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United States Patent [19]

Beretta et al.

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[54] **TEXT AND IMAGE SHARPENING OF JPEG COMPRESSED IMAGES IN THE FREQUENCY DOMAIN**

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[73] Assignee: **Hewlett-Packard Co.**, Palo Alto, Calif.

[21] Appl. No.: **940,695**

[22] Filed: **Sep. 30, 1997**

Related U.S. Application Data

[63] Continuation of Ser. No. 411,369, Mar. 27, 1995, abandoned.

[51] **Int. Cl.**[6] **G06K 9/36**

[52] **U.S. Cl.** **382/250**; 382/251; 382/239; 358/432; 348/404

[58] **Field of Search** 382/298, 233, 382/251, 244, 232, 253, 250, 274, 252, 238, 236, 166, 280, 270; 358/427, 426, 432, 261.3, 448, 261.1, 433, 261.2, 430, 458; 348/404, 432, 405, 433, 403, 391, 384, 422, 393, 430, 394, 409, 395, 390

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,776,030	10/1988	Tzou	358/432
4,780,761	10/1988	Daly et al.	358/133
5,063,608	11/1991	Siegel	382/56
5,073,820	12/1991	Nakagawa et al.	358/133
5,333,212	7/1994	Ligtenberg	382/56
5,410,352	4/1995	Watanabe	348/405
5,465,164	11/1995	Sugiura	358/432
5,488,570	1/1996	Agarwal	364/514 R

FOREIGN PATENT DOCUMENTS

0444884A2	2/1991	European Pat. Off. .	
0513520A2	4/1992	European Pat. Off.	H04N 7/133
0593159A2	9/1993	European Pat. Off.	G06F 15/64
07087491	3/1995	Japan	H04N 7/30
07143343	6/1995	Japan	H04N 1/41

OTHER PUBLICATIONS

G. B. Beretta et al., "Experience with the New Color Facsimile Standard", ISCC Annual Meeting, Apr. 23–25, 1995, pp. 1–7.

Albert J. Ahumada, Jr. et al., "Luminance–Model–Based DCT Quantization for Color Image Comression", Human Vision, Visual Processing, and Digital Display III, 1666, 365–374, SPIE, 1992.

(List continued on next page.)

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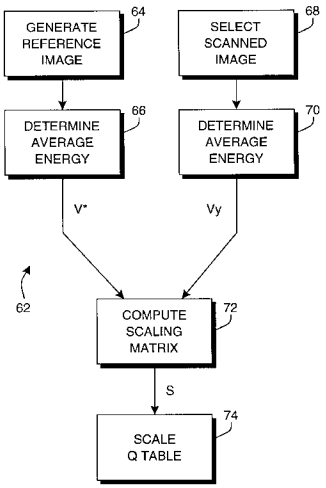
Assistant Examiner—Matthew C. Bella

[57] **ABSTRACT**

The text and image enhancing technique according to the invention is integrated into the decoding or inverse quantization step that is necessarily required by the JPEG standard. The invention integrates the two by using two different quantization tables: a first quantization table (Q_E) for use in quantizing the image data during the compression step and a second quantization table used during the decode or inverse quantization during the decompression process. The second quantization table Q_D is related to the first quantization table according to a predetermined function of the energy in a reference image and the energy in a scanned image. The energy of the reference image lost during the scanning process, as represented by the energy in the scanned image, is restored during the decompression process by appropriately scaling the second quantization table according to the predetermined function. The difference between the two tables, in particular the ratio of the two tables, determines the amount of image enhancing that is done in the two steps. By integrating the image enhancing and inverse quantization steps the method does not require any additional computations than already required for the compression and decompression processes.

35 Claims, 7 Drawing Sheets



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OTHER PUBLICATIONS

Kenneth R. Alexander et al., "Spatial–Frequency Characteristics of Letters Identification", J. Opt. Soc. Am. A, 11,9, 2375–2382, 1994.

Wen–Hsiung Chen et al., "Adaptive Coding of Monochrome and Color Images", IEEE Transactions on Communications, COM–25, 1285–1292, 1977.

