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REPLY TO Wilmington Office

October 15, 2007

The Honorable Gregory M. Sleet
United States District Court
District of Delaware
844 King Street
Wilmington, Delaware 19801

VIA E-FILING

Re: *U.S. Philips Corporation v. Eastman Kodak Company*, C.A. No. 06-251-GMS

Dear Chief Judge Sleet:

Pursuant to Paragraph 8 of the Scheduling Order, Defendant Eastman Kodak Company ("Kodak") submits this letter in opposition to Plaintiff U.S. Philips Corporation's ("Philips") October 9, 2007 letter requesting permission to file a motion for summary judgment on alleged infringement of U.S. Patent No. 4,901,075 ("the '075 patent").[1]

The Court should deny Philips' request to file a summary judgment motion on infringement, because many material facts are in dispute. Although Kodak acknowledges that the accused products use the baseline sequential mode of the JPEG standard, Philips cannot and will not be able to demonstrate that the properly construed claims of the '075 patent are infringed by Kodak's JPEG-enabled products. In fact, regardless how the Court construes the claims, Kodak has already demonstrated (in responses to written discovery and otherwise)—and will demonstrate at trial—why its JPEG-enabled products do not infringe the claims of the '075 patent. Furthermore, Philips' own conduct demonstrates that JPEG-enabled products do not infringe the patent: Philips sat silently by while it participated in JPEG standardization and for a decade after that, never once taking the position that its patent was relevant to the JPEG standard. Simply put, because of the many disputed factual issues surrounding Philips' infringement claims, this case is uniquely unsuited for summary judgment.

[1] Philips' original October 9, 2007 letter requested permission to file summary judgment motions on (1) infringement and (2) various of Kodak's affirmative defenses and counterclaims based on Philips' standard-setting abuses. On October 12, 2007, Philips withdrew its request on all issues except infringement.

Kodak's JPEG-Enabled Products Do Not Infringe the '075 Patent

For at least the following reasons, Kodak's JPEG-enabled products do not infringe independent claims 3 and 8 and dependent claims 4, 7, and 11 of the '075 patent. At the very least, there are genuine issues of disputed fact as to whether Kodak's products meet each and every limitation of these claims.

First, Kodak's JPEG-enabled products do not infringe independent claims 3 and 8 (and thus do not infringe dependent claims 4, 7, and 11 either) because Kodak's products do not practice the method step of "assigning a code word to represent" the non-zero coefficient and the run length, as recited in the claims. (*See* Ex. A, Kodak's Response to Philips' Interrogatory No. 5.)[2] This claim limitation requires that a code word be assigned that represents the run length of zero coefficients and the value of the non-zero coefficient. The JPEG standard, in contrast, describes a combination of the zero-coefficient run length and the category of a non-zero coefficient. This combination is assigned an 8-bit value, RRRRSSSS, where 'RRRR' represents the zero coefficient run length and 'SSSS' represents the category of the non-zero coefficient. (Philips' Ex. 2, JPEG Standard, Annex F, Section F.1.2.2.1.) The 'SSSS' categories are listed in Table F.2 of the JPEG standard:

Table F.2 – Categories assigned to coefficient values

SSSS	AC coefficients
1	–1,1
2	–3,–2,2,3
3	–7..–4,4..7
4	–15..–8,8..15
5	–31..–16,16..31
6	–63..–32,32..63
7	–127..–64,64..127
8	–255..–128,128..255
9	–511..–256,256..511
10	–1 023..–512,512..1 023

[2] Philips argues that Kodak's failure to provide a claim chart in its April 6, 2007 response to Philips' Interrogatory No. 5 supports its request for summary judgment. Philips makes this argument even though it failed to meet and confer with Kodak to seek a further response or to discuss Kodak's objections. The appropriate means to resolve an alleged discovery deficiency is through meet and confer efforts and, if necessary, the Court's resolution process set forth in Paragraph 5.a of the Scheduling Order. Nevertheless, before the close of fact discovery, Kodak supplemented its response to Interrogatory 5, setting forth its noninfringement contentions in the form of a claim chart. (*See* Ex. A.)

The JPEG baseline sequential mode then assigns a code word representing RRRRSSSS. (*Id.* at Annex F, Section F.1.2.2.3; Fig. F.2.) The category, SSSS, represents the number of additional bits following the code word assigned to RRRRSSSS that are used to encode the value of the non-zero coefficient. Thus, the JPEG baseline sequential mode does not assign a code word that represents a run length of zero-coefficients and a value of a non-zero coefficient. (*See* Ex. A, Response to Interrogatory No. 5; Ex. B, Rabbani Draft Depo. Tr. at 309:5 - 313:23.) Instead it assigns two separate code words to represent the run length and the value of the following non-zero coefficient. (*Id.*) This was specifically disclaimed by the applicants in arguments to overcome the prior art:

> However, in accordance with the instant invention, there is assigned only one codeword to the entire event. This codeword depends on the number of zero coefficients (in this case six) and the value of the non-zero coefficient. Different codewords are assigned to events having the same number of zero coefficients but different values of the non-zero coefficient.

(Ex. C, Excerpt of '075 Patent Prosecution History, Amendment dated June 2, 1989, p. 6, KODAK_000134, emphasis added.)[3]

Therefore, the JPEG standard does not perform the step of "assigning a code word to represent" the non-zero coefficient and the run length. Thus, Kodak does not infringe claims 3, 4, 7, 8, and 11 of the '075 patent. At the very least, genuine issues of material fact preclude summary judgment as to each asserted claim.

Second, Kodak's JPEG-enabled products do not infringe at least independent claim 3 (and thus do not infringe dependent claims 4 and 7)[4] because this claim is limited to encoding video signals. In contrast, Kodak's JPEG enabled products are only accused of infringement because they encode still image signals.[5] Claim 3 specifically states that the signal being encoded is one that "results after a blockwise transform of pixels of a video signal …." (Ex. D, '075 Patent, 7:42-43.) As Dr. Rabbani testified at his deposition, claim 3 is not infringed because it relates to video encoding, not still image encoding:

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[3] The complete '075 Patent Prosecution History was previously filed with the Court as Exhibit E to the Declaration of Nicole Wyll submitted in support of Kodak's opening claim construction brief.

[4] Kodak also contends that under the proper claim construction, Claims 8 and 11 are limited to video signal encoding. (*See* Ex. A, Response to Interrogatory No. 5.)

[5] It is undisputed that the accused Kodak JPEG enabled products that also encode video signals using MPEG encoding are licensed to the '075 patent for such encoding of video signals.

> Q. How does a JPEG process differ from the process described in claim 3?
>
> * * *
>
> A. I also think that a video signal is something that JPEG does not use, because JPEG is concerned with still image compression, not video compression.

(Ex. B, Rabbani Draft Depo. Tr. at 307:20 – 308:15.)

Thus, Kodak does not infringe claims 3, 4, and 7 of the '075 patent. At the very least, genuine issues of material fact preclude summary judgment as to each of these asserted claims.

Third, Kodak's JPEG-enabled products do not infringe dependent claim 7 for a separate reason—these products indisputably do not perform the method recited in that claim, which requires (among other things) that "the sign is coded by a separate bit." Kodak's JPEG-enabled products do not meet this limitation under any construction of that phrase, because the JPEG baseline sequential mode simply does not code the sign bit using a separate bit. As the JPEG standard states:

> The format for the additional bits is the same as in the coding of the DC coefficients. The value of SSSS gives the number of additional bits required to specify the sign and precise amplitude of the coefficient. The additional bits are either the low-order SSSS bits of ZZ(K) when ZZ(K) is positive or the low-order SSSS bits of ZZ(K) - 1 when ZZ(K) is negative. ZZ(K) is the Kth coefficient in the zig-zag sequence of coefficients being coded.

(Philips' Ex. 2, JPEG Standard, Annex F, Section F.1.2.2.1.) The additional bits specified in the JPEG baseline sequential mode do not use a separate bit to code the sign. Thus, Kodak's JPEG-enabled products do not infringe dependent claim 7 for this additional reason. At a minimum, this additional genuine issue of disputed material fact precludes summary judgment.

