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United States Patent [19]

Cass et al.

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[54] **DECODING DATA FROM PATTERNED COLOR MODULATED IMAGE REGIONS IN A COLOR IMAGE**

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[73] Assignee: **Xerox Corporation**, Stamford, Conn.

[21] Appl. No.: **09/162,257**

[22] Filed: **Sep. 28, 1998**

[51] **Int. Cl.**[7] **G06K 9/00**

[52] **U.S. Cl.** **382/166**; 382/232; 235/494

[58] **Field of Search** 382/166, 167, 382/232, 183, 233; 235/469, 494

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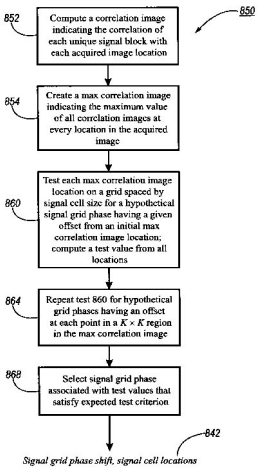
Assistant Examiner—Jingge Wu

[57] **ABSTRACT**

A technique for decoding message data that has been encoded into a printed color image locates small image regions called signal cells that carry the encoded message. Each signal cell is composed of a spatial pattern of colored subregions that collectively have an overall average color. The colors of the subregions are defined as changes (modulations) to the average color in one or more directions in a multi-dimensional color space. The decoding technique uses a set of valid signal blocks, each of which is a unique pattern of color modulated subregions. There is a valid signal block for each valid message value defined in the coding scheme. The decoding operation first locates the positions of the signal cells in the acquired image and then subtracts the local average color of each signal cell from the cell to produce a received signal block. Then the decoding operation determines which valid signal block each received signal block is by comparing each valid signal block to a received signal block. One implementation of the decoding technique decodes signal cells that have been arranged in the acquired image in a 2D array by synchronizing an imaginary grid-like structure with the most likely position of all of the signal cells. In one embodiment, a color space direction is selected for the color modulations that results in the differently colored subregions of a signal cell being substantially imperceptible to a human viewer, thus making the pattern that carries the message substantially imperceptible in an encoded image.

13 Claims, 22 Drawing Sheets



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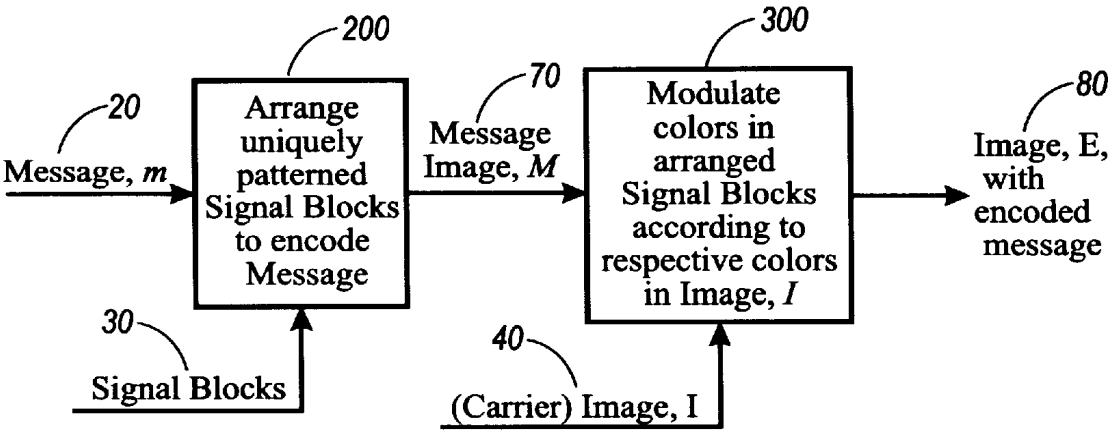