Bowonkoon Chitprasert et al., Human Visual Weighted Progressive Image Transmission, IEEE Transactions on Communications, COM–38, 7, 1040–1044, 1990.

R. J. Clarke, Spectral Responses of the Discrete Cosine and Walsh–Hadamard Transforms, IEE Proc., 130, Part F, 309–313, 1983.

K.K. De Valois et al., Color–Luminance Masking Interactions, Seeing Contour and Colour, J.J. Kulikowski, C.M. Dickinson and I.J. Murray Editors, Pergamon Press, Oxford, 1989.

J. Raymond Edinger, Jr., "A Measure for Stairstepping in Digitized Text that Correlates with the Subjective Impression of Quality", IS&T's Tenth International Congress on Advances in Non–Impact Printing Technologies, 552–558, 1994.

Yasushi Hoshino et al., Applicability of a Standardized Discrete Cosine Transform Coding Method to Character Images, J. Electronic Imaging, 1, 3, 322–327, 1992.

Chansik Hwang et al., Human Visual System Weighted Progresseive Image Transmission Using Lapped Orthogonal Transform/Classified Vector Quantization, Optical Engineering, 32, 7, 1524–1530, 1993.

International Organization for Standardization: Information Technology—Digital Compression and Coding of Continuous–Tone Still Images—Part 1: Requirements and Guidelines, ISO/IEC IS 10918–1, Oct. 20, 1992.

International Telecommunication Union: Amendments to ITU–T Rec. T.30 for Enabling Continuous–Tone Colour and Gray–Scale Modes for Group 3, COM 8–43–E, Question 5/8, Mar. 1994.

International Telecommunication Union: Amendments to ITU–T Rec. T–4 for Enabling Continuous–Time Colour and Gray–Scale Modes for Group 3, COM 8–44–E, Question 5/8, Mar. 1994.

Gordon E. Legge, "Reading: Effects of Contrast and Spatial Frequency", Applied Vision, OSA Technical Digest Series, 16, 90–93, 1989.

Gordon E. Legge et al., Contrast Masking in Human Vision, J. Opt. Soc. Am., 70,12,1458–1471, 1980.

David L. McLaren et al., "Removal of Subjective Redundancy from DCT–Coded Images", IEE Proceedings–I, 138, 5, 345–350, 1991.

I. Miyagawa et al., "Color–Facsimile System for Mixed–Color Documents", SID 94 Digest, 887–890, 1994.

Kathy T. Mullen, "The Contrast Sensitivity of Human Colour Vision to Red–Green and Blue–Yellow Chromatic Gratings", J. Physiol., 359, 381–400, 1985.

Daivd H. Parish et al., "Object Spatial Frequencies, Retinal Spatial Frequencies, Noise, and the Efficiency of Letter Discrimination", Vision Res., 31, 7/8, 1399–1415, 1991.

Denis G. Pelli et al., "Visual Factors in Letter Identification", IS&T's 47th Annual Conference/ICPS, p. 411, 1994.

Heidi A. Peterson et al., An Improved Detection Model for DCT Coefficient Quantization, Human Vision, Visual Processing, and Digital Display IV, 1913, 191–201, SPIE, 1993.

Ricardo L. de Queiroz et al., "Human Visual Sensitivity–Weighted Progressive Image Transmission Using the Lapped Orthogonal Transform", J. Electronic Imaging, 1, 3, 328–338, 1992.

Ricardo L. de Queiroz et al., Modulated Lapped Orthogonal Transforms in Image Coding, Digital Video Compression on Personal Computers: Algorithms and Technologies, 2187, 80–91, SPIE, 1993.

Robert J. Safranek et al., "A Perceptually Tuned Sub–Band Image Coder with Image Dependent Quantization and Post–Quantization Data Compression", Proc. ICASSP 89, 3, 1945–1948, 1989.

Robert J. Safranek, JPEG Compliant Encoder Utilizing Perceptually Based Quantization, Human Vision, Visual Processing, and Digital Display V, 1913, 117–126, SPIE, 1993.