Philips' Conduct Supports the Conclusion that the '075 Patent Does Not Apply to JPEG

The Court should deny Philips' request for summary judgment because the jury must be allowed to consider the question of infringement in light of all of Philips' conduct to the contrary. Said another way, Philips' present claim that the '075 patent covers the JPEG standard is directly at odds with its many years of conduct to the contrary. Philips was a member and an active participant in the standard-setting organizations responsible for setting the JPEG standard. JPEG and its parent organizations promulgated specific policies that required its participants to disclose patents that they believed would be relevant to the developing standard. Despite these policies, despite several verbal and written requests to disclose related patents, and despite patent disclosures by other participants, Philips never so much as hinted to the JPEG committees that the '075 patent might be relevant to JPEG. Philips' silence misled other participants, including Kodak, into believing that Philips did not have patents that might be relevant to the JPEG

standard. And Philips plainly understood its responsibility to disclose relevant patents—it disclosed the '075 patent to the committee responsible for setting the MPEG standard, which involved digital moving picture (video) compression. Philips' conduct therefore led participants in these standards efforts to conclude that the '075 patent related to video but not still image compression.

For a decade after the JPEG standard was promulgated, Philips continued to conduct itself as though the '075 patent had no alleged relevance to JPEG. During that decade, industries and consumers worldwide became locked into JPEG, a standard believed (then and now) to be free of patent claims. To this day, despite asserting the patent against Kodak's (and others') JPEG-enabled products, Philips still has never disclosed the patent to the relevant standards committees. Although Philips now asserts that JPEG-enabled products infringe the '075 patent, its past conduct supports the contrary conclusion. At a minimum, a jury should be allowed to compare Philips' starkly inconsistent claims of infringement with its prior conduct to determine whether Philips' infringement claims are actionable. Because these genuine issues of material fact cannot possibly be resolved on summary judgment, the Court should deny Philips' request.

Conclusion

For the foregoing reasons, Kodak requests that the Court deny Philips' request for permission to file a motion for summary judgment on the issue of infringement.

Respectfully submitted,

/s/ Francis DiGiovanni

Francis DiGiovanni (#3189)

Enclosures

cc: Clerk of the Court (by ECF)
John Allcock, Esq. (by ECF)
Steven J. Balick, Esq. (by ECF and hand)
Thomas W. Winland, Esq. (by ECF)
Steven Anzalone, Esq. (by ECF)

EXHIBIT A

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

U.S. PHILIPS CORPORATION, Plaintiff, v. EASTMAN KODAK COMPANY, Defendant.	)	Civil Action No. 06-00251-GMS

DEFENDANT EASTMAN KODAK COMPANY'S FOURTH SUPPLEMENTAL RESPONSE TO PLAINTIFF U.S. PHILIPS CORPORATION'S FIRST SET OF INTERROGATORIES (No. 5)

Pursuant to Rule 33 of the Federal Rules of Civil Procedure, Defendant Eastman Kodak Company ("Kodak") hereby supplements its responses to the First Set of Interrogatories ("Interrogatories") propounded by Plaintiff U.S. Philips Corporation ("Philips"), specifically No. 5, as follows:

PRELIMINARY STATEMENTS

1. Kodak's responses to Philips' Interrogatories are made to the best of Kodak's present knowledge, information and belief. Kodak reserves the right to supplement and amend these responses should future investigation indicate that such supplementation or amendment is necessary. Kodak's responses should in no way be considered prejudicial in relation to further discovery, research, analysis or production of evidence.

2. Kodak's responses are made solely for the purpose of and in relation to this action. Each response is given subject to all appropriate objections including, but not limited to, objections concerning privilege, competency, relevancy, materiality, propriety and admissibility. All objections are reserved and may be interposed at any time.

3. Until the Court enters a protective order in this case, Kodak will not provide Philips with any Kodak or third-party confidential, trade secret, or proprietary business, technical, marketing or financial information.

4. Kodak incorporates by reference each and every general objection set forth below into each and every specific response. From time to time a specific response may repeat a general objection for emphasis or some other reason. The failure to include any general objection in any specific response shall not be interpreted as a waiver of any general objection to that response.

5. By responding to Philips' Interrogatories, Kodak does not waive any objection that may be applicable to: (a) the use, for any purpose, by Philips of any information or documents given in this response to Philips' Interrogatories; or (b) the admissibility, relevancy or materiality of any of the information or documents at issue in this case.

GENERAL OBJECTIONS

1. Kodak objects to each and every Interrogatory, and to Philips' instructions and definitions, to the extent that they purport to impose additional burdens or duties on Kodak that exceed the scope of reasonable and permissible discovery under the Federal Rules of Civil Procedure, the Local Civil Rules for the District of Delaware, or the Individual Rules of the Judge(s) hearing this matter.

2. Kodak objects to each and every Interrogatory to the extent they seek information protected by attorney-client privilege, the work product immunity doctrine, or any other applicable law, protection or doctrine. The production of any privileged information or document by Kodak is unintentional, and Kodak does not intend to waive any applicable objection or privilege as a result of such production or disclosure.

3. Kodak objects to each and every Interrogatory to the extent it is overly broad or unduly burdensome or oppressive, particularly when the Interrogatory is unduly burdensome in view of Kodak's cost necessary to investigate weighed against Philips' need for the information.

4. Kodak objects to each and every Interrogatory to the extent it requires Kodak to make a legal conclusion and/or render an expert opinion.

5. Kodak objects to each and every Interrogatory as overly broad and unduly burdensome to the extent it is unlimited in temporal scope or otherwise not limited to a time frame that is relevant to this litigation and the patent in suit. Pursuant to 35 U.S.C. § 286, Philips is not entitled to recover for any infringement that allegedly occurred more than six years prior to the filing of the original Complaint on April 18, 2006. Kodak limits its interrogatory responses to the time period set forth in the specific responses and objections.

6. Kodak objects to each and every Interrogatory to the extent it seeks information already in Philips' possession or available in the public domain. Such information is as readily available to Philips as it is to Kodak.

7. Kodak objects to each and every Interrogatory to the extent it seeks information that is not in the possession, custody, or control of Kodak.

8. Kodak objects to each and every Interrogatory to the extent it seeks information that Kodak is not permitted to disclose pursuant to confidentiality obligations or agreements with third parties.

9. Kodak objects to each and every Interrogatory to the extent it seeks confidential, trade secret, or proprietary business, technical, marketing, or financial information. As noted above in Kodak's Preliminary Statements, Kodak will not provide such information until a suitable protective order has been entered by the Court.

10. Kodak objects to each and every Interrogatory to the extent it seeks information that is neither relevant to the issues in the lawsuit nor is reasonably calculated to lead to the discovery of admissible evidence.

11. Kodak objects to Philips' Definition No. 1 ("you" and "your") as overly broad and unduly burdensome to the extent it requests Kodak to produce documents maintained by other companies or entities. Kodak will produce only those documents in its possession, custody, or control.

12. Kodak objects to Philips' Instruction No. 2 as overly broad in time. Except as set forth below, Kodak will not separately identify the document, communication or item for which it claims privilege. Rather, Kodak will identify its privileged documents in the form of a privilege log. However, Kodak will not disclose, produce or include on a privilege log any documents or things created or dated after the filing of Philips' original Complaint on April 18, 2006.

SPECIFIC OBJECTIONS AND RESPONSES

INTERROGATORY NO. 5:

For every claim of the patent-in-suit that YOU deny is infringed, and separately for each JPEG image encoding product or service identified in YOUR response to Interrogatory No. 1, state each fact known by YOU that supports, refutes, or relates to YOUR allegations of noninfringement, including a claim chart which specifically identifies every claim limitation which is not present, either literally or by equivalents, in each of these products or services; identify each person who has knowledge about the subject matter of this interrogatory; and identify each document and thing relating to the subject matter of this interrogatory.

RESPONSE TO INTERROGATORY NO. 5:

Kodak objects to this Interrogatory to the extent it calls for legal conclusions or expert opinion. Kodak further objects to this Interrogatory as seeking information protected by the attorney-client privilege, the work product immunity doctrine and/or other applicable privileges or protections. Kodak objects to this Interrogatory as compound because it contains discrete subparts that require separate and distinct responses. Kodak objects to this Interrogatory as

overly broad and unduly burdensome. Kodak further objects to this Interrogatory to the extent it seeks to impose additional burdens or duties on Kodak that exceed the scope of reasonable and permissible discovery under the Federal Rules of Civil Procedure, the Local Civil Rules for the District of Delaware, or the Individual Rules of the Judge(s) hearing this matter. This interrogatory is premature in light of the expert discovery schedule agreed to by the parties and reflected in the Court's scheduling order. This Interrogatory is also premature because it seeks Kodak's contentions and analysis before Kodak has completed discovery relating to noninfringement, before Kodak has conducted expert discovery on noninfringement and before the Court has issued a claim construction ruling. Subject to these objections and the general objections set forth above, Kodak responds as follows:

Kodak understands Philips is asserting that claims 3, 4, 7, 8 and 11 of US Patent No. 4,901,075 are practiced by Kodak JPEG enabled products or services that encode images in accordance with the JPEG Baseline Sequential Mode. Kodak contends that these claims are not infringed by Kodak JPEG enabled products or services practicing the JPEG Baseline Sequential Mode for at least the reasons identified in the following chart:

US Patent 4,901,075	**Kodak's JPEG Baseline Sequential Mode Enabled Products and Services**
3. In a method of coding a signal comprising a sequence of coefficients which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate, said signal comprising a plurality of zero coefficients, and a plurality of non-zero coefficients said method comprising the steps of:	In Kodak's JPEG Baseline Sequential Mode Enabled Products and Services, there is no "signal comprising a sequence of coefficients which results after a blockwise transform of pixels of a video signal with subsequent quantization." Accordingly, there is no "coding of a signal." Nor is there such a signal which comprises "a plurality of zero coefficients, and a plurality of non-zero coefficients" Also, in Kodak's JPEG Baseline Sequential Mode Enabled Products and Services, there is no "transmission at a reduced bit rate."