FIG. 1

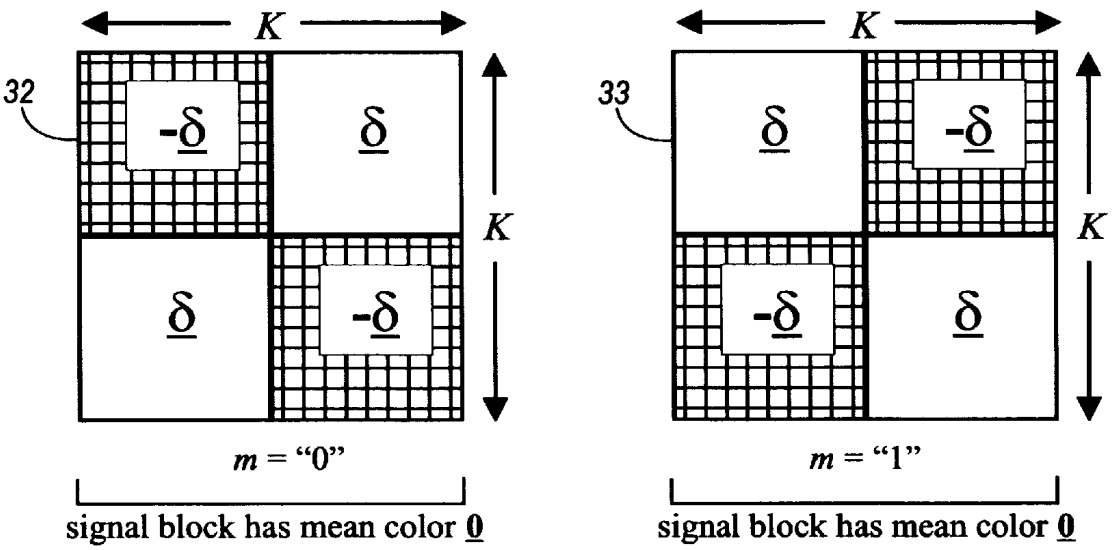

FIG. 2

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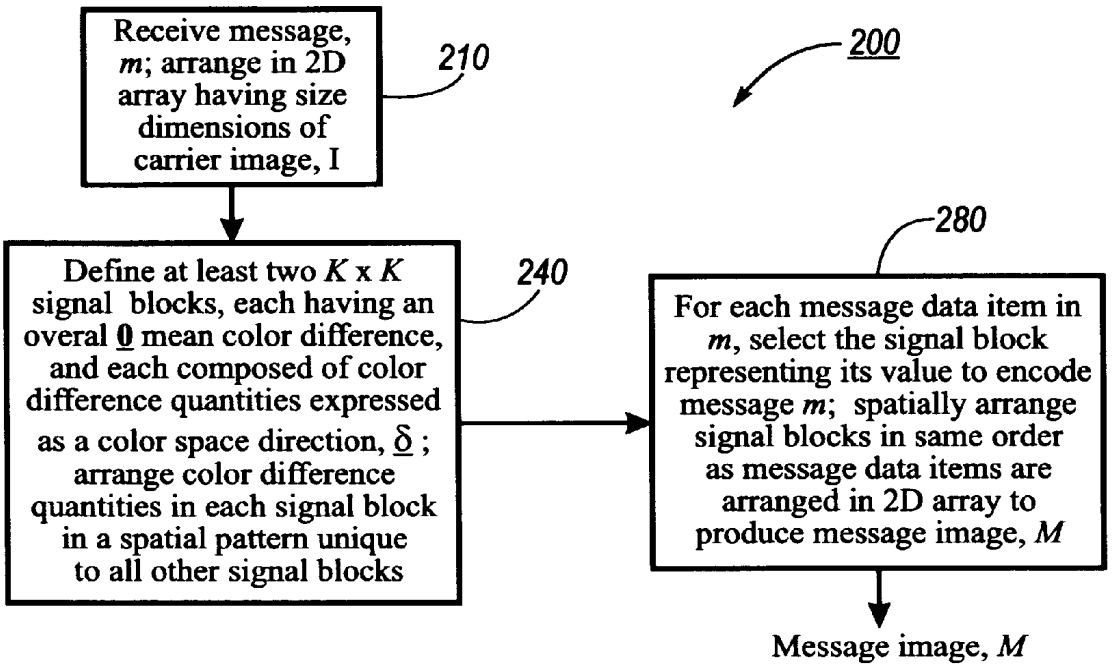

