



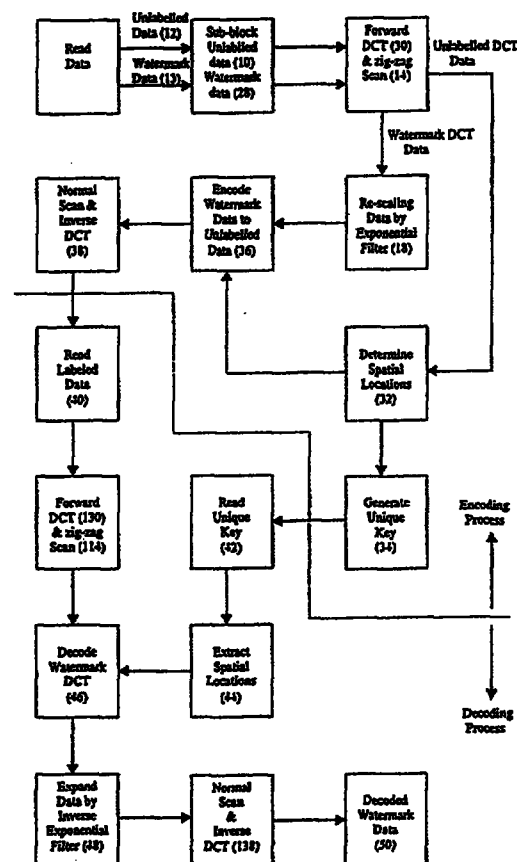
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(21) International Application Number: PCT/SG98/00039 (22) International Filing Date: 1 June 1998 (01.06.98) (71) Applicant (for all designated States except US): DATAMARK TECHNOLOGIES PTE LTD. [SG/SG]; Innovation Centre, Block 1, Suite 106, 16 Nanyang Drive, Singapore 637722 (SG). (72) Inventors; and (75) Inventors/Applicants (for US only): HO, Anthony, Tung, Shuen [GB/SG]; Nanyang Technological University, School of Electrical & Electronic Engineering, Block S2, Nanyang Avenue, Singapore 639798 (SG). TAM, Siu, Chung [SG/SG]; Nanyang Technological University, School of Electrical & Electronic Engineering, Block S2, Nanyang Avenue, Singapore 639798 (SG). (74) Agents: HAQ, Murgiana et al.; Haq & Namazie Partnership, Robinson Road, P.O. Box 765, Singapore 901515 (SG).		(81) Designated States: AU, CA, CN, ID, JP, KR, SG, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>