US Patent 4,901,075	Kodak's JPEG Baseline Sequential Mode Enabled Products and Services
(a) deriving from said signal, a plurality of events each comprising a run of said zero-coefficients having a respective run length and preceded or followed by at least one non-zero coefficient, and	Because there is no signal, as used in the claim, this step is not satisfied by Kodak's JPEG Baseline Sequential Mode Enabled Products and Services. Furthermore, in Kodak's JPEG Baseline Sequential Mode Enabled Products a "plurality of events" is not derived under the proper construction of that term.
(b) for each of said events, determining said respective run length and assigning a code word to represent said non-zero coefficient and said run length.	In Kodak's JPEG Baseline Sequential Mode Enabled Products and Services a "code word" is not assigned "to represent said non-zero coefficient and said run length."
4. The method of claim 3, wherein said code words are Huffman code words.	Because claim 3 is not infringed by Kodak's JPEG Baseline Sequential Mode Enabled Products and Services as described above, claim 4 is not infringed. Further, in Kodak's JPEG Baseline Sequential Mode Enabled Products and Services, there are no "Huffman code words" under the proper construction of that term.
7. A method as claimed in claim 4, characterized in that the Huffman codeword is independent of the sign of that non-zero coefficient which succeeds or precedes the run of zero-coefficients and in that the sign is coded by a separate bit.	Because claims 3 and 4 are not infringed by Kodak's JPEG Baseline Sequential Mode Enabled Products and Services as described above, claim 7 is not infringed. Further, in Kodak's JPEG Baseline Sequential Mode Enabled Products and Services, there is no "Huffman codeword" that is "independent of the sign of that non-zero coefficient which succeeds or precedes the run of zero-coefficients." Nor do Kodak's JPEG Baseline Sequential Mode Enabled Products and Services code the sign by a separate bit.
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Kodak's JPEG Baseline Sequential Mode Enabled Products and Services do not code a "signal" under the proper construction of that term. Also, in Kodak's JPEG Baseline Sequential Mode Enabled Products and Services, there is no "transmission at a reduced bandwidth."

(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	Because there is no "signal" in Kodak's JPEG Baseline Sequential Mode Enabled Products and Services, there is no "transforming said signal"
(b) deriving from said sequence, a plurality of events each comprised of a run of zero coefficients having a respective run length, which is preceded or followed by at least one non-zero coefficient, and	In Kodak's JPEG Baseline Sequential Mode Enabled Products there is no "deriving from said sequence, a plurality of events," under the proper construction of that term.
(c) for each of said events, determining the run length and assigning a code word to represent said run length and said non-zero coefficient.	In Kodak's JPEG Baseline Sequential Mode Enabled Products and Services there is no "assigning a code word to represent said run length and said non-zero coefficient."
11. The method of claim 8, comprising the additional steps of: determining whether the run length of each event exceeds a predetermined run length and if so, splitting said respective event into a plurality of sections so that each of said sections has a run length below said predetermined run length, and assigning a code word to each section.	Because claim 8 is not infringed by Kodak's JPEG Baseline Sequential Mode Enabled Products and Services as described above, claim 11 is not infringed. In Kodak's JPEG Baseline Sequential Mode Enabled Products and Services there is no "splitting said respective event into a plurality of sections so that each of said sections has a run length below said predetermined run length, and assigning a code word to each section."

Kodak's investigation into this Interrogatory is ongoing. Kodak will supplement and/or amend this response as circumstances and its ongoing investigation warrant.

Date: October 11, 2007

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CERTFICATE OF SERVICE

I, Kristen Healey Cramer, hereby certify that on October 11, 2007, I caused a copy of the foregoing document to be served by e-mail and hand delivery on the following counsel of record:

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I, Kristen Healey Cramer, hereby certify that on October 11, 2007, I caused a copy of the foregoing document to be served by e-mail and U. S. Mail on the following counsel of record:

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EXHIBIT B

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CONFIDENTIAL

THE VIDEOGRAPHER: We are about to begin a video recorded deposition of Majid Rabbani. I am David Parrotta from Parrotta Studio for Henderson legal services. Today is Thursday, October 11th 2007. The time is approximately 9:08 a.m.

We are at the offices of Wolford & Leclair, located at 16 East Main Street, Suite 16, Rochester, New York.

The party on whose behalf the deposition is being taken is the plaintiff in the action entitled US Phipps corporation, plaintiff, versus Eastman Kodak Company defendant. At this time I would like to have the attorneys introduce

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themselves. (Appearances were placed on the video record.)

THE VIDEOGRAPHER: Also in attendance is the court reporter Maria Wolczyk of Alliance Court Reporting located at 183 East Main Street, Rochester, New York. The witness may be sworn in. No stipulations.

EXAMINATION BY

MR. ANZALONE:

Q. High, Dr. Rabbani. Can you tell us where you reside?

A. You mean in?

Q. Home address.

A. 36 weeks forward Glenn in Pittsford, New York 14534.

Q. And are you employed?

A. Yes.

Q. Who are you employed by?

A. Eastman Kodak Company.

Q. What's your present position?

A. I am a department head and also a distinguished research fellow.

Q. You mentioned you are a department head. What department are you head of?

A. Department head of intelligent imaging department.

Q. And what is the mission of the intelligent imaging department?

A. This is a rather new department, so we are working out the mission. But it is about creating imaging systems that have some smartness built into them.

Q. Is it, would you describe it as a research department?

A. Yes, it is a research department.

Q. And what areas or product lines would that research be applied, if any?

A. The research would be applied to products that deal with digital imaging in general.

Q. Would they apply to digital cameras?

A. They potentially can apply to digital cameras.

Q. Would they apply to scanners?

MR. KINTON: Objection. Calls for speculation.

Q. You may answer.

A. They can potentially apply to scanners, too. But that's guessing.

THE WITNESS: I should answer this question?

MR. KINTON: Yeah, you can answer. If you have an understanding, which you said you did, you can explain your understanding.

My objection is that it calls, the he question calls for a legal conclusion and expert opinion. But you can answer.

A. Yeah, my personal understanding of the claim 3 that you mentioned is that what is considered an event here comprising a run of said zero coefficients having respective run length and proceeded or followed by at least one run zero coefficient and for each set events determining said respective run length and assigning a code word to respect said non-zero coefficient and said run length is a process that is not done in JPEG.

((Said not set).

Q. How does a JPEG process differ from the process described in claim 3?

MR. KINTON: Same objections. And vague as to the JPEG process.

A. The JPEG process would encode the runs of coefficients in combination with the category of

that coefficient, which essentially tells you the number of extra bits that are necessary in order to decode the exact value of the coefficient.

So what gets Huffman coded in -- the variable length coded in the JPEG Standard is not the same as what gets variable length coded in this claim.

Q. Any other distinctions you can think of?

MR. KINTON: Same objections.

(There was a pause in the proceeding.)

A. I also think that a video signal is something that JPEG does not use, because JPEG is concerned with still image compression, not video compression.

Q. Any other differences?

MR. KINTON: Same objections.

A. Please allow me to read that a little more carefully. Those are the two that stood out when I looked at it.

Q. Absolutely.

(There was a pause in the proceeding.)

A. Also the term for transmission at a reduced bit rate is very vague to me (transmission).

(There was a pause in the proceeding.)

A. Yeah, those would be my main, based on my current reading of the claim, these are the main things that I see different.

Q. Now, in the baseline sequential mode of JPEG encoding, when a code word is assigned to a run of zeros and a coefficient, doesn't the code word also include, or isn't there also appended to the code word additional bits to uniquely identify the particular coefficient?