Andrew B. Watson, DCT Quantization Matrices Visually Optimized for Individual Images, Human Vision, Visual Processing, and Digital Display IV, 1913, 202–216, SPIE, 1993.

Andrew B. Watson et al., Discrete Cosine Transform (DCT) Basis Function Visibility: Effects of Viewing Distance and Contrast Masking, Human Vision, Visual Processing, and Digital Display V, 2179, 99–108, SPIE, 1994.

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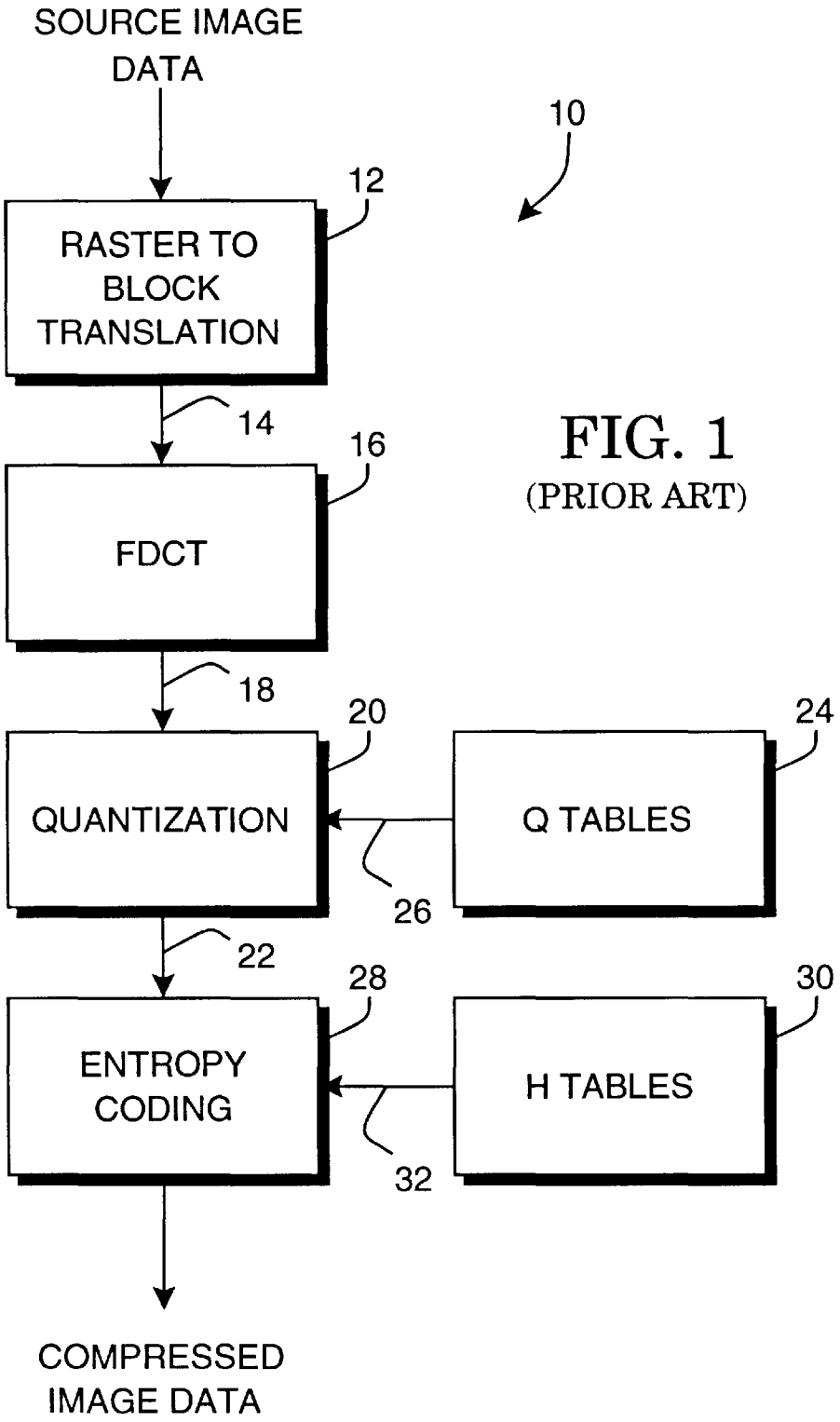

