cause of the strange patterns became immediately obvious when we inverted the collimator so that the holes were visible and put the bar phantom directly on top of it. The light and dark bands seen in the images were not the actual bars of the phantom; instead they were Moire patterns. The bars of the phantom had interacted with the hexagonal array of holes in the collimator so that four different types of interference patterns were produced.

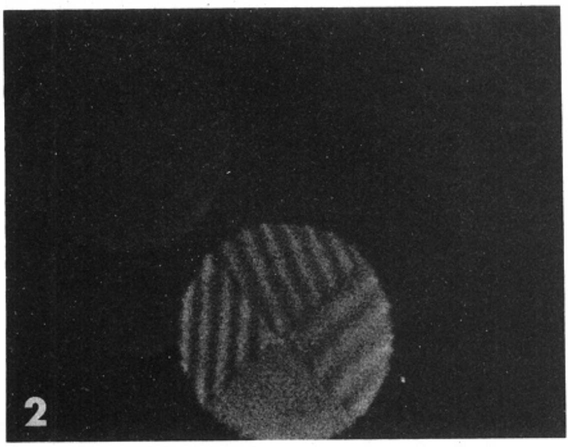
Figure 8 shows one type of interference pattern in which the bars form a repeating pattern of being in and out of phase with the rows of holes. The light and dark zones seen in the images are areas in which the holes are alternately covered and uncovered by the bars. The light and dark zones caused by this pattern are parallel to the bars, and different bar sizes cause patterns of different sizes. This type pattern can be seen in at least one quadrant of each of figures 1–5.

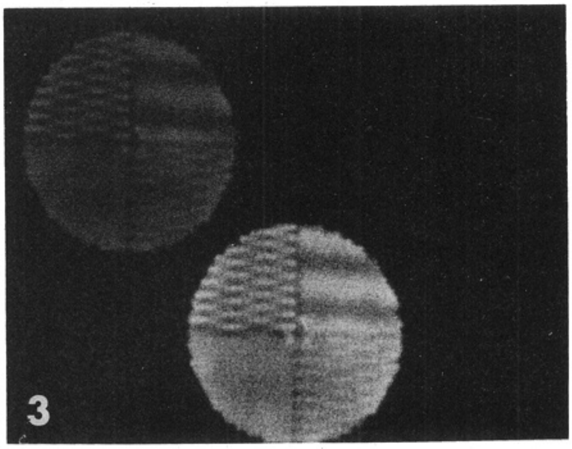
Figure 9 shows another pattern that can occur when the bars are parallel to a row of holes. This interaction causes the appearance of light and dark bands, which are perpendicular to the bars. This effect, combined with the effect shown in Fig. 8, is responsible for the appearance of parallel lines in the two quadrants of Fig. 1.

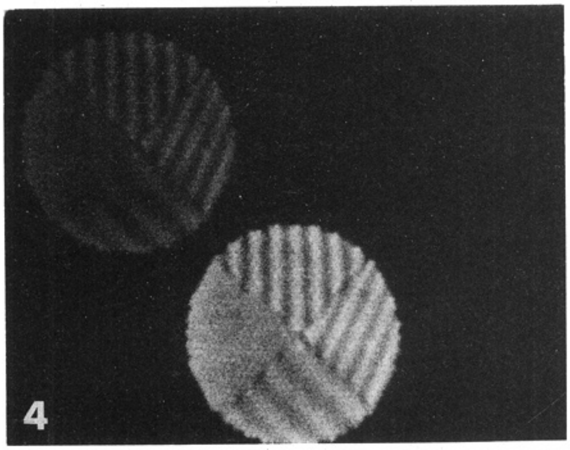
The above effect only occurs with the 4-mm bars since the spacing of the bars coincides with the 8-mm center-to-center distance between the holes, so the bars and the holes are in phase throughout the quadrant. With the other bars the distance does not coincide, producing a repeating pattern of the bars in and out of phase with the holes. This causes the discontinuous and staggered line pattern seen in two quadrants of Fig. 3. This pattern is similar to that described by Bonte and Dowdey with a line source phantom (*1*) although Fig. 10 shows that the cause of the pattern is different.