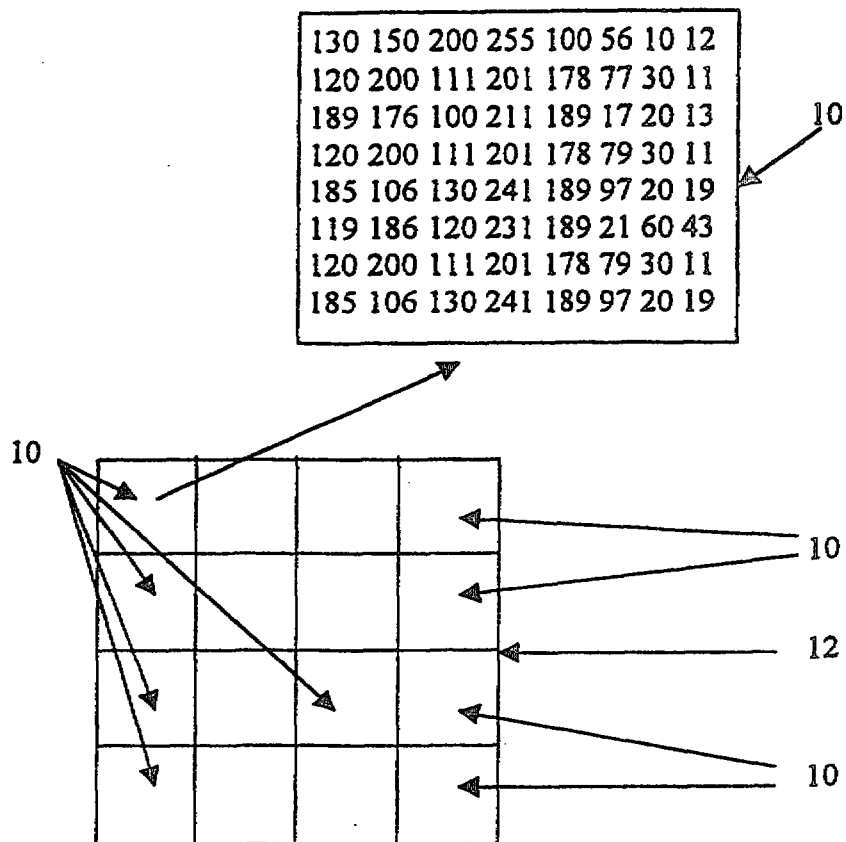
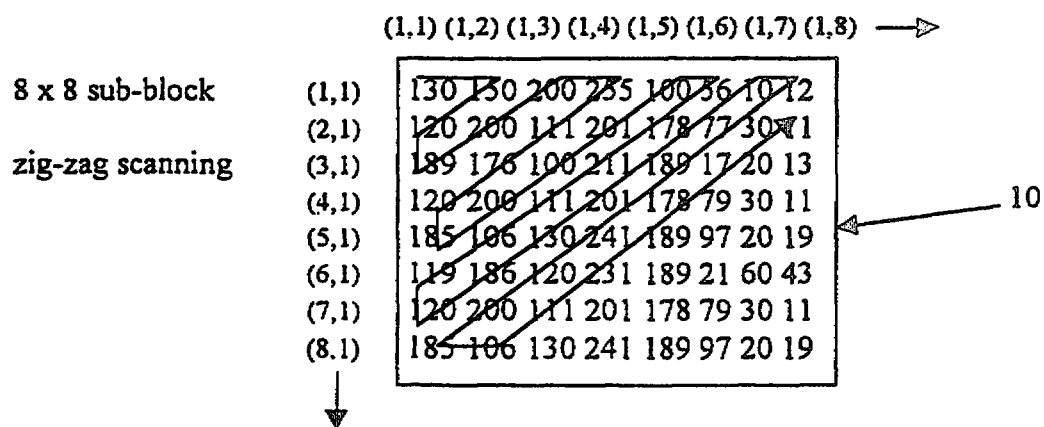
(54) Title: METHODS FOR EMBEDDING IMAGE, AUDIO AND VIDEO WATERMARKS IN DIGITAL DATA

(57) Abstract

A method for embedding an entire image, audio or video watermark sequence within another image, audio or video data sequence with minimum loss of data quality is presented. The method exploits the de-correlation property of data coefficients in the orthogonal transform domain, similar to the application in data compression through transform coding. The present invention describes the usage of a Discrete Cosine Transform as the embedding domain. However, other orthogonal transforms such as Fourier, Walsh-Hadamard, Haar, Sine and Wavelet can also be used for this operation. A unique key derived adaptively from spatial locations registering the thresholds of the ac transform energies is used to unlock or de-watermark the embedded image or audio sequence. Moreover, an exponential filter has been developed to compress and expand the watermark coefficients prior to the embedding and retrieval process. The method can be used in resolving multimedia copyright protection issues arising on the Internet and in the music industry, such as the inclusion of a company's logo or an artist's recorded voice. The method can also be incorporated as a built-in feature for digital recording devices, such as still and video cameras, as well as more recent devices such as VCD and DVD players. Moreover, the method can be applied to the commercial and service sectors, where security in transmission and reception of private information in terms of speech or image is of the utmost importance.