FIG. 3

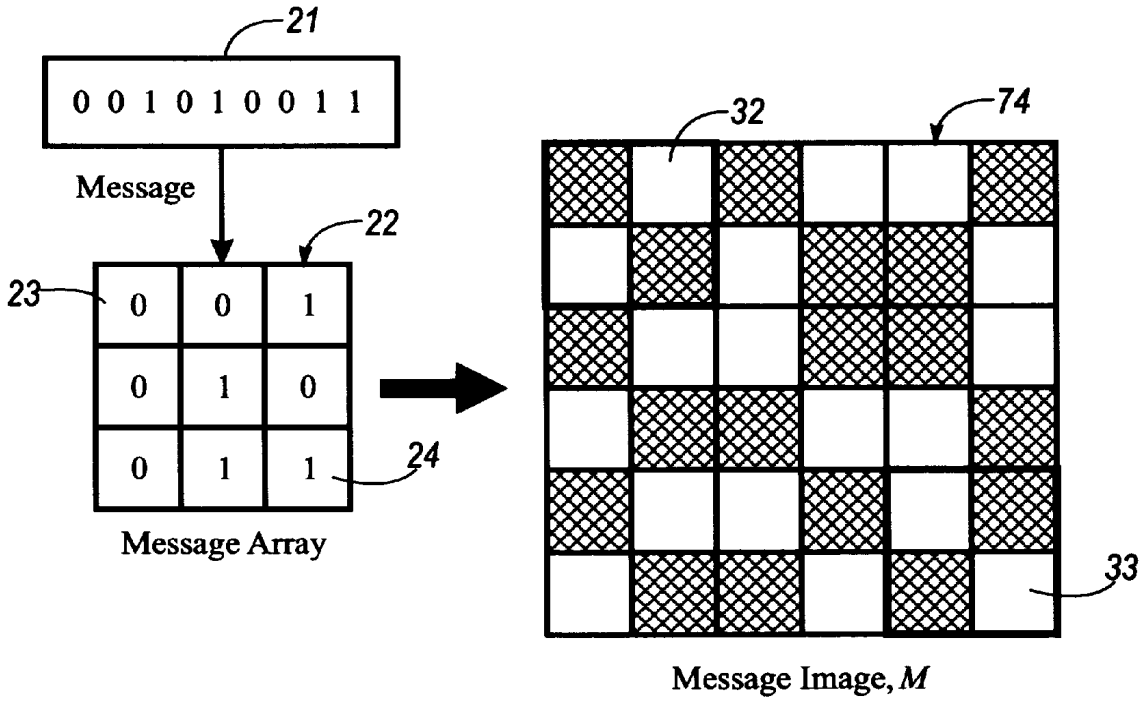

FIG. 4

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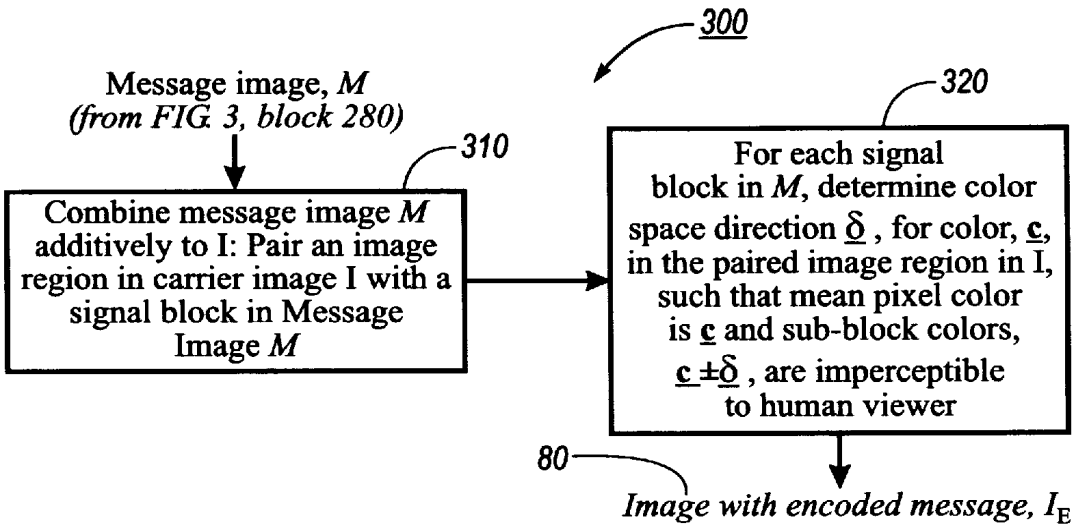

