IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

U.S. PHILIPS CORPORATION,	)	**REDACTED PUBLIC VERSION**
Plaintiff,	)	Civil Action No. 06-251-GMS
v.	)	
EASTMAN KODAK COMPANY,	)	
Defendant.	)	

PLAINTIFF'S APPENDIX OF EXHIBITS
IN SUPPORT OF ITS MOTIONS *IN LIMINE*

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Dated: February 11, 2008
188128.1

EXHIBIT 1

REDACTED

EXHIBIT 2

REDACTED

EXHIBIT 3

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

U.S. PHILIPS CORPORATION, Plaintiff, v. EASTMAN KODAK COMPANY, Defendant.	Civil Action No. 06-251 (GMS)

EXHIBIT I 3b:

FINAL JURY INSTRUCTIONS [PATENT]

Plaintiff and Counterclaim Defendant U.S. Philips Corporation ("Philips") and Defendant and Counterclaim Plaintiff Eastman Kodak Company ("Kodak") submit the following proposed final jury instructions and objections as of February 7, 2008. The parties reserve the right to submit modifications to these instructions and/or additional instructions on any pertinent issue.

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Attorneys for Defendant

5.2 FRAUD

Kodak alleges that Philips committed fraud, causing damage to Kodak. To prove that Philips committed fraud, Kodak must prove, by a preponderance of the evidence, all five of the following elements:

1. Philips made a false representation of an important fact either by affirmative conduct or misleading silence. Silence alone will not give rise to fraud unless there was a duty to speak;

2. Philips knew or believed that this representation was false, or made it with reckless indifference to the truth;

3. Philips intended to induce Kodak to act on the false representation, or to decline to act;

4. Kodak acted, or declined to act, in justifiable reliance on the false representation; and

5. Kodak was damaged as a result of this reliance.

A fact is important if it would cause a reasonable person to decide to act in a particular way, or if the maker of the misrepresentation knew another person would regard it as important.

Fraud may occur if Philips deliberately concealed important facts, causing Kodak to rely on the deception to its detriment. This concealment can occur by a person's silence despite a duty to disclose the facts, or by some action taken to prevent Kodak from discovering the important facts.

If Kodak was aware of the true facts of the transaction, even if they were concealed by Philips, or if Kodak did not rely on the concealment of these facts, then there is no fraud.

Source: Adapted from Delaware Superior Court Instructions §§ 16.1, 16.3, 16.4.

5.3 NEGLIGENT MISREPRESENTATION

Kodak alleges that Philips committed negligent misrepresentation, causing damage to Kodak. To prove that Philips committed negligent representation, Kodak must prove, by a preponderance of the evidence, all four of the following elements:

1. Philips had a duty to provide certain information based on Kodak's financial interest in that information;

2. Philips supplied false or incomplete information;

3. Philips failed to exercise reasonable care in obtaining or communicating information; and

4. Kodak suffered a financial loss caused by justifiable reliance upon the false information.

Source: *Atwell v. Rhis, Inc.*, No. 02C-12-003WLW, 2006 WL 2686532, at *1 (Del. Super. Ct. Aug. 18, 2006); *H-M Wexford LLC v. Encorp, Inc.*, 832 A.2d 129, 147 n.44 (Del. Ch. 2003); *In re Medical Wind Down Holdings III, Inc.*, 332 B.R. 98, 102 (Bankr. D.Del. 2005).

5.4 DECEPTIVE TRADE PRACTICES

Kodak alleges that Philips engaged in deceptive trade practices in violation of Delaware's Deceptive Trade Practices Act. To prove that Philips violated Delaware's Deceptive Trade Practices Act, Kodak must prove, by a preponderance of the evidence, that:

1. Philips caused a likelihood of confusion or of misunderstanding as to the applicability of the '075 patent to Kodak's products that practice the JPEG standard by failing to disclose the '075 patent to the JPEG committees and failing to raise the patent with Kodak before 2002;

2. Philips caused a likelihood of confusion or of misunderstanding by attempting to enforce the '075 patent against Kodak's products that practice the JPEG Standard;

3. Philips disparaged the goods, services, or business of Kodak by false or misleading representation of fact; or

4. Philips engaged in any other conduct which similarly created a likelihood of confusion or of misunderstanding.

Source: 6 Del. C. § 2532(a)(2)-(a)(3), (a)(8), (a)(12); *Roberts v. Am. Warranty Corp.*, 514 A.2d 1132 (Del. Sup. Ct. 1986); *Draper Commc'ns, Inc. v. Delaware Valley Broadcasters Ltd. P'ship*, 505 A.2d 1283, 1290 (Del.Ch. 1985); *Copi of Delaware, Inc. v. Kelly*, No. 14529, 1996 WL 633302, at *7 (Del. Ch. Oct. 25, 1996).

6. DAMAGES

6.1 COMPENSATORY DAMAGES IN GENERAL

If you find that one or more of Kodak's products infringes at least one valid claim of the '075 patent, you must determine the amount of damages to be awarded to Philips for the infringement. By statute, the amount of those damages must be adequate to compensate Philips for the infringement, but in no event may it be less than a "reasonable royalty." Damages "adequate to compensate" means "full compensation for 'any damages' [Philips] suffered as a result of the infringement."

Source: Uniform Instructions § 6.1; *Telcordia*, 04-876-GMS (D.I. 343) § 6.1.

6.2 REASONABLE CERTAINTY

Philips bears the burden of proving patent infringement damages by a preponderance of the evidence and is entitled to all damages that can be proven with "reasonable certainty." You may base your evaluation of reasonable certainty on opinion evidence. The amount of damages must not be the result of mere speculation or guess-work. Philips, however, does not need to prove its damages with absolute certainty.

Source: Adapted from Uniform Instructions § 6.3.

6.3 ENTIRE MARKET VALUE RULE

Under the "entire market value" rule, a patent owner may recover damages based on the value of an entire apparatus or product containing several features, even though only one feature is patented, where the unpatented components function together with the patented components in some manner to produce a desired end product or result. A patent owner may also recover damages under the entire market value rule where the infringing component was the basis of customer demand for the product.

Source: Adapted from Uniform Instructions § 6.4; *Telcordia*, 04-876-GMS (D.I. 343) § 6.4.

6.4 REASONABLE ROYALTY AS A MEASURE OF DAMAGES

By statute, Philips is entitled to damages adequate to compensate for the infringement, but in no event less than a reasonable royalty for any infringing sales. A reasonable royalty is the amount of money that would be agreed to in a hypothetical arms-length negotiation between Philips and Kodak, assuming that both parties were willing to enter into a license and with both operating under the assumption that the patent is valid and is being infringed. While the date of the hypothetical negotiation is the date on which infringement began, all relevant business facts (even those after the date of the hypothetical negotiation) are deemed known to both parties.

In the hypothetical arms-length negotiation, you must assume that the person negotiating on behalf of Kodak, and who was willing to take a license, would have known that the '075 patent was valid and enforceable, and infringed by Kodak.

Source: 35 U.S.C. § 284; adapted from Uniform Instructions § 6.10; *Telcordia*, 04-876-GMS (D.I. 343) § 6.5.

6.5 FACTORS FOR DETERMINING REASONABLE ROYALTY

In determining a reasonable royalty, some of the factors that may be considered are:

1. the royalties received by the patentee for licensing others under the patent-in-suit;

2. the rates paid by the licensee for the use of other patents comparable to the patent-in-suit;

3. the nature and scope of the license, as exclusive or non-exclusive, or as restricted or unrestricted in terms of territory or with respect to whom the manufactured product may be sold;

4. the licensor's established policy and marketing program to maintain his patent exclusivity by not licensing others to use the invention or by granting licenses under special conditions designed to preserve that exclusivity;

5. the commercial relationship between the licensor and licensee, such as, whether they are competitors in the same territory in the same line of business, or whether they are inventors or promoters;

6. the effect of selling the patented specialty in promoting sales of other products of the licensee, the existing value of the invention to the licensor as a generator of sales of his non-patented items, and the extent of such derivative or convoyed sales;

7. the duration of the patent and the term of the licenses;

8. the established profitability of the product made under the patent, its commercial success, and its current popularity;

9. the utility and advantages of the patent property over the old modes or devices, if any, that had been used for working out similar results;

10. the nature of the patented invention, the character of the commercial embodiment of it as owned and produced by the licensor, and the benefits to those who have used the invention;

11. the extent to which the infringer has made use of the invention, and any evidence probative of the value of that use;

12. the portion of the profit or of the selling price that may be customary in the particular business or in comparable businesses to allow for the use of the invention or analogous inventions;

13. the portion of the realizable profit that should be credited to the invention as distinguished from non-patented elements, the manufacturing process, business risks, or significant features or improvements added by the infringer;

14. the opinion testimony of qualified experts; and

15. any other economic factor that a normally prudent businessman would, under similar circumstances, take into consideration in negotiating the hypothetical license.

Source: Uniform Instructions § 6.11; *Telcordia*, 04-876-GMS (D.I. 343) § 6.6.

EXHIBIT 4

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

U.S. PHILIPS CORPORATION, Plaintiff, v. EASTMAN KODAK COMPANY, Defendant.	Civil Action No. 06-251 (GMS)

EXHIBIT I4:
DEFENDANT EASTMAN KODAK COMPANY'S PROPOSED VERDICT FORM

Defendant and Counterclaim Plaintiff Eastman Kodak Company ("Kodak") hereby submits its proposed verdict form as of February 7, 2008. Kodak reserves the right to submit revisions to its Proposed Verdict Form after meeting and conferring with Plaintiff U.S. Philips Corporation ("Philips") on outstanding trial management issues, after receiving the Court's rulings on the parties' respective motions *in limine*, and as necessary to conform to the evidence presented at trial and the rulings of the Court.

EXCERPTS

FRAUD

Question No. 6(a):

Do you find that Kodak has proven, by a preponderance of the evidence, that Philips has committed fraud?

Answer "Yes" or "No".

Yes (For Kodak)	No (For Philips)

Question No. 6(b):

If you have answered "Yes" to Question 6(a), please identify the amount of monetary damages that will compensate Kodak for Philips' conduct.

$_____

NEGLIGENT MISREPRESENTATION

Question No. 7(a):

Do you find that Kodak has proven, by a preponderance of the evidence, that Philips has committed negligent misrepresentation?

Answer "Yes" or "No".

Yes (For Kodak)	No (For Philips)

Question No. 7(b):

If you have answered "Yes" to Question 7(a), please identify the amount of monetary damages that will compensate Kodak for Philips' conduct.

$_____

DECEPTIVE TRADE PRACTICES

Question No. 8:

Do you find that Kodak has proven, by a preponderance of the evidence, that Philips has engaged in deceptive trade practices in violation of Delaware's Deceptive Trade Practices Act?

Answer "Yes" or "No".

Yes (For Kodak)	No (For Philips)

EQUITABLE ESTOPPPEL

Question No. 9:

Do you find that Kodak has proven, by a preponderance of the evidence, that Philips' U.S. Patent No. 4,901,075 is unenforceable against Kodak due to equitable estoppel?

Answer "Yes" or "No".

Yes (For Kodak)	No (For Philips)

EXHIBIT 5

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Ex Parte Reexamination Filing Data - December 31, 2007

1. Total requests filed since start of ex parte reexam on 07/01/81 ..... 9060[1]

a. By patent owner	3495	39%
b. By other member of public	5400	59%
c. By order of Commissioner	165	2%

2. Number of filings by discipline

a. Chemical Operation	2703	30%
b. Electrical Operation	3023	33%
c. Mechanical Operation	3334	37%

3. Annual Ex Parte Reexam Filings

Fiscal Yr.	No.	Fiscal Yr.	No.	Fiscal Yr.	No.	Fiscal Yr.	No.
1981	78 (3 mos.)	1989	243	1997	376	2005	524
1982	187	1990	297	1998	350	2006	511
1983	186	1991	307	1999	385	2007	643
1984	189	1992	392	2000	318	2008	165
1985	230	1993	359	2001	296		
1986	232	1994	379	2002	272		
1987	240	1995	392	2003	392		
1988	268	1996	418	2004	441		

4. Number known to be in litigation 2398 26%

5. Determinations on requests 8714

a. No. granted ..... 7998 ..... 92%

(1) By examiner	7885
(2) By Director (on petition)	113

b. No. denied ..... 716 ..... 8%

(1) By examiner	681
(2) Order vacated	35

[1]Of the requests received in FY 2008, 23 requests have not yet been accorded a filing date, and preprocessing of 3 requests was terminated for failure to comply with the requirements of 37 CFR 1.510. See Clarification of Filing Date Requirements for *Ex Parte* and *Inter Partes* Reexamination Proceedings, Final Rule, 71 Fed. Reg. 44219 (August 4, 2006).

6. Total examiner denials (includes denials reversed by Director) 794

a. Patent owner requester	439	55%
b. Third party requester	355	45%

7. Overall reexamination pendency (Filing date to certificate issue date)

a. Average pendency	24.0 (mos.)
b. Median pendency	18.6 (mos.)

8. Reexam certificate claim analysis:

	Owner Requester	3rd Party Requester	Comm'r Initiated	Overall
a. All claims confirmed	23%	29%	12%	26%
b. All claims cancelled	7%	12%	21%	10%
c. Claims changes	70%	59%	67%	64%

9. Total ex parte reexamination certificates issued (1981 - present) 6066

a. Certificates with all claims confirmed	1556	26%
b. Certificates with all claims canceled	636	10%
c. Certificates with claims changes	3874	64%

10. Reexam claim analysis - requester is patent owner or 3rd party; or Comm'r initiated.

a. Certificates - PATENT OWNER REQUESTER 2607

(1) All claims confirmed	592	23%
(2) All claims canceled	194	7%
(3) Claim changes	1821	70%

b. Certificates - 3rd PARTY REQUESTER 3313

(1) All claims confirmed	946	29%
(2) All claims canceled	413	12%
(3) Claim changes	1954	59%

c. Certificates - COMM'R INITIATED REEXAM 146

(1) All claims confirmed	18	12%
(2) All claims canceled	30	21%
(3) Claim changes	98	67%

EXHIBIT 6

United States Court of Appeals for the Federal Circuit

Median Time to Disposition in Cases Terminated After Hearing or Submission[1]

Docketing Date[2] to Disposition Date, in Months
FY 1999 - FY 2007

	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	Overall Median per Origin
District Court	11.7	12.8	13.3	12.3	11.3	11.7	11.6	11.5	11.6	11.9
Court of Federal Claims	10.6	11.4	12.0	11.4	9.8	11.0	11.2	10.0	10.0	11.0
Court of International Trade	12.6	13.1	14.5	14.7	11.2	12.0	11.5	11.7	11.9	12.4
Court of Appeals Veterans Claims	9.1	10.6	11.3	12.9	10.6	10.0	9.9	8.4	8.4	10.1
Board of Contract Appeals	12.1	13.1	12.0	11.3	12.6	9.7	10.5	11.7	10.4	11.6
Department of Veterans Affairs	n/a	15.0	19.9	11.1	13.8	n/a	14.4	13.7	11.3	14.3
International Trade Commission	11.9	24.3	6.8	n/a	17.1	16.0	16.4	15.6	13.6	15.4
Merit Systems Protection Board	6.6	7.2	7.5	7.2	7.6	6.9	7.5	6.5	6.4	7.0
Office of Compliance	12.5	7.2	10.2	n/a	19.6	10.1	13.3	14.0	n/a	13.2
Patent and Trademark Office	9.3	10.0	10.6	10.7	9.5	9.6	10.3	10.0	9.6	9.9
Overall Median per Fiscal Year	9.8	10.1	11.2	10.5	9.6	10.0	9.9	9.3	9.1	

[1] Excludes cross and consolidated appeals, writs, and OPM petitions
[2] Calculated from Date of Docketing or Date of Reinstatement, whichever is later

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EXHIBIT 7

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

U.S. PHILIPS CORPORATION, Plaintiff, v. EASTMAN KODAK COMPANY, Defendant.	Civil Action No. 06-251 (GMS)

EXHIBIT C2:
EASTMAN KODAK COMPANY'S TRIAL EXHIBIT LIST

Defendant and Counterclaim Plaintiff Eastman Kodak Company ("Kodak") hereby submits its trial exhibit list as of February 7, 2008. Kodak reserves the right to submit, as appropriate, additions and/or revisions to its list as the pre-trial and trial process evolves, including meeting and conferring with Plaintiff U.S. Philips Corporation ("Philips") on outstanding trial management issues, outstanding discovery issues and receiving the Court's rulings on matters such as the parties respective motions *in limine*.

Kodak further reserves the right to object to any of Philips trial exhibits, per the parties' agreement on February 5, 2008.

Also included in Exhibit C2 is a proposed joint trial exhibit list. This list includes the exhibits on Philips' proposed trial exhibit list, submitted on January 28, 2008, which are also found on Kodak's trial exhibit list. Such exhibits are labeled with a new "JTX" number.

TRIAL EXHIBIT NO. (DTX)	DATE	DESCRIPTION	BEGINNING BATES NUMBER	END BATES NUMBER	SOURCE (DEPO EXHIBIT NO. OR EXPERT REPORT)	PHILIPS' TRIAL EX. NUMBER PX 000000
DTX668	11/01/1986	DRAFT: VTC-56B Coder Theory of Operation, Widcom, Inc.	WIDCOM 019167	WIDCOM 019225		
DTX669	11/01/1986	DRAFT: VTC-56 Output Processor Theory of Operation, Widcom, Inc.	WIDCOM 019226	WIDCOM 019237		
DTX670	09/10/1986	English translation with certification of German Invention Disclosure to Vogel patent [Bates stamped PH_PAN 0188335-PH_PAN 0188339]	TBD	TBD		
DTX671	06/05/2007	Court of the Hague – Dutch Judgement LG Electronics Benelux Sales v. Koninkljke Philips Electronics (2007)	KODAK_024195	KODAK_024204		
DTX672	06/05/2007	English translation with certification of Dutch Judgement LG Electronics Benelux Sales v Koninkljke Philips Electronics (2007) [Bates stamped KODAK_024195-KODAK_024204]	TBD	TBD		
DTX673	00/00/2006	Korean District Court Decision of Noninfringement for Koninklijke Philips Electronics N.V. v. LG Electronics	KODAK_024205	KODAK_024232		
DTX674	00/00/2006	English translation with certification of Korean District Court Decision of Noninfringement for Koninklijke Philips Electronics N.V. v. LG Electronics [Bates stamped KODAK_024205-KODAK_024232]	TBD	TBD		
DTX675	00/00/2006	Korean IPT Decision of Noninfringement in the case of LG Electronics v. Koninkijke Philips Electronics	KODAK_024233	KODAK_024271		
DTX676	00/00/2006	English translation with certification of Korean IPT Decision of Noninfringement in the case of LG Electronics v. Koninkijke Philips Electronics [Bates stamped KODAK_024233-KODAK_024271]	TBD	TBD		
DTX677	00/00/2006	Korean IPT Decision of Validity in the case of LG Electronics v. Koninkijke Philips Electronics	KODAK_024272	KODAK_024313		

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TRIAL EXHIBIT NO. (DTX)	DATE	DESCRIPTION	BEGINNING BATES NUMBER	END BATES NUMBER	SOURCE [DEPO EXHIBIT NO. OR EXPERT REPORT]	PHILIPS TRIAL EX. NUMBER PX 000000
DTX678	00/00/2006	English translation with certification of Korean IPT Decision of Validity in the case of LG Electronics v. Koninkijke Philips Electronics [Bates stamped KODAK_024272-KODAK_024313]	TBD	TBD		
DTX679	06/05/2007	German Nullity Decision in the case of LG Electronics and Kodak v. Philips Intellectual Property and Standards	KODAK_024314	KODAK_024342		
DTX680	06/05/2007	English translation with certification of German Nullity Decision in the case of LG Electronics and Kodak v. Philips Intellectual Property and Standards [Bates stamped KODAK_024314-KODAK_024342]	TBD	TBD		
DTX681	00/00/0000	CD of NBC Today Show	KODAK_011345	KODAK_011345		
DTX682	00/00/1992	Kodak Professional DCS – Specifications of Kodak Professional Digital Camera System	KODAK_438406	KODAK_438409		
DTX683	01/13/93	International Standard DIS 10918-1; CCITT Recommendation T.81; Digital Compression and Coding of Continuous-Tone Still Images; Table of Contents and Forward	PHLPSKD_00070211	PHLPSKD00070212		
DTX684		Annex L (informative)	PHLPSKD_00070409	PHLPSKD_00070410		
DTX685	05/23/2007	Tijdslijn – deelname Philips aan diverse JPEG-studiegroepen	PH_PAN 0259847	4 pages total (not bated)		
DTX686	04/00/1989	Patents Statement; JPEG 314	PHLPSKD_00037690			
DTX687	06/06/1989	Statement on CSELT patents relevant to the ADCT algorithm; JPEG 325	PHLPSKD_00037713			
DTX688	08/08/1989	Patent Statement; JPEG 334	PHLPSKD_00060101			
DTX689	02/08/1993	Patent Statement from Electronic Imagery	PHLPSKD_00060502			
DTX690	04/12/1992	ISO/IEC DIS 11172; Coding of Moving Pictures and Associated Audio (MPEG); MPEG93/193	PHLPSKD_00046969			

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EXHIBIT 8

REDACTED

EXHIBIT 9

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

EXPERT REPORT OF DR. TOURADJ EBRAHIMI FOR U.S. PATENT NO. 4,901,075 ON INVALIDITY

I. INTRODUCTION

1. I submit this Expert Report in this case on issues relating to invalidity of U.S. Patent No. 4,901,075 (the "'075 Patent") being asserted by U.S. Philips Corporation ("Philips") against Eastman Kodak Company ("Kodak"). I reserve the right to supplement or modify this Expert Report as necessary or appropriate and in response to any expert reports served by Philips.

2. I have been retained by DLA Piper as an expert in this case as to the '075 Patent. No part of my compensation is dependent upon the outcome of this case or any issue in it.

3. I am being compensated at my usual rate of $300 per hour for work on this case.

4. This expert report contains eight sections, including this Introduction. The additional parts are: Qualifications (Part II), List of Materials Reviewed (Part III), Legal Basis for Opinion (Part IV), Background of Technology (Part V), Claim Construction (Part VI), Invalidity (Part VII) and Conclusion (Part VIII).

II. QUALIFICATIONS

5. A copy of my current curriculum vitae ("CV") is attached as Exhibit 1.

6. I am a Professor of Image Processing at the Swiss Federal Institute of Technology (EPFL), in Lausanne, Switzerland, involved in teaching and research in the field of Multimedia Signal Processing. Before joining EPFL as a faculty member in 1994, I was with AT&T Bell Laboratories Research Center in Holmdel, NJ, USA, where I worked on video compression techniques for communication. Prior to that, I was with Sony Corporation in Tokyo, Japan, working at its Corporate Research Center in the area of image and video compression for storage applications.

7. I hold a Masters of Science Degree from EPFL in Electrical Engineering with specialization in Image Processing, and a PhD from the same University on Video Compression.

8. During my career I have been closely involved in various projects on image and video compression including many related to standardization. I am the Head of the Swiss Delegation to JPEG, MPEG and SC29 which is the body overseeing the work of these two standards. I have been and continue to be the chair of various technical subgroups within the JPEG and MPEG standardization committees, including chairman of requirements in JPEG, editor of the secure JPEG 2000 standard, and editor of the MPEG-4 video standard. I also chaired the joint Ad Hoc Group between ISO/IEC and ITU-T experts in charge of examining proposals for inclusion of new Amendments to JPEG image compression standard.

9. I have received several awards and distinctions in the area of image and video compression standardization. Examples include four ISO certificates for outstanding contributions to JPEG 2000, Secure JPEG 2000, JPEG 2000 reference software, and the MPEG-4 video standard. I have received the first prize for best publication of the IEEE Transactions on Consumer Electronics in 2000 for a paper describing the JPEG 2000 standard. I have been author or co-author of more than 150 publications (books, book chapters, journal papers, conference proceedings), and hold several patents.

10. I regularly teach courses at graduate levels in European Universities (Switzerland, France, and Italy) on image and video compression which include detailed description of the JPEG compression standard.

III. MATERIALS RELIED UPON

11. A list of the materials I relied upon is contained on Appendix A to this Report.

IV. LEGAL BASIS FOR OPINION

A. The Asserted Claims.

12. I understand that the following claims of the '075 Patent are asserted in this litigation: 3-4, 7-8 and 11.

B. Invention Date/Priority Date

13. I have been informed by counsel for Kodak that the invention date of a patent is the date of conception of the invention. I understand that conception is the mental part of the inventive act, but is more than a mere vague idea of how to solve a problem. The means for solving the problem and their interaction must be comprehended also.

14. Counsel for Kodak has additionally informed me that the date for determining priority of invention over an alleged prior art reference (the priority date) is the earliest of one of three dates:

a) the date of actual reduction to practice of the invention prior to the effective date of the reference; or

b) the date of conception of the invention coupled with due diligence from a date prior to the reference date to a subsequent actual reduction to practice; or

c) the date of conception of the invention coupled with due diligence from prior to the reference date to the filing date of the application (also known as constructive reduction to practice).

15. Counsel for Kodak has additionally informed me that the date of actual reduction to practice is the date that the invention existed and worked for its intended purpose.

C. Anticipation

16. I have been informed by counsel for Kodak that a patent claim may be invalid under 35 U.S.C. §102 if prior art anticipates the claim. I further understand that for anticipation, every element in a claim must be identically shown in a single reference and arranged as in the claim in order for that reference to anticipate the claim.

1. 35 U.S.C. §102(a)

17. Counsel for Kodak has informed me that a patent is invalid under 35 U.S.C. §102(a) if the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent.

18. Counsel for Kodak has additionally informed me that a patent or printed publication reference qualifies as prior art under 35 U.S.C. §102(a) if it has a publication date that predates the priority date of the invention.

2. 35 U.S.C. §102(b)

19. Counsel for Kodak has informed me that a patent is invalid under 35 U.S.C. §102(b) if the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States.

20. Counsel for Kodak has additionally informed me that a patent or printed publication reference qualifies as prior art under 35 U.S.C. §102(b) if it has a publication date that is more than one year before filing of the application for patent.

3. 35 U.S.C. §102(e)

21. Counsel for Kodak has informed me that a patent is invalid under 35 U.S.C. §102(e) if the invention was described in: (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for the purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

22. Counsel for Kodak has additionally informed me that a U.S. Patent qualifies as prior art under 35 U.S.C. §102(e) if it has an effective filing date that predates the priority date of the invention.

D. Obviousness

23. Counsel for Kodak has informed me that a patent claim is invalid when the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. I have further been informed that the inquiry as to whether a patent claim is obvious includes the steps of determining the scope and content of the prior art; determining the differences between the prior art and the claims at issue; and determining the level of ordinary skill in the art. Against this background the obviousness or non-obviousness of the claim is determined.

24. I have also been informed by counsel for Kodak that a patent claim composed of several elements is not proved obvious merely by demonstrating that each element was,

independently, known in the prior art. This is because most, if not all, inventions will be combinations of known elements. A primary reference may not be modified in light of or combined with one or more secondary references where the result would be to render the primary reference inoperable for its intended purpose. Rather, the combination is likely to be obvious when it is the predictable use or variation of prior art elements according to their established functions. Stated another way, the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand that the prior art reference must be viewed without the benefit of hindsight reasoning.

E. Indefiniteness

25. Counsel for Kodak also has informed me that, under 35 U.S.C. § 112, patent claims must particularly point out and distinctly claim the subject matter which the applicant regards as his invention. Kodak's counsel has also informed me that this definiteness requirement does not compel absolute clarity, but that only claims not amenable to construction or insolubly ambiguous are indefinite. I further understand that the definiteness of claim terms depends on whether those terms can be given any reasonable meaning, and that claims are found indefinite only if reasonable efforts at claim construction prove futile.

V. BACKGROUND OF TECHNOLOGY

A. Digital Images and Compression

26. Digital images are produced as the result of a sampling and quantization process applied to an analog signal (picture). In their canonical form, digital images are often represented by one or three matrices whose elements contain the luminance or the three color components values of the quantized samples of the image also referred to as pixels. The

canonical form (also known as raw format) of a digital image typically generates very large files in size when compared to other digital files containing text, speech or audio.

27. Even though the size of available memory and the bandwidth of communication channels have not ceased to increase, and continue to do so, most consumer and professional applications cannot be deployed in a cost effective way unless compression is applied. Thanks to image compression, digital images have become part of everyday life, on the Internet, in Digital Still Cameras, and in Multimedia enabled Mobile Phones, to mention a few examples.

28. Image compression algorithms, as a special case of multimedia data compression, can be divided into two main processing blocks. The first processing block consists in building the messages to be coded which represent the multimedia signal. In the case of an image, the message can be the value of the color of a pixel, the pattern representing exactly or approximately a collection of pixels, or any other appropriate representation of an image. The result of the first processing block (the message) is then input to a second processing block where based on different considerations, such as statistical characteristics of the messages generated by the signal seen as a source, codewords are assigned to each message or a collection of messages.