MR. KINTON: Objection. Calls for a legal conclusion, expert opinion. Vague.

A. Interpreting the word code word and all I think is something that we need to more specifically define.

But -- but in the JPEG Standard, the run of zeros and the number of bits that needs to follow that Huffman code word are defined as the symbol, and I'm using the word symbol because in encoding we code symbols, so the symbol that gets coded in JPEG is the run of zeros and the category of the coefficients, and the interpretation of the category is the number of extra bits that need to follow the Huffman code word so they would uniquely identify that coefficient, or precisely identify the

coefficient.

Q. Now, when you actually send that data out, will it be in the form of I believe a 4 bit portion which is the run length, then I believe a 4 bit portion which was designated with the letter S, which you described as indicating the category, and then won't that data immediately be followed by the number of bits specified by those four S bits so that you can uniquely identify the particular coefficient?

MR. KINTON: Same objections.

A. Uhm, that -- that is not actually -- I mean, the four bits and the four bits that you just mentioned, that is not the coded sequence. That's the symbol, right.

Q. Uh-huh.

A. That symbol is -- it's an abstract thing. It's just constructed. That symbol gets constructed and then gets coded. So what the code word is is not an 8-bit entity. It is a variable length Huffman code, right?

Q. Uh-huh.

A. And that Huffman code represents the number of zeros -- see, that Huffman code represents

a symbol, okay? In the jargon of coding, we code symbols. And symbols have different statistics or frequency of occurrence. So each symbol gets a code word, and we have already talked about what Huffman coding means in terms of the statistics of a symbol.

So in JPEG, we define a symbol to be a run length and the category of the succeeding non-zero coefficient. And what that category means really is the extra number of bits that are needed to follow that Huffman code word in order to uniquely specify the category -- I'm sorry, the coefficient itself.

However, there is an important distinction to be made here, because in a typical Huffman code word, if you just receive a portion of the code word you cannot decode anything, okay, unless you receive the entire code word. You then can define the symbol or decode the symbol, okay?

So a Huffman code word ends when you can decode a symbol. And with the JPEG you can decode the symbol which is the run length of zeros followed by the category by receiving that Huffman code word. So what comes after the Huffman code word is not part of the had you ever man code word any more,

it's just extra information. So it's the start of a new code word, essentially. It's not the continuation of the old code word because the code word is decoded by the time that you have decoded the run length and the category.

Q. Now, does that code word point you to a particular location in a Huffman table?

MR. KINTON: Same objections.

A. I'm not sure if I understand your question. When you are saying the Huffman table, the Huffman table consists of symbols. And the corresponding code words. Okay? So your decoding procedure will match a symbol against the code word that you are decoding.

Q. Uh-huh.

A. So by the time that you have decoded that code word, you essentially know what symbol had resulted in that code word. And that's the end of the Huffman code. So by the time that you have decoded that code word, you will know in the JPEG case that you have a run length of certain number of zeros and a certain category for the non-zero coefficient, and that's a symbol.

Q. In the JPEG encoding process, how do you

arrive at an exact value of the coefficient and the code for it?

MR. KINTON: Same objections, which are calls for a legal conclusion, expert opinion, and vague.

A. You, in my expert opinion, I believe that you arrive at that by decoding two code words. The first code word tells you the number of zeros and the category of the non-zero coefficients, which is also pointing you to the second code word, which will have the add additional number of bits which will of course be determined by the category because you wouldn't know how many words are in the second code word until you have decoded the first code word.

And then once you die code the second code word which are the extra bits, then you will know the exact value of the non-zero coefficient and of course you know the run length of zero that precedes it from decoding the first code word.

So by decoding those two portions, you have the complete information.

Q. Okay.

MR. ANZALONE: Good place to break.

EXHIBIT C

IW 1458226

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

May 12, 2006

THIS IS TO CERTIFY THAT ANNEXED IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF THE FILE WRAPPER AND CONTENTS OF:

APPLICATION NUMBER: *07/096,177*
FILING DATE: *September 11, 1987*
PATENT NUMBER: *4,901,075*
ISSUE DATE: *February 13, 1990*

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office

N. WILLIAMS
Certifying Officer

U.S. PAT. & TRADE MARK OFFICE JUN 7 1989

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GROUP 210

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of PETER VOGEL

Atty. Docket PHD 86-327

Serial No. 07/096,177

Group Art Unit 217

Filed: September 11, 1987

Ex. B. Young

METHOD OF AND CIRCUIT ARRANGEMENT FOR BIT RATE REDUCTION

Honorable Commissioner of Patents and Trademarks
Washington, D.C. 20231

AMENDMENT

Sir:

Applicant respectfully requests reconsideration of the above-referenced application in view of the following amendment:

IN THE SPECIFICATION

Page 1, line 15, change "part" to --number--;

line 16, change "part" to --number--; change "is" to --are--;

line 27, change "it is investigated at what" to --the--; after "frequency" insert --with which--;

line 28, after "signal" insert --is investigated--;

Page 2, line 2, change "(quantised)" to --(quantized)--;

line 15, change "solved in that" to --achieved by assigning--; delete "is" (last occurrence);

line 16, delete "assigned"; change "signal values A" to --signals having the value A, where A

10224 06/14/89 096177 21-0450 010 102 72.00CH

C1 amended

equals for example, zero, and--; change "the" to --a--;

(amended twice) line 39, delete "represents";

line 40, delete "the coefficient having the value of" and substitute therefor --equals zero or approximately zero--;

C2

Page 3, line 14, change "(quantised)" to --(quantized)--;

Page 8, line 32, change "addres" to --address--.

IN THE CLAIMS

Cancel claims 4 and 5 without prejudice, amend claims 6, 7, 8 and 11 and add new claim 18:

Claim 6, line 1, change "5" to --12--;

line 2, delete "checked";

line 3, change "signal values A" to --zero-coefficients--;

line 4, change "signal value" to --non-zero-coefficient--.

Claim 7, line 4, delete "and in that the signal value A is the zero value,";

line 7, change "signal value" to --non-zero coefficient--;

C3 amended

~~7~~ 4 ~~8~~ 12. (twice amended) A method as claimed in Claim [4] ~~12~~, characterized in that the [Hufmann] Huffman codeword is independent of the sign of that non-zero coefficient which

C3 cancelled

succeeds or precedes the [zero] run of zero-coefficients and in that the sign is coded by a separate bit.

~~11~~ 3. (amended) In a method of coding a signal comprising a sequence of coefficients which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate, said signal comprising a plurality of zero [first] coefficients [having a value designated as signal value A and occurring mostly in runs in said signal], and a plurality of [other] non-zero coefficients [having signal values which are not equal to signal value A, characterized by] said method comprising the [following] steps of:

C4

a) deriving from said signal, a plurality of events each comprising a run of said [first] zero- coefficients having a respective run length[, which is] and preceded or followed by at least one [other] non-zero coefficient, and

b) for each of said events, determining said respective run length and assigning a code word to represent said [other] non-zero coefficient and said run length.

~~12~~ 13. In a method of coding a signal comprising a sequence of coefficients which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate, said signal comprising a plurality of first coefficients having a signal value A and occurring in runs most frequently in said signal, and a

C5 cancelled

plurality of second coefficients having values not equal to A, said method comprising the steps of:

a) deriving from said signal, a plurality of events each comprising a run of said first coefficients having a respective run length, which is preceded or followed by at least one second coefficient, and

b) for each of said events, determining said respective run lengths and assigning a code word to represent said second coefficient and said run length.

C5 cancelled

REMARKS

Applicant respectfully requests reconsideration of the above-referenced application in view of the amendments herein and the remarks which follow.

In the Office Action dated March 6, 1989 the Examiner rejected claims 4-8 and 11 under 35 U.S.C. 112, second paragraph. Claims 4 and 5 have been cancelled herein and claims 6, 7, 8 and 11 have been amended herein to address the Examiner's remarks. In particular, references to "first coefficient" and "other coefficients" have been replaced by "zero-coefficient" and "non-zero coefficient" respectively. However, new claim 18 has been added which restates claim 11 in terms of "coefficients having a signal value A". As stated in the specification as amended previously on December 8, 1988 and as originally filed, the invention comprises the possibility that the value which occurs most frequently in the signal can be a value other than zero. Hence, reference to a value A. In the examples shown herein that value was zero, however, the

Applicant respectfully wishes to make it clear that the invention also comprises the situation where this value is other than zero. Claim 8 has been amended herein to remove the lack of antecedent basis referred to by the Examiner.