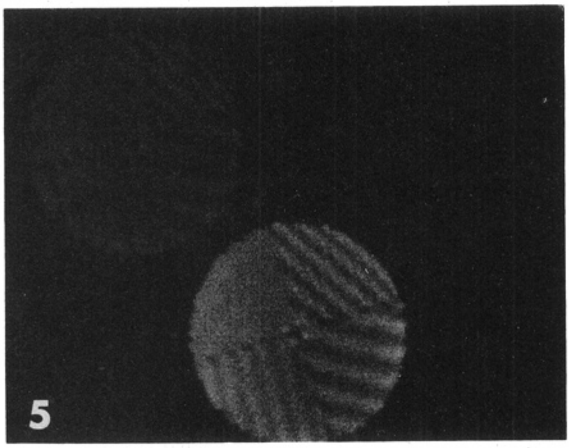
The fourth type of interference pattern (Fig. 11) occurs when the bars are at an angle to the rows of holes, causing the appearance of diagonal lines. A small change in the angle between the bars and holes causes a much larger change in the direction of the lines. This accounts for the

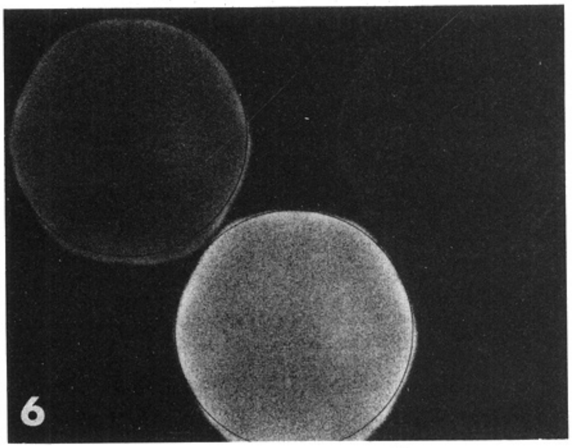


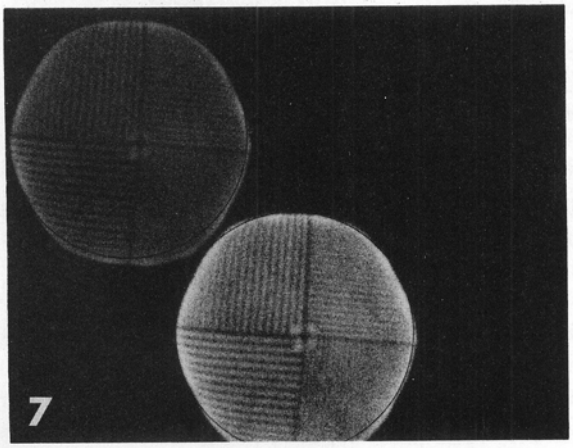




**FIG. 1.** This pattern mimics a normal bar phantom image by having large bands in one quadrant and smaller bands in an adjacent quadrant; however, bands are parallel instead of perpendicular. **FIG. 2.** This image was obtained after rotating bar phantom 45° counterclockwise. Now bands are neither parallel nor perpendicular. **FIG. 3.** Rotation of the bar phantom another 45° counterclockwise resulted in this image; bands are again parallel but now some appear broken up and discontinuous. **FIG. 4.** Bands are no longer parallel after another 45° rotation of phantom. **FIG. 5.** A 15° rotation of bar phantom caused this pattern to appear, in which some of the bands change direction by almost 90°. **FIG. 6.** Normal flood field. **FIG. 7.** An image made with bar phantom placed directly on crystal was normal.

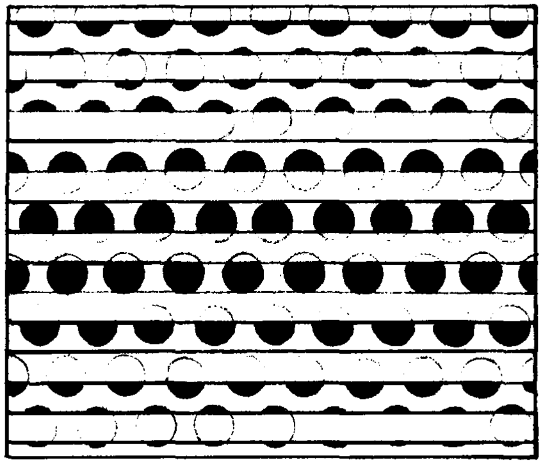


**FIG. 8.** Bars interact with rows of holes to form wide light and dark bands parallel to bars. Black areas represent holes not covered by bars.