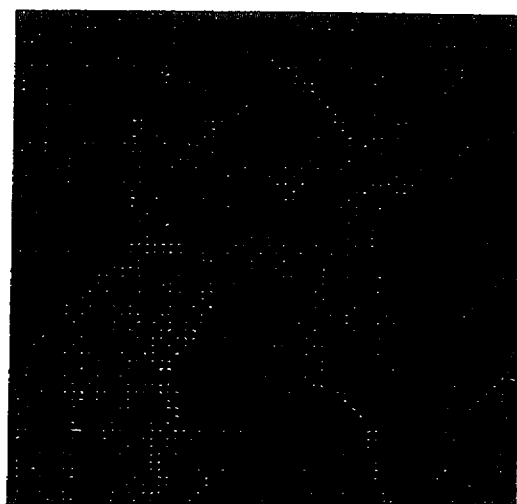


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**FIGURE 1****FIGURE 2**

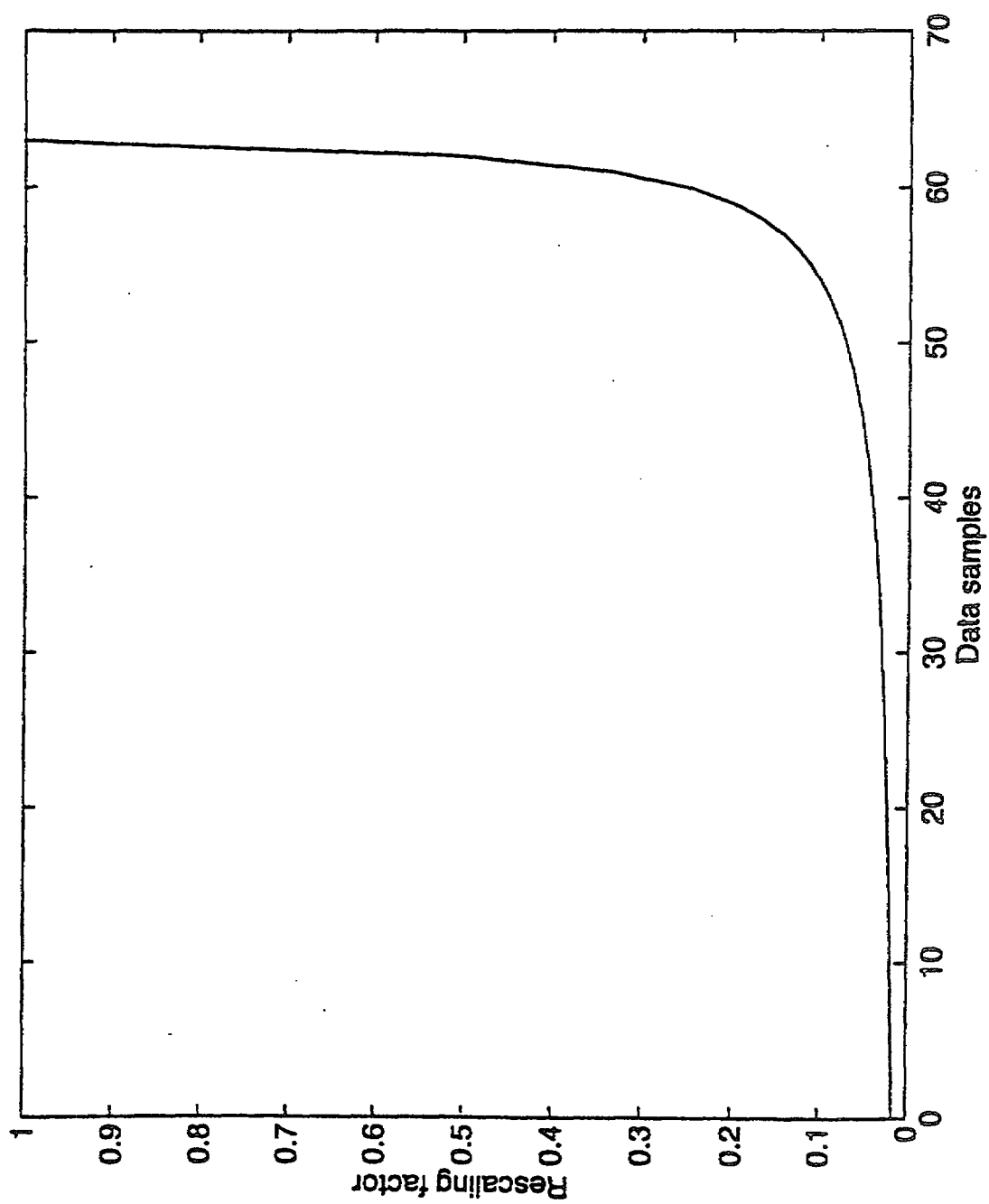


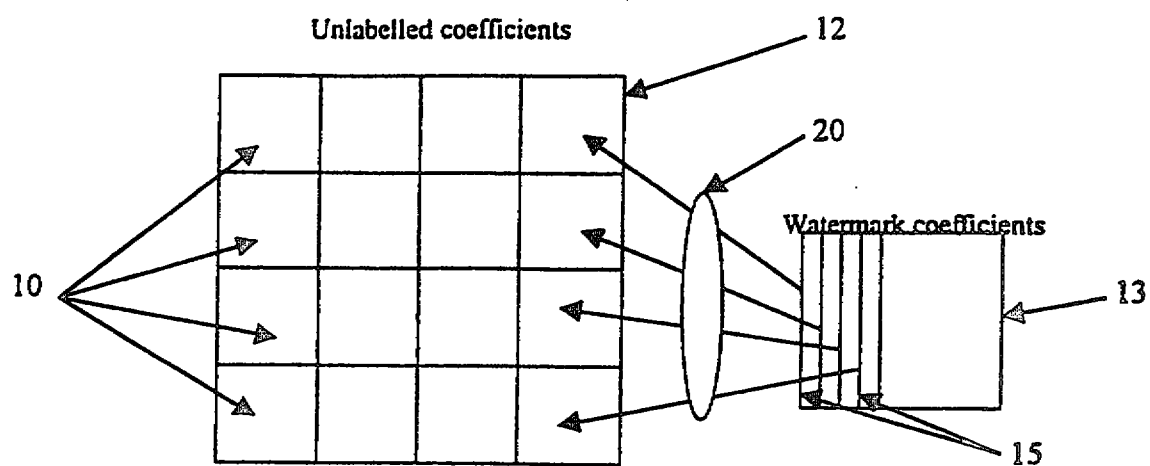
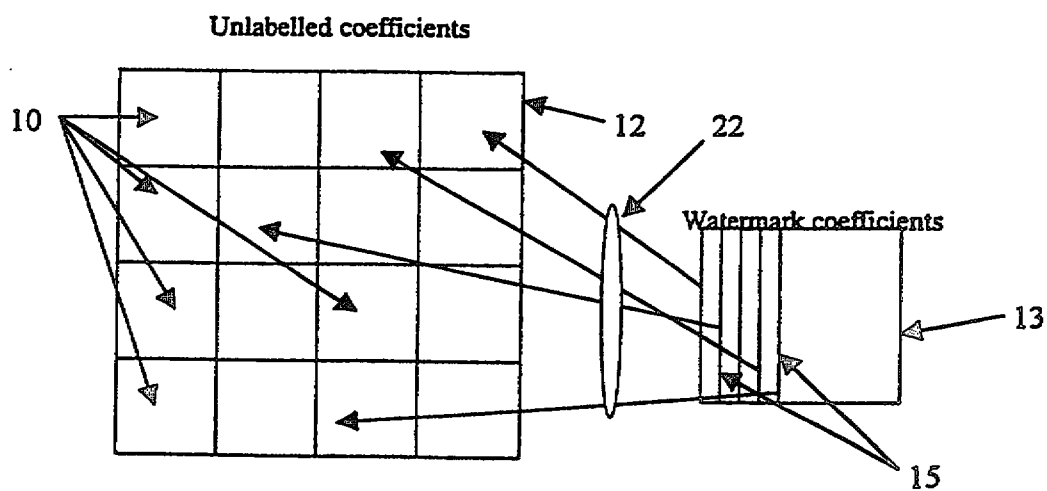
(a)



(b)