29. Depending on the choice of the method to build the message in the first processing block, there are two main approaches for digital image compression, namely, predictive coding, and transform coding. In predictive coding, the value of an image pixel is predicted from past pixels, and only the error of such a prediction is considered as the message. Several variants of predictive coding can be distinguished depending on the way the prediction is performed, and on the method used to represent the prediction error. Transform based coding first transforms the pixel values from their original spatial domain into an abstract space in which

their energy is concentrated on a smaller number of non-zero coefficients. These coefficients are then quantized and eventually reordered in order to create the messages. Here too, several variants can be distinguished depending on the type of the transform performed, the method used for quantization, the method of re-ordering of coefficients, etc. Since the 1960s where the first operational digital image coding schemes were put forward, literally hundreds of digital image compression algorithms have been reported in the literature. Among those include the "Scene Adaptive Coder" by Pratt and Chen, published in 1984 which is also referred to in the Vogel patent. According to this approach, the digital image to be compressed is divided into blocks of size 16x16 pixels to which a 2D Discrete Cosine Transform (DCT) is applied. The resulting coefficients are then quantized and reorganized in a zig-zag scan. The message to be coded then becomes runs of consecutive zero valued coefficients, and the amplitude of non-zero coefficients.

30. An important issue in any data compression and in particular in image compression schemes is the methodology used for the bit assignment in the second processing block. The purpose of the bit assignment is to produce a uniquely decodable, and preferably an as compact as possible sequence of binary data (1 and 0) also called a bitstream, representing the encoded messages and therefore the compressed digital image. One important class of bit assignment techniques is entropy coding. The idea behind entropy coding is to assign shorter codewords (in number of bits) to messages that occur more often. In 1952, Huffman proposed a method to build minimum redundancy codes which produce optimal results in terms of compression if messages to which bits are to be assigned are independent, if each message is assigned to an integer number of bits, and if their frequency (probability) of occurrence is known. Since then, Huffman codewords have been widely used in data compression.

31. At this point, it is important to mention a few observations regarding Huffman codewords. As said above, Huffman codewords rely on statistical characteristics of the messages produced by the signal to be coded. There are two ways in which such statistics can be generated, namely, by off-line, or by on-line methods. In off-line methods, the statistics (probabilities) of the messages of the signal to be coded are estimated from a set of signals similar to the signal to be coded. A Huffman table is then built off-line based on such statistics where shorter codewords are assigned to more frequent messages. The Huffman codewords used to compress a signal is therefore based on statistics of other signals as opposed to those of the signal to be coded. The compression efficiency of such a Huffman coding will depend on how closely the statistics of the signals used to generate the Huffman codewords match those of the signal to be coded. To improve this, in on-line methods, care is taken to use the statistics of the signal to be coded in order to generate the Huffman codewords. For example, in a first pass, the statistics of messages of the signal to be coded are gathered. Based on these statistics, Huffman codewords are generated, and then used to code the signal during a second pass. The Huffman table containing the codewords of messages extracted from the signal is also included into the compressed bitstream.

32. A number of other practical considerations have to be taken into account when using Huffman codewords. On the one hand, the less frequently a message occurs in a signal, the more difficult it is to accurately estimate the probability of such an occurrence. Fortunately, this is not a serious drawback because such rare messages occur less frequently, and therefore their impact on the overall compression efficiency is limited. On the other hand, for a large population of messages (which is often the case in image compression), the less frequent messages tend to receive very long codewords which makes their implementation less practical. Based on the

above two observations, variants of Huffman codewords have been frequently used in which only Huffman codewords are produced for most frequent messages. For less frequent messages, an escape code is designed to signal that a rare message is expected. Other suboptimal bit assignment approaches are then applied to such rare messages.

B. The '075 Patent

33. The '075 patent is entitled "Method and apparatus for bit rate reduction" and defines a method for compression of digital images by transform coding. The core of the method is based on the work of Pratt and Chen in their paper entitled "Scene Adaptive Coder", published in 1984, also referred to by the inventor.

34. The major difference between the '075 Patent and the Scene Adaptive Coder is as follows. In the Scene Adaptive Coder, after quantization and zig-zag scan of transformed coefficients, the message is defined to be either the runs of consecutive zero valued coefficients or the amplitude of a non-zero coefficient. The Vogel patent instead defines the runs of consecutive zero valued coefficients together with the amplitude of the next or the previous non-zero coefficient as the message to be coded. This is justified by the fact that, based on experiments carried out, it has been observed that the probability of such a combined message is smaller than the product of the probability of the corresponding zero run multiplied by the probability of the corresponding non-zero amplitude. This means that there exists a statistical dependency between the run of zero coefficients and the amplitude of the non-zero coefficient that follows or precedes such a run. It is a known fact that in situations when there are statistical dependencies between two messages, Huffman coding of a message defined as the combination of two statistically dependent messages produces higher compression efficiency when compared to independent Huffman coding of each message separately, as was proposed in the Scene

Adaptive Coder by Chen and Pratt. Hence, Vogel proposes a single Huffman coding of zero-runs and the previous or the following non-zero amplitude coefficients, by proposing a 2D-VLC table containing the appropriate codewords of combinations of runs and the following (or the preceding) non-zero amplitude based on the statistics of the signal to be coded (see claim 3 of the Vogel patent). The Vogel patent reports gains of 12% when compared to Chen and Pratt.

35. For practical reasons, the Vogel patent also proposes various escape codes in order to reduce the number of messages that are Huffman coded by breaking them into smaller events which are signaled using appropriate and well known mechanisms.

VI. CLAIM CONSTRUCTION

36. I have reviewed the claim construction positions of Kodak. I agree with them because Kodak's claim construction positions are consistent with the way in which a person of ordinary skill in the relevant art would interpret the claims of the '075 Patent.

37. After reading the '075 patent and its prosecution history, it is my opinion that a person of ordinary skill in the art in the 1986-1987 time frame would have been an engineer having a masters degree in electrical engineering plus at least two years of experience in the field of digital signal compression.

38. My analysis of the prior art based on Kodak's claim construction positions are set forth below.

39. I have also reviewed the claim construction positions of Philips. I do not agree with their claim construction positions. However, for completeness, I have analyzed the prior art under Philips' claim constructions and, where appropriate because my opinion is different under Philips' claim constructions, I have provided a separate analysis of that prior art based on Philips' claim constructions.

VII. INVALIDITY

A. Anticipatory Prior Art Under Kodak's Constructions

40. It is my opinion that the prior art listed in this section below anticipates one or more of the Asserted Claims under Kodak's claim constructions for the reasons set forth below.

1. Widcom VTC-56

41. It is my opinion that the Widcom VTC-56 codec anticipates claims 3-4 and 7-8 of the '075 Patent. The details of my analysis of the Widcom VTC-56 codec under Kodak's constructions are set forth in Appendix B, Exhibit 1.

2. U.S. Patent No. 4,698,672 to Chen et al.

42. It is my opinion that U.S. Patent No. 4,698,672 to Chen et al. anticipates claims 3-4 and 7-8 of the '075 Patent. The details of my analysis of U.S. Patent No. 4,698,672 to Chen et al. under Kodak's constructions are set forth in Appendix B, Exhibit 2.

3. "Block Coding Using a Two-Dimensional Run-Length Table" Paper published to the COST 211bis Simulation Subgroup

43. It is my opinion that the "Block Coding Using a Two-Dimensional Run-Length Table" Paper anticipates claims 3-4 and 7-8 of the '075 Patent. The details of my analysis of the "Block Coding Using a Two-Dimensional Run-Length Table" Paper under Kodak's constructions are set forth in Appendix B, Exhibit 3.

B. Anticipatory Prior Art Under Philips' Constructions

44. It is my opinion that the prior art listed in this section below anticipates one or more of the Asserted Claims under Philips' claim constructions for the reasons set forth below.

1. Widcom VTC-56

45. It is my opinion that the Widcom VTC-56 codec anticipates claims 3-4 and 7-8 of the '075 Patent under Philips' constructions for the same reasons as set forth in Appendix B, Exhibit 1 above.

2. U.S. Patent No. 4,698,672 to Chen et al.

46. It is my opinion that U.S. Patent No. 4,698,672 to Chen et al. anticipates claims 3-4 and 7-8 of the '075 Patent under Philips' constructions for the same reasons as set forth in Appendix B, Exhibit 2 above.

3. "Block Coding Using a Two-Dimensional Run-Length Table" Paper published to the COST 211bis Simulation Subgroup

47. It is my opinion that the "Block Coding Using a Two-Dimensional Run-Length Table" Paper anticipates claims 3-4 and 7-8 of the '075 Patent under Philips' constructions for the same reasons as set forth in Appendix B, Exhibit 3 above.

C. Obviousness Prior Art Under Kodak's Constructions

48. It is my opinion that the prior art listed in this section below renders one or more of the Asserted Claims unpatentable under Kodak's claim constructions for the reasons set forth below.

1. U.S. Patent No. 3,984,833 Van Voorhis in view of Chen Article

49. It is my opinion that claims 3, 4 and 8 of the '075 Patent are unpatentable over U.S. Patent No. 3,984,833 to van Voorhis in view of the Chen Article. The details of my analysis of U.S. Patent No. 3,984,833 to van Voorhis in view of the Chen Article under Kodak's constructions are set forth in Appendix C, Exhibit 1.

2. U.S. Patent No. 4,420,771 to Pirsch in View of the Chen Article

50. It is my opinion that claims 3, 4 and 8 of the '075 Patent are unpatentable over U.S. Patent No. 4,420,771 to Pirsch in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,420,771 to Pirsch under Kodak's constructions are set forth in Appendix C, Exhibit 2.

3. U.S. Patent No. 4,316,222 to Subramaniam in view of Chen Article

51. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,316,222 to Subramaniam in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,316,222 to Subramaniam in view of the Chen Article under Kodak's constructions are set forth in Appendix C, Exhibit 3.

4. U.S. Patent No. 4,363,036 to Subramaniam in view of Chen Article

52. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,363,036 to Subramaniam in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,363,036 to Subramaniam in view of the Chen Article under Kodak's constructions are set forth in Appendix C, Exhibit 4.

5. U.S. Patent No. 4,092,676 to Saran in view of Chen Article

53. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,092,676 to Saran in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,092,676 to Saran in view of the Chen Article under Kodak's constructions are set forth in Appendix C, Exhibit 5.

6. U.S. Patent No. 4,136,363 to Saran in view of Chen Article

54. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,136,363 to Saran in view of the Chen Article. The details of my analysis of

U.S. Patent No. 4,136,363 to Saran in view of the Chen Article under Kodak's constructions are set forth in Appendix C, Exhibit 6.

7. U.S. Patent No. 4,494,151 to Liao in view of Chen Article

55. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,494,151 to Liao in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,494,151 to Liao in view of the Chen Article under Kodak's constructions are set forth in Appendix C, Exhibit 7.

8. "Upper Bound, Lower Bound and Run-Length Substitution Coding" Article by Henry Liao in view of Chen Article

56. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over Liao Article in view of the Chen Article. The details of my analysis of the Liao Article in view of the Chen Article under Kodak's constructions are set forth in Appendix C, Exhibit 8.

D. Obviousness Prior Art Under Philips' Constructions

57. It is my opinion that the prior art listed in this section below renders one or more of the Asserted Claims unpatentable under Philips' claim constructions for the reasons set forth below.

1. U.S. Patent No. 3,984,833 Van Voorhis in view of Chen Article

58. It is my opinion that claims 3-4 and 8 of the '075 Patent are unpatentable over U.S. Patent No. 3,984,833 to van Voorhis in view of the Chen Article. The details of my analysis of U.S. Patent No. 3,984,833 to van Voorhis in view of the Chen Article under Philips' constructions are set forth in Appendix C, Exhibit 9.

2. U.S. Patent No. 4,420,771 to Pirsch in View of the Chen Article

59. It is my opinion that claims 3, 4 and 8 of the '075 Patent are unpatentable over U.S. Patent No. 4,420,771 to Pirsch in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,420,771 to Pirsch under Philips' constructions are set forth in Appendix C, Exhibit 10.

3. U.S. Patent No. 4,316,222 to Subramaniam in view of Chen Article

60. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,316,222 to Subramaniam in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,316,222 to Subramaniam in view of the Chen Article under Philips' constructions are the same as set forth in Appendix C, Exhibit 3.

4. U.S. Patent No. 4,363,036 to Subramaniam in view of Chen Article

61. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,363,036 to Subramaniam in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,363,036 to Subramaniam in view of the Chen Article under Philips' constructions are set forth in Appendix C, Exhibit 11.

5. U.S. Patent No. 4,092,676 to Saran in view of Chen Article

62. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,092,676 to Saran in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,092,676 to Saran in view of the Chen Article under Philips' constructions are set forth in Appendix C, Exhibit 12.

6. U.S. Patent No. 4,136,363 to Saran in view of Chen Article

63. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,136,363 to Saran in view of the Chen Article. The details of my analysis of

U.S. Patent No. 4,136,363 to Saran in view of the Chen Article under Philips' constructions are set forth in Appendix C, Exhibit 13.

7. U.S. Patent No. 4,494,151 to Liao in view of Chen Article

64. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over U.S. Patent No. 4,494,151 to Liao in view of the Chen Article. The details of my analysis of U.S. Patent No. 4,494,151 to Liao in view of the Chen Article under Philips' constructions are set forth in Appendix C, Exhibit 14.

8. "Upper Bound, Lower Bound and Run-Length Substitution Coding" Article by Henry Liao in view of Chen Article

65. It is my opinion that claims 3-4, 8 and 11 of the '075 Patent are unpatentable over Liao Article in view of the Chen Article. The details of my analysis of the Liao Article in view of the Chen Article under Philips' constructions are set forth in Appendix C, Exhibit 15.

E. Indefinitness under 35 USC 112, second paragraph of Terms "For Transmission at a Reduced Bit Rate" and "For Transmission at a Reduced Bandwidth" (Claims 3 and 8)

66. The preambles of claim 3 and claim 8 include claim elements that are ambiguous and would not have been understood by those skilled in the art because there are no disclosures within the '075 patent or its prosecution history to determine what is meant by the phrases "reduced bit rate" and " reduced bandwidth." Alternately, these phrases might be construed relative to the encoding method of the Chen 1984 article against which the claimed encoding method purportedly provides a 12% reduction.

1. Both Claim Phrases Should be Found Indefinite

67. Neither the patent nor the file history provide the person of ordinary skill in the art with information sufficient to determine whether the claimed coding method provides for transmission at a reduced " bit rate" or " bandwidth."

68. "Reduced" is a relative term: this reduction must be in comparison to a reference value. "Transmission" and "bit rate," in the context of the '075 patent's video signal, refer to the transfer speed of data per unit of time, that is, how fast the bits of encoded video data are transferred in a given time interval. An analogy might be that a small pipe lets a given amount of water flow (transmits water) per unit second and a pipe that is twice as large lets twice as much water flow over the same time period. Applying this to transmission of information, in 1986, a 1200 bps modem could transfer data at 1200 bits per second over a telephone line. By contrast, in 1986, a 2400 bps modem could transfer twice as many bits per second, over the same telephone line.

69. In order to determine what " for transmission at a reduced bit rate" means in the context of the '075 patent, the person of ordinary skill in the art must be able to perform a comparison between the transmitted bit rate of the alleged invention and the transmitted bit rate of the system that is accused of infringement. But if the person of ordinary skill does not know the transmission channels that are used by both methods, a reduced bit rate (i.e., a slower speed) can be shown simply by using a slower type of transmission channel (or hardware). For example, the '075 patent claims to improve the bit rate over the Chen method by 12%. If a video signal encoded by the Chen method is transmitted using a 2400 bps modem and the same video signal is encoded using the '075 patent method and transmitted using the 1200 bps modem, the '075 patent method will transmit the video signal at a reduced bit rate, regardless of the reduction

attributable to the claimed coding method. In other words, the signal transferred over the 1200 bps modem will be " transmitted at a reduced bit rate." But, the claimed invention should not be covering admitted prior art. The scope of the claim should cover coding methods that " improve" over Chen, and without additional detail, not disclosed in the patent, this comparison cannot be made.

70. A person of ordinary skill would know that determining " transmission at a reduced bit rate" requires knowing information that is not disclosed anywhere in the patent. For example, in order to determine the bit rate being compared against, it requires knowing the transmission rate of the equipment, the transmission rate of the medium (wires, atmosphere, telephone lines, etc.) and how the signals are packaged (modulated) for transmission. In other words, to determine if an accused device is transmitting at a reduced bit rate, the accused device must be compared to a transmission bit rate recited in the claim. There must be a "reference" to compare against, in order to determine if the transfer rate of the claimed coding method is reduced.

71. Because there is no disclosure of a reference coding bit rate, and further because there is no disclosure of the transmitted bit rate produced by the claimed method, it would not have been possible for a person of ordinary skill to determine if the claimed coding method produced a transmission that offered " a reduced bit rate."

72. There is a similar lack of disclosure problem for "bandwidth" as there is for "bit rate." "Bandwidth" is the actual space in a frequency spectrum through which data is sent. The frequency spectrum used for all communications are partitioned into smaller portions which are assigned to each different type of communication (e.g. radio, TV, etc). Within each portion, for example in the TV portion, there are further divisions into smaller adjacent frequency ranges,

each range corresponding to a channel on a TV. The width of the frequency used to transmit one TV channel (i.e., one video signal) corresponds to that channel' s bandwidth.

73. For another example, AM radio has stations, each of which has a bandwidth. When you tune the radio to a particular radio station on the AM dial, you do this by selecting a number on the AM dial that corresponds to the middle of the segment (bandwidth) of the frequency range that AM station is transmitted on. That is, there is a portion of frequencies above and below that center point over which the signal is transmitted. The length (width) of this segment is the bandwidth used by that radio station.

74. In order to determine whether an accused system meets the limitation " for transmission at a reduced bandwidth," the person of ordinary skill in the art must know what size bandwidth qualifies as a " reduced bandwidth." Is a bandwidth reduced by a certain percentage ? Is a bandwidth reduced by a certain amount of frequency? The '075 patent is silent on this.

75. Because there is no disclosure of any bandwidths in the patent, there is no way to determine when a sufficient reduction in bandwidth is achieved. In fact, there is not even a disclosure of the bandwidth used by the claimed coding method. Nor would a person of ordinary skill in the art be able to determine the bandwidth used or the amount reduced after performing the claimed coding method of the '075 patent.

76. Moreover, the term " bandwidth" is never used in the patent, other than in claim 8. Accordingly there is no disclosure in the '075 patent sufficient to inform a person of ordinary skill how to effect a reduction in bandwidth using the claimed encoding method.

77. Therefore, based on the above, it is my opinion that claims 3 and 8 are invalid under 35 USC 112, second paragraph.

VIII. CONCLUSION

78. In my expert opinion, the Asserted Claims of the '075 Patent are invalid because the Asserted Claims are anticipated by a piece of prior art, unpatentable over a piece of prior art or a combination of prior art or are indefinite.

79. I reserve the right to modify and supplement this report in response to any reports drafted by or testimony offered by Philips' expert witnesses and in response to any other fact discovery that is conducted by the parties.

Dated: 14 Dec 2007

Touradj Ebrahimi, Ph.D.

EXHIBIT 1

EXHIBIT 1: Touradj Ebrahimi, Ph.D. CV

CURRICULUM VITAE

Touradj Ebrahimi

December 2007

Civil Status	Married with two children
Age	42
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Email	Touradj.Ebrahimi@epfl.ch
Web	http://www.ebrahimi.ch



Education and degrees

IMD, ETHZ, EPFL
Leadership Competences Program (1995)

Swiss Federal Institute of Technology (EPFL)
Ph.D. in Video Compression (1992)

Swiss Federal Institute of Technology (EPFL)
M.Sc. in Electrical Engineering (1989)

Present and past positions

EMITALL S.A.
Founder, Chairman and Technical Advisor
October 2002 to present
Montreux, Switzerland

EMITALL Surveillance S.A.

Founder, Chairman and Technical Advisor
July 2005 to present
Montreux, Switzerland

Swiss Federal Institute of Technology (EPFL)
Titular Professor
October 1994 to present
Lausanne, Switzerland

AT&T Bell Laboratories
Consultant
November 1993 to October 1994
Holmdel, NJ, USA

Sony Corporation
Research Engineer
October 1992 to October 1993
Tokyo, Japan

Swiss Federal Institute of Technology (EPFL)
Research and teaching assistant
February 1989 to October 1992
Lausanne, Switzerland

University of Southern California (USC)
Visiting Researcher
June 1990 to September 1990
Los Angeles, CA, USA

Other activities

- Associate Editor of IEEE Transactions on Multimedia 2003-2005
- Member of the Editorial board for IEEE Signal Processing Magazine 2003 -2005
- Associate Editor of EURASIP's Journal of Applied Signal Processing 2003-2005
- Associate Editor of SPIE's Optical Engineering Magazine 2001-2004
- Area Editor of Eurasip's Image Communication Journal since 2001-2006
- Associate Editor of IEEE Transactions on Image Processing 1999-2003
- Head of Swiss delegation to ISO/IEC JTC1/SC29.
- Head of Swiss Delegation to ISO/IEC JTC1/SC29/WG1 (JPEG)
- Head of Swiss Delegation to ISO/IEC JTC1/SC29/WG11 (MPEG)
- Chair of several technical subgroups at MPEG and JPEG standardization

committees.

- Editor of MPEG-4 standard (Visual)
- Editor of Secure JPEG 2000 standard
- Member of scientific advisory board of several high-tech companies in the field of information technology, multimedia and communications.
- Expert/evaluator of the European Commission for various European projects and grants
- Expert/evaluator of the Greek Ministry of Development for Research and Development projects and Centers
- Expert/evaluator of the Belgian federal funding agency and Wallonnie region for Research and Development projects
- Consultant in several companies active in information technologies and communications
- General co-chair of SPIE International Conference on Image and Video Processing and Coding, January 2003, San Jose, CA, USA
- Genral co-chair of SPIE/IS&T International Conference on Visual Communications and Image Processing (VCIP 2003), July 2003, Lugano, Switzerland
- General co-chair of Workshop on Image Analysis and Multimedia Interactive Systems (WIAMIS 2005), April 2005, Montreux
- General co-chair of International Conference on Video and Image Processing (ICVIP 2005), April 2005, Montreux
- Co-chair of First MPEG Workshop on Future Directions in Video Compression, April 2005, Busan, Korea
- Co-chair of Second MPEG Workshop on Future Directions in Video Compression, October 2005, Nice, France

Awards

- The Swiss national award of the Association of Electrical Engineers and the IEEE chapter on communications.
- PROFIL - Swiss National Science Foundation Grant for advanced researchers
- ISO-Certificate for outstanding contributions to MPEG-4 standardization
- Best paper award for publication at IEEE Transactions on Consumer Electronics, November 2000
- Three ISO-Certificates for outstanding contributions to JPEG 2000 standardization
- Fellow of SPIE

Publications and patents

Books	3
Book chapters	5
Journal papers	54
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APPENDIX A

APPENDIX A: LIST OF MATERIALS RELIED UPON

1. U.S. Patent No. 3,984,833 Van Voorhis, KODAK_050973 – KODAK_050990

2. U.S. Patent No. 4,363,036 to Subramaniam, KODAK_051042 – KODAK_051071

3. U.S. Patent No. 4,092,676 to Saran, KODAK_051001 – KODAK_051012

4. U.S. Patent No. 4,136,363 to Saran, KODAK_051013 – KODAK_051024

5. U.S. Patent No. 4,420,771 to Pirsch, KODAK_051456 – KODAK_051466

6. "Upper Bound, Lower Bound and Run-Length Substitution Coding" Article by Henry Liao, KODAK_050261 – KODAK_050267

7. U.S. Patent No. 4,494,151 to Liao, KODAK_051072 – KODAK_051089

8. U.S. Patent No. 4,698,672 to Chen et al., KODAK_074752 – KODAK_074770

9. "Block Coding Using a Two-Dimensional Run-Length Table" Paper published to the COST 211bis Simulation Subgroup, PHLPSKD_00070973 – PHLPSKD_00070979

10. "Design and Testing of a Facility for Two-Way Video Teleconferencing" by William Cushman and Robert Derounian, KODAK_015739 – KODAK_015743.

11. Widcom Customer Base document, WIDCOM 001550 – 001551.

12. "Codec Squeezes Color Teleconferencing Through Digital Telephone Lines", J. Anderson et al., Electronics, January 26, 1984, pp. 113-115 at KODAK_051224 – KODAK_051226.

13. Widcom VTC-56 machine.

14. VTC-56B Coder Theory of Operation by Widcom, Inc., KODAK_079513 – KODAK_079570.

15. The Expert Report of Charles J. Neuhauser. Ph.D. (the "Neuhauser Expert Report") executed on December 13, 2007 and the exhibits of the Neuhauser Expert Report including:

Exhibit	Summary
A	**Neuhauser CV**
B	Directory of Technical Documents CD
C	VTC-56 Coder Theory of Operation (WID01000263- WID01000321)
D	VTC-56 Theory of Operation (WID01000475 - WID01000490)
E	Directory of CD CLI351725
F	Chipworks Data Extraction Report
G	Data Input Files
H	VTC-56 Electronics Rack Photo (CLI351725.006.jpg)
I	VTC-56 Coder Board Photo (CLI351725.143.jpg)
J	Component Datasheets
K	Data Extraction Files from Chipworks
L	Model and Test Files
M	PROM Translation Programs
N	PROM Initialization Files
O	Board Photos of Location 9F
P	Board Photos of Location 16A
Q	Procedure for Transforming 16PALR6 Equations
R	Logic Simulated
S	Board Photos of Location 10E
T	Verilog Simulation
U	State Diagram (WID01000310)
V	Input Data File
W	Input Processing Program
X	Formatted Input for Simulation
Y	Coder Board Block Diagram
Z	Address Table from WID01000302
AA	Complete Code Tables
AB	Simulation Output
AC	Annotated Output for Block 8
AD	Input Stream with Block 8 Highlighted
AE	Prior Testimony of Neuhauser

16. Deposition transcripts and exhibits for the following depositions: Robert Derounian, Eric Hamilton, Dr. Andrew Tescher, Dr. Stanley Fralick and Shrikant Acharya.

APPENDIX B

[redacted]*ntains Confidential Business Information*

Appendix B: Anticipatory Invalidity Charts

U.S. Patent No. 4,901,075 (the '075 Patent)

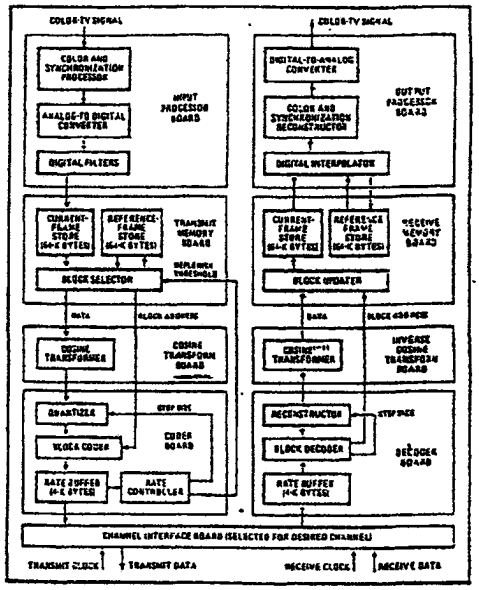
1. Below are claim charts showing how each limitation of claims 3, 4, 7, 8 and/or 11 of the '075 Patent are anticipated by one or more pieces of prior art.