Applicant submits therefore, that claims 6, 7, 8 and 11 are patentable under 35 U.S.C. 112, second paragraph.

The Examiner rejected claims 11-17 under 35 U.S.C. 102(b) over Fukuoka. The Applicant respectfully traverses the Examiner's rejection. The Fukuoka patent discloses a plurality of binary run length coding methods (one and zeros). In each of these methods, a run is defined as a series of equal elements, for instance a run of "zero" elements may consist of one, two, or three, or even 100 zeros. Similarly run of "one" elements may consist of one or 2 or three, etc. ones. All of these methods are more or less modifications of the run length Huffman coding method. In the instant invention, the coefficients are not limited to either ones or zeros, i.e. they are not merely binary. They can have any one of the values zero, one, two, three and up to, for example, 256 if eight bits are used to code them. As specifically described in the claims, for example claim 11, the method comprises the step of deriving from said signal a plurality of events each comprising not only a run of zero coefficients but a run of zero coefficients having a respective run length which is preceded or followed by at least one non-zero coefficient. In other words, we define events, and an event is constituted for example, by a run of zero coefficients and the subsequent or preceding non-zero coefficient. Consider an event 000000C

where each zero indicates a zero coefficient and the "C" indicates a non-zero coefficient. According to the teachings of Fukuoka there would be assigned a code word to the run of six zeros and a further codeword to the non-zero coefficient. However, in accordance with the instant invention, there is assigned only one codeword to the entire event. This codeword depends on the number of zero coefficients (in this case six) and the value of the non-zero coefficient. Different codewords are assigned to events having the same number of zero coefficients but different values of the non-zero coefficient.

As discussed above, claim 11 has been amended to describe the coefficients in terms of zero coefficient and non-zero coefficient, however the arguments with regard to Fukuoka are equally valid for new claim 18 which maintains the "signal value A" language.

It is therefore respectfully submitted that claims 11-18 are patentable over Fukuoka under 35 U.S.C. 102(b).

The Examiner has already stated the claims 9 and 10 are allowable over the prior art and therefore allowance of claims 6-18 is respectfully requested.

Respectfully submitted,

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Assoc. Attorney for Applicant
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June 2, 1989

EXHIBIT D

United States Patent [19]

Vogel

[11] **Patent Number: 4,901,075**

[45] **Date of Patent: Feb. 13, 1990**

[54] **METHOD AND APPARATUS FOR BIT RATE REDUCTION**

[75] Inventor: **Peter Vogel**, Diepersdorf, Fed. Rep. of Germany

[73] Assignee: **U. S. Philips Corporation**, New York, N.Y.

[21] Appl. No.: **96,177**

[22] Filed: **Sep. 11, 1987**

[30] **Foreign Application Priority Data**

Sep. 13, 1986 [DE] Fed. Rep. of Germany 3631252
Nov. 8, 1986 [DE] Fed. Rep. of Germany 3638127
May 23, 1987 [DE] Fed. Rep. of Germany 3717399

[51] **Int. Cl.**[4] **H03M 7/46**

[52] **U.S. Cl.** **341/63**; 341/59; 358/261.1

[58] **Field of Search** ..... 340/347 DD; 358/13, 358/136, 138, 261.2, 261.3, 261.4, 263, 261.1; 341/63, 106; 375/25

[56] **References Cited**

U.S. PATENT DOCUMENTS

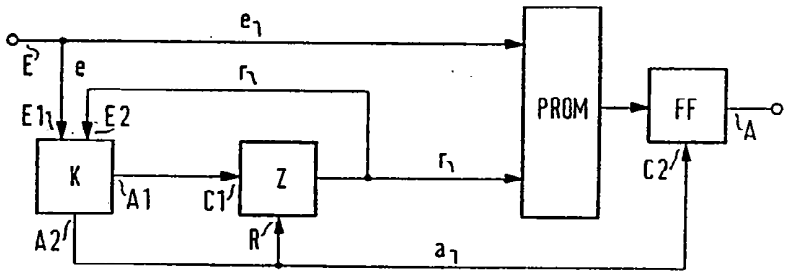
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4,316,222 2/1982 Subramaniam 358/261.4
4,394,774 7/1983 Widergren et al. ..... 340/347 DD
4,698,672 10/1987 Chen et al. 358/136

Primary Examiner—William M. Shoop, Jr.
Assistant Examiner—Brian K. Young
Attorney, Agent, or Firm—Michael E. Marion

[57] **ABSTRACT**

A method and apparatus for coding a signal for transmission in order to achieve improved reduction in the bit rate. A signal is a transform coded in order to form a sequence of zero coefficients and non-zero coefficients, and run lengths of zero coefficients together with preceding or subsequent non-zero coefficients are grouped as events and coded.

13 Claims, 5 Drawing Sheets



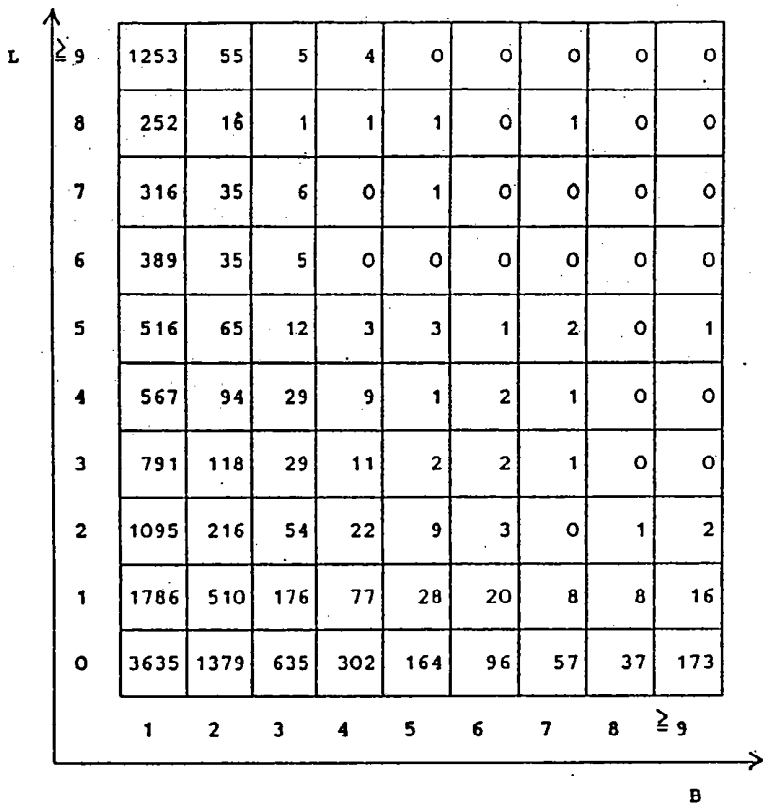

L
≥9
8
7
6
5
4
3
2
1
0
1253 55 5 4 0 0 0 0 0
252 16 1 1 1 0 1 0 0
316 35 6 0 1 0 0 0 0
389 35 5 0 0 0 0 0 0
516 65 12 3 3 1 2 0 1
567 94 29 9 1 2 1 0 0
791 118 29 11 2 2 1 0 0
1095 216 54 22 9 3 0 1 2
1786 510 176 77 28 20 8 8 16
3635 1379 635 302 164 96 57 37 173
1 2 3 4 5 6 7 8 ≥9
B