FIGURE 3

FIGURE 4

**FIGURE 5****FIGURE 6**

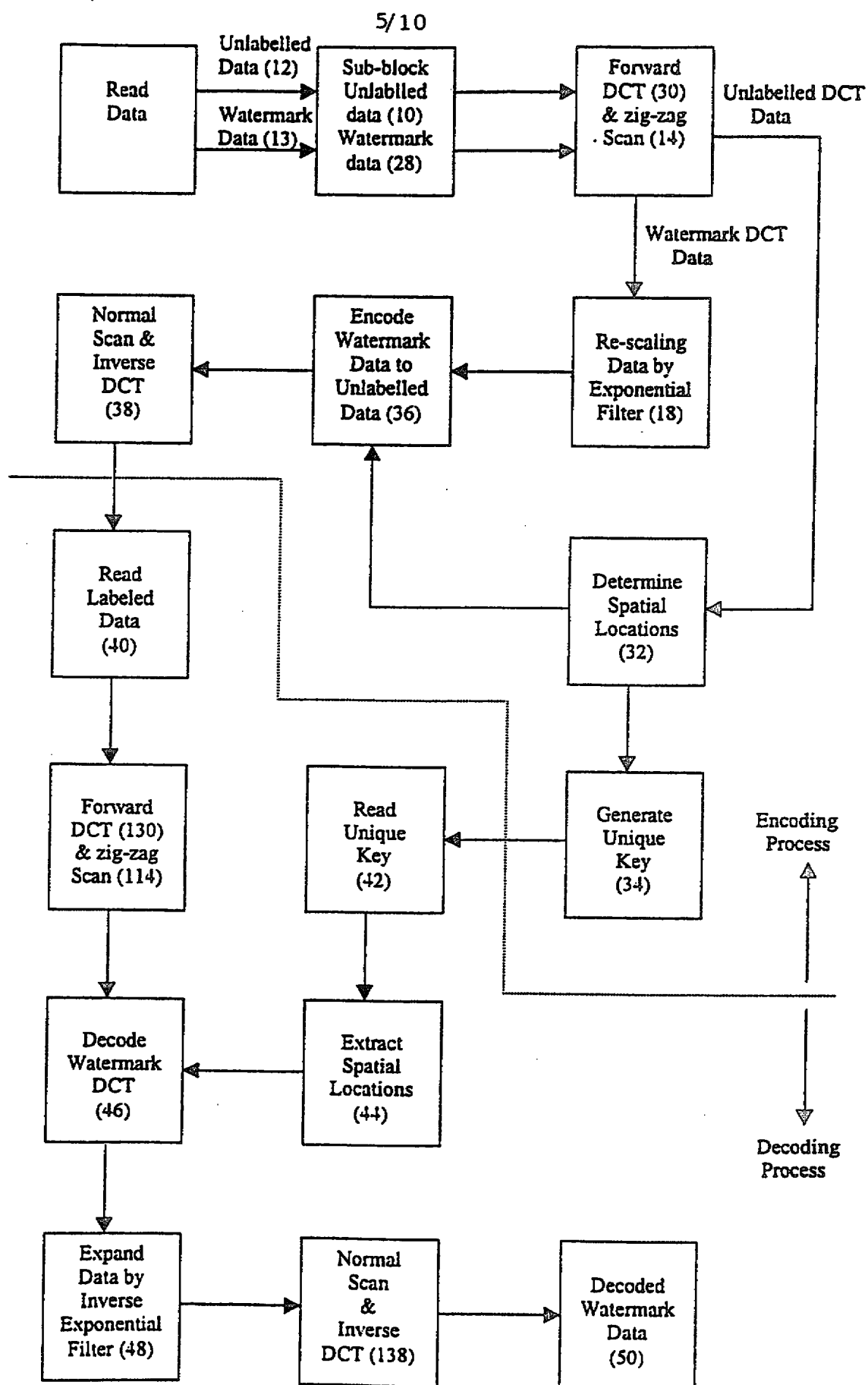


FIGURE 7

PSEUDOCODE

PROCEDURE WATERMARK CODER

BEGIN

READ UNLABELLED DATA;
 CONVERT UNLABELLED DATA TO MATRIX (M,N);
 PERFORM SUB-BLOCKING of UNLABELLED DATA;
 PERFORM DCT ON UNLABELLED DATA SUB-BLOCKS;
 RE-ORDER DCT COEFFICIENTS TO FOLLOW ZIG-ZAG PATTERN;
 DETERMINE AC ENERGIES OF DCT COEFFICIENTS;
 SET THRESHOLD BASED ON AC ENERGY MEAN AND STANDARD
 DEVIATION;
 COMPARE SUB-BLOCK AC ENERGIES WITH THRESHOLD;
 IF AC ENERGIES LESS THAN THRESHOLD THEN
 STORE SPATIAL LOCATIONS;
 ELSE
 SET TO OFFSET SPATIAL LOCATIONS;
 END
 GENERATE UNIQUE KEY FROM STRUCTURED/RANDOM SPATIAL
 LOCATIONS;
 STORE UNIQUE KEY FOR DECODING;