EXHIBIT B-1

EXHIBIT B-1

Invalidity Chart For Widcom VTC-56

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
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:	Prior to the end of 1985, Kodak developed a video conferencing center that included a video conference room at the State Street Kodak office and a video conference room at Kodak Park Building 205. Each of the video conference rooms had a Widcom VTC-56 codec. *See KODAK_015739 – KODAK_015743. See also Final Transcript of Deposition of Robert Derounian taken on September 14, 2007 ("Derounian Tr.") at 13:7 – 15:17 and 21:22-24, 23:20- 24:24, 30:25-31_23, 34:17- 36:15 and Exhibits 4-8.* The Widcom VTC-56 codecs were purchased by Kodak prior to the end of 1985. *See Derounian Tr. at 24:25 – 25:11 and 26:21 – 27:15 and WIDCOM 001550 and WIDCOM 001551.* Mr. Derounian trained more than 100 people to use the Widcom VTC-56 (and in fact the Widcom VTC-56 was used during each training) and was present during each training. *See Derounian Tr. at 27:19 – 30:24.* The Widcom VTC-56 codec was used for two-way video conferencing more than 100 times. *See Derounian Tr. at 44:16-20.* In total, more than 100 Widcom VTC-56 codec were sold and the sales occurred prior to the end of January 1986. *See WIDCOM 001550 and WIDCOM 001551. See also Final Transcript of Deposition of Shrikant Acharya taken on October 30, 2007 ("Acharya Tr.") at 28:7-15. See also Final Transcript of Deposition of Stanley Fralick taken on October 22, 2007 ("Fralick Tr.") at 31:7 – 32:22.* The Widcom VTC-56 is a video codec that has the boards shown in the diagram reproduced below. *See "Codec Squeezes Color Teleconferencing Through Digital Telephone Lines", J Anderson et al., Electronics, January 26, 1984, pp. 113-115 at KODAK_051224 – KODAK_051226 ("Widcom 1984 Article") at pg. 115.*

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
	

The boards include a cosine transform board and a coder board. The VTC-56 divides each frame of video signal into 8X8 blocks of pixels that are then cosine transformed. In particular, the cosine transform board performs a cosine transform that generates an array of transform coefficients that contains a DC coefficient and 63 AC coefficients with many zero-valued AC coefficients. *See Widcom 1984 Article, pg. 114. See Widcom 1984 Article, pg. 114.* See also *Expert Report of Charles Neuhauser, Ph.D. ("Neuhauser Expert Report") at 2 and Exhibit H.* The coefficients in the array of transform coefficients are quantized and coded. *See Widcom VTC-56 machine. See also Neuhauser Expert Report at 17 and 19 and Exhibit AA.*

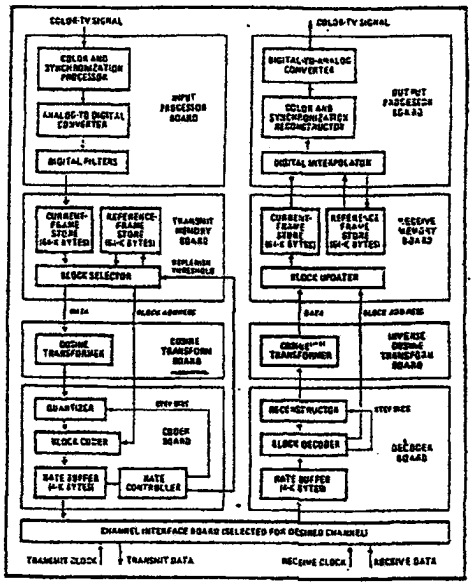
The operation and coding of the Widcom VTC-56 machine was simulated using software written in Fortran and the Fortran software performed the same coding as the Widcom VTC-56 machine. *See Acharya Tr. at 40:17-22 and WIDCOM 003705 – WIDCOM 003712. See Acharya Tr. at 41:9 – 49:10.*

The Widcom VTC-56 performs bandwidth compression (on color video signals) at ratios of up to 1,440:1 which is sufficient to transmit color-TV signals through a telephone

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
	line. *See Widcom 1984 Article, pg. 113.* The cosine transform coding for the pixel-to-pixel decorrelation (performed by the cosine transform and coder board) result in a 6:1 compression ratio (*See Widcom 1984 Article, pg. 113, table*) of the color-TV signals (converting into quantized coefficient values which are the sequence of signal values.) The bandwidth compression causes a bitrate reduction of the sequence of signal values. Based on the above, it is my opinion that the VTC-56 machine performs a method of coding a signal that has 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.
(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	The VTC-56 derives from the transformed and quantized video signals, a series of events that are made up of runs of zero AC coefficients followed by an AC coefficient having an absolute value of one (RL1) and runs of zero AC coefficients followed by an AC coefficient having an absolute value greater than one (RL0). *See VTC-56B Coder Theory of Operation by Widcom, Inc. (KODAK_079513 – KODAK_079570) ("VTC-56B Coder Theory of Operation") at KODAK_079517. See Fralick Tr. at 52:3 - 53:2. See also Widcom VTC-56 machine.* These events are then encoded with a code word wherein more frequently occurring values are represented by short code words and less frequently occurring values are represented by longer code words. *See Widcom 1984 Article at pg. 114.* In the VTC-56, the codewords are selected from several different tables based on the entropy of the image being encoded. In particular, there are six different tables that are used to code the AC coefficients wherein each table is optimized for a particular entropy level of the image to be coded. The table is selected based on a calculation of a standard deviation of the computed transform coefficients. *See VTC-56B Coder Theory of Operation at KODAK_079516.* See also *Final Transcript of Deposition of Eric Hamilton taken on October 10, 2007 ("Hamilton Tr.") at 90:7- 93:20. See also Widcom VTC-56 machine.* Based on the above, it is my opinion that the VTC-56 machine derives, from the video signal, a plurality of events each comprising a run of said zero-coefficients

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
	having a respective run length and preceded or followed by at least one non-zero coefficient.
(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 the VTC-56, each event that includes a run of zero AC coefficients followed by an AC coefficient having an absolute value of one (RL1) are assigned a single Huffman code word to represent the event. *See Widcom 1984 Article at pg. 114. See also Hamilton Tr. at 87:13 – 100:16. See also Widcom VTC-56 machine.* The hardware of the VTC-56 machine produces such single Huffman code when coding typical video signals as demonstrated by the simulation of the VTC-56 hardware done by Dr. Neuhauser. *See Neuhauser Expert Report at 16, 18 and 19 and Exhibits AB and AC.* The AC coefficients in the array of quantized transform coefficients are encoded in which runs of zero AC coefficients followed by a non-zero AC coefficient are encoded. In the VTC-56, runs are zero valued AC coefficients are encoded: *"Because there are so many zero-valued coefficients, the final code is further compressed by coding run lengths instead of transmitting long runs of 0 bits." See Widcom 1984 Article, p. 114.* Based on the above, it is my opinion that the VTC-56 machine determines, for each event the respective run length and assigns 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.	The code words are Huffman codewords. In the VTC-56, the Huffman codeword is selected from several different tables based on the entropy of the image being encoded. In particular, there are six different tables that are used to code the AC coefficients wherein each table is optimized for a particular entropy level of the image to be coded. The table is selected based on a calculation of a standard deviation of the computed transform coefficients. See *Hamilton Tr. at 90:7- 93:20 and Acharya Tr. at 37:7-15. See also Widcom VTC-56 machine. See Widcom 1984*

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
	Article at pg. 114.
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.	The VTC-56 codes the AC coefficient magnitudes with the Huffman code words above so that the Huffman codewords are independent of the sign of that coefficient. The coder board then sends the sign separately from the code for the AC coefficient magnitude. *See VTC-56B Coder Theory of Operation at KODAK_079516. See also Widcom VTC-56 machine. See Neuhauser Expert Report at 18-19 and Exhibits AB and AC.*
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Prior to the end of 1985, Kodak developed a video conferencing center that included a video conference room at the State Street Kodak office and a video conference room at Kodak Park Building 205. Each of the video conference rooms had a Widcom VTC-56 codec. *See KODAK_015739 – KODAK_015743. See also Final Transcript of Deposition of Robert Derounian taken on September 14, 2007 ("Derounian Tr.") at 13:7 – 15:17 and 21:22-24, 23:20- 24:24, 30:25-31_23, 34:17- 36:15 and Exhibits 4-8.* The Widcom VTC-56 codecs were purchased by Kodak prior to the end of 1985. *See Derounian Tr. at 24:25 – 25:11 and 26:21 – 27:15 and WIDCOM 001550 and WIDCOM 001551.* Mr. Derounian trained more than 100 people to use the Widcom VTC-56 (and in fact the Widcom VTC-56 was used during each training) and was present during each training. *See Derounian Tr. at 27:19 – 30:24.* The Widcom VTC-56 codec was used for two-way video conferencing more than 100 times. *See Derounian Tr. at 44:16-20.* In total, more than 100 Widcom VTC-56 codec were sold and the sales occurred prior to the end of January 1986. *See WIDCOM 001550 and WIDCOM 001551. See also Final Transcript of Deposition of Shrikant Acharya taken on October 30, 2007 ("Acharya Tr.") at 28:7-15. See also Final Transcript of Deposition of Stanley Fralick taken on October*

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
	22, 2007 ("Fralick Tr.") at 31:7 – 32:22. The Widcom VTC-56 is a video codec that has the boards shown in the diagram reproduced below. *See "Codec Squeezes Color Teleconferencing Through Digital Telephone Lines", J Anderson et al., Electronics, January 26, 1984, pp. 113-115 at KODAK_051224 – KODAK_051226 ("Widcom 1984 Article") at pg. 115.*  The boards include a cosine transform board and a coder board. The VTC-56 divides each frame of video signal into 8X8 blocks of pixels that are then cosine transformed. In particular, the cosine transform board performs a cosine transform that generates an array of transform coefficients that contains a DC coefficient and 63 AC coefficients with many zero-valued AC coefficients. *See Neuhauser Expert Report at 2 and Exhibit H.* The coefficients in the array of transform coefficients are quantized and coded. *See also Widcom VTC-56 machine. See Neuhauser Expert Report at 17 and 19 and Exhibit AA.* The operation and coding of the Widcom VTC-56 machine was simulated using software written in Fortran and the Fortran software

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
	performed the same coding as the Widcom VTC-56 machine. *See Acharya Tr. at 40:17-22 and WIDCOM 003705 – WIDCOM 003712. See Acharya Tr. at 41:9 – 49:10.* The Widcom VTC-56 performs bandwidth compression (on color video signals) at ratios of up to 1,440:1 which is sufficient to transmit color-TV signals through a telephone line. *See Widcom 1984 Article, pg. 113.* The cosine transform coding for the pixel-to-pixel decorrelation (performed by the cosine transform and coder board) result in a 6:1 compression ratio (*See Widcom 1984 Article, pg. 113, table*) of the color-TV signals (converting into quantized coefficient values which are the sequence of signal values.) The bandwidth compression causes a bitrate reduction of the sequence of signal values. Based on the above, it is my opinion that the VTC-56 machine performs a method of coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	The boards of the VTC-56 include a cosine transform board. The VTC-56 divides each frame into 8X8 blocks of pixels that are then cosine transformed. In particular, the cosine transform board performs a cosine transform that generates an array of transform coefficients that contains a DC coefficient and 63 AC coefficients with many zero-valued AC coefficients. *See Widcom 1984 Article, pg. 114. See also Widcom VTC-56 machine.* Based on the above, it is my opinion that the VTC-56 machine transforms the video signal into a sequence of 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	The VTC-56 derives from the transformed and quantized video signals, a series of events that are made up of runs of zero AC coefficients followed by an AC coefficient having an absolute value of one (RL1) and runs of zero AC coefficients followed by an AC coefficient having an absolute value greater than one (RL0). *See VTC-56B Coder Theory of Operation by Widcom, Inc. (KODAK_079513 – KODAK_079570) ("VTC-56B Coder Theory of Operation") at KODAK_079517. See Fralick Tr. at 52:3 - 53:2. See also Widcom VTC-56 machine.* Based on the above, it is my opinion that the VTC-56

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
	machine derives, from the video 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.
(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.	These events are then encoded with a code word wherein more frequently occurring values are represented by short code words and less frequently occurring values are represented by longer code words. *See Widcom 1984 Article at pg. 114.* In the VTC-56, the codewords are selected from several different tables based on the entropy of the image being encoded. In particular, there are six different tables that are used to code the AC coefficients wherein each table is optimized for a particular entropy level of the image to be coded. The table is selected based on a calculation of a standard deviation of the computed transform coefficients. *See VTC-56B Coder Theory of Operation at KODAK_079516.* See also *Final Transcript of Deposition of Eric Hamilton taken on October 10, 2007 ("Hamilton Tr.") at 90:7- 93:20. See also Widcom VTC-56 machine.* In the VTC-56, each event that includes a run of zero AC coefficients followed by an AC coefficient having an absolute value of one (RL1) are assigned a single Huffman code word to represent the event. *See Widcom 1984 Article at pg. 114. See also Hamilton Tr. at 87:13 – 100:16. See also Widcom VTC-56 machine.* The hardware of the VTC-56 machine produces such single Huffman code when coding typical video signals as demonstrated by the simulation of the VTC-56 hardware done by Dr. Neuhauser. *See Neuhauser Expert Report at 16, 18 and 19 and Exhibits AB and AC.* The AC coefficients in the array of quantized transform coefficients are encoded in which runs of zero AC coefficients followed by a non-zero AC coefficient are encoded. In the VTC-56, runs are zero valued AC coefficients are encoded: *"Because there are so many zero-valued coefficients, the final code is further compressed by*

US 4,901,075 CLAIM ELEMENTS	Widcom VTC-56
	coding run lengths instead of transmitting long runs of 0 bits." *See Widcom 1984 Article, p. 114.* Based on the above, it is my opinion that the VTC-56 machine determines, for each event the respective run length and assigns a code word to represent said non-zero coefficient and said run length.

EXHIBIT B-2

EXHIBIT B-2

Invalidity Chart for US Patent No. 4,698,672 to Chen et al. (the "Chen Patent")

US 4,901,075 CLAIM ELEMENTS	Chen Patent
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:	Chen discloses a coding system for reducing redundancy. *See Title*. Chen discloses "methods and apparatus for processing signals to remove redundant information thereby making the signals more suitable for transfer through a limited bandwidth medium." Chen is specifically related to methods and apparatus useful in video compression systems. *See Abstract, Figures 1-4 and Col. 1, lines 15-20.* In the background, Chen discusses a prior patent in which, "Each frame of the video image is divided into a predetermined matrix of spatial sub-frames or blocks. This system performs a spatial domain to transform domain transformation of the picture elements of each block to provide transform coefficients for each block." *See Col. 1, lines 54-58.* Prior to coding in a coder 14, a forward processor 52 processes the spatial domain input signals to form processed signals which typically are transform domain signals arranged in blocks of transform domain coefficients. *See Figure 1 and Col. 4, lines 45-49.* The signals to be coded in Chen are multiple values where the multivalued digital numbers X(k) are typically the integers 0, 1, 2, 3, 4,.... Chen discloses that, in one example of the digital numbers, the highest frequency of occurrence is the value 0, the next highest frequency of occurrence is the value 1 and the other values greater than 1 (namely 2, 3, 4, 5 and so on) occur less frequently. *See Col. 3, lines 22-26.* Based on the above, it is my opinion that Chen discloses a method for coding a signal that has 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.
(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	The coder 14 may perform runlength coding of the types R and R'. *See Col. 5, lines 30 -36.* "...This system codes the highest, most frequently occurring values (0's in the usual example) using run length coding. In the most preferably example, the run length coding is of two types, R and R'.

US 4,901,075 CLAIM ELEMENTS	Chen Patent
followed by at least one non-zero coefficient, and	The first type, R, is utilized when the runlength of 0's is followed by the next most frequently occurring value (1 in the usual case) ..." *See Col. 3, lines 30 -37 and Col. 5, lines 36-38.* "Whenever the first type, R, of run-length coding is employed, no coding of the second value (usually 1) is required because an amplitude of 1 is implied by the use of the first type, R, of run-length coding." *See Col. 3, lines 45-48 and Col. 5, lines 45-49.* Based on the above, Chen discloses deriving from a video 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.
(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.	The type, R, is coded with One's Redundancy (OR) coding or scene adaptive coding using Huffman codes. *See Col. 13, line 37- Col. 17, line 48 and Tables 6-9.* The type R encodes the run length of the zero coefficient and the following amplitude of 1. *See Col. 3, lines 32-37 and Col. 5, lines 36-38.* Based on the above, it is my opinion that Chen discloses determining, for each event, a run length and assigns a code word that represents the non-zero coefficient and the run length.
4. The method of claim 3, wherein said code words are Huffman code words.	The type, R, is coded with One's Redundancy (OR) coding or scene adaptive coding using Huffman codes. *See Col. 13, line 37- Col. 17, line 48 and Tables 6-9.* Based on the above, it is my opinion that Chen discloses that the codewords are Huffman codewords.
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.	In Chen, as shown in Tables 6 and 7, the coding tables assume that a separate sign bit, not in the tables, is used to indicate the sign of each value coded in the manner indicated in Table 5. *See Col. 18, lines 3-17.* Chen also discloses that coefficient differences of one at the end of the consecutive zeros encode with R + SIGN. *See Col. 14, lines 35-37.* Based on the above, it is my opinion 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.

US 4,901,075 CLAIM ELEMENTS	Chen Patent
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Chen discloses a coding system for reducing redundancy. *See Title*. Chen discloses "methods and apparatus for processing signals to remove redundant information thereby making the signals more suitable for transfer through a limited bandwidth medium. Chen is specifically related to methods and apparatus useful in video compression systems. *See Abstract, Figures 1-4 and Col. 1, lines 15-20.* Based on the above, it is my opinion that Chen discloses a method for coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	Prior to coding in a coder 14, a forward processor 52 processes the spatial domain input signals to form processed signals which typically are transform domain signals arranged in blocks of transform domain coefficients. *See Figure 1 and Col. 4, lines 45-49.* The signals to be coded in Chen are multiple values where the multivalued digital numbers X(k) are typically the integers 0, 1, 2, 3, 4,.... Chen discloses that, in one example of the digital numbers, the highest frequency of occurrence is the value 0, the next highest frequency of occurrence is the value 1 and the other values greater than 1 (namely 2, 3, 4, 5 and so on) occur less frequently. *See Col. 3, lines 22-26.*
(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	The coder 14 may perform runlength coding of the types R and R'. *See Col. 5, lines 30 -36.* "...This system codes the highest, most frequently occurring values (0's in the usual example) using run length coding. In the most preferably example, the run length coding is of two types, R and R'. The first type, R, is utilized when the runlength of 0's is followed by the next most frequently occurring value (1 in the usual case) ..." *See Col. 3, lines 30 -37 and Col. 5, lines 36-38.* "Whenever the first type, R, of run-length coding is employed, no coding of the second value (usually 1) is required because an amplitude of 1 is implied by the use of the first type, R, of run-length coding." *See Col. 3, lines 45-48 and Col. 5, lines 45-49.* Based on the above, Chen discloses deriving from a video signal a plurality of events each comprising a run of said zero-coefficients having a respective run length and

US 4,901,075 CLAIM ELEMENTS	Chen Patent
	preceded or followed by at least one non-zero coefficient.
(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.	The type, R, is coded with One's Redundancy (OR) coding or scene adaptive coding using Huffman codes. *See Col. 13, line 37- Col. 17, line 48 and Tables 6-9.* The type R encodes the run length of the zero coefficient and the following amplitude of 1. *See Col. 3, lines 32-37 and Col. 5, lines 36-38.* Based on the above, it is my opinion that Chen discloses determining, for each event, a run length and assigns a code word that represents the non-zero coefficient and the run length.

EXHIBIT B-3

EXHIBIT B-3

Invalidity Chart for COST 211bis Simulation Subgroup Paper entitled "Block Coding Using a Two-Dimensional Run-Length Table", published September 9, 1986 PHLPSKD_00070973 - PHLPSKD_00070979 (the "COST Paper")

US 4,901,075 CLAIM ELEMENTS	COST Paper
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:	The COST Paper was a proposal made by Dr. Peter Vogel to the COST 211bis Simulation Subgroup. *See Rough Deposition Transcript of Peter Vogel, Ph. D. (the "Vogel Tr.") at 117, lines 12- 24.* The paper was made public and distributed to the participants of the COST 211bis Simulation Subgroup by at least September 9, 1986. *See Vogel Tr. at 120, line 2 – 121, line 20.* The COST paper discloses a 2D-run-length coding of a video signal. See Vogel Tr. at 122, lines 3-7. "For the 2D-run-length coding the events corresponding to a run-length of consecutive zero coefficients and coefficients unequal to zero defining the end of the run-length are considered as composite rather than separate statistical events..." *See COST Paper at PHLPSKD_00070973. See Vogel Tr. at 122:22 – 123:1.* The 2D-run-length coding with the Huffman codes provides a bit reduction of approximately 12% compared with coding by an amplitude-and- run-length lookup table using Huffman codes. *See COST Paper at PHLPSKD_00070974.* The COST paper introduces "...the coding of an integer block by a two-dimensional run-length table" and compares it "...with coding by an amplitude lookup table for coding the magnitude of the coefficients and a run length lookup table for coding the addresses of the coefficients related to as certain block scan." *See COST Paper at PHLPSKD_00070973.* Based on the above, it is my opinion that the COST Paper discloses 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.
(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	"For the 2D-run-length coding the events corresponding to a run-length of consecutive zero coefficients and coefficients unequal to zero defining the end of the run-length are considered as composite rather than separate statistical events..." *See COST Paper at*

US 4,901,075 CLAIM ELEMENTS	COST Paper
followed by at least one non-zero coefficient, and	*PHLPSKD_00070973 and Appendix A at PHLPSKD_00070977 - PHLPSKD_00070978.* Based on the above, it is my opinion that the COST Paper discloses deriving from the video 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.
(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.	As shown in Appendix A, a Huffman code for the composite events are assigned to the composite events that are a run-length of consecutive zero coefficients and coefficient unequal to zero. *See COST Paper at PHLPSKD_00070973, and Appendix A at PHLPSKD_00070977- PHLPSKD_00070978.* For example, a composite event with a zero run length of "2" and a "5" coefficient unequal to zero is assigned the Huffman code "00101011110". *See COST Paper at PHLPSKD_00070977.* Based on the above, it is my opinion that the COST Paper discloses determining, for each event, the 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.	The codes shown in Appendix A of the COST Paper are Huffman codes. *See COST Paper at PHLPSKD_00070973 and Appendix A at PHLPSKD_00070977- PHLPSKD_00070978.* Based on the above, it is my opinion that the COST Paper discloses that the codewords are Huffman codwords.
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.	The Huffman codes in Appendix A of the COST Paper are independent of the sign of the non-zero coefficient since each code in Appendix A is based on the magnitude of the coefficient unequal to zero. *See COST Paper Appendix A at PHLPSKD_00070977- PHLPSKD_00070978.* The sign bit is coded with a separate bit. *See COST Paper at PHLPSKD_00070973 and Appendix A at PHLPSKD_00070977- PHLPSKD_00070978.* Based on the above, it is my opinion that the Huffman codeword is independent of the sign of that non-zero

US 4,901,075 CLAIM ELEMENTS	COST Paper
	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:	The COST Paper was a proposal made by Dr. Peter Vogel to the COST 211bis Simulation Subgroup. *See Rough Deposition Transcript of Peter Vogel, Ph. D. (the "Vogel Tr.") at 117, lines 12- 24.* The paper was made public and distributed to the participants of the COST 211bis Simulation Subgroup by at least September 9, 1986. *See Vogel Tr. at 120, line 2 – 121, line 20.* The 2D-run-length coding using the Huffman codes provides a bit reduction of approximately 12% compared with coding by an amplitude-and- run-length lookup table using Huffman codes. *See COST Paper at PHLPSKD_00070974.* The COST paper introduces "…the coding of an integer block by a two-dimensional run-length table" and compares it "…with coding by an amplitude lookup table for coding the magnitude of the coefficients and a run length lookup table for coding the addresses of the coefficients related to as certain block scan." *See COST Paper at PHLPSKD_00070973.* Based on the above, it is my opinion that the COST Paper discloses a method of coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	The COST paper discloses a 2D-run-length coding of a video signal. See Vogel Tr. at 122, lines 3-7. "For the 2D-run-length coding the events corresponding to a run-length of consecutive zero coefficients and coefficients unequal to zero defining the end of the run-length are considered as composite rather than separate statistical events…" *See COST Paper at PHLPSKD_00070973. See Vogel Tr. at 122:22- 123:1.* Based on the above, it is my opinion that the COST Paper discloses transforming the video 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	"For the 2D-run-length coding the events corresponding to a run-length of consecutive zero coefficients and coefficients unequal to zero defining the end of the run-length are considered as composite rather than separate statistical events…" *See COST Paper at*

US 4,901,075 CLAIM ELEMENTS	COST Paper
at least one non-zero coefficient, and	*PHLPSKD_00070973. See also COST Paper, Appendix A at PHLPSKD_00070977 - PHLPSKD_00070978.* Based on the above, it is my opinion that the COST Paper discloses deriving from the video 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.
(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.	As shown in Appendix A, a Huffman codes for the composite events are assigned to the composite events that are a run-length of consecutive zero coefficients and coefficients unequal to zero. *See COST Paper at PHLPSKD_00070973, and PHLPSKD_00070977-PHLPSKD_00070978.* For example, a composite event with a zero run length of "2" and a "5" coefficient unequal to zero, the Huffman code is "00101011110". *See COST Paper at PHLPSKD_00070977.* Based on the above, it is my opinion that the COST Paper discloses determining, for each event, the respective run length and assigning a code word to represent said non-zero coefficient and said run length.

APPENDIX C

[redacted]*ntains Confidential Business Information*

Appendix C: Obviousness Invalidity Charts

U.S. Patent No. 4,901,075 (the '075 Patent)

1. Below are claim charts showing how each limitation of claims 3, 4, 7, 8 and/or 11 of the '075 Patent are unpatentable over one or more single pieces of prior art or over one or more combinations of pieces of prior art.

EXHIBIT C-1

EXHIBIT C-1

Invalidity Chart for U.S. Patent No. 3,984,833 to vanVoorhis In View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4 and 8 of the '075 Patent would be obvious over the combination of U.S. Patent No. 3,984,833 to van Voorhis and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of the coding techniques in van Voorhis to the video coding as taught by the Chen Article is a predictable use of the coding techniques. Furthermore, the combination of the elements from the Chen Article and van Voorhis yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
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:	Van Voorhis discloses an apparatus for encoding extended run-length codes for the compression of digital images that are a two-dimensional array of image points. *See Col. 1:13-19.* The compression of the digital images (using run length codes) reduces the storage requirements for digital images and reduces the bandwidth required for the transmission of the digital images *See Col. 1:27-31.* The value zero occurs far more frequency than the signal value one. From the examples, the value zero occurs most frequency in uninterrupted runs. For example, column 14, lines 64 to 66, mentions: *"For the purpose of the illustration, a run is defined as a one or as a string of one or more zeros and the first one following this string of zeros."* Van Voorhis discloses that an image, for a black/white image, has image points that are converted into a single bit of information with a value of either 0 or 1 to indicate that the corresponding area of the picture is light or dark. *See Col. 1, lines 19-23.*	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression in video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used for image and video coding to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
	Based on the above, van Voorhis discloses a method of coding a signal comprising a plurality of a zero values occurring in runs and other values.	rate.
(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	Van Voorhis discloses that an event may be a binary encoded representation of an alphanumeric character, an analog voltage, a run of binary video information, a run of binary image information or any other type of information capable of recognition. *See Col. 6, lines 59-65.* Van Voorhis also describes that, from the signal, runs are recognized as follows: "*In such as circumstance, the event recognizer 10 of Van Voorhis may recognize each sequence of consecutive bits of the same logic , which is denoted as a run. Runs may also be sequences of bits of one of the logic levels, or sequences of a level terminating in another level.*" *See Col. 7:11-15.* Van Voorhis discloses an example of a run (See Col. 14:64-66; underlining was added): *"For the purpose of the illustration, a run is defined as a one or as a string of one or more zeros and the first one following this string of zeros."* Further examples can be found in col. 15, lines 11- 32. Based on the above, it is my opinion that van Voorhis discloses deriving a plurality of events wherein each event is a sequence of bits of one logic level	Chen discloses using DCT coefficients in a video coding process. *See pp. 225-227.*

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
	(zero) terminating in another logic level (one).	
(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.	Van Voorhis discloses coding of events where the event may include a string of one or more zeros and the first one following this string of zeros. *See Col. 14, lines 64-66.* The encoder then calculates and outputs code words for a specific class of ordinary and extended run-length codes. *See Col, 3, lines 58-61.* Examples of the codes used by the coder are shown in Tables 1 and 2. *See Col. 3, line 58 – Col. 4, line 64 and Tables 1 and 2.* Based on the above, it is my opinion that van Voorhis discloses determining a run length and assigning a code word to the sequence of one logic level terminating in another logic level.	
4. The method of claim 3, wherein said code words are Huffman code words.	Van Voorhis describes a coding method wherein the relative frequencies of the occurrence for the various runs and special situations may be measured in a sample of images and the relative frequencies are used to calculate code word lengths that are ordered and bounded. The coding method places regular events approximately in order of decreasing relative frequency. *See Col, 5, lines 3-56.* Based on the above, it is my opinion that van Voorhis discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Van Voorhis discloses an apparatus for encoding extended run-length codes for the compression of digital images that are a two-dimensional array of image points. *See Col. 1:13-*	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
	19. The compression of the digital images (using run length codes) reduces the storage requirements for digital images and reduces the bandwidth required for the transmission of the digital images *See Col. 1:27-31.* Based on the above, van Voorhis discloses a method of coding a signal for reduced bandwidth.	bandwidth compression in video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used for image and video coding to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	Van Voorhis discloses that an image, for a black/white image, has image points that are transformed into a single bit of information with a value of either 0 or 1 to indicate that the corresponding area of the picture is light or dark. *See Col. 1, lines 19-23.* The value zero occurs far more frequency than the other signal value one. From the examples, the value zero occurs most frequency in uninterrupted runs. For example, column 14, lines 64 to 66, mentions: *"For the purpose of the illustration, a run is defined as a one or as a string of one or more zeros and the first one following this string of zeros."* Based on the above, van Voorhis discloses a method of coding a signal comprising a plurality of a zero values occurring in runs and other values.	Chen discloses using DCT coefficients in a video coding process that have zero values and non-zero values. *See pp. 225-227.*
(b) deriving from said sequence, a plurality of events each comprised	Van Voorhis discloses that an event may be a binary encoded representation of an alphanumeric	Chen discloses using DCT coefficients in a video coding process that have zero values

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
of a run of zero coefficients having a respective run length, which is preceded or followed by at least one non-zero coefficient, and	character, an analog voltage, a run of binary video information, a run of binary image information or any other type of information capable of recognition. *See Col. 6, lines 59-65.* Van Voorhis also describes that, from the signal, runs are recognized as follows: "*In such a circumstance, the event recognizer 10 of Van Voorhis may recognize each sequence of consecutive bits of the same logic , which is denoted as a run. Runs may also be sequences of bits of one of the logic levels, or sequences of a level terminating in another level.*" *See Col. 7:11-15.* Van Voorhis discloses an example of a run (See Col. 14:64-66; underlining was added): *"For the purpose of the illustration, a run is defined as a one or as a string of one or more zeros and the first one following this string of zeros."* Further examples can be found in column 15, lines 11- 32. Based on the above, it is my opinion that van Voorhis discloses deriving a plurality of events wherein each event is a sequence of bits of one logic level (zero) terminating in another logic level (one).	and non-zero values. *See pp. 225-227.*
(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.	Van Voorhis discloses coding of events where the event may include a string of one or more zeros and the first one following this string of zeros. *See Col. 14, lines 64-66.* The encoder then calculates and outputs code words for a specific class of ordinary and extended run-length	

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
	codes. *See Col, 3, lines 58-61.* Examples of the codes used by the coder are shown in Tables 1 and 2. *See Col. 3, line 58 – Col. 4, line 64 and Tables 1 and 2.* Based on the above, it is my opinion that van Voorhis discloses determining a run length and assigning a code word to the sequence of one logic level terminating in another logic level.	