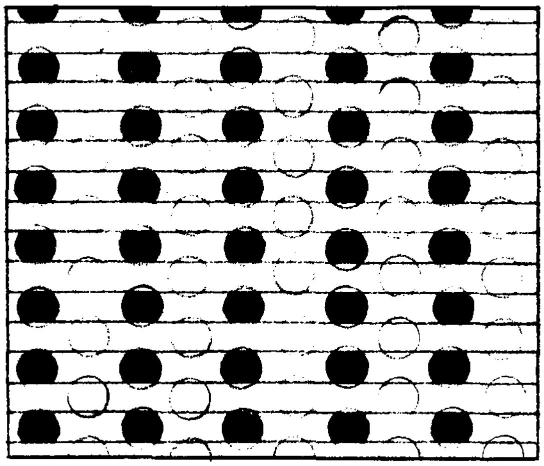


**FIG. 9.** The 4-mm bars in phase with rows of holes produce dark bands perpendicular to bars.

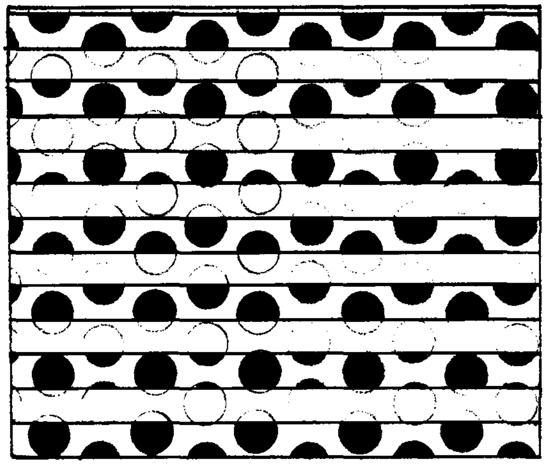


**FIG. 10.** The 4.5-mm bars in and out of phase with holes, producing discontinuous bands seen in Figure 3.

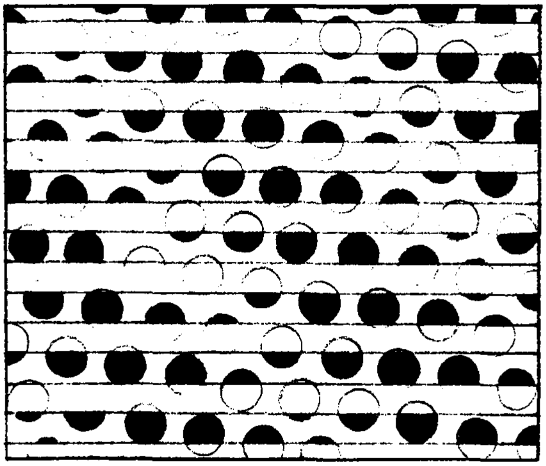


**FIG. 11.** Bars not parallel to holes form diagonal bands.

apparent 90° rotation of some of the lines between figures 4 and 5 when the phantom had been rotated only 15°.

## Conclusion

Several other collimators were tested with this bar phantom and one with larger bars. The interference patterns did not appear with low energy collimators, but were present whenever a medium or high energy collimator was used. Image aberrations occur because of the interaction between the bars and the hexagonal array of holes with thick septa. Suggestions for reducing or eliminating these image aberrations have been published (*2, 3*). These include: uniform rotation of the collimator while the image is being made; use of a pinhole collimator; use of low energy collimators whenever possible; and increasing the collimator-to-object distance. In this particular case, however, when trying to determine the resolution of the camera with a high energy collimator, a different type of phantom or a different type of resolution test, such as full-width-half-maximum or modulation transfer function, is necessary.

## References


*1.* Bonte FJ, Dowdey JE: Further observations of the septum effect produced by multichannel collimators for a scintillation camera. *Radiology* 102: 653-656, 1972

*2.* Bramlett RC: Elimination of collimator artifacts in scintillation-camera images. *Radiology* 94: 417-419, 1970

*3.* Bonte FJ, Graham KD, Dowdey JE: Image abberations produced by multichannel collimators for a scintillation camera. *Radiology* 98: 329-334, 1971