FIG. 5

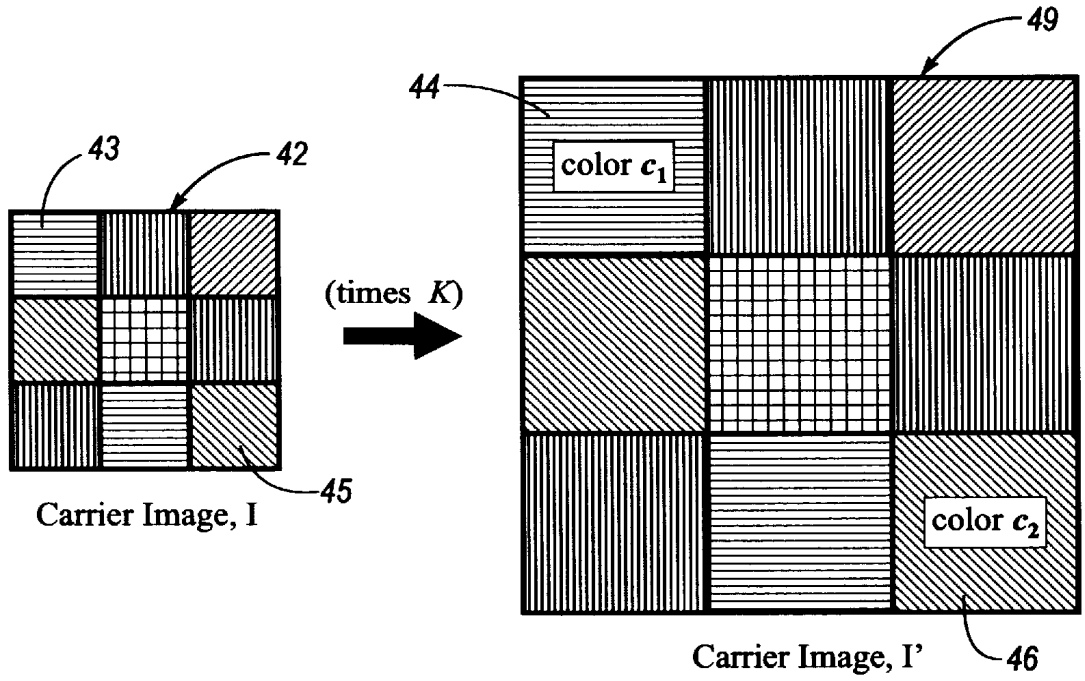

FIG. 6

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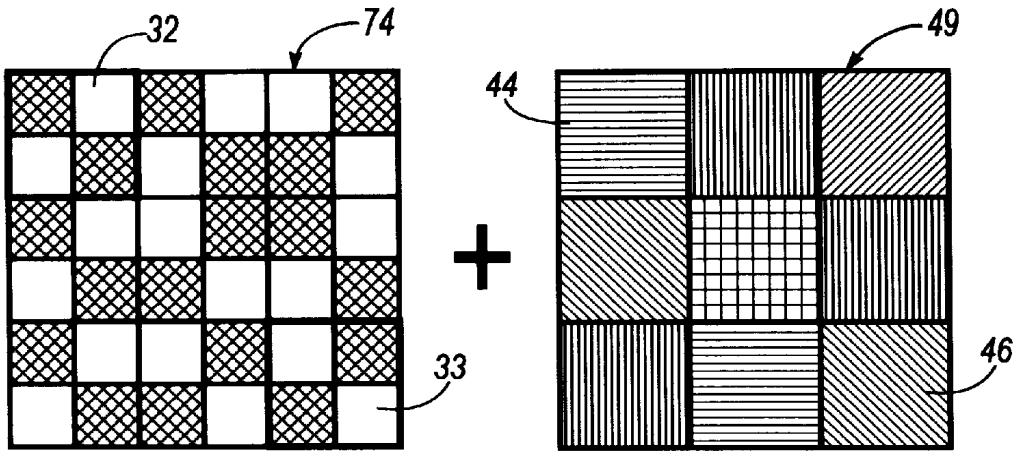