EXHIBIT C-2

EXHIBIT C-2

Invalidity Chart for U.S. Patent No. 4,420,771 to Pirsch In View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4 and 8 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,430,771 to Pirsch and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the application of the coding technique taught by Pirsch to the video coding as taught by the Chen Article is a predictable use of the coding techniques of Pirsch. Furthermore, the combination of the elements from the Chen Article and Pirsch yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
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:	Pirsch discloses a method for encoding multi-level signals. *See Title and Col. 1:60- 2:8 and 2:34-50.* Pirsch also discloses that multi-level signal encoding results in reducing redundancy in the signal and reducing the amount of data needed to represent the signal and the object of the present invention is to enable more efficient encoding of a multi-level signal. *See Col. 1:45-57.* Pirsch states that "The present invention relates generally to a technique for encoding multi-level signal and, in particular, to a form of run-length coding of such signals when one of the levels occurs much more frequently than all of the other possible levels." *See Col. 1, lines 6-10.* In addition, Pirsch discloses that the system is used for encoding error prediction values wherein "a large number of the error values will have values at or near ZERO." These large number of error values "form the "frequent value" inputs to the encoder.." *See Col. 2, lines 39-45.* The error prediction values may be quantized. *See Col. 3, lines 2-5.*	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
	Pirsch discloses that "multi-level signals derived from other sources may be processed in accordance with the instant invention and that advantageous results will be achieved as long as a heavy bias exists in favor of a given most frequent value." and "the present invention is useful with any series of input samples or words capable of having at least M different values." *See Col. 2, lines 45-50 and Col. 11, lines 9-24.* Based on the above, it is my opinion that Pirsch describes a multi-level signal encoding system to reduce the amount of data where signals containing a large number of zero values.	
(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	In the preferred embodiment of Pirsch, run length codes for frequent values (FRL), run length codes for non-frequent values (NFRL) and codes for the non-frequent value (NFV) are generated. *See Figure 3, Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* Pirsch provides "The definition of a "run" stated previously, namely, a series of consecutive inputs having the same value, can also be modified, if desired, without diminishing the advantages of the present invention. Specifically, an alternative definition of a run may be a series of consecutive words of like value as well as the next (subsequent) word of different value." (Emphasis added*) See Col. 11, lines 25-43.* Based on the above, it is my opinion that Pirsch discloses that events are derived from the signal and each	

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
	event comprises a run of most likely value (zero) followed by a different value (non-zero).	
(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.	Pirsch discloses a method for encoding multi-level signals in which runs are encoded by a coder 191 using a variable length codes with an example of the codes for encoding the non-frequent values shown in Table 4. *See Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* In Pirsch, using the alternative definition of a "run", the series of consecutive words of like value as well as the next (subsequent) word of different value are assigned a code word of variable length. Based on the above, it is my opinion that Pirsch discloses determining, for each event, a run length and assigning a codeword that represents a series of consecutive words of like value as well as the next (subsequent) word of different value.	
4. The method of claim 3, wherein said code words are Huffman code words.	The runs of the "frequent values" and the less frequent values are encoded by a coder 191 using a variable length Huffman code with an example of the Huffman codes for encoding the non-frequent values shown in Table 4. *See Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* Based on the above, it is my opinion that Pirsch discloses using Huffman code words to code events.	
8. A method for coding a signal for transmission at a reduced bandwidth,	Pirsch discloses a method for encoding multi-level signals. *See Title and Col. 1:60- 2:8 and 2:34-50.*	Chen discloses a system and method wherein transform image coding (which was

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
comprising the steps of:	Pirsch also discloses that multi-level signal encoding results in reducing redundancy in the signal and reducing the amount of data needed to represent the signal and the object of the present invention is to enable more efficient encoding of a multi-level signal. *See Col. 1:45-57.* Pirsch states that "The present invention relates generally to a technique for encoding multi-level signal and, in particular, to a form of run-length coding of such signals when one of the levels occurs much more frequently than all of the other possible levels." *See Col. 1, lines 6-10.* Based on the above, it is my opinion that Pirsch describes a multi-level signal encoding system to reduce the amount of data..	developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	In the example of Pirsch given in Col. 11:31-43, only binary values are given. However, it is apparent that, in encoding method disclosed in Pirsch, that the other signal values can also take other values than "1" since Pirsch deals with "multi-level" coding, i.e. coding of signals with at least three values. *See Col. 11:9-14: "$M \geq 3$".* In addition, Pirsch provides that "it is to be clearly understood that multi-level signals derived from other sources may be processed ..." and "that advantageous results will be achieved as long as a heavy bias exists in favor of a given most frequent value." *See Col. 2:25-50.*	

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
	In addition, Pirsch discloses that the system is used for encoding error prediction values wherein "a large number of the error values will have values at or near ZERO." These large number of error values "form the "frequent value" inputs to the encoder.." *See Col. 2, lines 39-45.* The error prediction values may be quantized. *See Col. 3, lines 2-5.* Based on the above, it is my opinion that Pirsch discloses that events may be a run of most likely value (zero) followed by a different value (non-zero).	
(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 the preferred embodiment of Pirsch, run length codes for frequent values (FRL), run length codes for non-frequent values (NFRL) and codes for the non-frequent value (NFV) are generated. *See Figure 3, Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* Pirsch provides "The definition of a "run" stated previously, namely, a series of consecutive inputs having the same value, can also be modified, if desired, without diminishing the advantages of the present invention. Specifically, an alternative definition of a run may be a series of consecutive words of like value as well as the next (subsequent) word of different value." (Emphasis added) *See Col. 11, lines 25-43.* Based on the above, it is my opinion that Pirsch discloses that events are derived from the signal and each event comprises a run of most likely value (zero) followed by a different value (non-zero).	

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
(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.	The runs of the "frequent values" and the next subsequent value are encoded by a coder 191 using a variable length code with an example of the codes for encoding the non-frequent values shown in Table 4. *See Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* Based on the above, it is my opinion that Pirsch discloses determining, for each event, a run length and assigning a codeword that represents a series of consecutive words of like value as well as the next (subsequent) word of different value.	\

EXHIBIT C-3

EXHIBIT C-3

Invalidity Chart for US Patent No. 4,316,222 to Subramaniam in view of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,316,222 to Subramaniam and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of the coding technique from Subramaniam in video coding as taught by the Chen Article is a predictable use of the coding techniques. Furthermore, the combination of the elements from the Chen Article and Subramaniam yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article
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	A method is disclosed for reducing the number of bits of information when transmitting a video image. *See Col. 1:7-11.* In the method, an image is divided into a series of rows of data elements of different types, such as black and white colors, so that a series of digital elements (white areas generate a "0" output and black areas generate a "1" output) are generated which correspond to the sequence of signal values. *See Col. 2:30-38.* When working with documents, the image processor 10 converts the original image data into long strings of 0's followed by short strings of 1's and short strings of 1's followed by long strings of 0's. *See Col. 2:62-66.* Based on the above, it is my opinion that Subramaniam discloses a method of coding a signal for transmission at a reduced bit rate, that is converted into a signal that has a plurality of zero values, and a plurality of non-zero values.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression of video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a

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US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article
said method comprising the steps of:		video signal with subsequent quantization, for transmission at a reduced bit rate.
(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	From the image signals, runs length symbols are located and these runs are white-black (WB) runs and black-white (BW) runs. *See Col. 2:66- Col. 3:8.* In the preferred implementation, the WB run has a white half run 1 to 511 pixels and the black half run is 0 to 7 pixels and the BW run has black half run of 1 to 7 pixels and a white half run of 0 to 511 pixels. *See Col. 3:4-8.* Based on the above, it is my opinion that Subramaniam discloses deriving WB or BW events that have long strings of "0"'s and "1"s.	
(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.	As shown in Figures 2A and 2B (reproduced below), the encoder codes "01", "001", 511 0s followed by a 1, "10", "100" and a 1 followed by 511 zeros with the variable length code words "111", "01001", "010001110", "10", "1100" and "01000" respectively wherein a series of 0s or 1s are followed by a single bit of the other value.	

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US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article

RUN LENGTH	RUN FEATURE	ENCODING SYMBOL	BINARY PROM ADDRESS	VARIABLE LENGTH CODE WORD
01	1,0	8	1000	111
011	1,1	9	1001	011
01111111	1,6	14	1110	1010
011111111	1,7	15	1111	10111
001	2,0	16	10000	01001
0011111111	2,6	22	10110	110011
00111111111	2,7	23	10111	110000
0001	3,0	24	11000	100111
00···00 (8) 11···11 (7)	8,7	71	1000111	100001
00···0 (139) 11	139,1	1113	10001011001	110001100
00···0 (500) 1111111 (7)	500,7	4007	11111010001111	010101000
000···00 (511)	511,0	4088	11111111111000	010111000
0000 (511) 1	511,1	4089	11111111111001	010001110
00···0 (511) 111111	511,6	4094	11111111111110	001010001
00···00 (511) 1111111	511,7	4095	11111111111111	001010100

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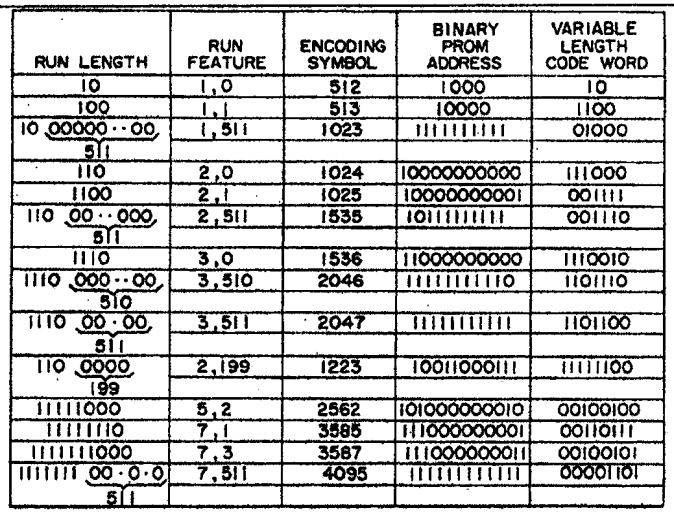
US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article
		

RUN LENGTH	RUN FEATURE	ENCODING SYMBOL	BINARY PROM ADDRESS	VARIABLE LENGTH CODE WORD
10	1,0	512	1000	10
100	1,1	513	10000	1100
10 00000··00 (511)	1,511	1023	1111111111	01000
110	2,0	1024	10000000000	111000
1100	2,1	1025	10000000001	001111
110 00··000 (511)	2,511	1535	10111111111	001110
1110	3,0	1536	11000000000	1110010
1110 000··00 (510)	3,510	2046	11111111110	1101110
1110 00·00 (511)	3,511	2047	11111111111	1101100
110 0000 (199)	2,199	1223	10011000111	1111100
11111000	5,2	2562	10100000010	00100100
11111110	7,1	3585	11100000001	00110111
111111000	7,3	3587	11100000011	00100101
1111111 00·0·0 (511)	7,511	4095	11111111111	00001101

See Figures 2A and 2B.

Subramaniam provides that, "*the run length symbols are used to address an encoder PROM (programmable read-only memory) in which a series of variable-length code words are stored. These code words are assigned to their corresponding symbol addresses based upon their frequency of occurrence.*" *See Col. 2:1-6.* An example of the codewords are shown in Figures 2A and 2B (reproduced above).

Based on the above, it is my opinion that Subramaniam determining a run length and assigning a code word to represent a string of Bs or Ws following by the other value.

4. The method of claim 3, wherein	The variable length codes may be Huffman codes. *See Col. 1:21-22.*	

US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article
said code words are Huffman code words.	Based on the above, Subramainiam discloses that the code words are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	A method is disclosed for reducing the number of bits of information when transmitting a video image. *See Col. 1:7-11.* In the method, an image is divided into a series of rows of data elements of different types, such as black and white colors, so that a series of digital elements (white areas generate a "0" output and black areas generate a "1" output) are generated which correspond to the sequence of signal values. *See Col. 2:30-38.* Based on the above, Subramaniam discloses a method of coding a signal for transmission at a reduced bandwidth, that has a plurality of zero values, and a plurality of non-zero values.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generated DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	When working with documents, the image processor 10 converts the original image data into long strings of 0's followed by short strings of 1's and short strings of 1's followed by long strings of 0's. *See Col. 2:62-66.* Based on the above, Subramaniam discloses a method of coding a signal for transmission at a reduced bit rate, that is converted into a signal that has a plurality of zero values, and a plurality of non-zero values.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generated DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.*

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US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article
		Based on the above, it is my opinion that the Chen Article discloses transforming a signal into a plurality of zero coefficients and a plurality of non-zero coefficients which results after a blockwise transform of pixels of a video 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	From the image signals, runs length symbols are located and these runs are white-black (WB) runs and black-white (BW) runs. *See Col. 2:66- Col. 3:8.* As can be seen the value "0" is the signal value (A) occurring most frequently in runs. In the preferred implementation, the WB run has a white half run 1 to 511 pixels and the black half run is 0 to 7 pixels and the BW run has black half run of 1 to 7 pixels and a white half run of 0 to 511 pixels. *See Col. 3:4-8.* Based on the above, it is my opinion that Subramaniam discloses deriving WB or BW events that have long strings of "0"'s and "1"s.	
(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.	As shown in Figures 2A and 2B (reproduced below), the encoder codes "01", "001", 511 0s followed by a 1, "10", "100" and a 1 followed by 511 zeros with the variable length code words "111", "01001", "010001110", "10", "1100" and "01000" respectively wherein a series of 0s or 1s are followed by a single bit of the other value.	

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US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article

RUN LENGTH	RUN FEATURE	ENCODING SYMBOL	BINARY PROM ADDRESS	VARIABLE LENGTH CODE WORD
01	1,0	8	1000	111
011	1,1	9	1001	011
01111111	1,6	14	1110	1010
011111111	1,7	15	1111	10111
001	2,0	16	10000	01001
0011111111	2,6	22	10110	11001
00111111111	2,7	23	10111	110000
0001	3,0	24	11000	100111
00···00 (8) 11···11 (7)	8,7	71	1000111	100001
00···0 (139) 11	139,1	1113	10001011001	110001100
00···0 (500) 1 1111111 (7)	500,7	4007	11111010001111	010101000
000···00 (511)	511,0	4088	111111111000	010111000
0000 (511) 1	511,1	4089	111111111001	010001110
00···0 (511) 111111	511,6	4094	111111111110	001010001
00···00 (511) 1111111	511,7	4095	111111111111	001010100

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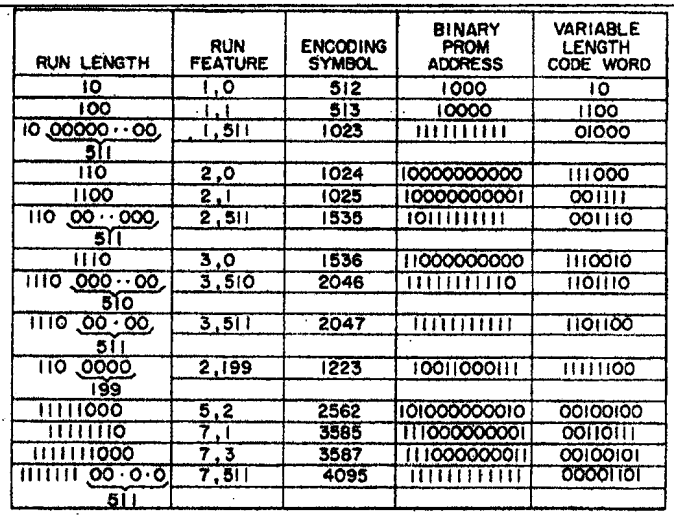
US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article
	 *See Figures 2A and 2B.* Subramaniam provides that, "*the run length symbols are used to address an encoder PROM (programmable read-only memory) in which a series of variable-length code words are stored. These code words are assigned to their corresponding symbol addresses based upon their frequency of occurrence.*" *See Col. 2:1-6.* An example of the codewords are shown in Figures 2A and 2B (reproduced above). Based on the above, it is my opinion that Subramaniam determining a run length and assigning a code word to represent a string of Bs or Ws following by the other value.	
11. The method of claim 8,	The method provides that, if the first half or second half of a run length exceeds the maximum length specified for that particular color, then that	

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US 4,901,075 CLAIM ELEMENTS	Subramaniam '222 Patent	Chen Article
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.	run length must be broken down by using both the general rule and its exception. *See Col. 3:44- Col. 4:68.* Based on the above, it is my opinion that Subramaniam discloses 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.	

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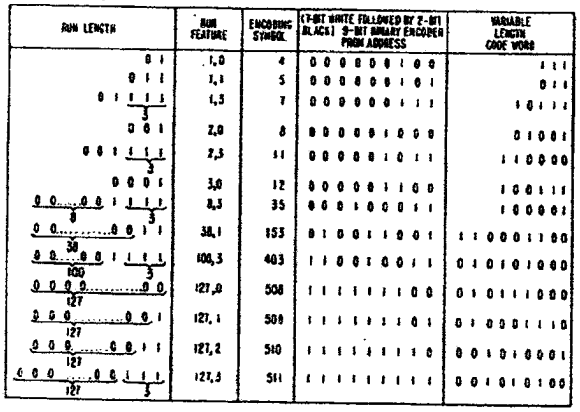
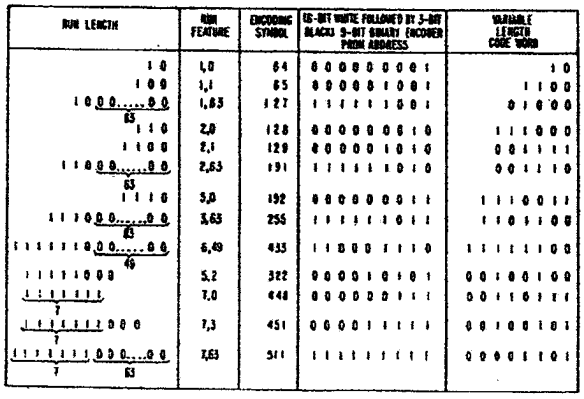
EXHIBIT C-4

EXHIBIT C-4

Invalidity Chart for US Patent No. 4,363,036 in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

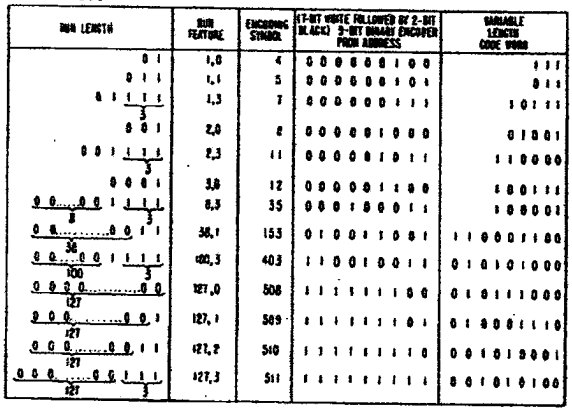
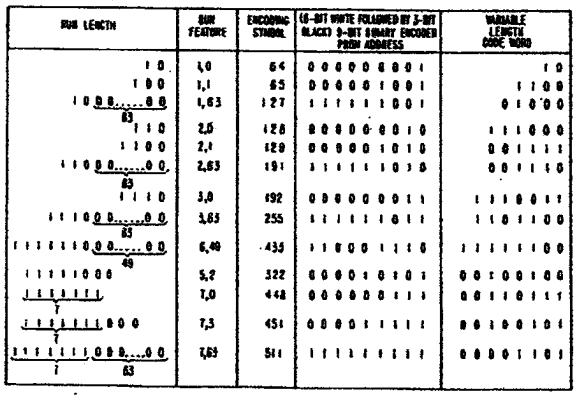
As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,363,036 to Subramaniam and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of the coding technique taught in Subramaniam to video coding as taught by the Chen Article is a predictable use of the coding techniques. Furthermore, the combination of the elements from the Chen Article and Subramaniam yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
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 method for compressing digital data is disclosed that generates prediction error pixels from the digital data to form symbols (WB runs or BW runs) which are then coded using variable length codewords. *See Abstract, Figures 8A and 8B and Col. 3:54 – Col. 4:51.* The invention relates to data compression and in particular a novel method and apparatus for reducing the number of bits of information needed to transmit a video image which reduces bandwidth requirements and storage requirements. *See Col. 1: 15-24.* In the method, a prediction table and a window predictor transform the facsimile image into prediction error values with "0" values and "1" values with minimum redundancy. *See Col. 2:56-58.* The window predictor consists of 13 pixels with pixels in the current scan line and 3 previous scan lines (a block) as shown in Figure 4B. *See Col. 9:40-44.* Based on the above, it is my opinion that Subramaniam discloses a method of coding a signal for transmission at a reduced bit rate, that is converted into a signal that has a plurality of zero values, and a plurality of non-zero values.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
		zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.
(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	Once the digital image is scanned and prediction errors are determined, run lengths are determined wherein the run lengths are: 1) white-black (WB) runs; and 2) black-white (BW) runs wherein each run has two sections called a black half and a white half. *See Col. 10:45-59 and Figures 8A and 8B.* FIG-8A  FIG-8B 	

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
	As shown in Figures 8A and 8B, "01", "001", "0001" and "127 0's and a "1", "10", "100" and "1 with 63 0's" are examples of the run lengths. Based on the above, it is my opinion that Subramaniam discloses deriving WB or BW events that have long strings of "0"'s and "1"s.	
(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.	As shown in Figure 8A and 8B, each of the run lengths (including the specific examples above) is coded using a variable length code. *See Figures 8A and 8B and Col. 10:45-59.* Based on the above, it is my opinion that Subramaniam determining a run length and assigning a code word to represent a string of Bs or Ws following by the other value.	
4. The method of claim 3, wherein said code words are Huffman code words.	The variable length codes are Huffman codes. *See Col 1:31-3, Col. 10:45-59 and Figures 8A and 8B.*	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	A method for compressing digital data is disclosed that generates prediction error pixels from the digital data to form symbols (WB runs or BW runs) which are then coded using variable length codewords. *See Abstract, Figures 8A and 8B and Col. 3:54 – Col. 4:51.* The invention relates to data compression and in particular a novel method and apparatus for reducing the number of bits of information needed to transmit a video image which reduces bandwidth requirements and storage requirements. *See Col. 1: 15-24.* Based on the above, Subramaniam discloses a method of coding a signal for transmission at a reduced bandwidth, that has a plurality of zero values, and a plurality of non-zero values.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See*

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
		pp. 225-227. Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	In the method, a prediction table and a window predictor transform the facsimile image into prediction error values with "0" values and "1" values with minimum redundancy. *See Col. 2:56-58.* The window predictor consists of 13 pixels with pixels in the current scan line and 3 previous scan lines (a block) as shown in Figure 4B. *See Col. 9:40-44.* Based on the above, Subramaniam discloses a method of coding a signal for transmission at a reduced bit rate, that is converted into a signal that has a plurality of zero values, and a plurality of non-zero values.	The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses transforming a signal into a sequence comprising zero coefficients 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	Once the digital image is scanned and prediction errors are determined, run lengths are determined wherein the run lengths are: 1) white-black (WB) runs; and 2) black-white (BW) runs wherein each run has two sections called a black half and a white half. *See Col. 10:45-59 and Figures 8A and 8B.* As shown in Figures 8A and 8B, "01", "001", "0001" and "127 0's and a "1", "10", "100" and "1 with 63 0's" are examples of the run lengths.	

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
	FIG-8A  FIG-8B  Based on the above, it is my opinion that Subramaniam discloses deriving WB or BW events that have long strings of "0"'s and "1"s.	
(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.	As shown in Figure 8A and 8B, each of the run lengths (including the specific examples above) is coded using a variable length code. *See Figures 8A and 8B and Col. 10:45-59.* Based on the above, it is my opinion that Subramaniam determining a run length and assigning a code word to represent a string of Bs or Ws following by the other value.	
11. The method of claim 8,	The method provides that, if the first half or second half of a run length exceeds the maximum	

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
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.	length specified for that particular color, then that run length must be broken down by using both the general rule and its exception. *See Col. 11:26-Col. 12:54.* Based on the above, it is my opinion that Subramaniam discloses 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.	

EXHIBIT C-5

EXHIBIT C-5

Invalidity Chart For U.S. Patent Nos. 4,092,676 to Saran in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,092,676 to Saran and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the coding technique disclosed in Saran being used for video coding as taught by the Chen Article is a predictable use of the coding technique in Saran. Furthermore, the combination of the elements from the Chen Article and Saran yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
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:	Saran discloses a system and method for encoding a video signal generated based on a scan of a document wherein the video signal includes black terminated white runs (in difference modulated and unmodulated signals) that are run length encoded using a code to reduce redundancies and compress binary video signals. *See Col. 1:67 – Col. 2:38; Col. 3:31-34; Col. 4:50-Col. 5:7; Col. 9:7-26 and Col. 9:27-45.* In Saran, a raster input scanner converts the information content of an original document into a corresponding signal which is in turn converted into a raw binary video signal which is then difference modulator using a difference modulator 31. *See Col. 4:50-59 and Col. 5:56-62.* The difference modulator generates difference modulated picture elements and unmodulated picture elements of opposite logic levels (i.e., "1" and "0"). *See Col. 6:9-19.* An example of the series of difference modulated and unmodulated picture elements are shown lines a-c of Figure 4. "0"	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
	is the signal value occurring most frequently in runs. *See Col. 9:7-17.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bit rate that has a signal value occurring in runs and another logic level.	
(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	As shown in Figure 4, black terminated white runs are derived (a run of "0" different modulated signals with a "1"). *See Col. 9:7-26 and Figure 4.* Based on the above, Saran derives a plurality of events (black terminated white runs) wherein each event has a run length and followed by a non-zero value.	
(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.	Saran discloses that the codewords formed for the black terminated white runs (a run of zeros with a "1" at the end), such as 3W+B and 6W+B as shown in Figure 4, are the codewords "10111" and "11010" respectively. *See Col. 9:7-26 and Figure 4.* These codewords are residue codes e. *See Col. 13:1-16 and Figure 4.* Based on the above, Saran discloses determining the run length of the black terminated white runs and then assigning a codeword to represent the black terminated white run.	
4. The method of claim 3, wherein said code words are Huffman code words.	Saran discloses that, "Thus, it should be recalled that the basic Huffman rule for taking advantage of variable length run length message codes is that the code assigned to any given run length should be no longer than the code assigned to any less	

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
	probable run length. *See Col. 2:27-38 and Col. 9:39-43.* Based on the above, Saran discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Saran discloses a system and method for encoding a video signal generated based on a scan of a document wherein the video signal includes black terminated white runs (in difference modulated and unmodulated signals) that are run length encoded using a code to reduce redundancies and compress binary video signals. *See Col. 1:67 – Col. 2:38; Col. 3:31-34; Col. 4:50-Col. 5:7; Col. 9:7-26 and Col. 9:27-45.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bandwidth.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	In Saran, a raster input scanner converts the information content of an original document into a corresponding video signal which is in turn converted into a raw binary video signal which is then difference modulator using a difference modulator 31. *See Col. 4:50-59 and Col. 5:56-62.* The difference modulator generates difference modulated picture elements and unmodulated picture elements of opposite logic levels (i.e., "1" and "0"). *See Col. 6:9-19.* An example of the series of difference modulated and unmodulated picture elements are shown lines a-c of Figure 4. *See*	The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses transforming a signal into a sequence comprising zero coefficients in runs and non-zero coefficients.