READ WATERMARK DATA;
 CONVERT WATERMARK DATA TO MATRIX (J,K);
 PERFORM SUB-BLOCKING of WATERMARK DATA;
 PERFORM DCT ON UNLABELLED DATA SUB-BLOCKS;
 RE-ORDER DCT COEFFICIENTS TO FOLLOW ZIG-ZAG PATTERN;
 RE-SCALE DCT COEFFICIENTS USING EXPONENTIAL FILTER;

EMBED RE-SCALED WATERMARK DCT COEFFICIENTS INTO
 UNLABELLED DCT SUB-BLOCKS;
 CONVERT ZIG-ZAG SCAN BACK TO NORMAL SCAN;
 INVERSE DCT SUB-BLOCKS TO OBTAIN LABELED DATA;

END

FIGURE 8a

PSEUDOCODE

PROCEDURE WATERMARK DECODER

BEGIN

 READ LABELED DATA;
 CONVERT LABELED DATA TO MATRIX (M,N);
 PERFORM SUB-BLOCKING of LABELED DATA;
 PERFORM DCT ON LABELED DATA SUB-BLOCKS;
 RE-ORDER DCT COEFFICIENTS TO FOLLOW ZIG-ZAG PATTERN;

 EXTRACT SPATIAL LOCATIONS FROM UNIQUE KEY;
 DECODE WATERMARK DCT COEFFICIENTS FROM SPATIAL
 LOCATIONS;
 SCALE WATERMARK DCT COEFFICIENTS USING INVERSE
 EXPONENTIAL FILTER;
 CONVERT ZIG-ZAG SCAN BACK TO NORMAL SCAN;
 INVERSE DCT SUB-BLOCKS TO OBTAIN WATERMARK DATA;

END

FIGURE 8b

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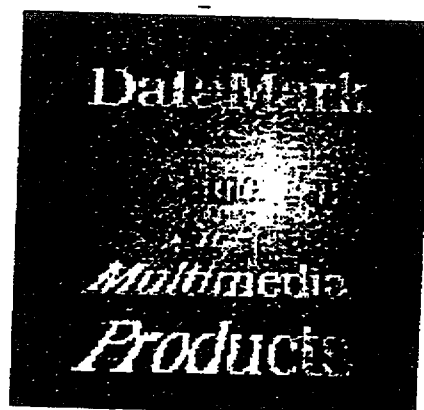
(a)



(b)



(a)



(b)

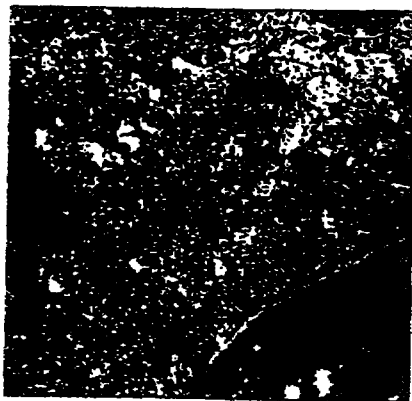
FIGURE 9



(a)



(b)