FIG. 7

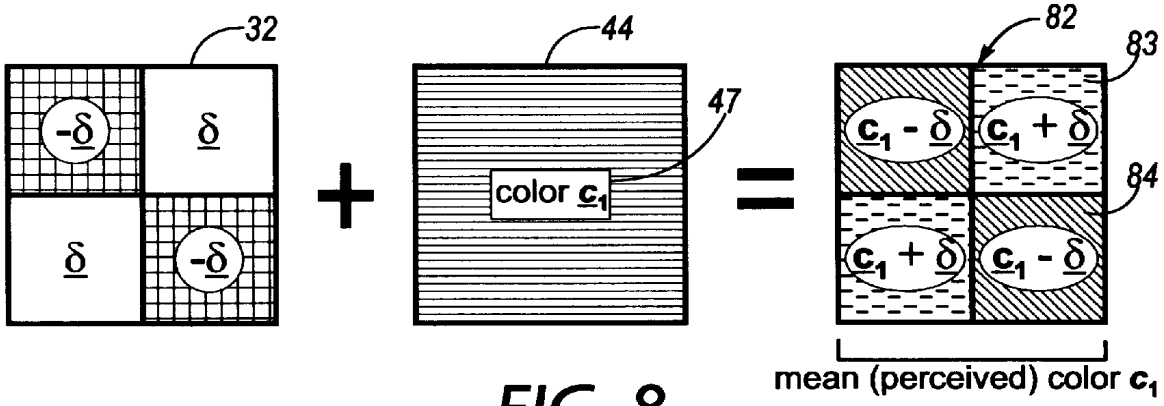

FIG. 8

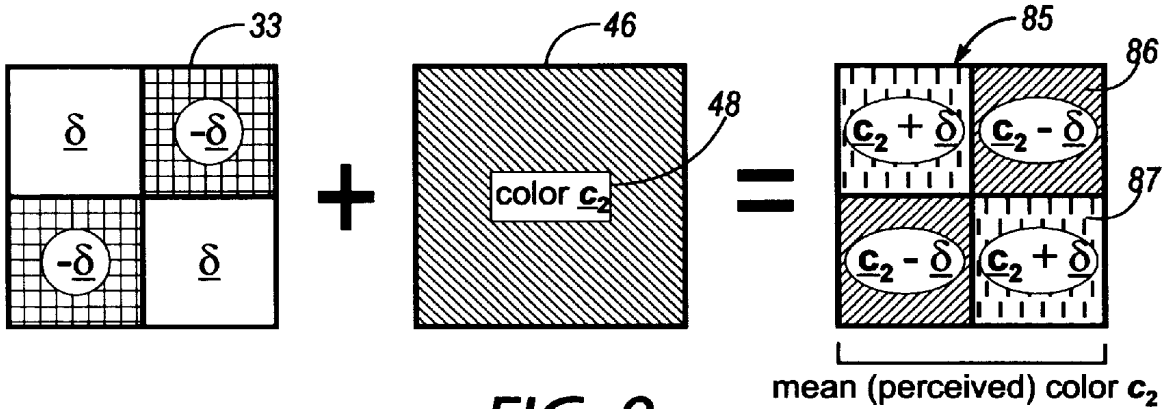

FIG. 9

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