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
	Col. 9:7-17. Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bit rate that has a signal value occurring in runs and another logic level.	
(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	As shown in Figure 4, black terminated white runs are derived (a run of "0" different modulated signals with a "1"). *See Col. 9:7-26 and Figure 4.* Based on the above, Saran derives a plurality of events (black terminated white runs) wherein each event has a run length and followed by a non-zero value.	
(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.	Saran discloses that the codewords formed for the black terminated white runs (a run of zeros with a "1" at the end), such as 3W+B and 6W+B as shown in Figure 4, are the codewords "10111" and "11010" respectively. *See Col. 9:7-26 and Figure 4.* These codewords are residue codes e. *See Col. 13:1-16 and Figure 4.* Based on the above, Saran discloses determining the run length of the black terminated white runs and then assigning a codeword to represent the black terminated white run.	
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	Saran discloses that, "For conserving on the storage capacity required of the memory banks 62,63 and 64,65, a block length multiple plus run length residue code format is utilized in encoding the black terminated white runs of difference modulated and unmodulated picture elements.	

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
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.	The advantage of that format is, as shown in FIG. 4, that black terminated white runs in excess of a predetermined block length are represented by a block length multiple code d plus, if the run happens to be a noninteger multiple of the block length, a run length residue code e." *See Col. 13:1-16.* Thus, for black terminated white runs that exceed a predetermined length, Saran uses a block length multiple code d and a run length residue code e for encoding the black terminated white runs that exceed the predetermined length. In the example shown in Figure 4, a black terminated white run of 258W+B is encoded as eight 32W Huffman codes ("10011001") and then a 2W+B Huffman code ("1010") to form 9 sections with each section being less than a predetermined value (a run length of 33 in this example) and each section has a Huffman codeword assigned to the section. Based on the above, it is my opinion that Saran discloses 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.	

EXHIBIT C-6

EXHIBIT C-6

Invalidity Chart for US Patent 4,136,363 to Saran in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,092,676 to Saran and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of the coding technique in Saran to video coding as taught by the Chen Article is a predictable use of the coding techniques taught in Saran. Furthermore, the combination of the elements from the Chen Article and Saran yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
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:	Saran discloses a system and method for encoding a video signal generated based on a scan of a document wherein the video signal includes black terminated white runs (in difference modulated and unmodulated signals) that are run length encoded using a code to reduce redundancies and compress binary video signals. *See Col. 1:67 – Col. 2:38; Col. 3:31-34; Col. 4:50-Col. 5:7; Col. 9:7-26 and Col. 9:27-45.* In Saran, a raster input scanner converts the information content of an original document into a corresponding video signal which is in turn converted into a raw binary video signal which is then difference modulator using a difference modulator 31. *See Col. 4:50-59 and Col. 5:56-62.* The difference modulator generates difference modulated picture elements and unmodulated picture elements of opposite logic levels (i.e., "1" and "0"). See 6:9-19. An example of the series of difference modulated and unmodulated picture elements are shown lines a-c of Figure 4. "0" is	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
	the signal value (A) occurring most frequently in runs. *See Col. 9:7-17.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bit rate that has a signal value occurring in runs and another logic level.	
(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	As shown in Figure 4, black terminated white runs are derived (a run of "0" different modulated signals with a "1"). *See Col. 9:7-26 and Figure 4.* Based on the above, Saran derives a plurality of events (black terminated white runs) wherein each event has a run length and followed by a non-zero value.	
(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.	Saran discloses that the codewords formed for the black terminated white runs (a run of zeros with a "1" at the end), such as 3W+B and 6W+B as shown in Figure 4, are the codewords "10111" and "11010" respectively. *See Col. 9:7-26 and Figure 4.* These codewords are residue codes e. *See Col. 13:1-16 and Figure 4.* Based on the above, Saran discloses determining the run length of the black terminated white runs and then assigning a codeword to represent the black terminated white run.	
4. The method of claim 3, wherein said code words are Huffman code words.	Saran discloses that, "Thus, it should be recalled that the basic Huffman rule for taking advantage of variable length run length message codes is that the code assigned to any given run length should be no longer than the code assigned to any less	

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
	probable run length. *See Col. 2:27-38 and Col. 9:39-43.* Based on the above, Saran discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Saran discloses a system and method for encoding a video signal generated based on a scan of a document wherein the video signal includes black terminated white runs (in difference modulated and unmodulated signals) that are run length encoded using a code to reduce redundancies and compress binary video signals. *See Col. 1:67 – Col. 2:38; Col. 3:31-34; Col. 4:50-Col. 5:7; Col. 9:7-26 and Col. 9:27-45.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bandwidth.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	In Saran, a raster input scanner converts the information content of an original document into a corresponding video signal which is in turn converted into a raw binary video signal which is then difference modulator using a difference modulator 31. *See Col. 4:50-59 and Col. 5:56-62.* The difference modulator generates difference modulated picture elements and unmodulated picture elements of opposite logic levels (i.e., "1" and "0"). *See Col. 6:9-19.* An example of the series of difference modulated and unmodulated picture elements are shown lines a-c of Figure 4. "0"	The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses transforming a signal into a sequence comprising zero coefficients in runs and non-zero coefficients.

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
	is the signal value (A) occurring most frequently in runs. *See Col. 9:7-17.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bit rate that has a signal value occurring in runs and another logic level.	
(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	As shown in Figure 4, black terminated white runs are derived (a run of "0" different modulated signals with a "1"). *See Col. 9:7-26 and Figure 4.* Based on the above, Saran derives a plurality of events (black terminated white runs) wherein each event has a run length and followed by a non-zero value.	
(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.	Saran discloses that the codewords formed for the black terminated white runs (a run of zeros with a "1" at the end), such as 3W+B and 6W+B as shown in Figure 4, are the codewords "10111" and "11010" respectively. *See Col. 9:7-26 and Figure 4.* These codewords are residue codes e. *See Col. 13:1-16 and Figure 4.* Based on the above, Saran discloses determining the run length of the black terminated white runs and then assigning a codeword to represent the black terminated white run.	
11. The method of claim 8, comprising the additional steps of: determining whether the run length of each event exceeds a predetermined	Saran discloses that, "For conserving on the storage capacity required of the memory banks 62,63 and 64,65, a block length multiple plus run length residue code format is utilized in encoding the black terminated	

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
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.	white runs of difference modulated and unmodulated picture elements. The advantage of that format is, as shown in FIG. 4, that black terminated white runs in excess of a predetermined block length are represented by a block length multiple code d plus, if the run happens to be a noninteger multiple of the block length, a run length residue code e." *See Col. 13:1-16.* Thus, for black terminated white runs that exceed a predetermined length, Saran uses a block length multiple code d and a run length residue code e (both Huffman codewords) for encoding the black terminated white runs that exceed the predetermined length. In the example shown in Figure 4 of Saran, a black terminated white run of 258W+B is encoded as eight 32W Huffman codes ("10011001") and then a 2W+B Huffman code ("1010") to form 9 sections with each section being less than a predetermined value (a run length of 33 in this example) and each section has a Huffman codeword assigned to the section. Based on the above, it is my opinion that Saran discloses 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.	

EXHIBIT C-7

EXHIBIT C-7

Invalidity Chart For
US Patent No. 4,494,151 to Liao in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of the U.S. Patent No. 4,494,151 to Liao and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of the video coding as taught by the Chen Article within the image coding technique taught by Liao is a predictable use of the coding techniques in Liao for video coding. Furthermore, the combination of the elements from the Chen Article and the Liao yields predictable results.

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
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:	Liao states that, "There is a need for electronic systems for compacting data so that the information contained within said data may be stored in less memory space or transmitted at a higher rate." *See Col. 1:14-17.* Liao also discloses that one technique (to transmit at higher speed or reduce the bitrate) is the use of a simple run length code. *See Col. 1:18-21.* Liao also discloses that "*The object of the invention, therefore, is to provide a modified run-length encoding circuit which allows the efficient encoding/decoding of binary data at high data rates.*" *See Col. 2:15-19.* The uncoded signal values in Liao is a sequence of predictive values "0" and "1" values from an image predictor 31 as shown in Figures 2 and 3 which are input to an encoder 32. See Figures 2 and 3. Liao discloses, with reference to Figure 3 that, "*The majority of bits output are white or 0 bits since the scanned document usually is text*" when referring to the output bits from a raster input scanner 30 which are input to a predictor 31 that usually	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	further reduces the number of 1 bits. *See Figure 3 and Col. 3:42-54*. Thus, in Liao, "*Because the data is first processed by a predictor, there is an increased likelihood of the encoder input comprising long strings of 0s.*" *See Col. 1:62-64*. Based on the above, it is my opinion that Liao discloses a method of coding a signal comprising a plurality of zero nibbles and a non-zero nibble.	rate.
(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	In Liao, "*The encoder maximizes the compression of these strings by grouping the input data into data words comprising an uninterrupted line of nibbles containing all 0s, regardless of how many that may be, followed by a terminating nibble having at least one 1 bit. A first code word portion is assigned to the number of all-zero nibbles, and a second code word portion is assigned to the data pattern of the terminating nibble. The final code word is the combination of the first and second code word portions.*" *See Col. 1:64 – Col. 2:5*. Based on the above, it is my opinion that Liao discloses deriving a plurality of events that have a number of all-zero nibbles followed by a terminating non-zero nibble.	Chen discloses using DCT coefficients in a video coding process which results in zero coefficients and non-zero coefficients. *See pp. 225-227*
(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.	The code words assigned to each portion is shown in Figure 1A and the code words are of variable length and wherein the code words are shorter than the original data and the more frequently occurring run lengths are assigned to short code words. *See Figure 1A and Col. 6:20- 44*. Thus, Liao discloses that a series of Huffman codewords are formed from the signal	

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	values. In Liao, "*In Example 1, the first string comprises 31 all-zero nibbles and a terminating nibble of 1000. XεA and 26≤Y≤63 so a Type 3A output word is called for. In this case, 11,nnnnnnn,bbbb =11,011111 (31 all-zero nibbles), 1000 (actual bit pattern).*" *See Figure 2 and Col. 3:13-18.* Thus, a terminating nibble such as "1000" and a preceding run of all zero nibbles (such as 31 all-zero nibbles) are coded using a codeword. Based on the above, it is my opinion that Liao discloses determining the run length and assigning a code word to represent a run of zero nibbles followed by terminating non-zero nibble.	
4. The method of claim 3, wherein said code words are Huffman code words.	The code words assigned to each portion is shown in Figure 1A and the code words are of variable length which are Huffman codewords. *See Figure 1A and Col. 6:20- 44.* Based on the above, it is my opinion that Liao discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Liao states that, "*There is a need for electronic systems for compacting data so that the information contained within said data may be stored in less memory space or transmitted at a higher rate.*" *See Col. 1:14-17.* Liao also discloses that one technique (to transmit at higher speed or reduce the bitrate) is the use of a simple run length code. *See Col. 1:18-21.* Liao also discloses that "*The object of the invention, therefore, is to provide a modified run-length encoding circuit*	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	which allows the efficient encoding/decoding of binary data at high data rates." *See Col. 2:15-19.* Based on the above, it is my opinion that Liao discloses a method of coding for reduced bandwidth.	and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	Liao discloses, with reference to Figure 3 that, "*The majority of bits output are white or 0 bits since the scanned document usually is text*" when referring to the output bits from a raster input scanner 30 which are input to a predictor 31 that usually further reduces the number of 1 bits. *See Figure 3 and Col. 3:42-54.* Thus, in Liao, "*Because the data is first processed by a predictor, there is an increased likelihood of the encoder input comprising long strings of 0s.*" *See Col. 1:62-64.* The sequence of predictive values "0" and "1" values from an image predictor 31 as shown in Figures 2 and 3 are input to an encoder 32. *See Figures 2 and 3.* In Liao, "The encoder maximizes the compression of these strings by grouping the input data into data words comprising an uninterrupted line of nibbles containing all 0s, regardless of how many that may be, followed by a terminating nibble having at least one 1 bit. A first code word portion is assigned to the number of all-zero nibbles, and a second code word portion is assigned to the data pattern of the terminating nibble. The final code word is the combination of the first and second	Chen discloses transforming a video signal into DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See 225-227.*

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	code word portions." *See Col. 1:64 – Col. 2:5.* Based on the above, it is my opinion that Liao discloses transforming a signal into a sequence of zero nibbles and non-zero nibbles.	
(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 Liao, "The encoder maximizes the compression of these strings by grouping the input data into data words comprising an uninterrupted line of nibbles containing all 0s, regardless of how many that may be, followed by a terminating nibble having at least one 1 bit. A first code word portion is assigned to the number of all-zero nibbles, and a second code word portion is assigned to the data pattern of the terminating nibble. The final code word is the combination of the first and second code word portions." *See Col. 1:64 – Col. 2:5.* Based on the above, it is my opinion that Liao discloses deriving from said sequence, a plurality of events each comprised of a run of zero nibbles having a respective run length, which is followed by at least a terminating non-zero nibble.	
(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.	The code words assigned to each portion is shown in Figure 1A and the code words are of variable length wherein the code words are shorter than the original data and the more frequently occurring run lengths are assigned to short code words. *See Figure 1A and Col. 6:20- 44.* In Liao, "*In Example 1, the first string comprises 31 all-zero nibbles and a terminating nibble of 1000. X≤A and 26≤Y≤63 so a Type 3A output word is*	

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	called for. In this case, 11,nnnnnnn,bbbb =11,011111 (31 all-zero nibbles), 1000 (actual bit pattern)." *See Figure 2 and Col. 3:13-18.* Thus, the different signal value (a terminating nibble such as "1000") and a preceding run of all zero nibbles (such as 31 all-zero nibbles) are coded using a codeword. Based on the above, it is my opinion that Liao discloses determining the run length and assigning a code word to represent the zero nibbles and the terminating non-zero nibble.	
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.	Liao discloses that "*If there are 64 or more all-zero nibbles before a non-zero terminating nibble, the data string is converted into a first part comprising a number of sets of 64 all-zero nibbles and a second part comprising the remaining 0 to 63 all-zero nibbles and the terminating nibble.*" *See Col. 3:2-7.* Thus, when a run of non-zero nibbles together with the terminating nibble exceeds a predetermined length (more than 64 all-zero nibbles), the run of non-zero nibbles and the terminating nibble are split into sections (the first and second parts) wherein the length of each section is below a predetermined value (64 all-zero nibbles), and each section has a codeword assigned to the section. Based on the above, it is my opinion that Liao discloses 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	

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	length below said predetermined run length, and assigning a code word to each section.	

EXHIBIT C-8

EXHIBIT C-8

Invalidity Chart For Henry H. J. Liao, "Upper Bound, Lower Bound and Run-Length Substitution Coding", NTC '77 Conference Record, Vol. 3, pp. 49:3-1 to 49:3-6 (1977) (the "Liao Article") in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of the Liao Article and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of the coding techniques in the Liao Article to video coding as taught by the Chen Article is a predictable use of the coding techniques in the Liao Article. Furthermore, the combination of the elements from the Chen Article and the Liao Article yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
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:	The Liao Article discusses several bounds of "bandwidth compression for run-length coding." *See pg. 49:3-1, left column, Abstract.* The Liao Article discusses run-length coding for a facsimile signal quantized into a sequence of binary digits (1's and 0's) which directly represent black and white picture elements. *See pg. 49:3-1, left column, first paragraph of Introduction.* The Liao Article also discusses image data run-length coding after a set of prediction errors are generated. *See pg. 49:3-1, left column, first paragraph of Introduction.* Thus, the Liao Article discusses bandwidth compression (bit rate reduction) bounds for run length coding of a sequence of binary digits or predictive error values. Based on the above, it is my opinion that the Liao Article discloses a method of coding a signal comprising a plurality of zero values and a non-zero value.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
		transmission at a reduced bit rate.
(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	The Liao Article, the prediction error values are determined in which the run-length of prediction errors constitute a majority of single bit runs (B) and a few other short runs. *See pg. 49:3-2, left column, first paragraph of Maximum Entropy Lower Bound section.* The prediction errors are recorded as "B" and correct predictions are recorded as "W" so that a message set for these prediction values in shown in Table 1 that have runs of W followed by B. *See pg. 49:3-2, left column, first paragraph of Maximum Entropy Lower Bound section and Table 1.* Based on the above, it is my opinion that the Liao Article discloses deriving a plurality of events that have a run of values, W, followed by another value, B.	Chen discloses using DCT coefficients in a video coding process which results in zero coefficients and non-zero coefficients. *See pp. 225-227.*
(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.	The Liao Article states that, "The best code assignment will be the set of codes with the shortest average length, i.e., the minimum redundancy code. Huffman's coding is a systematic procedure for constituting such as code with minimum redundancy." *See pg. 49:3-1, left column, second paragraph of Introduction section.* The Liao Article also contains a table with a run-length substitution code that is a Huffman code that represent a run of W values (zero to nine) followed by a B value. *See pg. 49:3-3, left and right columns, Run-Length Substitution section, Table 2 and pg. 49:3-6, Table 5.* Table 5 shows the frequency of each run-length and the Huffman length assigned to each run-length based on the frequency. In	

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
	these tables, Huffman codes are formed from the prediction error values. Based on the above, it is my opinion that the Liao Article discloses determining the run length and assigning a code word to represent a run of values, W, followed by another value, B.	
4. The method of claim 3, wherein said code words are Huffman code words.	The Liao Article also contains a table with a run-length substitution code that is a Huffman code that represent a run of W values (zero to nine) followed by a B value. *See pg. 49:3-3, left and right columns, Run-Length Substitution section, Table 2 and pg. 49:3-6, Table 5.* Table 5 shows the frequency of each run-length and the Huffman length assigned to each run-length based on the frequency. In these tables, Huffman codes are formed from the prediction error values. Based on the above, it is my opinion that the Liao Article discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	The Liao Article discusses several bounds of "bandwidth compression for run-length coding." *See pg. 49:3-1, left column, Abstract.* The Liao Article discusses run-length coding for a facsimile signal quantized into a sequence of binary digits (1's and 0's) which directly represent black and white picture elements. *See pg. 49:3-1, left column, first paragraph of Introduction.* The Liao Article also discusses image data run-length	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generated DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See 225-227.*

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
	coding after a set of prediction errors are generated. *See pg. 49:3-1, left column, first paragraph of Introduction.* Based on the above, it is my opinion that the Liao Article discloses bandwidth compression (bit rate reduction) bounds for run length coding of a sequence of binary digits or predictive error values.	Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	The Liao Article discusses run-length coding for a facsimile image that is converted into a sequence of binary digits (1's and 0's) which directly represent black and white picture elements. *See pg. 49:3-1, left column, first paragraph of Introduction.* The Liao Article also discusses image data run-length coding after a set of prediction error values are determined. *See pg. 49:3-1, left column, first paragraph of Introduction.* Based on the above, it is my opinion that the Liao Article discloses a method of coding a signal comprising a plurality of zero values and a non-zero value.	Chen discloses transforming a video signal into DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See 225-227.*
(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	The prediction error values are determined in which the run-length of prediction errors constitute a majority of single bit runs (B) and a few other short runs. *See pg. 49:3-2, left column, first paragraph of Maximum Entropy Lower Bound section.* The prediction errors are recorded as "B" and correct predictions are recorded as "W" so that a message set for these prediction values in shown in Table 1 that have runs of W followed by B. *See pg. 49:3-2, left column, first paragraph of Maximum Entropy*	

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
	Lower Bound section and Table 1. Based on the above, it is my opinion that the Liao Article discloses deriving a plurality of events that have a run of values, W, followed by another value, B.	
(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.	The Liao Article states that, "The best code assignment will be the set of codes with the shortest average length, i.e., the minimum redundancy code. Huffman's coding is a systematic procedure for constituting such as code with minimum redundancy." *See pg. 49:3-1, left column, second paragraph of Introduction section.* The Liao Article also contains a table with a run-length substitution code that is a Huffman code that represents a run of W values (zero to nine) followed by a B value. *See pg. 49:3-3, left and right columns, Run-Length Substitution section, Table 2 and pg. 49:3-6, Table 5.* Table 5 shows the frequency of each run-length and the Huffman length assigned to each run-length based on the frequency. In these tables, Huffman codes are formed from the prediction error values (the sequence of signal values). Based on the above, it is my opinion that the Liao Article discloses determining the run length and assigning a code word to represent a run of values, W, followed by another value, B.	
11. The method of claim 8, comprising the additional steps of: determining whether the	The Liao Article discloses that in run-length substitution, "a fixed number of runs is picked from the entire message set." *See pg. 49:3-3,*	

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
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.	*left column, first paragraph of Run-Length Substitution section.* The Liao Article further discloses that, "Runs without codes can be represented by two or more shorter runs with codes. For example, in Table 2, the run-length 4W is selected and 5W+B is not selected, the run 5W+B is substituted by 4W + (W+B)." *See pg. 49:3-3, left and right columns, first paragraph of Run-Length Substitution section and Table 2.* Based on the above, it is my opinion that the Liao Article discloses 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.	

EXHIBIT C-9

EXHIBIT C-9

Invalidity Chart for U.S. Patent No. 3,984,833 to vanVoorhis In View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4 and 8 of the '075 Patent would be obvious over the combination of U.S. Patent No. 3,984,833 to van Voorhis and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of DCT coefficients in video coding as taught by the Chen Article within the coding technique taught by van Voorhis is a predictable use of the well known DCT coefficients. Furthermore, the combination of the elements from the Chen Article and van Voorhis yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
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:	Van Voorhis discloses an apparatus for encoding extended run-length codes for the compression of digital images that are a two-dimensional array of image points. *See Col. 1:13-19.* The compression of the digital images (using run length codes) reduces the storage requirements for digital images and reduces the bandwidth required for the transmission of the digital images *See Col. 1:27-31.* The value zero occurs far more frequency than the signal value one. From the examples, the value zero occurs most frequency in uninterrupted runs. For example, column 14, lines 64 to 66, mentions: *"For the purpose of the illustration, a run is defined as a one or as a string of one or more zeros and the first one following this string of zeros."* Van Voorhis discloses that an image, for a black/white image, has image points that are converted into a single bit of information with a value of either 0 or 1 to indicate that the corresponding area of the picture is light or dark. *See Col. 1, lines 19-23.*	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression in video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used for image and video coding to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
	Based on the above, van Voorhis discloses a method of coding a signal comprising a plurality of a zero values occurring in runs and other values.	rate.
(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	Van Voorhis discloses that an event may be a binary encoded representation of an alphanumeric character, an analog voltage, a run of binary video information, a run of binary image information or any other type of information capable of recognition. *See Col. 6, lines 59-65.* Van Voorhis also describes that, from the signal, runs are recognized as follows: "*In such as circumstance, the event recognizer 10 of Van Voorhis may recognize each sequence of consecutive bits of the same logic , which is denoted as a run. Runs may also be sequences of bits of one of the logic levels, or sequences of a level terminating in another level.*" *See Col. 7:11-15.* Van Voorhis discloses an example of a run (See Col. 14:64-66; underlining was added): *"For the purpose of the illustration, a run is defined as a one or as a string of one or more zeros and the first one following this string of zeros."* Further examples can be found in col. 15, lines 11- 32. Based on the above, it is my opinion that van Voorhis discloses deriving a plurality of events wherein each event is a sequence of bits of one logic level	Chen discloses using DCT coefficients in a video coding process. *See pp. 225-227.*

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
	(zero) terminating in another logic level (one).	
(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.	Van Voorhis discloses coding of events where the event may include a string of one or more zeros and the first one following this string of zeros. *See Col. 14, lines 64-66.* The encoder then calculates and outputs code words for a specific class of ordinary and extended run-length codes. *See Col, 3, lines 58-61.* Examples of the codes used by the coder are shown in Tables 1 and 2. *See Col. 3, line 58 – Col. 4, line 64 and Tables 1 and 2.* Based on the above, it is my opinion that van Voorhis discloses determining a run length and assigning a code word to the sequence of one logic level terminating in another logic level.	
4. The method of claim 3, wherein said code words are Huffman code words.	Van Voorhis describes a coding method wherein the relative frequencies of the occurrence for the various runs and special situations may be measured in a sample of images and the relative frequencies are used to calculate code word lengths that are ordered and bounded. The coding method places regular events approximately in order of decreasing relative frequency. *See Col, 5, lines 3-56.* Based on the above, it is my opinion that van Voorhis discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Van Voorhis discloses an apparatus for encoding extended run-length codes for the compression of digital images that are a two-dimensional array of image points. *See Col. 1:13-*	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
	19. The compression of the digital images (using run length codes) reduces the storage requirements for digital images and reduces the bandwidth required for the transmission of the digital images *See Col. 1:27-31.* Based on the above, van Voorhis discloses a method of coding a signal for reduced bandwidth.	bandwidth compression in video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used for image and video coding to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	Van Voorhis discloses that an image, for a black/white image, has image points that are transformed into a single bit of information with a value of either 0 or 1 to indicate that the corresponding area of the picture is light or dark. *See Col. 1, lines 19-23.* The value zero occurs far more frequency than the other signal value one. From the examples, the value zero occurs most frequency in uninterrupted runs. For example, column 14, lines 64 to 66, mentions: *"For the purpose of the illustration, a run is defined as a one or as a string of one or more zeros and the first one following this string of zeros."* Based on the above, van Voorhis discloses a method of coding a signal comprising a plurality of a zero values occurring in runs and other values.	Chen discloses using DCT coefficients in a video coding process that have zero values and non-zero values. *See pp. 225-227.*
(b) deriving from said sequence, a plurality of events each comprised	Van Voorhis discloses that an event may be a binary encoded representation of an alphanumeric	Chen discloses using DCT coefficients in a video coding process that have zero values

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
of a run of zero coefficients having a respective run length, which is preceded or followed by at least one non-zero coefficient, and	character, an analog voltage, a run of binary video information, a run of binary image information or any other type of information capable of recognition. *See Col. 6, lines 59-65.* Van Voorhis also describes that, from the signal, runs are recognized as follows: "*In such a circumstance, the event recognizer 10 of Van Voorhis may recognize each sequence of consecutive bits of the same logic , which is denoted as a run. Runs may also be sequences of bits of one of the logic levels, or sequences of a level terminating in another level.*" *See Col. 7:11-15.* Van Voorhis discloses an example of a run (See Col. 14:64-66; underlining was added): *"For the purpose of the illustration, a run is defined as a one or as a string of one or more zeros and the first one following this string of zeros."* Further examples can be found in column 15, lines 11- 32. Based on the above, it is my opinion that van Voorhis discloses deriving a plurality of events wherein each event is a sequence of bits of one logic level (zero) terminating in another logic level (one).	and non-zero values. *See pp. 225-227.*
(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.	Van Voorhis discloses coding of events where the event may include a string of one or more zeros and the first one following this string of zeros. *See Col. 14, lines 64-66.* The encoder then calculates and outputs code words for a specific class of ordinary and extended run-length	

US 4,901,075 CLAIM ELEMENTS	Van Voorhis Patent	Chen Article
	codes. *See Col, 3, lines 58-61.* Examples of the codes used by the coder are shown in Tables 1 and 2. *See Col. 3, line 58 – Col. 4, line 64 and Tables 1 and 2.* Based on the above, it is my opinion that van Voorhis discloses determining a run length and assigning a code word to the sequence of one logic level terminating in another logic level.	