FIG. 1
(PRIOR ART)

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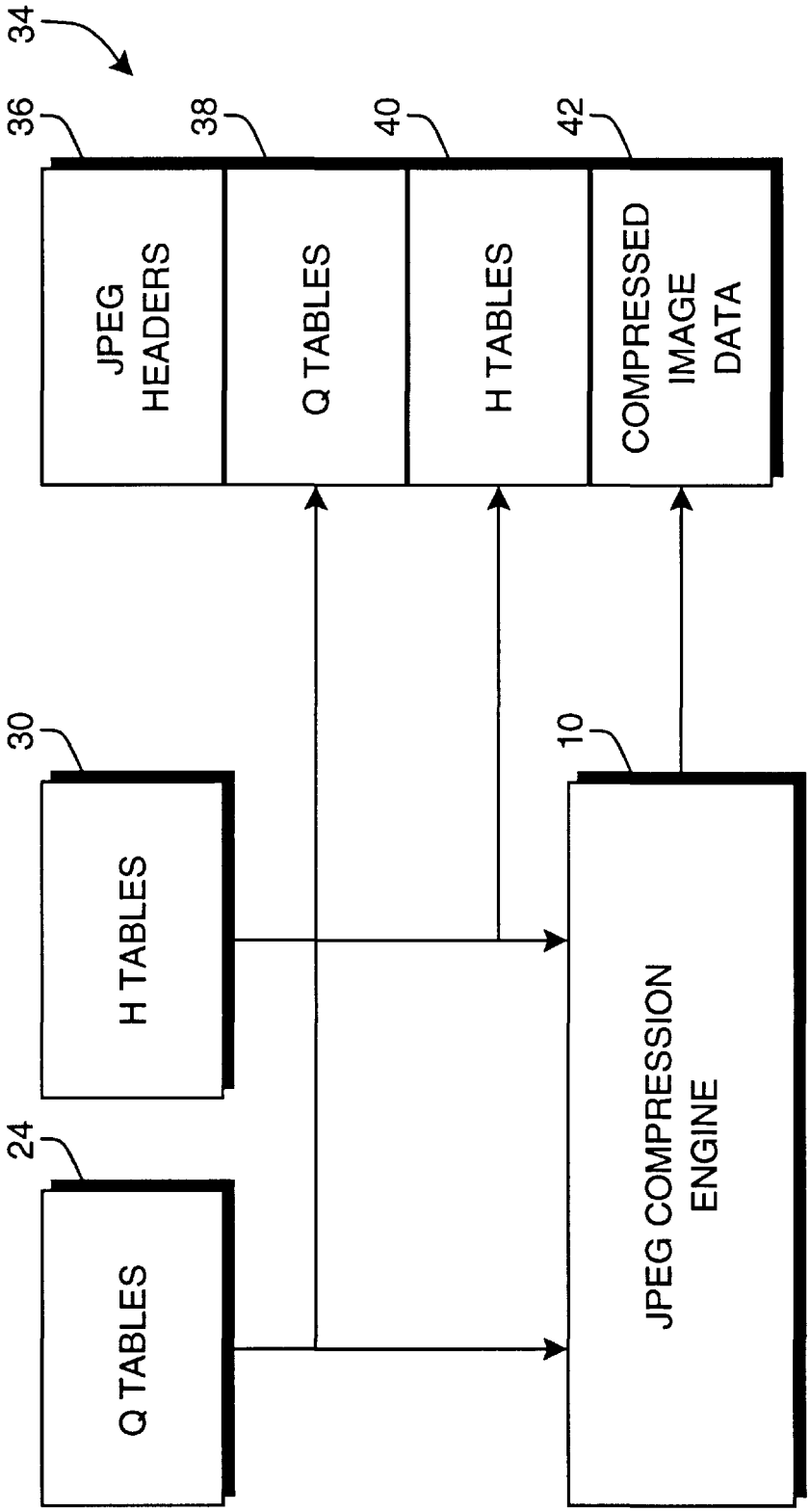