FIG. 1

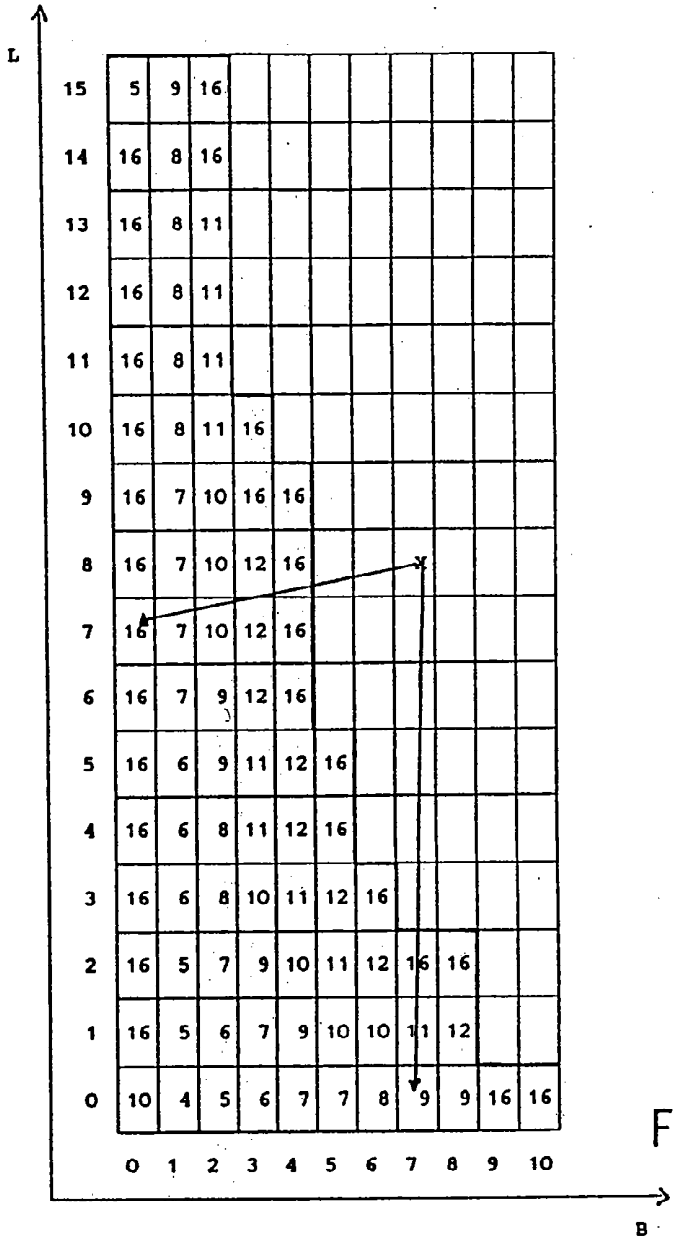

L
B
15 5 9 16
14 16 8 16
13 16 8 11
12 16 8 11
11 16 8 11
10 16 8 11 16
9 16 7 10 16 16
8 16 7 10 12 16
7 16 7 10 12 16
6 16 7 9 12 16
5 16 6 9 11 12 16
4 16 6 8 11 12 16
3 16 6 8 10 11 12 16
2 16 5 7 9 10 11 12 16 16
1 16 5 6 7 9 10 10 11 12
0 10 4 5 6 7 7 8 9 9 16 16
0 1 2 3 4 5 6 7 8 9 10

FIG. 2

Nr.	B	L	code word		length
1	-	-	11	(end of block)	2
2	1	0	010s		4
3	1	1	1000s		5
4	1	2	1001s		5
5	2	0	1010s		5
6	0	15	10110		5
7	1	3	10111s		6
8	1	4	01100s		6
9	1	5	01101s		6
10	2	1	01110s		6
11	3	0	01111s		6
12	1	6	001000s		7
13	1	7	001001s		7
14	1	8	001010s		7
15	1	9	001011s		7
16	2	2	001100s		7
17	3	1	001101s		7
18	4	0	001110s		7
19	5	0	001111s		7
20	1	10	0001000s		8
21	1	11	0001001s		8
22	1	12	0001010s		8
23	1	13	0001011s		8
24	1	14	0001100s		8
25	2	3	0001101s		8
26	2	4	0001110s		8
27	6	0	0001111s		8
28	1	15	00001000s		9
29	2	5	00001001s		9
30	3	2	00001010s		9
31	4	1	00001011s		9
32	7	0	00001100s		9
33	8	0	00001101s		9

FIG. 3

Nr.	B	L	code word	length
34	2	6	00001110s	9
35	2	7	000001000s	10
36	2	8	000001001s	10
37	2	9	000001010s	10
38	3	3	000001011s	10
39	4	2	000001100s	10
40	5	1	000001101s	10
41	6	1	000001110s	10
42	0	0	0000011111	10
43	2	10	0000011110s	11
44	3	4	0000001000s	11
45	3	5	0000001001s	11
46	4	3	0000001010s	11
47	5	2	0000001011s	11
48	7	1	0000001100s	11
49	2	11	0000001101s	11
50	2	12	0000001110s	11
51	2	13	0000001111s	11
52	3	6	00000001000s	12
53	3	7	00000001001s	12
54	3	8	00000001010s	12
55	4	4	00000001011s	12
56	4	5	00000001100s	12
57	5	3	00000001101s	12
58	6	2	00000001110s	12
59	8	1	00000001111s	12
60	9	0	00001111s+++++++	16
61	0	1	00000000100000--	16
62	0	2	00000000100001--	16
63	0	3	00000000100010--	16
64	0	4	00000000100011--	16
65	0	5	00000000100100--	16

FIG. 4

Nr.	B	L	code word	length
66	0	6	00000000100101--	16
67	0	7	00000000100110--	16
68	0	8	00000000100111--	16
69	0	9	00000000101000--	16
70	0	10	00000000101001--	16
71	0	11	00000000101010--	16
72	0	12	00000000101011--	16
73	0	13	00000000101100--	16
74	0	14	00000000101101--	16
75	2	14	00000000101110s-	16
76	2	15	00000000101111s-	16
77	3	9	00000000110000s-	16
78	3	10	00000000110001s-	16
79	4	6	00000000110010s-	16
80	4	7	00000000110011s-	16
81	4	8	00000000110100s-	16
82	4	9	00000000110101s-	16
83	5	4	00000000110110s-	16
84	5	5	00000000110111s-	16
85	6	3	00000000111000s-	16
86	7	2	00000000111001s-	16
87	8	2	00000000111010s-	16

FIG. 5

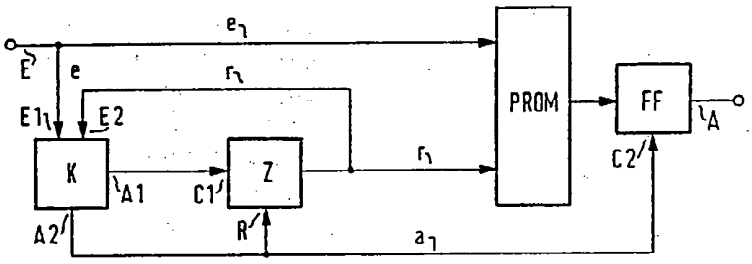


FIG.6

METHOD AND APPARATUS FOR BIT RATE REDUCTION

BACKGROUND OF THE INVENTION

The invention relates to a method of and a circuit arrangement for bit rate reduction. Bit rate reduction is carried out when coding a signal, which comprises a series of digital signal values and has a signal value A, occurring most frequently in runs.

An Article by Wen-Hsiung Chen and William K. Pratt (Chen, When-Hsiung and Pratt, William K.; Scene Adaptive Coder IEEE Transactions on Communications, vol. Com-32, No. 3, March 1984, pages 225–232) describes a coding process of video signals for the purpose of transmitting video pictures of satisfactory quality at a minimum possible bit rate. Coding is effected in several steps. First, equally large video picture sections which are represented by blocks of pixels are subjected to a Discrete Cosine Transform. In this transform process, a special two-dimensional Fourier transform is used. By the transform, a new block of values (coefficients) is obtained from the original block. This coefficient block has the property that a large number of its elements—thus a large number of the coefficients—are approximately 0 or exactly 0. A subsequent quantization of the coefficients always renders the greater part of the elements 0 so that a subsequent Huffman coding would therefore already involve a considerable bit rate reduction. The authors of the above-mentioned Article achieve a further bit rate reduction in that the frequent occurrence of zero runs in the intermediate signal in which the coefficients are serially arranged is utilized by means of a Huffman coding.

It is known that in a Huffman coding in which the codewords have different lengths, statistic properties of the signal to be coded are utilized. In the present case this particularly implies that the frequency with which zero runs having lengths 1, 2, 3, etc. occur in the above-mentioned intermediate signal is investigated. The shortest Huffman codeword is then assigned to the run that occurs most frequently. The next larger codeword is assigned to the run that occurs less frequently, and so forth.

For coding the intermediate signal two Huffman code tables are required according to the above-mentioned Article. A first table shows how the (quantized) coefficients different from 0 are to be coded. Only the coefficient values are coded because equally large coefficients also occur at the same frequency. The signs are transmitted in a separate bit. A second table shows how the run length is to be coded. In order that the codewords of one table can be distinguished from those of the other table during decoding, a separate codeword, the so-called run length prefix, is used for the identification of the coded run length.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a coding method for a signal of the kind mentioned in the opening paragraph and comprising in a special case, an intermediate signal resulting from a picture coding operation, leading to a bit rate reduction which is larger than that hitherto known.

This object is achieved by assigning a Huffman codeword to each run of signals having the value A, where A having length 0, 1, 2 etc., together with the signal value subsequent to the run or together with the signal value preceding the run.