EXHIBIT C-10

EXHIBIT C-10

Invalidity Chart for U.S. Patent No. 4,420,771 to Pirsch In View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4 and 8 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,430,771 to Pirsch and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of DCT coefficients in video coding as taught by the Chen Article within the coding technique taught by Pirsch is a predictable use of the well known DCT coefficients. Furthermore, the combination of the elements from the Chen Article and Pirsch yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
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:	Pirsch discloses a method for encoding multi-level signals. *See Title and Col. 1:60- 2:8 and 2:34-50.* Pirsch also discloses that multi-level signal encoding results in reducing redundancy in the signal and reducing the amount of data needed to represent the signal and the object of the present invention is to enable more efficient encoding of a multi-level signal. *See Col. 1:45-57.* Pirsch states that "The present invention relates generally to a technique for encoding multi-level signal and, in particular, to a form of run-length coding of such signals when one of the levels occurs much more frequently than all of the other possible levels." *See Col. 1, lines 6-10.* In addition, Pirsch discloses that the system is used for encoding error prediction values wherein "a large number of the error values will have values at or near ZERO." These large number of error values "form the "frequent value" inputs to the encoder.." *See Col. 2, lines 39-45.* The error prediction values may be quantized. *See Col. 3, lines 2-5.*	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
	Pirsch discloses that "multi-level signals derived from other sources may be processed in accordance with the instant invention and that advantageous results will be achieved as long as a heavy bias exists in favor of a given most frequent value." and "the present invention is useful with any series of input samples or words capable of having at least M different values." *See Col. 2, lines 45-50 and Col. 11, lines 9-24.* Based on the above, it is my opinion that Pirsch describes a multi-level signal encoding system to reduce the amount of data where signals containing a large number of zero values.	
(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	In the preferred embodiment of Pirsch, run length codes for frequent values (FRL), run length codes for non-frequent values (NFRL) and codes for the non-frequent value (NFV) are generated. *See Figure 3, Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* Pirsch provides "The definition of a "run" stated previously, namely, a series of consecutive inputs having the same value, can also be modified, if desired, without diminishing the advantages of the present invention. Specifically, an alternative definition of a run may be a series of consecutive words of like value as well as the next (subsequent) word of different value." (Emphasis added*) See Col. 11, lines 25-43.* Based on the above, it is my opinion that Pirsch discloses that events are derived from the signal and each	

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
	event comprises a run of most likely value (zero) followed by a different value (non-zero).	
(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.	Pirsch discloses a method for encoding multi-level signals in which runs are encoded by a coder 191 using a variable length codes with an example of the codes for encoding the non-frequent values shown in Table 4. *See Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* In Pirsch, using the alternative definition of a "run", the series of consecutive words of like value as well as the next (subsequent) word of different value are assigned a code word of variable length. Based on the above, it is my opinion that Pirsch discloses determining, for each event, a run length and assigning a codeword that represents a series of consecutive words of like value as well as the next (subsequent) word of different value.	
4. The method of claim 3, wherein said code words are Huffman code words.	The runs of the "frequent values" and the less frequent values are encoded by a coder 191 using a variable length Huffman code with an example of the Huffman codes for encoding the non-frequent values shown in Table 4. *See Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* Based on the above, it is my opinion that Pirsch discloses using Huffman code words to code events.	
8. A method for coding a signal for transmission at a reduced bandwidth,	Pirsch discloses a method for encoding multi-level signals. *See Title and Col. 1:60- 2:8 and 2:34-50.*	Chen discloses a system and method wherein transform image coding (which was

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
comprising the steps of:	Pirsch also discloses that multi-level signal encoding results in reducing redundancy in the signal and reducing the amount of data needed to represent the signal and the object of the present invention is to enable more efficient encoding of a multi-level signal. *See Col. 1:45-57.* Pirsch states that "The present invention relates generally to a technique for encoding multi-level signal and, in particular, to a form of run-length coding of such signals when one of the levels occurs much more frequently than all of the other possible levels." *See Col. 1, lines 6-10.* Based on the above, it is my opinion that Pirsch describes a multi-level signal encoding system to reduce the amount of data..	developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	In the example of Pirsch given in Col. 11:31-43, only binary values are given. However, it is apparent that, in encoding method disclosed in Pirsch, that the other signal values can also take other values than "1" since Pirsch deals with "multi-level" coding, i.e. coding of signals with at least three values. *See Col. 11:9-14: "$M \geq 3$".* In addition, Pirsch provides that "it is to be clearly understood that multi-level signals derived from other sources may be processed ..." and "that advantageous results will be achieved as long as a heavy bias exists in favor of a given most frequent value." *See Col. 2:25-50.*	

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
	In addition, Pirsch discloses that the system is used for encoding error prediction values wherein "a large number of the error values will have values at or near ZERO." These large number of error values "form the "frequent value" inputs to the encoder.." *See Col. 2, lines 39-45.* The error prediction values may be quantized. *See Col. 3, lines 2-5.* Based on the above, it is my opinion that Pirsch discloses that events may be a run of most likely value (zero) followed by a different value (non-zero).	
(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 the preferred embodiment of Pirsch, run length codes for frequent values (FRL), run length codes for non-frequent values (NFRL) and codes for the non-frequent value (NFV) are generated. *See Figure 3, Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* Pirsch provides "The definition of a "run" stated previously, namely, a series of consecutive inputs having the same value, can also be modified, if desired, without diminishing the advantages of the present invention. Specifically, an alternative definition of a run may be a series of consecutive words of like value as well as the next (subsequent) word of different value." (Emphasis added) *See Col. 11, lines 25-43.* Based on the above, it is my opinion that Pirsch discloses that events are derived from the signal and each event comprises a run of most likely value (zero) followed by a different value (non-zero).	

US 4,901,075 CLAIM ELEMENTS	Pirsch Patent	Chen Article
(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.	The runs of the "frequent values" and the next subsequent value are encoded by a coder 191 using a variable length code with an example of the codes for encoding the non-frequent values shown in Table 4. *See Col. 1:60- Col. 2:9, Col. 7:5- Col. 8:15 and Table 4.* Based on the above, it is my opinion that Pirsch discloses determining, for each event, a run length and assigning a codeword that represents a series of consecutive words of like value as well as the next (subsequent) word of different value.	\

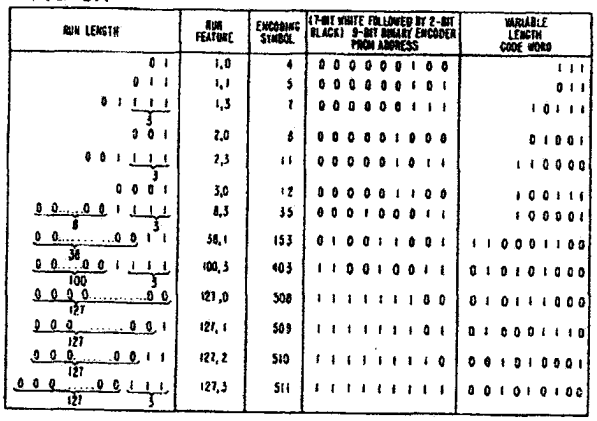
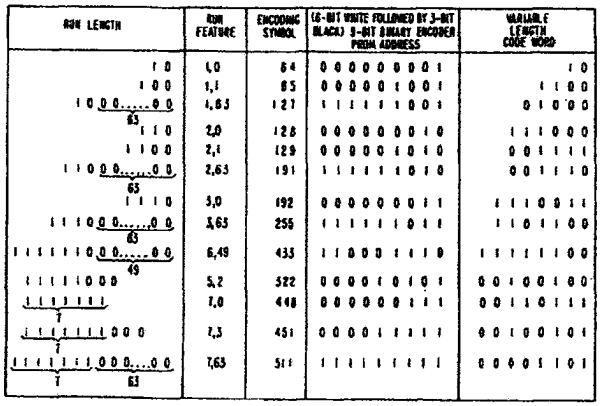
EXHIBIT C-11

EXHIBIT C-11

Invalidity Chart for US Patent No. 4,363,036 in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

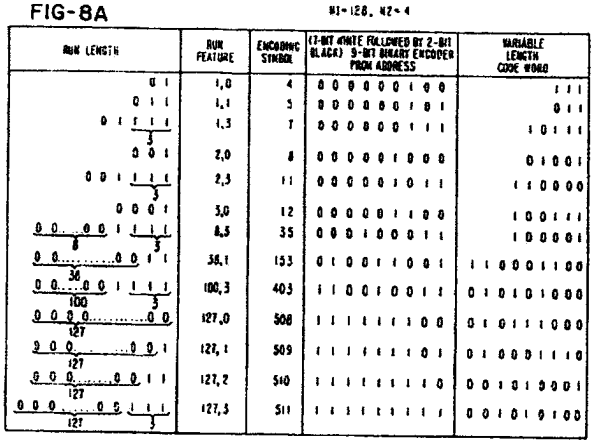
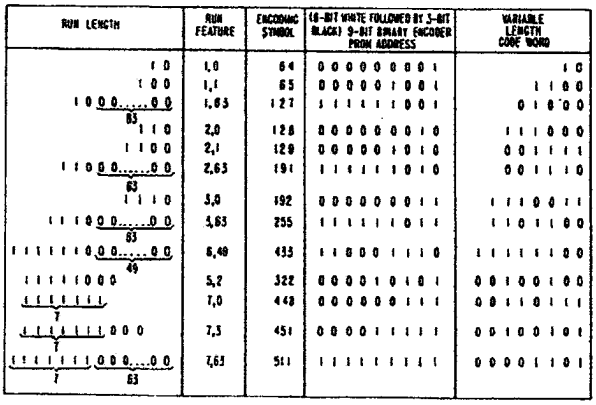
As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,363,036 to Subramaniam and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of DCT coefficients in video coding as taught by the Chen Article within the coding technique taught by Subramaniam is a predictable use of the well known DCT coefficients. Furthermore, the combination of the elements from the Chen Article and Subramaniam yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
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 method for compressing digital data is disclosed that generates prediction error pixels from the digital data to form symbols (WB runs or BW runs) which are then coded using variable length codewords. *See Abstract, Figures 8A and 8B and Col. 3:54 – Col. 4:51.* The invention relates to data compression and in particular a novel method and apparatus for reducing the number of bits of information needed to transmit a video image which reduces bandwidth requirements and storage requirements. *See Col. 1: 15-24.* In the method, a prediction table and a window predictor transform the facsimile image into prediction error values with "0" values and "1" values with minimum redundancy. *See Col. 2:56-58.* The window predictor consists of 13 pixels with pixels in the current scan line and 3 previous scan lines (a block) as shown in Figure 4B. *See Col. 9:40-44.* Based on the above, it is my opinion that Subramaniam discloses a method of coding a signal for transmission at a reduced bit rate, that is converted into a signal that has a plurality of zero values, and a plurality of non-zero values.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
		zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.
(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	Once the digital image is scanned and prediction errors are determined, run lengths are determined wherein the run lengths are: 1) white-black (WB) runs; and 2) black-white (BW) runs wherein each run has two sections called a black half and a white half. *See Col. 10:45-59 and Figures 8A and 8B.* FIG-8A M1=128, M2=4  FIG-8B M3=8, M4=64 	

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
	As shown in Figures 8A and 8B, "01", "001", "0001" and "127 0's and a "1", "10", "100" and "1 with 63 0's" are examples of the run lengths. Based on the above, it is my opinion that Subramaniam discloses deriving WB or BW events that have long strings of "0"'s and "1"s.	
(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.	As shown in Figure 8A and 8B, each of the run lengths (including the specific examples above) is coded using a variable length code. *See Figures 8A and 8B and Col. 10:45-59.* Based on the above, it is my opinion that Subramaniam determining a run length and assigning a code word to represent a string of Bs or Ws following by the other value.	
4. The method of claim 3, wherein said code words are Huffman code words.	The variable length codes are Huffman codes. *See Col 1:31-3, Col. 10:45-59 and Figures 8A and 8B.*	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	A method for compressing digital data is disclosed that generates prediction error pixels from the digital data to form symbols (WB runs or BW runs) which are then coded using variable length codewords. *See Abstract, Figures 8A and 8B and Col. 3:54 – Col. 4:51.* The invention relates to data compression and in particular a novel method and apparatus for reducing the number of bits of information needed to transmit a video image which reduces bandwidth requirements and storage requirements. *See Col. 1: 15-24.* Based on the above, Subramaniam discloses a method of coding a signal for transmission at a reduced bandwidth, that has a plurality of zero values, and a plurality of non-zero values.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See*

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
		pp. 225-227. Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	In the method, a prediction table and a window predictor transform the facsimile image into prediction error values with "0" values and "1" values with minimum redundancy. *See Col. 2:56-58.* The window predictor consists of 13 pixels with pixels in the current scan line and 3 previous scan lines (a block) as shown in Figure 4B. *See Col. 9:40-44.* Based on the above, Subramaniam discloses a method of coding a signal for transmission at a reduced bit rate, that is converted into a signal that has a plurality of zero values, and a plurality of non-zero values.	The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses transforming a signal into a sequence comprising zero coefficients 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	Once the digital image is scanned and prediction errors are determined, run lengths are determined wherein the run lengths are: 1) white-black (WB) runs; and 2) black-white (BW) runs wherein each run has two sections called a black half and a white half. *See Col. 10:45-59 and Figures 8A and 8B.* As shown in Figures 8A and 8B, "01", "001", "0001" and "127 0's and a "1", "10", "100" and "1 with 63 0's" are examples of the run lengths.	

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
	FIG-8A  FIG-8B  Based on the above, it is my opinion that Subramaniam discloses deriving WB or BW events that have long strings of "0"'s and "1"s.	
(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.	As shown in Figure 8A and 8B, each of the run lengths (including the specific examples above) is coded using a variable length code. *See Figures 8A and 8B and Col. 10:45-59.* Based on the above, it is my opinion that Subramaniam determining a run length and assigning a code word to represent a string of Bs or Ws following by the other value.	
11. The method of claim 8,	The method provides that, if the first half or second half of a run length exceeds the maximum	

US 4,901,075 CLAIM ELEMENTS	Subramaniam '036 Patent	Chen Article
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.	length specified for that particular color, then that run length must be broken down by using both the general rule and its exception. *See Col. 11:26-Col. 12:54.* Based on the above, it is my opinion that Subramaniam discloses 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.	

EXHIBIT C-12

EXHIBIT C-12

Invalidity Chart For U.S. Patent Nos. 4,092,676 to Saran in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,092,676 to Saran and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of DCT coefficients in video coding as taught by the Chen Article within the coding technique taught by Saran is a predictable use of the well known DCT coefficients. Furthermore, the combination of the elements from the Chen Article and Saran yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
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:	Saran discloses a system and method for encoding a video signal generated based on a scan of a document wherein the video signal includes black terminated white runs (in difference modulated and unmodulated signals) that are run length encoded using a code to reduce redundancies and compress binary video signals. *See Col. 1:67 – Col. 2:38; Col. 3:31-34; Col. 4:50-Col. 5:7; Col. 9:7-26 and Col. 9:27-45.* In Saran, a raster input scanner converts the information content of an original document into a corresponding signal which is in turn converted into a raw binary video signal which is then difference modulator using a difference modulator 31. *See Col. 4:50-59 and Col. 5:56-62.* The difference modulator generates difference modulated picture elements and unmodulated picture elements of opposite logic levels (i.e., "1" and "0"). *See Col. 6:9-19.* An example of the series of difference modulated and unmodulated picture elements are shown lines a-c of Figure 4. "0"	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
	is the signal value occurring most frequently in runs. *See Col. 9:7-17.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bit rate that has a signal value occurring in runs and another logic level.	
(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	As shown in Figure 4, black terminated white runs are derived (a run of "0" different modulated signals with a "1"). *See Col. 9:7-26 and Figure 4.* Based on the above, Saran derives a plurality of events (black terminated white runs) wherein each event has a run length and followed by a non-zero value.	
(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.	Saran discloses that the codewords formed for the black terminated white runs (a run of zeros with a "1" at the end), such as 3W+B and 6W+B as shown in Figure 4, are the codewords "10111" and "11010" respectively. *See Col. 9:7-26 and Figure 4.* These codewords are residue codes e. *See Col. 13:1-16 and Figure 4.* Based on the above, Saran discloses determining the run length of the black terminated white runs and then assigning a codeword to represent the black terminated white run.	
4. The method of claim 3, wherein said code words are Huffman code words.	Saran discloses that, "Thus, it should be recalled that the basic Huffman rule for taking advantage of variable length run length message codes is that the code assigned to any given run length should be no longer than the code assigned to any less	

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
	probable run length. *See Col. 2:27-38 and Col. 9:39-43.* Based on the above, Saran discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Saran discloses a system and method for encoding a video signal generated based on a scan of a document wherein the video signal includes black terminated white runs (in difference modulated and unmodulated signals) that are run length encoded using a code to reduce redundancies and compress binary video signals. *See Col. 1:67 – Col. 2:38; Col. 3:31-34; Col. 4:50-Col. 5:7; Col. 9:7-26 and Col. 9:27-45.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bandwidth.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	In Saran, a raster input scanner converts the information content of an original document into a corresponding video signal which is in turn converted into a raw binary video signal which is then difference modulator using a difference modulator 31. *See Col. 4:50-59 and Col. 5:56-62.* The difference modulator generates difference modulated picture elements and unmodulated picture elements of opposite logic levels (i.e., "1" and "0"). *See Col. 6:9-19.* An example of the series of difference modulated and unmodulated picture elements are shown lines a-c of Figure 4. *See*	The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses transforming a signal into a sequence comprising zero coefficients in runs and non-zero coefficients.

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
	Col. 9:7-17. Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bit rate that has a signal value occurring in runs and another logic level.	
(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	As shown in Figure 4, black terminated white runs are derived (a run of "0" different modulated signals with a "1"). *See Col. 9:7-26 and Figure 4.* Based on the above, Saran derives a plurality of events (black terminated white runs) wherein each event has a run length and followed by a non-zero value.	
(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.	Saran discloses that the codewords formed for the black terminated white runs (a run of zeros with a "1" at the end), such as 3W+B and 6W+B as shown in Figure 4, are the codewords "10111" and "11010" respectively. *See Col. 9:7-26 and Figure 4.* These codewords are residue codes e. *See Col. 13:1-16 and Figure 4.* Based on the above, Saran discloses determining the run length of the black terminated white runs and then assigning a codeword to represent the black terminated white run.	
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	Saran discloses that, "For conserving on the storage capacity required of the memory banks 62,63 and 64,65, a block length multiple plus run length residue code format is utilized in encoding the black terminated white runs of difference modulated and unmodulated picture elements.	

US 4,901,075 CLAIM ELEMENTS	Saran '676 Patent	Chen Article
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.	The advantage of that format is, as shown in FIG. 4, that black terminated white runs in excess of a predetermined block length are represented by a block length multiple code d plus, if the run happens to be a noninteger multiple of the block length, a run length residue code e." *See Col. 13:1-16.* Thus, for black terminated white runs that exceed a predetermined length, Saran uses a block length multiple code d and a run length residue code e for encoding the black terminated white runs that exceed the predetermined length. In the example shown in Figure 4, a black terminated white run of 258W+B is encoded as eight 32W Huffman codes ("10011001") and then a 2W+B Huffman code ("1010") to form 9 sections with each section being less than a predetermined value (a run length of 33 in this example) and each section has a Huffman codeword assigned to the section. Based on the above, it is my opinion that Saran discloses 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.	

EXHIBIT C-13

EXHIBIT C-13

Invalidity Chart for US Patent 4,136,363 to Saran in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of U.S. Patent No. 4,092,676 to Saran and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of DCT coefficients in video coding as taught by the Chen Article within the coding technique taught by Saran is a predictable use of the well known DCT coefficients. Furthermore, the combination of the elements from the Chen Article and Saran yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
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:	Saran discloses a system and method for encoding a video signal generated based on a scan of a document wherein the video signal includes black terminated white runs (in difference modulated and unmodulated signals) that are run length encoded using a code to reduce redundancies and compress binary video signals. *See Col. 1:67 – Col. 2:38; Col. 3:31-34; Col. 4:50-Col. 5:7; Col. 9:7-26 and Col. 9:27-45.* In Saran, a raster input scanner converts the information content of an original document into a corresponding video signal which is in turn converted into a raw binary video signal which is then difference modulator using a difference modulator 31. *See Col. 4:50-59 and Col. 5:56-62.* The difference modulator generates difference modulated picture elements and unmodulated picture elements of opposite logic levels (i.e., "1" and "0"). See 6:9-19. An example of the series of difference modulated and unmodulated picture elements are shown lines a-c of Figure 4. "0" is	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit rate.

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
	the signal value (A) occurring most frequently in runs. *See Col. 9:7-17.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bit rate that has a signal value occurring in runs and another logic level.	
(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	As shown in Figure 4, black terminated white runs are derived (a run of "0" different modulated signals with a "1"). *See Col. 9:7-26 and Figure 4.* Based on the above, Saran derives a plurality of events (black terminated white runs) wherein each event has a run length and followed by a non-zero value.	
(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.	Saran discloses that the codewords formed for the black terminated white runs (a run of zeros with a "1" at the end), such as 3W+B and 6W+B as shown in Figure 4, are the codewords "10111" and "11010" respectively. *See Col. 9:7-26 and Figure 4.* These codewords are residue codes e. *See Col. 13:1-16 and Figure 4.* Based on the above, Saran discloses determining the run length of the black terminated white runs and then assigning a codeword to represent the black terminated white run.	
4. The method of claim 3, wherein said code words are Huffman code words.	Saran discloses that, "Thus, it should be recalled that the basic Huffman rule for taking advantage of variable length run length message codes is that the code assigned to any given run length should be no longer than the code assigned to any less	

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
	probable run length. *See Col. 2:27-38 and Col. 9:39-43.* Based on the above, Saran discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Saran discloses a system and method for encoding a video signal generated based on a scan of a document wherein the video signal includes black terminated white runs (in difference modulated and unmodulated signals) that are run length encoded using a code to reduce redundancies and compress binary video signals. *See Col. 1:67 – Col. 2:38; Col. 3:31-34; Col. 4:50-Col. 5:7; Col. 9:7-26 and Col. 9:27-45.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bandwidth.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	In Saran, a raster input scanner converts the information content of an original document into a corresponding video signal which is in turn converted into a raw binary video signal which is then difference modulator using a difference modulator 31. *See Col. 4:50-59 and Col. 5:56-62.* The difference modulator generates difference modulated picture elements and unmodulated picture elements of opposite logic levels (i.e., "1" and "0"). *See Col. 6:9-19.* An example of the series of difference modulated and unmodulated picture elements are shown lines a-c of Figure 4. "0"	The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses transforming a signal into a sequence comprising zero coefficients in runs and non-zero coefficients.

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
	is the signal value (A) occurring most frequently in runs. *See Col. 9:7-17.* Based on the above, it is my opinion that Saran discloses a method of coding a signal for transmission at a reduced bit rate that has a signal value occurring in runs and another logic level.	
(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	As shown in Figure 4, black terminated white runs are derived (a run of "0" different modulated signals with a "1"). *See Col. 9:7-26 and Figure 4.* Based on the above, Saran derives a plurality of events (black terminated white runs) wherein each event has a run length and followed by a non-zero value.	
(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.	Saran discloses that the codewords formed for the black terminated white runs (a run of zeros with a "1" at the end), such as 3W+B and 6W+B as shown in Figure 4, are the codewords "10111" and "11010" respectively. *See Col. 9:7-26 and Figure 4.* These codewords are residue codes e. *See Col. 13:1-16 and Figure 4.* Based on the above, Saran discloses determining the run length of the black terminated white runs and then assigning a codeword to represent the black terminated white run.	
11. The method of claim 8, comprising the additional steps of: determining whether the run length of each event exceeds a predetermined	Saran discloses that, "For conserving on the storage capacity required of the memory banks 62,63 and 64,65, a block length multiple plus run length residue code format is utilized in encoding the black terminated	

US 4,901,075 CLAIM ELEMENTS	Saran '363 Patent	Chen Article
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.	white runs of difference modulated and unmodulated picture elements. The advantage of that format is, as shown in FIG. 4, that black terminated white runs in excess of a predetermined block length are represented by a block length multiple code d plus, if the run happens to be a noninteger multiple of the block length, a run length residue code e." *See Col. 13:1-16.* Thus, for black terminated white runs that exceed a predetermined length, Saran uses a block length multiple code d and a run length residue code e (both Huffman codewords) for encoding the black terminated white runs that exceed the predetermined length. In the example shown in Figure 4 of Saran, a black terminated white run of 258W+B is encoded as eight 32W Huffman codes ("10011001") and then a 2W+B Huffman code ("1010") to form 9 sections with each section being less than a predetermined value (a run length of 33 in this example) and each section has a Huffman codeword assigned to the section. Based on the above, it is my opinion that Saran discloses 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.	

EXHIBIT C-14

EXHIBIT C-14

Invalidity Chart For
US Patent No. 4,494,151 to Liao in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of the U.S. Patent No. 4,494,151 to Liao and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of DCT coefficients in video coding as taught by the Chen Article within the coding technique taught by Liao is a predictable use of the well known DCT coefficients. Furthermore, the combination of the elements from the Chen Article and the Liao yields predictable results.

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
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:	Liao states that, "There is a need for electronic systems for compacting data so that the information contained within said data may be stored in less memory space or transmitted at a higher rate." *See Col. 1:14-17.* Liao also discloses that one technique (to transmit at higher speed or reduce the bitrate) is the use of a simple run length code. *See Col. 1:18-21.* Liao also discloses that "*The object of the invention, therefore, is to provide a modified run-length encoding circuit which allows the efficient encoding/decoding of binary data at high data rates.*" *See Col. 2:15-19.* The uncoded signal values in Liao is a sequence of predictive values "0" and "1" values from an image predictor 31 as shown in Figures 2 and 3 which are input to an encoder 32. See Figures 2 and 3. Liao discloses, with reference to Figure 3 that, "*The majority of bits output are white or 0 bits since the scanned document usually is text*" when referring to the output bits from a raster input scanner 30 which are input to a predictor 31 that usually	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for transmission at a reduced bit

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	further reduces the number of 1 bits. *See Figure 3 and Col. 3:42-54.* Thus, in Liao, "*Because the data is first processed by a predictor, there is an increased likelihood of the encoder input comprising long strings of 0s.*" *See Col. 1:62-64.* Based on the above, it is my opinion that Liao discloses a method of coding a signal comprising a plurality of zero nibbles and a non-zero nibble.	rate.
(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	In Liao, "*The encoder maximizes the compression of these strings by grouping the input data into data words comprising an uninterrupted line of nibbles containing all 0s, regardless of how many that may be, followed by a terminating nibble having at least one 1 bit. A first code word portion is assigned to the number of all-zero nibbles, and a second code word portion is assigned to the data pattern of the terminating nibble. The final code word is the combination of the first and second code word portions.*" *See Col. 1:64 – Col. 2:5.* Based on the above, it is my opinion that Liao discloses deriving a plurality of events that have a number of all-zero nibbles followed by a terminating nibble.	Chen discloses using DCT coefficients in a video coding process which results in zero coefficients and non-zero coefficients. *See pp. 225-227*
(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.	The code words assigned to each portion is shown in Figure 1A and the code words are of variable length and wherein the code words are shorter than the original data and the more frequently occurring run lengths are assigned to short code words. *See Figure 1A and Col. 6:20- 44.* Thus, Liao discloses that a series of Huffman codewords are formed from the signal	

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	values. In Liao, "*In Example 1, the first string comprises 31 all-zero nibbles and a terminating nibble of 1000. X≤A and 26≤Y≤63 so a Type 3A output word is called for. In this case, 11,nnnnnnn,bbbb =11,011111 (31 all-zero nibbles), 1000 (actual bit pattern).*" *See Figure 2 and Col. 3:13-18.* Thus, a terminating nibble such as "1000" and a preceding run of all zero nibbles (such as 31 all-zero nibbles) are coded using a codeword. Based on the above, it is my opinion that Liao discloses determining the run length and assigning a code word to represent a run of zero nibbles followed by terminating nibble.	
4. The method of claim 3, wherein said code words are Huffman code words.	The code words assigned to each portion is shown in Figure 1A and the code words are of variable length which are Huffman codewords. *See Figure 1A and Col. 6:20- 44.* Based on the above, it is my opinion that Liao discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	Liao states that, "*There is a need for electronic systems for compacting data so that the information contained within said data may be stored in less memory space or transmitted at a higher rate.*" *See Col. 1:14-17.* Liao also discloses that one technique (to transmit at higher speed or reduce the bitrate) is the use of a simple run length code. *See Col. 1:18-21.* Liao also discloses that "*The object of the invention, therefore, is to provide a modified run-length encoding circuit which allows the efficient*	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients.

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	encoding/decoding of binary data at high data rates." *See Col. 2:15-19.*	*See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	Liao discloses, with reference to Figure 3 that, "*The majority of bits output are white or 0 bits since the scanned document usually is text*" when referring to the output bits from a raster input scanner 30 which are input to a predictor 31 that usually further reduces the number of 1 bits. *See Figure 3 and Col. 3:42-54.* Thus, in Liao, "*Because the data is first processed by a predictor, there is an increased likelihood of the encoder input comprising long strings of 0s.*" *See Col. 1:62-64.* The sequence of predictive values "0" and "1" values from an image predictor 31 as shown in Figures 2 and 3 are input to an encoder 32. *See Figures 2 and 3.* In Liao, "The encoder maximizes the compression of these strings by grouping the input data into data words comprising an uninterrupted line of nibbles containing all 0s, regardless of how many that may be, followed by a terminating nibble having at least one 1 bit. A first code word portion is assigned to the number of all-zero nibbles, and a second code word portion is assigned to the data pattern of the terminating nibble. The final code word is the combination of the first and second code word portions." *See Col. 1:64 –*	Chen discloses transforming a video signal into DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See 225-227.*

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	Col. 2:5. Based on the above, it is my opinion that Liao discloses transforming a signal into a sequence of zero nibbles and non-zero nibbles.	
(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 Liao, "The encoder maximizes the compression of these strings by grouping the input data into data words comprising an uninterrupted line of nibbles containing all 0s, regardless of how many that may be, followed by a terminating nibble having at least one 1 bit. A first code word portion is assigned to the number of all-zero nibbles, and a second code word portion is assigned to the data pattern of the terminating nibble. The final code word is the combination of the first and second code word portions." *See Col. 1:64 – Col. 2:5.* Based on the above, it is my opinion that Liao discloses deriving from said sequence, a plurality of events each comprised of a run of zero nibbles having a respective run length, which is followed by at least a terminating nibble.	
(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.	The code words assigned to each portion is shown in Figure 1A and the code words are of variable length wherein the code words are shorter than the original data and the more frequently occurring run lengths are assigned to short code words. *See Figure 1A and Col. 6:20- 44.* In Liao, "*In Example 1, the first string comprises 31 all-zero nibbles and a terminating nibble of 1000. X≤A and 26≤Y≤63 so a Type 3A output word is called for. In this case,*	

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	11,nnnnnnn,bbbb =11,011111 (31 all-zero nibbles), 1000 (actual bit pattern)." *See Figure 2 and Col. 3:13-18.* Thus, the different signal value (a terminating nibble such as "1000") and a preceding run of all zero nibbles (such as 31 all-zero nibbles) are coded using a codeword. Based on the above, it is my opinion that Liao discloses determining the run length and assigning a code word to represent the zero nibbles and the terminating nibble.	
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.	Liao discloses that "*If there are 64 or more all-zero nibbles before a non-zero terminating nibble, the data string is converted into a first part comprising a number of sets of 64 all-zero nibbles and a second part comprising the remaining 0 to 63 all-zero nibbles and the terminating nibble.*" *See Col. 3:2-7.* Thus, when a run of non-zero nibbles together with the terminating nibble exceeds a predetermined length (more than 64 all-zero nibbles), the run of non-zero nibbles and the terminating nibble are split into sections (the first and second parts) wherein the length of each section is below a predetermined value (64 all-zero nibbles), and each section has a codeword assigned to the section. Based on the above, it is my opinion that Liao discloses 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	

US 4,901,075 CLAIM ELEMENTS	US Patent No. 4,494,151 to Liao	Chen Article
	length, and assigning a code word to each section.	