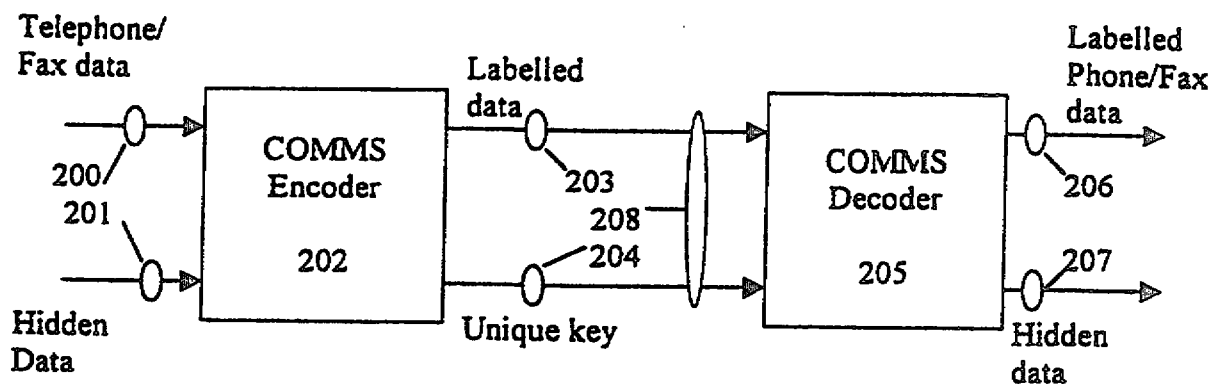
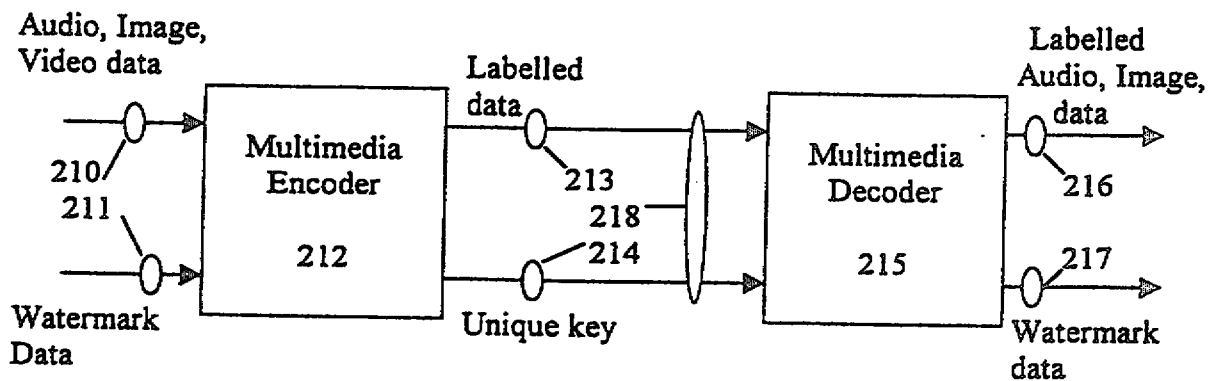
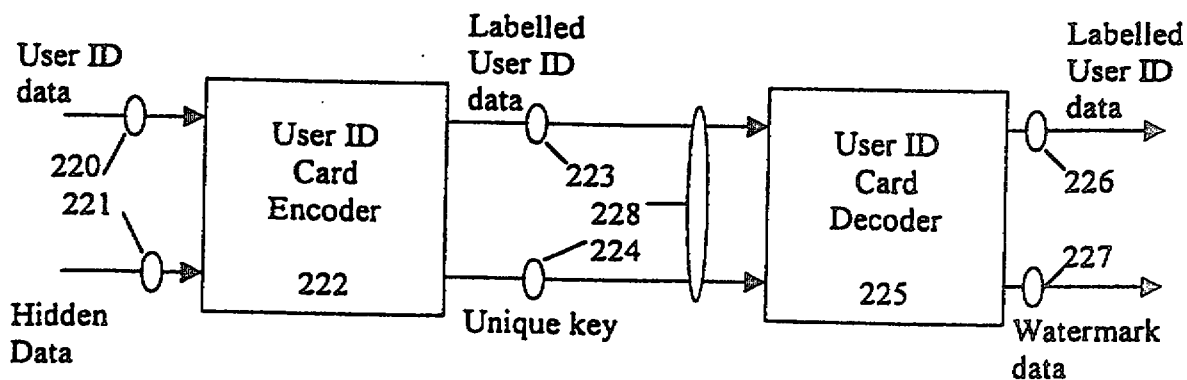
(a)



(b)

FIGURE 10

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**FIGURE 11****FIGURE 12****FIGURE 13**