Advantageous embodiments of the invention, particularly for exeptional cases of the signal characterized in the opening paragraph as well as a circuit arrangement for carrying out the method according to the invention, can be derived from the sub-claims.

BRIEF DESCRIPTION OF THE DRAWING

The invention will now be described in greater detail by way of examples with reference to the accompanying drawings in which

FIG. 1 is a table stating the occurrence of events,

FIG. 2 is a further table elucidating the split-up of the events,

FIG. 3 to FIG. 5 show a coding table, and

FIG. 6 shows the circuit diagram of arrangements for coding video signals according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following embodiments, the intermediate signal referred to results from the transform coding of blocks of picture elements (pixels). The signal values of the intermediate signal thus represent the transform coefficients. As stated above, the coefficient which occurs most frequently in runs within the intermediate signal is represented herein as having the signal value A. In the following embodiments, signal value A equals zero or approximately zero zero (referred to hereinafter as the "zero-coefficient") because it appears most frequently in runs after transform coding. All coefficients not having a value of zero will be referred to hereinafter as "non-zero coefficients".

As used in the following description, a run of zero coefficients and the non-zero coefficient which immediately precedes or follows this run, is referred to as an event. Each non-zero coefficient which is not preceded or followed by one or more zero coefficients is also referred to as an event. According to the invention these events are to be coded.

It is to be noted that some events are more likely to occur than others. For example coefficients having small values will occur more frequently than coefficients having large values, and it is more likely that a coefficient having a small value will be preceded by a run of zero coefficients.

FIG. 1 shows the frequency distribution of the above-mentioned events in the case of a cosine-transformed and subsequently quantized video signal. Each field of the table represents an event characterized by the zero run length L and by the value B of the subsequent (quantized) coefficient. The values B proceed through the natural numbers without the zero and the length L proceeds through the natural numbers with the zero. In order that the table does not become arbitrarily large, all events with B larger than or equal to 9 are combined to an overall event. The same applies to L when larger than or equal to 9.

The numbers in the different fields indicate how often the associated event occurs in a quantized video signal with approximately 15000 signal values. The assignment of Huffman codewords is shown in the table: the series L=0, B=1 acquires the shortest codeword; this is followed by the series L=1, B=1 with the next longer codeword, and so forth.

If the assigned codewords instead of the frequencies are introduced in the event fields of the table, a two-dimensional coding table is obtained. It is not shown for the events according to FIG. 1 because such coding tables can generally be set up by those skilled in the art. For the sake of completeness it is to be noted that a maximum number of 11 bits follows for the events in which L is larger than or equal to 9 or in which B is larger than or equal to 9 after the assigned Huffman codeword, which bits give the receiver accurate information about the value of L and the value of B, respectively.

An additional bit rate reduction of 12% is obtained when coding video signals in accordance with the above-mentioned two dimensional coding table as compared with the coding method described in the opening paragraph.

This additional bit rate reduction is possible because, for example if the probability of a coefficient having the value 2 occurring equals P1, and the probability of run of three zero-coefficients occurring equals P2, and the probability of the run of three zero-coefficients occurring followed by a coefficient having the value 2, equals P3; probability P3 will not be equal to the product of probabilities P1 and P2.

The limitation of FIG. 1 will now be considered in greater detail. As is evident from the above-mentioned embodiments the number of the events to be coded in accordance with FIG. 1 is kept within efficient limits because all zero runs with an equally large subsequent value of a coefficient are considered as an event if the run length L is larger than eight.

Similarly, all zero runs of equal length are considered as an event if the subsequent value B of a coefficient is larger than eight.

As is shown in FIG. 1, relatively rarely occurring events are concerned, and therefore they are coded with relatively long Huffman codewords. Since the receiver for decoding should know the exact zero run length or the exact value of a coefficient without any loss of information, an additional codeword is added to the Huffman codeword—as already indicated above—from which the exact length or the exact value or both can be derived.

A clearly defined state is encoded by the Huffman codeword and the additional information. Since the number of bits of such combinations is also dependent on the statistic properties of the signal, such combinations should also be present at the receiver and the decoder in order that the state which is based on these combinations can unambiguously be recognized at the receiver end.

The Huffman codewords defined in this sense may be up to 30 bits long. Since the processing of codewords which are at most 16 bits long does not require any special arrangements, but is possible, for example with a 16-bit microprocessor, given events are split into sub-events—to improve the method described so far—such that codewords whose length is at most 16 bits are sufficient for coding all events and sub-events. This split-up will now be described in greater detail.

Firstly, an event to be coded consisting of an L=Lm zero run with subsequent coefficient of the value B=Bm is designated by (Lm, Bm). In contrast to the foregoing, Bm=0 is now also explicitly admitted. It is true that the two-dimensional diversity of events (Lm, Bm) occurring in practice is finite, because arbitrarily large values of coefficients do not occur, but it is very large. Consequently, the Huffman codewords to be used are correspondingly large as regards number and length. To reduce the overall number of the events to be coded the starting point is that, for example a run of 19 zeros with subsequent coefficient of the value 7 can be split up into sections, the first of which represents a run of 16 zeros, the second of which represents a run of 3 zeros and the third of which is a run without a zero and subsequent coefficient of the value 7. Each of these sections is now considered as a sub-event which is coded by a Huffman codeword. The length of each section is below a given value which can be predetermined and which will be further dealt with below.

This split-up is illustrated in FIG. 2. In the horizontal direction all occurring values B—including the value 0—of the coefficients are shown. In the vertical direction the length—also starting at 0—of coefficient runs of the value 0 is shown. The "events Fields" shown symbolize the event (Lm, Bm) i.e. Lm zeros followed by a coefficient of the value Bm. The event (0, 3) for example, means that a coefficient of the value 3 is preceded by a run length 0 which means that there is no coefficient of the value 0 preceding. Isolated zeros in the signal are symbolized by the event (0, 0). The reference (3, Bm) refers inter alia to the event in which a coefficient of the value Bm is succeeded by three successive zeros. Since the value of zero is also admitted for Bm, the event (3, 0) means that there are four successive zeros.

FIG. 2 shows a polygonal curve in a solid line dividing the series fields into two ranges. The left-hand range comprises the events which are referred to as being codable and the right-hand range shows the events which are referred to as non-codable. The maximum length for a section of signal values—corresponding to a codable event—is 16; the events (0, 15), (1, 15) and (2, 15) are involved. All other codable events correspond to signal sections which are shorter. The division into codable and non-codable events is not completely arbitrary; the most frequently occurring event should be associated with the codable ones. The crossed non-codable event (8, 7) is split, for example, into the events (0, 7) and (7, 0). There are various possibilities for the split-up; the simplest is the indicated "projection on the event axes".

The numbers in the event fields which are associated with the codable events signify the length—hence the number of bits—of the Huffman codewords with which the events are coded. The codewords also comprise the signs of the coefficients and possibly data about the magnitude of the value B; none of them is longer than 16 bits. In setting up the Huffman codewords it was assumed that coefficients having values of more than 136 do not occur.

FIGS. 3 to 5 show the exact structure of the Huffman codewords used. The first codeword 11 represents the coded signal value for characterizing a block end; at the transmission it succeeds the last codeword which is associated with a coefficient block. The first column of these figures states consecutive numbers, the second column states the values B of the coefficients and the third states the lengths L of the zero runs. The two latter data combined result in the "coordinates" of a codable event according to FIG. 2. In the fourth column of FIGS. 3–5 the code words are shown bitwise. The bit s denotes the sign bit, the positions indicated by "—" are meaningless, and the positions indicated by "+" comprise the coded values of the coefficients in so

far as they are larger than eight. The last column once more states the length of the Huffman codewords.

A possibility of further reducing the bit rate results from the fact that—as in the present embodiment—the signal to be coded is structured in accordance with blocks. As already indicated, the coefficients of a coefficient block are separated from those of the next block by an "end-of-block" signal. Also this "end-of-block" signal is converted into a codeword (compare FIG. 3) while the sequence of m (codable) events of the type

(L1, B1) (L2, B2) . . . (Lm, Bm)	(1)

and into a sequence of assigned codewords. The number m of the events is dependent on the special values of the coefficients. If the overall coefficient block comprises, for example 63 zeros with subsequent coefficients of the value 1, it is split up into only one event, namely (63, 1) or into several codable events according to FIG. 2. As it is not known in advance into how many codable events a coefficient block is split, the separate blocks must for this reason already be separated from one another by means of an "end-of-block" signal. At the receiver end the transmitted Huffman codewords are retransformed into events and these events are again converted into a sequence of coefficients. The receiver knows that, for example, 64 coefficients are associated with a coefficient block.