EXHIBIT C-15

EXHIBIT C-15

Invalidity Chart For Henry H. J. Liao, "Upper Bound, Lower Bound and Run-Length Substitution Coding", NTC '77 Conference Record, Vol. 3, pp. 49:3-1 to 49:3-6 (1977) (the "Liao Article") in View of Wen-Hsiung Chen and William K. Pratt, "Scene Adaptive Coder", IEEE Transactions on Communications, Vol. COM-32, No. 3, March 1984, pages 225 to 232 (the "Chen Article")

As set forth below in the chart, claims 3-4, 8 and 11 of the '075 Patent would be obvious over the combination of the Liao Article and the Chen Article because the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the invention pertains. In particular, the use of DCT coefficients in video coding as taught by the Chen Article within the coding technique taught by the Liao Article is a predictable use of the well known DCT coefficients. Furthermore, the combination of the elements from the Chen Article and the Liao Article yields predictable results.

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
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:	The Liao Article discusses several bounds of "bandwidth compression for run-length coding." *See pg. 49:3-1, left column, Abstract.* The Liao Article discusses run-length coding for a facsimile signal quantized into a sequence of binary digits (1's and 0's) which directly represent black and white picture elements. *See pg. 49:3-1, left column, first paragraph of Introduction.* The Liao Article also discusses image data run-length coding after a set of prediction errors are generated. *See pg. 49:3-1, left column, first paragraph of Introduction.* Thus, the Liao Article discusses bandwidth compression (bit rate reduction) bounds for run length coding of a sequence of binary digits or predictive error values. Based on the above, it is my opinion that the Liao Article discloses a method of coding a signal comprising a plurality of zero values and a non-zero value.	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generate DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See pp. 225-227.* Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal comprising a sequence of coefficient (including a plurality of zero coefficients, and a plurality of non-zero coefficients) which results after a blockwise transform of pixels of a video signal with subsequent quantization, for

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
		transmission at a reduced bit rate.
(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	The Liao Article, the prediction error values are determined in which the run-length of prediction errors constitute a majority of single bit runs (B) and a few other short runs. *See pg. 49:3-2, left column, first paragraph of Maximum Entropy Lower Bound section.* The prediction errors are recorded as "B" and correct predictions are recorded as "W" so that a message set for these prediction values in shown in Table 1 that have runs of W followed by B. *See pg. 49:3-2, left column, first paragraph of Maximum Entropy Lower Bound section and Table 1.* Based on the above, it is my opinion that the Liao Article discloses deriving a plurality of events that have a run of values, W, followed by another value, B.	Chen discloses using DCT coefficients in a video coding process which results in zero coefficients and non-zero coefficients. *See pp. 225-227.*
(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.	The Liao Article states that, "The best code assignment will be the set of codes with the shortest average length, i.e., the minimum redundancy code. Huffman's coding is a systematic procedure for constituting such as code with minimum redundancy." *See pg. 49:3-1, left column, second paragraph of Introduction section.* The Liao Article also contains a table with a run-length substitution code that is a Huffman code that represent a run of W values (zero to nine) followed by a B value. *See pg. 49:3-3, left and right columns, Run-Length Substitution section, Table 2 and pg. 49:3-6, Table 5.* Table 5 shows the frequency of each run-length and the Huffman length assigned to each run-length based on the frequency. In	

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
	these tables, Huffman codes are formed from the prediction error values. Based on the above, it is my opinion that the Liao Article discloses determining the run length and assigning a code word to represent a run of values, W, followed by another value, B.	
4. The method of claim 3, wherein said code words are Huffman code words.	The Liao Article also contains a table with a run-length substitution code that is a Huffman code that represent a run of W values (zero to nine) followed by a B value. *See pg. 49:3-3, left and right columns, Run-Length Substitution section, Table 2 and pg. 49:3-6, Table 5.* Table 5 shows the frequency of each run-length and the Huffman length assigned to each run-length based on the frequency. In these tables, Huffman codes are formed from the prediction error values. Based on the above, it is my opinion that the Liao Article discloses that the codewords are Huffman codewords.	
8. A method for coding a signal for transmission at a reduced bandwidth, comprising the steps of:	The Liao Article discusses several bounds of "bandwidth compression for run-length coding." *See pg. 49:3-1, left column, Abstract.* The Liao Article discusses run-length coding for a facsimile signal quantized into a sequence of binary digits (1's and 0's) which directly represent black and white picture elements. *See pg. 49:3-1, left column, first paragraph of Introduction.* The Liao Article also discusses image data run-length	Chen discloses a system and method wherein transform image coding (which was developed 15 years before 1984) may be used for bandwidth compression for video signals. The Chen Article discloses that discrete cosine transforms (DCT) may be used to generated DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See 225-227.*

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
	coding after a set of prediction errors are generated. *See pg. 49:3-1, left column, first paragraph of Introduction.* Based on the above, it is my opinion that the Liao Article discloses bandwidth compression (bit rate reduction) bounds for run length coding of a sequence of binary digits or predictive error values.	Based on the above, it is my opinion that the Chen Article discloses a method of coding a signal for transmission at a reduced bandwidth.
(a) transforming said signal into a sequence comprising zero coefficients occurring in runs and non-zero coefficients;	The Liao Article discusses run-length coding for a facsimile image that is converted into a sequence of binary digits (1's and 0's) which directly represent black and white picture elements. *See pg. 49:3-1, left column, first paragraph of Introduction.* The Liao Article also discusses image data run-length coding after a set of prediction error values are determined. *See pg. 49:3-1, left column, first paragraph of Introduction.* Based on the above, it is my opinion that the Liao Article discloses a method of coding a signal comprising a plurality of zero values and a non-zero value.	Chen discloses transforming a video signal into DCT coefficients that are quantized which results in zero coefficients and non-zero coefficients. *See 225-227.*
(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	The prediction error values are determined in which the run-length of prediction errors constitute a majority of single bit runs (B) and a few other short runs. *See pg. 49:3-2, left column, first paragraph of Maximum Entropy Lower Bound section.* The prediction errors are recorded as "B" and correct predictions are recorded as "W" so that a message set for these prediction values in shown in Table 1 that have runs of W followed by B. *See pg. 49:3-2, left column, first paragraph of Maximum Entropy*	

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
	Lower Bound section and Table 1. Based on the above, it is my opinion that the Liao Article discloses deriving a plurality of events that have a run of values, W, followed by another value, B.	
(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.	The Liao Article states that, "The best code assignment will be the set of codes with the shortest average length, i.e., the minimum redundancy code. Huffman's coding is a systematic procedure for constituting such as code with minimum redundancy." *See pg. 49:3-1, left column, second paragraph of Introduction section.* The Liao Article also contains a table with a run-length substitution code that is a Huffman code that represents a run of W values (zero to nine) followed by a B value. *See pg. 49:3-3, left and right columns, Run-Length Substitution section, Table 2 and pg. 49:3-6, Table 5.* Table 5 shows the frequency of each run-length and the Huffman length assigned to each run-length based on the frequency. In these tables, Huffman codes are formed from the prediction error values (the sequence of signal values). Based on the above, it is my opinion that the Liao Article discloses determining the run length and assigning a code word to represent a run of values, W, followed by another value, B.	
11. The method of claim 8, comprising the additional steps of: determining whether the	The Liao Article discloses that in run-length substitution, "a fixed number of runs is picked from the entire message set." *See pg. 49:3-3,*	

US 4,901,075 CLAIM ELEMENTS	Liao Article	Chen Article
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.	*left column, first paragraph of Run-Length Substitution section.* The Liao Article further discloses that, "Runs without codes can be represented by two or more shorter runs with codes. For example, in Table 2, the run-length 4W is selected and 5W+B is not selected, the run 5W+B is substituted by 4W + (W+B)." *See pg. 49:3-3, left and right columns, first paragraph of Run-Length Substitution section and Table 2.* Based on the above, it is my opinion that the Liao Article discloses 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.	

EXHIBIT 10

UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF DELAWARE

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U.S. PHILIPS CORPORATION, :

Plaintiff, :

vs. : Case No. 06-251-GMS

EASTMAN KODAK COMPANY, :

Defendant. :

- - - - - - - - - - - - - - - - - -x

Palo Alto, California

Thursday, January 31, 2008

Videotaped Deposition of TOURADJ EBRAHIMI, Ph.D., held at the offices of Finnegan, Henderson, Farabow, Garrett & Dunner, 3300 Hill View Avenue, Palo Alto, California, commencing at 9:05 a.m., before Sharon Lancaster, a Certified Shorthand Reporter of the State of California.

EXCERPTS

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Did you see in paragraph 23 of your report, you indicated that counsel informed you what the legal standard was for obviousness?

A. That is correct.

Q. And one of the things you're supposed to do is determining the differences between the prior art and the claims at issue. Did you understand that was one of the things you were supposed to do?

A. I believe I understood, yes.

Q. So isn't one of the differences between each of those eight prior art references in the claims at issue the fact that none of those eight prior art references describe a coefficient, as that term is construed by the Court?

A. So, again, we have to be specific because I cannot answer to this question in this generality.

As I told you in one of your prior questions, I did not see that predictive coding was excluded in claim No. 3.

Q. Mm-hmm.

A. I could not answer to that question, because I did not see it. And for that purpose, I'm sure that

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there are cases that I'm not making the difference.

Q. What about for claim 8?

A. I can look at the claim 8.

(Witness reviewing document.)

If I have not mentioned, it means that those references that are in claim 8 eventually are not -- that there are no differences between them. It is possible that, in this case, for those that -- those patents that are comparing the differences between the claim 8 and those patents, the transform coding is not the differentiator.

Do you want me to repeat?

Q. No, because I don't -- I'm not sure you've answered the question.

The issue is: Isn't one of the differences between each of those prior art references that you list in your report and the claimed invention in claim 8 the fact that none of those eight prior art references that you list describe a coefficient, as that term has been construed by the Court?

A. I do not think that I have made such a statement. Can you show me in my report?

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Q. I didn't say you made the statement. I said, in paragraph 23, one of the things you're supposed to do --

A. Yes.

Q. -- when you do an obviousness analysis is determine the differences between the prior art and the claimed invention to see whether it would be obvious to combine, modify, or to come up with the claimed invention.

A. That is correct.

Q. You understand that?

A. Yes.

Q. Now, in your claim charts, I noticed that you did not mention, for any of those eight references, that they teach a coefficient as defined by the Court; namely, something that is a multiplication factor that results from transform coding.

So the issue for you, and the question for you is: Isn't it true that none of those eight references that you're relying on for purposes of obviousness teach or describe coefficient as defined in claim 8 and construed by the Court?

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A. As I said, and I repeat, I don't have any -- any indication that this is not the case. I did not see in any of these -- that's in all of these; right? Maybe in some, it is the case.

But in all of them, I did not see that there was a contradiction between the definition of the term coefficient as today constructed by the -- by the Court and as it is in these references.

Q. You don't think there is a contradiction between a reference which uses a Raster scan as opposed to a reference such as Chen and Pratt or the Vogel patent which uses transform coding?

A. Obviously for Chen and Pratt, we are perfectly talking about coefficients as it is also defined in the court. So I believe what you are concentrating on is, for instance, Van Voorhis.

As I said, I do not have any indication that the term coefficient as it is used -- maybe the exact term is not used. But what maybe is equivalent word that is used is excluding in all the other references than Chen and Pratt the use of transform coefficients.

Q. The question is not whether a prior art

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reference that you're relying on to show obviousness excludes the possibility.

The question is: Does the reference actually teach or disclose what is described in the claim? Can you answer that question?

A. Yes. I can answer by saying that the combination of Chen and Pratt and any of these references that are mentioned in my annex C are cause of obviousness.

I repeat again, I did not understand or -- or I do not understand, and I believe I am not making a mistake by assuming that I have to point out in a very single of these all the causes of obviousness, and that you can actually have two references, and their combination are cause of obviousness.

Q. Again, let me repeat the question. And, again, the question is not whether two references combined show all the elements.

The question I'm asking you is, for the specific eight references I'm talking about and that you rely on, do they teach a specific element in the claim? And I saw that nowhere in your claim charts.

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So the question is: Do any of those eight references that you listed in Appendix C, do any of those eight references describe or teach a coefficient as that term is construed by the Court?

A. My answer -- and I have to also repeat the same -- is that I did not believe and do not believe that it is a requirement to do it for a single reference, but a combination of two would be sufficient. Therefore, the simple answer is that I did not do this -- this analysis because, for the sake of the conclusion of my expert report, it was not required.

Q. For the sake of your expert report, you understood it was required for you to identify the differences between the prior art and the claims at issue; correct?

A. That is correct.

Q. And one of the differences that you're supposed to determine is: How does this reference differ from the claims?

A. That is correct.

Q. And you're supposed to do that for every

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reference you rely on?

A. That is correct.

Q. So for each of those eight references, don't they differ from the claims, particularly claim 8, and in none of those eight references teach coefficients?

A. If you are -- if you are talking about the word coefficient --

Q. As construed by the Court.

A. Okay. So is the meaning of the word coefficient, which is a "multiplication factor that results from transform coding." And this, of course, would need to be then referred to No. 12, transform coding. I don't repeat it. So you know.

So what I'm saying is that, if I had an indication that some of these single references, without any reasonable doubt, was differentiating in terms of coefficient or transform, I would have put it. But it is not the case, as far as I know. And I did not even look at it this way because the combination, to my knowledge, is enough.

Q. So, in other words, you didn't look to see whether any of those eight references taught a

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coefficient as defined by the Court?

A. At the time when I wrote my report, there were only the coefficients as described by Philips and as described by Kodak. So I only did it for these two.

Q. Right. And the Court adopted the ones described by Philips. And you have a whole set of claim charts directed to Philips construction.

A. That is correct. And in this case, I did not -- In order to see if there is a difference, one has to see a specific reason to believe there is a difference. Yes?

If some of these or all of these are silent about exclusion of transform coefficients, I cannot neither confirm or do the opposite about their differences, because it is not mentioned.

Q. Well, for instance, fax machines that do the line-by-line scanning, those don't do transform coding.

A. So let's see the definition of transforms. Okay? Definition of transform is, according to the Court -- I go back again to 12: -- "A mathematical

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operation which yields an alternative representation of a sequence or array of values."

And there is nowhere in a fax machine patent that I looked -- if there was one -- I could find anything that was different according to this definition. And it is probably the reason for which I did not put the term transform nor coefficient in my summary. But, again, I'm basing myself on your judgment that you looked at them.

Q. Well, for instance, if you look at the very top of claim 3 of the patent -- Do you have it?

A. Yes.

Q. "The coefficients which result after a blockwise transform of pixels," do you see that phrase?

A. Yes.

Q. And do you see that's also construed in paragraph 14 of the Court's order?

A. Yes.

Q. That doesn't happen in a fax machine.

A. I don't see the relationship.

Q. In a fax machine that scans line by line, you

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don't create coefficients based on a blockwise transform of pixels; correct?

A. In the fax machines that are used in standards today, this is correct.

However, I don't really see the -- The patents I'm referring to are not all exclusively for fax machines. You have to look at their claims, and maybe the preferred embodiment in some of them is fax machine. But I don't know -- I cannot confirm that it is only for fax machine. And I don't think that the requirement here was to say for which application each of these patents were foreseen.

Q. So in coming up with a conclusion of obviousness, you believe you cannot only look at what is disclosed in the patent, but also consider was is claimed in the patent and possible applications?

A. No. I said the opposite.

Q. Okay.

A. So I said that I do not believe I should look at what are the possible applications. And the reason I said that is because you mentioned fax. So I just stated the fact that I do not think that this was a

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requirement, as far as I understood from the information I received from the counsel of Kodak.

Q. So you don't have any -- withdraw that.

Are paragraphs 23 and 24 of Exhibit 23 the sum total of what you understand the legal requirements are for obviousness?

A. This is a summary of what I understood, indeed, of the definition of obviousness as told to me by counsel of Kodak.

Q. Did counsel for Kodak, or do you know from any other source that there are other factors you're supposed to consider when coming to a conclusion of obviousness?

A. I -- I have put in this paragraph what is my understanding. I cannot confirm if there was any other parameters or any other considerations I was told to take into account. I took into account what is, to the best of my understanding, summarized in section D, pages C -- pages 6 and 7, paragraphs 23, 24 with regard to what is obviousness.

Q. So what you came up with your claim charts and you came up with your opinions on obviousness, you

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basically, to the best of your ability, followed the legal standard you believe is set forth in paragraphs 23 and 24?

A. That is correct.

Q. Did you consider any other factors other than the factors set forth in 23 and 24?

A. I do not believe so.

Q. Are you aware, in patent law, that in deciding whether an invention is obviousness, one is supposed to also consider what are referred to as objective indicia or secondary considerations of non-obviousness?

A. Can you rephrase your question?

Q. Are you aware that under U.S. patent law, before you come to a conclusion or arrive at an opinion as to whether an invention is obvious, you are first supposed to look at objective indicia, also referred to as secondary considerations of non-obviousness?

A. I believe that I have -- I have been informed of that. And I believe it is also written maybe not with the terms and words you used, but it is in there.

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Q. Where is it in there?
A. I will try to find it.
(Witness reviewing document.)
Okay. So here. The last few lines of paragraph 23 says, "I have further been informed that the inquiry as to whether a patent claim is obvious includes the steps of determining the scope and content of the prior art, determining the differences between the prior art and the claims, and determining the level of ordinary skill in the art. Against this background, the obviousness or nonobviousness of the claim is determined."
So my understanding is that the term that you used, that I have to -- you have to repeat to me -- is, in fact, part of determining the differences between the prior art and the claims issues.
Q. Actually, it's not. But let me just confirm this.
So you went through a three-step process in determining obviousness?
A. That is correct.
Q. You did not go through a four-step process?

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A. I -- I do not think so.
Q. And the reason that you didn't go through a four-step process is you were never informed that there is a fourth step?
A. That I cannot confirm, because this is what I understood in my -- and put in my report. If they informed me or not -- if the message passed, I cannot know. But this is what I understood.
Q. Well, in paragraph 23 you indicate this standard that you applied came from counsel for Kodak; correct?
A. This is how I understood the information that was given to me from counsel for Kodak.
Q. So you asked them to tell you what the standard was, and to the best of your ability, you put it in down in paragraph 23?
A. This is my writing of what I received as information.
Q. So your understanding is it's a three-step process as opposed to a four-step process?
A. If you allow me, I have to look.
It will help me to answer to you if you tell me what is the fourth step. But it is possible that I used it, but I do not know that I used it.
Q. Sure.
Before I mentioned the words "objective indicia of non-obviousness" in this deposition or "secondary indicia of non-obviousness," had you heard them before?
A. Well, you just told me that, and I couldn't repeat it. So it is possible that I heard it.
Q. But to the best of your knowledge, counsel for Kodak never informed you that you were supposed to consider objective indicia of non-obviousness or secondary considerations of non-obviousness?
A. I cannot confirm that. I just do not know the meaning of these words, and it is possible that it has been told to me. As I said, I have written in my own understanding, my own words, what are the steps.
Now, it is possible that one of the steps is what you are referring to in these terms.
Q. Well, for instance, in your claim charts -- take any of your claim charts for obviousness.
A. Yes, I'm -- one of them, yeah.

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Q. Don't they all state the same analysis?
A. They follow --
Q. The witnesses are different, but isn't it identical for each of these 15 claim charts? Isn't that what you said?
A. These are, to the best of my understanding, the process I followed to field these charts.
Q. So, in other words, you looked at the differences --
A. Yes.
Q. -- and you said -- you concluded that they were predictable.
But nowhere in any of these claim charts and nowhere in the body the Exhibit 23 do you mention or take into account any secondary indicia or objective indicia of non-obviousness that may exist in this case; correct?
A. I cannot answer to you until I understand what is the meaning of these terms you use.
Q. Okay.
A. I'm not a lawyer.
Q. Correct. So you relied on counsel for Kodak

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to tell you what the standard was?
A. This is obvious. Because I'm not a lawyer.
Q. Okay. So, for instance, were you informed by Kodak that you should consider, before you decide whether an invention is obvious: Whether it is commercially successful; whether the prior art teaches away from it; whether there were any unexpected results; whether the patent has been licensed; whether there has been professional approval of the invention; whether there has been copying of the invention; whether the invention fills a long but unsolved need?
Were any of those terms described to you?
A. Yes, in fact, some of them are familiar, and I have taken them into account. But if go one by one, I will tell you.
Q. Where in the report is any of that mentioned?
A. Yes. I can -- again, if you just -- if you just provide me words and like a machine gun tell me there's 200 words -- so give me one of them and the meaning, and I will try to find where they are.
Q. Licensing.
A. Licensing?

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Q. Where is that mentioned in your report?
A. So my understanding of licensing is that I should have examined for the case of obviousness. This is what you say; right? For the case of proving obvious ness, I should show that any of the references has been licensed?
Q. No, that's not the standard at all.
A. So this is not something I --
Q. So obviously you didn't take it into account.
A. Sorry?
Q. So obviously you didn't take it into account.
A. No, I did not -- In this context of obviousness, I did not take it into account.
Q. Did you take into account whether there has been professional approval of the invention?
A. Yes. Because if I understand well what you refer to, when a patent is granted, there is a professional approval of a patent. And when a publication like Chen and Pratt is published, it has gone through review by peers, experts, a peer review. And so, therefore, what is in there has gone through the necessary steps of verifying its validity to a

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reasonable degree.
Q. Do you understand that objective indicia had and secondary considerations apply not to the prior art but to the invention? You seem to be applying it to the prior art.
A. This is, I think, where the confusion is.
So to the invention itself -- but this is a part of the -- I don't understand it should be part of the annex C. To the best of my understanding, I don't see that this is part of annex C.
Q. I agree. You didn't put it in annex C.
A. No. Yeah.
Q. And you didn't put it anywhere in your report.
A. Well, that I don't know, because we are just talk about that. My report is not annex C only. So I'm understanding -- trying to understand, rather, whether -- what is this fourth step that you are mentioning in the study of obviousness. That is what you told me.
Q. Yes. There is a fourth step --
A. Yes.

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Q. -- that is well known, discussed in the case law, which involves: Before coming to a conclusion, you look at certain factors and facts, and you take those into account.
Now, nowhere in your report is there a mention of any of those. Is that because no one told you to take them into account?
A. I cannot tell you until you explain to me what they are.
Q. Well, I explained one of them; licensing.
A. Yes?
Q. Did you look into that?
A. Whether the Philips patent has been -- the Vogel patent has been licensed?
Q. Yes. Is that mentioned in your report?
A. It is not mentioned in my report.
Q. So you didn't take it into account?
A. It doesn't mean that I did not take it into account. It is not mentioned in my report.
Q. Did you make any attempt to find out if the patent was licensed before you came to these conclusions?

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A. Personally, no.
Q. Okay. Let me move on to section E of your invalidity report on page 7.
A. I'm in section E.
Q. Now, your indefiniteness conclusion was based on Kodak's interpretation of the preamble of claims 3 and 8; Isn't that correct?
A. So, you are referring to terms for transmission at a reduced bandwidth and for transmission at a reduced bit rate?
Q. That's correct.
A. To the best of my knowledge, I took indeed these two in my report into account, these two terms, yes.
Q. Now, it's your understanding that in paragraphs 21 and 22 of the Court's order, the Court rejected Kodak's interpretation?
A. I am aware of that.
Q. And you're also aware that the Court, in paragraphs 21 and 22, indicated -- if you look at footnotes 20 and 22 -- actually, not even the footnotes. Let's look at paragraphs 21 and 22. The

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Court said, "The term is not a claim limitation."
A. Yes.
Q. Do you understand what that means if a term is not a claim limitation?
A. I understand.
Q. What does it mean?
A. It means that -- that the work, so the -- for transmission at a reduced bit rate is not one of the limitations that have to be considered to know whether a given technology is or not -- is not infringing a claim.
Q. Okay. And in paragraph 25 of your opinion -- excuse me -- of your report, on page 7, your last sentence says? I further understand that the definiteness of claim terms depends on whether those claims can be given any reasonable meaning and that claims are found indefinite only if reasonable efforts of claim construction prove futile."
Do you see that?
A. Yes.
Q. Is that your understanding of determining whether the claim terms are indefinite?

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A. I have put in paragraph 21 my understanding, as I can express it, of what is the term indefiniteness, or what is indefiniteness in the study of invalidity of a patent or study of its claim.
Q. And you see that in paragraphs 21 and 22 of the Court's order, which is Exhibit 21, the Court did in fact construe those terms from the preamble of the claims; correct?
A. What I understand from the Court decision is that, indeed, paragraphs 21 and 22 of Exhibit 21 indicate that the claims -- sorry -- that the terms for transmission at a reduced bit rate and the term reduced for transmission at a reduced bandwidth are not anymore claim limitations.
Q. And the Court also defined what they mean --
A. They also --
Q. -- in paragraphs 21 and 22; isn't that correct?
A. That is correct. They also mean what it means.
Q. And so applying the standard you applied in the last sentence in paragraph 25, do you believe the

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Court's claim construction in paragraphs 21 and 22 of its claim construction order is what you referred to as a "reasonable effort at claim construction"?
A. Not being a lawyer and not knowing the process in which this conclusion has been made, I cannot answer to this question.
Q. Well, you gave an opinion on indefiniteness, presumably based on your analysis in paragraph 25 that the claim should be indefinite because reasonable efforts at claim construction would prove futile. Isn't that the standard you applied?
A. That is my understanding.
Q. Well, the Court has now construed the claims. Do you believe the Court's construction is a reasonable effort at claim construction?
A. Since I did not make this conclusion, I cannot know. I do not know.
Q. It's not a subjective test; it's an objective test. Is it a reasonable effort at claim construction, the construction that the Court came up with in paragraphs 21 and 22?
A. I do not know. I did not play a role, nor

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analysis myself. But I understand that from the evidences that are there, these -- these information is available, and I had access to them.

Q. Now, in paragraph 22 of your expert report, you refer to "priority date of the invention." Do you see that?

A. Yes. Yes.

Q. Now, in your expert report, Exhibit 23, you don't attempt to make any analysis, and you don't offer any opinions on what the appropriate priority date is for the '075 patent; is that correct?

A. I did not make a personal analysis of this. But the evidences that -- that they were available gave me the information about the priority date of the invention, as best as I could understand.

Q. So in summary, you did not offer any opinions in Exhibit 23 and you did not make any personal analysis of either the invention date or priority date of the '075 patent?

A. I used this information.

Q. Well, the question is: In Exhibit 23, you did not offer any opinions and you did not make any

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personal analysis of what the invention date or priority date should be for the '075 patent?

A. This is a composite question, and I think the answer to it is not the same. Can you break it in two?

Q. Sure. In Exhibit 23, you do not offer any opinions on what the invention date is for the '075 patent; correct?

A. Can you ask the second question? I'll come back to the first.

Q. Well, let's stick with this one.

A. I have a question about this one.

Q. In Exhibit 23, you do not offer any opinions on what the priority date is for the '075 patent?

A. I only access information that was given me in this. I did not make a personal analysis to find whether it is indeed -- the date that is mentioned is indeed the date or not.

Q. So is the answer to the question "yes"?

A. This was the second question?

Q. Yes.

A. Can you repeat it again?

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Q. The second question was: In Exhibit 23, you do not offer any opinions on what the priority date is for the '075 patent?

A. I have difficulties answering yes or no because I still have difficulties understanding this without any context. I repeat, and you interpret or you explain to me further whether it is yes or no.

I used this information. Therefore, I believe and I assumed this was the correct information. I did not do a personal analysis or examination to find out whether this date is, indeed, the date that is portended to be.