FIG. 2
(PRIOR ART)

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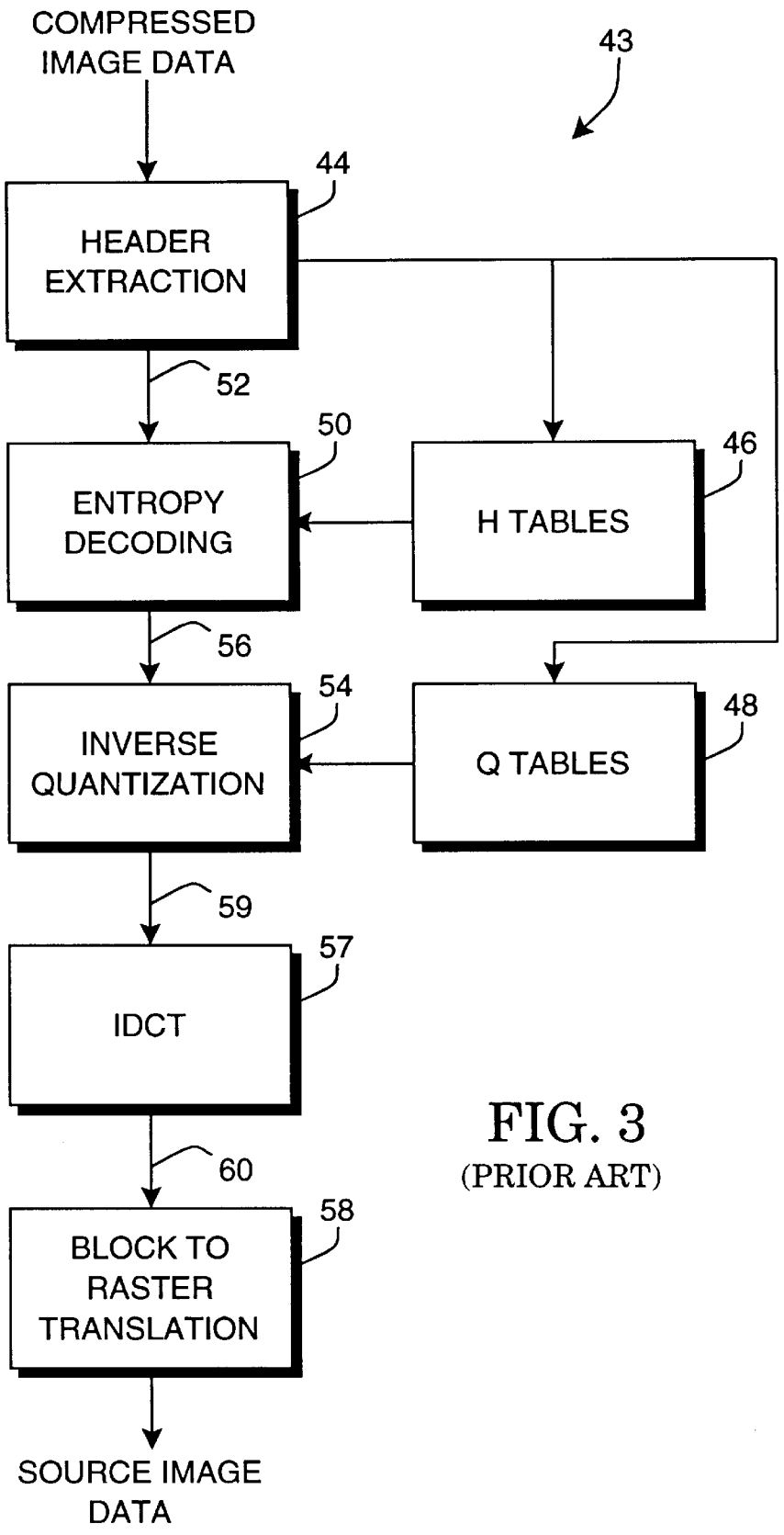

FIG. 3
(PRIOR ART)

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