For further explanation and for the sake of simplicity, it is assumed that 4×4 blocks are concerned, so that one block comprises a total of 16 coefficients. All data associated with a block are separated from the data of the subsequent block by an "end of block" sign. This sign and the corresponding codeword is excepted from the split-up of the signal to be coded in accordance with the events. If, for example the sequence of coefficients of a block in a decimal representation has the form of

XX 4005000050000001 XX, (2)

The block is split up according to scheme (1) into the following events.

(0, 4) (2, 5)(4, 5) (6, 1)	(3)

In order that the coefficient sequence of a block can at any rate be split into events in accordance with scheme (1) or (3) above, the coefficients are temporarily stored before they are further processed. The temporal sequence of the coefficients in scheme (2) and that of the events in schemes (1) and (3) corresponds to the sequence of their written registration (European writing direction assumed). The symbols XX in the embodiment according to scheme (2) symbolize the "end-of-block" signs of the previous block and the represented block.

The coefficients in scheme (2) which are different from 0 are all positive and are represented as integral multiples of the smallest unit, namely 1. As can be seen from scheme (3), the last event is the event (6, 1). The Huffman codewords assigned to the events are not indicated.

Firstly, the weight of reception of the last event, namely (6, 1) of the block according to (2) is checked for the receiver. In the coding of pictures general experience has proved that the transmission of events with a run of more than five zeros become less worthwhile as the value of the subsequent coefficient is smaller. If in accordance with the rule based on experience, checked events for which L=5 and B=1 are not transmitted, the transmission of the last event does not take place. In that case the preceding series (4, 5) is checked in accordance with the same criterion. In the example according to (2) the check for this block is ended because the event (4, 5) and the assigned Huffman codeword must be transmitted.

After decoding the Huffman codewords at the receiver end all coefficients of the block according to scheme (2) can be recovered, but for those which are associated with non-transmitted events. However, since these are associated with the last coefficients of the block, the decoded coefficients at the receiver end are augmented with coefficients of the value 0 until the overall number of coefficients is 16.

FIG. 6 shows a circuit arrangement realising a simple split-up of the sequence of coefficients in accordance with codable events. The supply of clock pulses and details of the logic operation of binary values are not shown because they are known to those skilled in the art. In the circuit arrangement according to FIG. 6 events are coded which consist of a run of coefficients of the value zero and a subsequent coefficient. If the run length L in the signal to be coded exceeds a predetermined length Lmax, the associated event cannot be encoded and is split into codable events. Due to the predetermined maximum length Lmax which is independent of the subsequent coefficient, no delays or intermediate storages of the coefficients are required.

The coefficients are serially applied from an input E via a multiple lead e to the address inputs of an addressable memory PROM and to a first input E1 of a comparator circuit K. The multiple lead e comprises as many wires as bits are required for the binary representation of a coefficient. A coding table is filed in the memory PROM.

The position of a counter Z is applied to a second input E2 of the comparator K—via a multiple lead f. The multiple lead f is simultaneously connected to further address inputs of the memory PROM.

It is assumed that a coefficient which is different from zero is present at the input E1. In this case the comparator circuit K supplies a pulse from an output A2, which pulse is applied via a lead a to the reset input R of the counter Z and to the clock input C2 of a flipflop circuit FF. The counter is reset to the zero position with this pulse and the codeword which is present at the output of the memory PROM is bit-parallel taken over in the flipflop circuit FF. The codeword can be derived from the output A of the circuit arrangement according to FIG. 6. The codewords present at output A are not the ultimate Huffman codewords because all of them have the same length. To convert codewords of the same length into codewords of unequal length, and conversely—the latter conversion is required at the receiver end—reference is made to patent applications DE 35 10 902, DE 35 10 901 and DE 36 32 682.

If a zero is present at the input E1, the comparator circuit K supplies a counting pulse from a further output A1 and applies it to the clock input C1 of the counter Z which increases it count by one unit. The comparator circuit K continuously compares the actual

counting with the value Lmax which is stored in one of its memories not shown. If the count reaches the value Lmax, the supply of a further counting pulse does not take place. Instead, the reset or transfer pulse is supplied from the output A2.

The complete coefficients—thus also their signs—are processed in the circuit arrangement according to FIG. 6. In a modification the signs of the coefficients are applied via a separate wire to the output A of the circuit arrangement and to accept them from a comparison by the comparator circuit K and from determining the codewords by the programmable memory PROM.

What is claimed is:

1. A circuit arrangement for coding a signal comprising a run of zero coefficients and a subsequent coefficient, wherein said coefficients are applied with predetermined delays to the address inputs of a memory (PROM) and to a first input (E1) of a comparator circuit (K), in that a counter (Z) is provided whose count is applied to further address inputs of the memory (PROM) and to a second input (E2) of the comparator circuit (K), in that the comparator circuit (K) supplies a counting pulse to the counter (Z) from a first output (A1) if a zero coefficient is present at the first input (E1) and if the count has not exceeded a value stored in a memory of the comparator circuit (K) supplies a pulse from a second output (A2) if the conditions for the supply of a counting pulse are not fulfilled, and in that the counter (Z) is reset by means of the pulse at the second output (A2) of the comparator circuit (K), and in that the codeword present at the outputs of the memory (PROM) is transferred to an intermediate memory (FF).

2. A circuit arrangement as claimed in claim 1, characterized in that only the values of the coefficients are applied to the address inputs of the memory (PROM) and the comparator circuit (K) and in that the sign bits of the coefficients are supplied through a separate wire to the output (A) of the circuit arrangement.

3. In a method of coding a signal comprising a sequence of coefficients which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate, said signal comprising a plurality of zero coefficients, and a plurality of non-zero coefficients said method comprising the steps of:

(a) deriving from said signal, a plurality of events each comprising a run of said zero-coefficients having a respective run length and preceded or followed by at least one non-zero coefficient, and

(b) for each of said events, determining said respective run length and assigning a code word to represent said non-zero coefficient and said run length.

4. The method of claim 3, wherein said code words are Huffman code words.

5. A method as claimed in claim 4, characterized in that a Huffman codeword is not transmitted if the length of the associated run of zero-coefficients exceeds a barrier which is dependent on the magnitude of the subsequent non-zero-coefficients.

6. A method as claimed in claim 4, characterized in that the signal comprises a sequence of coefficients which results after a blockwise transform of pixels of a video signal with subsequent quantisation and in that a checked Huffman codeword is not transmitted if the length of the associated zero run is larger than five and if the magnitude of the subsequent non-zero-coefficient has the smallest possible value different from zero.

7. A method as claimed in claim 4, characterized in that the Huffman codeword is independent of the sign of that non-zero coefficient which succeeds or precedes the run of zero-coefficients and in that the sign is coded by a separate bit.

8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:

(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;

(b) deriving from said sequence, a plurality of events each comprised of a run of zero coefficients having a respective run length, which is preceded or followed by at least one non-zero coefficient, and

(c) for each of said events, determining the run length and assigning a code word to represent said run length and said non-zero coefficient.

9. The method of claim 8, comprising the additional steps of:

determining for each event, whether the run length of said run of zero coefficients exceeds a predetermined length and if so assigning the same code word to represent each said run length and respective non-zero coefficient.

10. The method of claim 8, comprising the additional steps of:

determining for each event, whether the non-zero coefficient exceeds a predetermined value and if so assigning the same code to represent said run length and said non-zero coefficient.

11. The method of claim 8, comprising the additional steps of:

determining whether the run length of each event exceeds a predetermined run length and if so, splitting said respective event into a plurality of sections so that each of said sections has a run length below said predetermined run length, and assigning a code word to each section.

12. An apparatus for coding a signal comprising a run of zero coefficients and a subsequent coefficient, said apparatus comprising:

(a) means for determining if the length of said run exceeds a predetermined length;

(b) splitting means coupled to said length determining means, for splitting a run which exceeds said predetermined length into a plurality of codable events; and

(c) coding means coupled to said splitting means for assigning a code word to represent each said codable event.

13. In a method of coding a signal comprising a sequence of coefficients which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate, said signal comprising a plurality of first coefficients having a signal value A and occurring in runs most frequently in said signal, and a plurality of second coefficients having values not equal to A, said method comprising the steps of:

(a) deriving from said signal, a plurality of events each comprising a run of said first coefficients having a respective run length, which is preceded or followed by at least one second coefficient, and

(b) for each of said events, determining said respective run lengths and assigning a code word to represent said second coefficient and said run length.

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