Is this answering to your question?

Q. Yes, I think so.

You did not do any personal analysis or examination in Exhibit 23 as to what the invention date was of the '075 patent?

A. I used this information. But I did not do a personal examination of this date.

Q. Okay. Did counsel for Kodak inform you as to what dates you should use for invention date and priority date?

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A. Yes, I believe they did.

Q. What dates did they tell you to use?

A. There are several cases, of course, because there is a first patent that is a German -- actually, a set of patents. I don't know offhand, but I can probably find the dates of them.

Q. It's actually listed on the patent.

A. It is listed on the patent; you're right. Exactly.

Q. Right on there. Exhibit 20.

A. Yes. It is foreign application priority date. So it is September 13, 1986, November -- I think it's 8, 1986, and May 23rd, 1987.

Q. So did you use September 13, 1986 as the priority date for the '075 patent?

A. Yes. This is the -- this is what was given in the -- in the patent. So this is the date I used. But I also at times used the -- the date of the U.S. application. But I -- let's say, you know, I cannot answer like this. To the best of my knowledge, I -- I base myself on the earliest, which is September 13th, 1986, as prior date. But it is possible that I

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also referred -- or used the date of the filing, which is September 11, 1987.

Q. Well, there are certain circumstances in which the filing date, such as 102B, is the date you use. But let's focus to paragraph 22 of your report.

A. Yes.

Q. Which is referring to a particular type of prior art, section 102(e) prior art. And it refers to a U.S. patent qualifying as prior art under section 102(e) if it has an effective filing date that predates the priority date of the invention.

Do you see that phrase?

A. Yes.

Q. So when applying this section, did you use September 13, 1986, as the priority date of the '075 patent?

(Witness reviewing document.)

A. I don't know. You have to -- because there are several cases, as you know, if I have referred to -- to anywhere in my report to 35 USC 102(e), I have to see to be able to confirm or not.

Q. Actually, I don't think you did. So I guess

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it's more a general question: Based on paragraph 22, what date did you use?

A. As I said, I am referring to in various parts of my report on different types of anticipation. And sometimes I refer -- no, it's not necessarily always referred to all three.

So there are, to my understanding, three different dates to be considered. And this depends on whether it is under 35 USC 102(a), 35 USC 102(b) or 35 USC 102(e). And I can answer to you specifically, because I cannot generally tell you. If you show me one place I'm referring to, I can tell you which one I used.

Q. Sure.

What date did you use for the Chen patent in Exhibit B-2?

A. Can you tell me which page or --

Q. Sure. Paragraph 42.

(Witness reviewing document.)

A. Will you have a copy of this patent here with you?

Q. Yes, I do. Would that help?

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A. I believe it will, yes.

MR. ANZALONE: Actually, let me mark Exhibit 24 as the JPEG standard. And let me mark as Exhibit 25 a patent to Chen and Klenke, U.S. Patent Number 4,698,672. She has to mark it first.

(EBRAHIMI Deposition Exhibits 24 and 25 were marked for identification.)

BY MR. ANZALONE:

Q. Do you have Exhibit 25 in front of you?

A. Yes, I do.

So this patent has been filed on October 27, 1986?

Q. That's correct.

A. Yes. And I believe in this case, following the paragraph 22 that you mentioned, I used -- So the priority date for this patent, actually I examined in this particular case, now that I look at them, in both cases. But probably your question is which one of them I put here.

Q. Yes.

A. Yes. And the one that I used is September 11, 1987.

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Q. But that's not the priority date for the Vogel patent. Isn't the priority date for the Vogel patent September 13, 1986?

A. The claims in the September 13th, 1986 -- and I believe you also have an English translation of that -- if I can have it, I can show you that the claims are not the same. There are four claims, if I'm recalling that well, that make it difficult to compare with the claims of this one (indicating).

So the date of September 11th, 1987, of the claims I have here are -- you know, this is the earliest date I have in terms of priority with these claims.

The other, September 13th, 1986, as far as I understand, does not have the same claims. But you probably -- if you show me -- for sure they are not the same. But if you want, I can show you why they are not the same.

Q. So we've already agreed that you didn't do any personal analysis or examination of priority date in your expert report; correct?

A. I did not.

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following JPEG use Baseline JPEG is because this is one way to ensure that the largest number of operatives and software and services can access and view them.

Q. Do you have an understanding as to why the coding strategy used in progressive JPEG wasn't chosen as the baseline?

A. I have to only again guess the reason. I do not -- I do not know for sure the reason why progressive JPEG was not used as a baseline.

Q. What is your best understanding? Are there parameters such as complexity, memory requirements, efficiency that would come into play?

A. Yes, probably this could be a good reason. So I tend to agree with that.

But also there might be another reason that I mentioned this morning. Also, the context of which product and which application the JPEG is used is important to select which mode.

And I'm speculating again, but I don't think that all products and services do necessarily require a progressive functionality, progressiveness

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functionality in their application. Therefore, because there is more likelihood that people need a sequential codec, desire the features of a sequential codec than a progressive codec, probably that's why a sequential algorithm has been used as a baseline.

Q. The next strategy listed as part of the toolbox is hierarchical JPEG. How often is hierarchical JPEG used in commercial products?

A. Again, here I did not really make a thorough study of the number of products and services that are using hierarchical JPEG.

But what I can observe, and, indeed, to the best of my knowledge confirm, is that hierarchical JPEG is used less often than progressive JPEG, as progressive JPEG is, to the best of my knowledge, used less often than JPEG baseline sequential.

Q. And do you have any understanding as to why that is?

A. Similar reasons -- and I'm speculating again -- to progressive JPEG, very likely.

Q. And then lastly, you mentioned one coding strategy known as lossless JPEG. How often is that

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used in commercial products?

A. Not often. Here, there is an additional reason probably in addition to the ones that we mentioned.

The lossless JPEG does not perform very efficiently compared to maybe some more complex, but more efficient schemes. Again, here I'm making a guesswork. The lossless JPEG is using a very simple algorithm; it is based on DPM. So it is not based on DCT or anything similar to the other algorithms, you know, the paper of Chen and Pratt or the Vogel patent or the JPEG baseline. It is extremely simple algorithm. It was selected because of its simplicity, I assume.

However, the committee found out that there was probably, in the state of the art, better -- or at least they found out later on, I assume, better algorithms, more complex but better, and they decided that maybe they have to standardize another scheme. And, in fact, although not part of JPEG toolbox, there is a standard called JPEG-LS. JPEG-LS. LS.

Q. Okay.

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A. And which is using a different approach. It is again not based on DCT. This one -- I don't remember when exactly, but this one was standardized much later, and it is based on an algorithm called LOCO, L-O-C-O. But, again, if you want to ask me whether this JPEG-LS has been used with products, I do not know. But I believe it is being used. I have impression it is being used, but definitely not to the extent of Baseline JPEG or even progressive JPEG.

Q. Okay. Let me ask you to look at page 6 of your report. Towards the bottom of the page, you discuss and compare the Chen and Pratt encoding method with the Vogel or '075 patent encoding method.

You make the statement that, "With respect to the '075 patent" -- and I'm looking at about the fourth line from the bottom -- "runs of consecutive non-zero coefficients cannot be decoded without also decoding at the same time the amplitude of the next or previous non-zero coefficient."

Do you see that?

A. Yes, I see it.

Q. So that's an accurate description of the

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Vogel encoding method; is that correct?
A. Yes, it is correct.
Q. Have you ever heard the phrase "two-dimensional variable length coding" used?
A. Yes.
Q. What does that mean?
A. A 2D-VLC, as it is usually referred to -- 2D usually dash VLC -- is valuable encode, not necessarily Huffman -- but it could be, for instance, Huffman -- in which you have two entries that correspond usually to two messages that are coded in a combined manner.
So if one attempts to decode the 2D-VLC -- a specific 2D-VLC, this would at the same time give both of the messages, and usually, if you are talking generally, you cannot decode only one separately.
Q. Okay. So the '075 patent describes a 2D-VLC technique; is that correct?
A. I'm not sure I used this term of 2D-VLC. But I tend to agree.
Q. Now, the next sentence right after the one I referred to on page 6, your sentence, is "The Chen

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technique, in contrast, allows separate decoding of these entities."
Do you see that sentence?
A. Yes.
Q. Is that an accurate description of the Chen and Pratt technique?
A. Yes.
Q. Can you explain, possibly in layman's terms, what you mean when you indicate that Chen and Pratt allows separate decoding of these entities?
A. So if I refer back to the example that it is starting from; when there are two entities or two messages, you either code them with one code word that will represent the combination of both or you can use two different codewords, each for one of the messages or entities. The Chen and Pratt technique, they chose to code these entities separately.
This is why when one attempts to decode any image compressed or a video compressed by Chen and Pratt, it will be able to decode each of the entities separately if it is needed. But anyway, this is part of the process.

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Q. And by each of the entities, or each of the messages, the two entities you're talking about are a run of zero coefficients and a subsequent or preceding non-zero coefficient?
A. Okay. Here, we have to make a difference between what is an event and what is a message. So the event is indeed what you mentioned; it is a run of zeros followed by a non-zero coefficient.
In Chen and Pratt, the method has decided that this event is divided into two sub-events: the run of zeros of only, and the amplitude of non-zero, and then a different code word is used to code each of them.
Were there any other parts in the question?
Q. What did you mean by "message"? You said you wanted to define the word "message."
A. Yes. So "message" is the sub-entity. Or sorry. The sub-event. Message is the sub-event. Message is what is assigned bits to. In other words, it's the entry of a VLC table or a general code word table. It doesn't need to be VLC, it could be even constant length code.

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Q. Now, Chen and Pratt, the encoding technique there is not a two-dimensional variable length code; is that correct?
A. Okay. Let me first clarify something, and then I can answer to this.
It is always possible to create a 2D-VLC even if you decide to code the two messages separately by simply creating a 2D table in which you concatenate the two messages. So I suppose this is not -- the trivial case is not what you are referring to.
Q. Well, that is properly referred to as a trivial case because if all you're doing is concatenating, you're not taking advantage of any statistical dependency. Is that correct?
A. That is correct.
So the VLC, as I said -- the VLC is not necessarily Huffman. This is why I thought it is important to point that out.
Usually, 2D-VLC is understood as a code word that is generated by some set of predefined set of rules. And in some cases it could be based on the statistics, in some cases it could be based on some

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other considerations. As far as the rule is, no.
That's why I told you that even the concatenation, it's a rule. It's not necessarily a very intelligent rule maybe, but it's a rule.
Now, so -- but I believe we are in agreement that we are not talking about this case.
Q. That's correct.
A. So then in the Chen and Pratt, indeed, the messages extracted from the event are coded not using a 2D-VLC, considering exclusion of the trivial case I just mentioned.
Q. Now, in Baseline JPEG, aren't the messages coded using a 2D-VLC?
A. Okay. Yeah. So in order to answer to this question also, I have to first define with you what is meant by "message," because the message in the case of JPEG baseline is different again.
In the case of JPEG baseline, both the event and the messages are different. Let me explain why. In the case of JPEG baseline, the event is a run of zeros followed by an entity that is referred to as "category."

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It's not really the amplitude of the non-zero coefficients, as in the case of Chen or the Vogel patent, it's an information that is used to represent what will follow in a clear and unambiguous way; namely, how many bits are used for a constant length code. So -- so let's keep this on one side. So the event is different already.
Now, from these events, JPEG extracts messages, of course, also. One message is the combination of number of zeros followed by the category that I just referred to, and the other message is the amplitude of the non-zero version.
And in this case, obviously the amplitude of the non-zero coefficient is not a 2D-VLC. It's not even a VLC, because it has a constant number of bits to represent it for all the amplitudes that are in that category. So it's just an address, an index, which one of many possible amplitudes it is. And there is a 2D-VLC, indeed, that is applied this time to the runs of zeros and the entity that is referred to as category.
Q. Okay. So in summary, in Baseline JPEG there

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is a two-dimensional variable length coding technique that is applied in which two messages are coded together in a combined manner, and those entities or messages are run length and category?
A. That is correct.
Q. And the category in Baseline JPEG is an indication of the magnitude of the non-zero coefficient?
A. I would qualify it -- and I think that we can look at the exact wording in the spec. I would qualify it as the number of bits that is used to represent, in a binary representation, the amplitude.
Q. When you said "the spec," did you mean the JPEG standard --
A. Yes.
Q. -- which is Exhibit 24?
A. Yes. May I?
Q. Yes, you may.
(Witness reviewing document.)
A. So I would like to refer to page 89 of the ISO/ICE version of JPEG standard. This is Exhibit 24. In fact, I believe the -- Well, the page number of the

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spec is 89, but the exhibit number is KODAK_012964. And I would like to draw your attention to section F-122.
Now, this section starts by saying that an entity RS is the binary representation of two times 4 bits, so 8 bits. But the first four are referred to as RRRR, and the second four are referred to as SSSS.
Now, the SSSS -- and this is what we are talking about -- is indeed this category, yes. And it says "The four least significant bits SSSS define a category for the amplitude of the non-zero coefficient." Yes. The other one is probably not interesting for now.
And here it says, below the figure on the next page, in Figure F1, "The magnitude ranges assigned to each value SSSS are defined in the Table F2." And it just says "categories assigned to coefficient values."
So as we see, basically, for category SSSS 1, we have some -- only two, actually, possible amplitudes. For two, you have four and so on until ten, where you have many more. And, in fact, this is

EXHIBIT 11

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.

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[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

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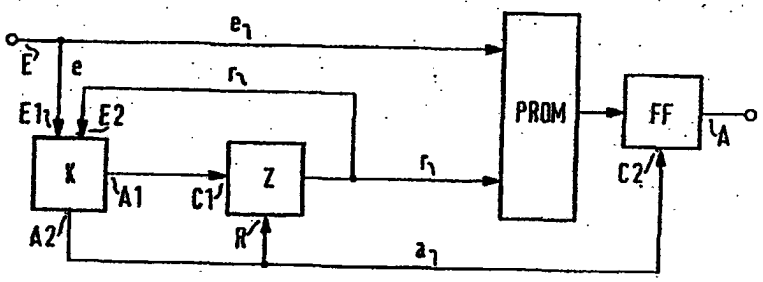
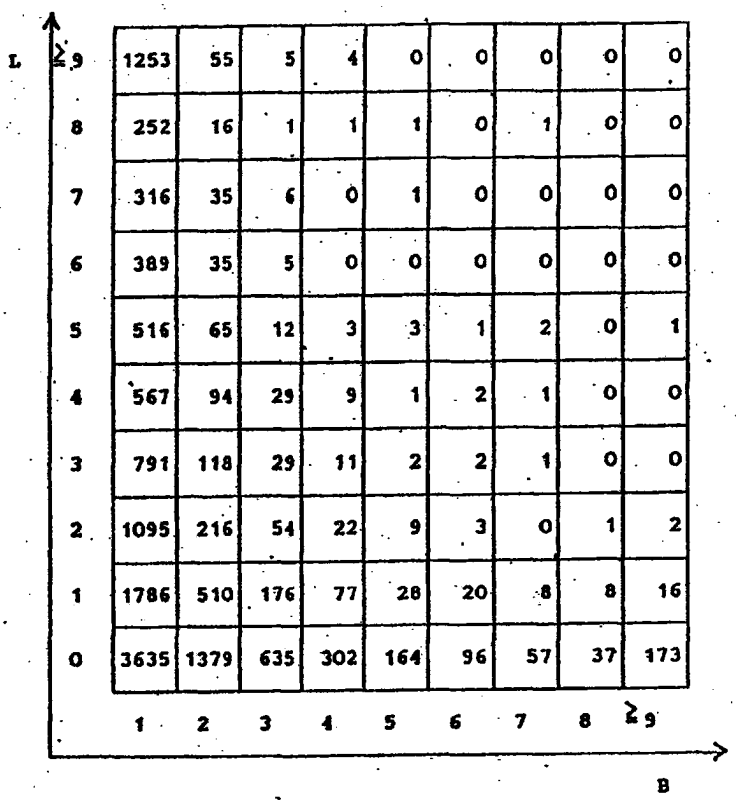
Assistant Examiner—Brian K. Young
Attorney, Agent, or Firm—Michael E. Marion

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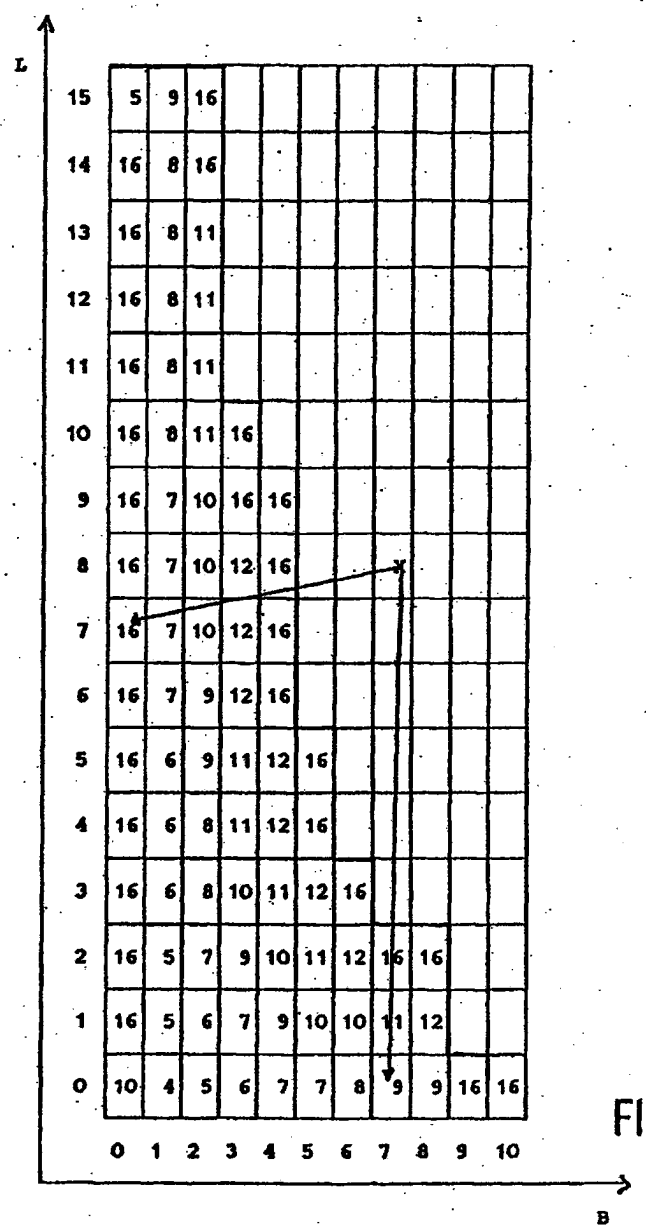
252 16 1 1 1 0 1 0 0
316 35 6 0 1 0 0 0 0
389 35 5 0 0 0 0 0 0
516 65 12 3 3 1 2 0 1
567 94 29 9 1 2 1 0 0
791 118 29 11 2 2 1 0 0
1095 216 54 22 9 3 0 1 2
1786 510 176 77 28 20 8 8 16
3635 1379 635 302 164 96 57 37 173
1 2 3 4 5 6 7 8 ≥9
B

FIG. 1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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
B

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

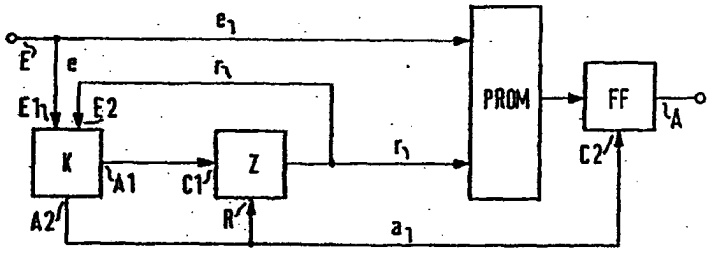

FIG.6

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 exceptional 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 (8, 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) (1)
...
(Lm, Bm)

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) (3)
(6, 1)

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.

* * * * *

EXHIBIT 12

Kopie

COST 211bis Simulation Subgroup

Paper No
09.Sept.86

Block coding using a two-dimensional run-length table

1. Introduction

In this paper coding of an integer block by a two-dimensional run-length table is introduced and compared with coding by an amplitude lookup table for coding the magnitude of the coefficients and a run-length lookup table for coding the addresses of the coefficients related to a certain block scan. While coding by an amplitude-and run-length lookup table makes use of consecutive zeros only, coding by a 2D-run-length-table uses additionally the statistical property between the length of consecutive zeros and the magnitude of the following nonzero coefficient. Our statistical measurements have shown that e.g. a large run-length of zero coefficients frequently is followed by a small rather than a large coefficient value.

2. Definition of a two-dimensional run-length table

For 2D-run-length coding the events corresponding to a run-length of consecutive zero coefficients and coefficients unequal to zero defining the end of the run-length are considered as composite rather than seperate statistical events of the form

number of preceeding zeros (= run-length) coefficient magnitude unequal to zero

The run-length and the magnitude of composite events define the entries of the 2D-run-length table which contains the code words for the composite events.

3. Numerical results

Tab.1 shows the histogram for composite events based on a zig-zag scan of the first 5000 inter-frame coded blocks of the split screen scene. As can be seen a high run-length mostly is associated with a small subsequent coefficient magnitude. High coefficient magnitudes occur very rarely after a large run-length. From Tab.1 the Huffman codes for the composite events (appendix A) as well as for the magnitude-and run-length-events (apppendix

B) have been derived by a computer program. Eight additional bits are allocated for magnitudes greater than or equal to nine, whereas a run-length greater than or equal to nine requires additionally six bits for the run-length (range 2 ... 63). To compare coding by a 2D-run-length table with coding by an amplitude-and run-length lookup table Tab.2 and 3 have to be considered. The values in Tab.2 are directly taken from appendix A, adding to each code word an additional sign-bit. In Tab.3 the code length of the composite events are shown, if the amplitude-and run-length lookup tables from appendix B would be used to code the composite events. For example, the composite event given by

Run-length = 3, Magnitude = 2

is coded as (see appendix B)

run-length prefix	2Bit
run-length = 3	3Bit
magnitude = 2	4Bit
sign-bit	1Bit
sum	10Bit

Multiplying the code length for every entry of the 2D-run-length tables of Tabs.2,3 with the number of the associated events in Tab.1 yields

101.893 bits	for Tab.2
115.745 bits	for Tab.3

Thus coding by a 2D-run-length table using Huffman Codes provides a bit reduction of approx. 12% compared with coding by an amplitude-and run-length lookup table using Huffman codes.

4. Conclusion

The numerical results show that run-length coding using a amplitude and run-length lookup table can be significantly improved by a two-dimensional run-length table. A bit-reduction of about 12% is demonstrated. Further investigations are required for modified Huffman codes which exhibit the self synchronizing property and a maximum length of 16 bits.

MAGNITUDE (UNEQUAL TO ZERO) →

RUN-LENGTH ↓	1	2	3	4	5	6	7	8	≥ 9
0	4	5	6	7	8	9	9	10	16
1	4	6	8	9	10	11	12	12	19
2	5	7	10	11	12	14	20	15	22
3	6	8	10	12	14	14	15	20	28
4	6	9	10	12	15	14	15	20	28
5	6	9	12	13	13	15	14	20	23
6	7	10	13	20	20	20	20	20	29
7	7	10	13	20	15	20	20	20	28
8	7	11	15	15	15	20	15	19	27
≥ 9	11	15	19	19	25	25	25	25	33

RUN-LENGTH
(NUMBER OF CONSECUTIVE ZEROS BEFORE COEFFICIENT UNEQUAL TO ZERO APPEARS)

TAB.2 CODE LENGTH OF THE HUFFMAN CODES OF A 2D-RUN-LENGTH TABLE FOR THE HISTOGRAM OF TAB. 1 (CMP. APPENDIX A) (INCL. SIGN-BIT)

MAGNITUDE (UNEQUAL TO ZERO) →

RUN-LENGTH ↓	1	2	3	4	5	6	7	8	≥ 9
0	3	5	6	7	9	9	10	10	17
1	6	8	9	10	12	12	13	13	20
2	7	9	10	11	13	13	14	14	21
3	8	10	11	12	14	14	15	15	22
4	8	10	11	12	14	14	15	15	22
5	9	11	12	13	15	15	16	16	23
6	9	11	12	13	15	15	16	16	23
7	9	11	12	13	15	15	16	16	23
8	10	12	13	14	16	16	17	17	24
≥ 9	13	15	16	17	19	19	20	20	27

RUN-LENGTH
(NUMBER OF CONSECUTIVE ZEROS BEFORE AMPLITUDE UNEQUAL TO ZERO APPEARS)

TAB. 3 CODE LENGTH OF THE CODE WORDS OF A 2D-RUN-LENGTH-TABLE WHICH WOULD RESULT FROM HUFFMAN CODING THE COEFFICIENT MAGNITUDE AND RUN-LENGTH SEPERATELY FOR THE HISTOGRAM OF TAB. 1 (APPENDIX B) (INCL. SIGN-BIT)

APPENDIX A

2-D RUN-LENGTH TABLE DERIVED FROM TAB. 1
(THE SIGN-BIT WHICH IS REQUIRED FOR EVERY TABLE ENTRY IS NOT SHOWN)

MAGNITUDE	RUN-LENGTH	HUFFMAN CODE	LENGTH
1	0	111	3 BIT
1	1	000	3 BIT
1	2	0100	4 BIT
1	3	11011	5 BIT
1	4	01010	5 BIT
1	5	00111	5 BIT
1	6	110101	6 BIT
1	7	011110	6 BIT
1	8	001011	6 BIT
1	≥ 9	0110 + 6	4 BIT + 6 BIT
2	0	1100	4 BIT
2	1	00110	5 BIT
2	2	001000	6 BIT
2	3	0010100	7 BIT
2	4	01111101	8 BIT
2	5	00101010	8 BIT
2	6	010111000	9 BIT
2	7	010111001	9 BIT
2	8	0010101100	10 BIT
2	≥ 9	00100100 + 6	8 BIT + 6 BIT
3	0	01110	5 BIT
3	1	1101000	7 BIT
3	2	110100111	9 BIT
3	3	001001101	9 BIT
3	4	001001110	9 BIT
3	5	11010011011	11 BIT
3	6	011111001100	12 BIT
3	7	110100110101	12 BIT
3	8	00101011101110	14 BIT
3	≥ 9	011111001101 + 6	12 BIT + 6 BIT
4	0	010110	6 BIT
4	1	01011101	8 BIT
4	2	1101001100	10 BIT
4	3	01111100111	11 BIT
4	4	00101011111	11 BIT
4	5	001001111000	12 BIT
4	6	0010011111010010100	19 BIT
4	7	0010011111010011010	19 BIT
4	8	00101011101111	14 BIT
4	≥ 9	001001111011 + 6	12 BIT + 6 BIT
5	0	0101111	7 BIT
5	1	001001100	9 BIT
5	2	00101011110	11 BIT
5	3	0010101110000	13 BIT
5	4	00101011101001	14 BIT
5	5	001001111001	12 BIT
5	6	0010011111010010101	19 BIT
5	7	00101011101101	14 BIT
5	8	11010011010000	14 BIT
5	≥ 9	0010011111010000010 + 6	18 BIT + 6 BIT
6	0	11010010	8 BIT
6	1	0111110010	10 BIT
6	2	1101001101001	13 BIT
6	3	0010101110001	13 BIT

6		4	0010101110010	13 BIT
6		5	00101011101011	14 BIT
6		6	0010011110100010110	19 BIT
6		7	0010011110100011011	19 BIT
6		8	0010011110100011111	19 BIT
6	>	9	0010011110100000011 + 6	18 BIT + 6 BIT
7		0	00100101	8 BIT
7		1	00101011010	11 BIT
7		2	0010011110100001110	19 BIT
7		3	00101011101000	14 BIT
7		4	00101011101010	14 BIT
7		5	0010101110011	13 BIT
7		6	0010011110100010111	19 BIT
7		7	0010011110100011100	19 BIT
7		8	11010011010001	14 BIT
7	>	9	0010011110100000100 + 6	18 BIT + 6 BIT
8		0	011111000	9 BIT
8		1	00101011011	11 BIT
8		2	00100111101001	14 BIT
8		3	0010011110100001111	19 BIT
8		4	0010011110100010001	19 BIT
8		5	0010011110100010011	19 BIT
8		6	0010011110100011000	19 BIT
8		7	0010011110100011101	19 BIT
8		8	0010011110100000000	18 BIT
8	>	9	0010011110100000101 + 6	18 BIT + 6 BIT
9		0	0111111 + 8	7 BIT + 8 BIT
9		1	0010011111 + 8	10 BIT + 8 BIT
9		2	0010011110101 + 8	13 BIT + 8 BIT
9		3	0010011110100010000 + 8	19 BIT + 8 BIT
9		4	0010011110100010010 + 8	19 BIT + 8 BIT
9		5	00101011101100 + 8	14 BIT + 8 BIT
9		6	0010011110100011001 + 8	19 BIT + 8 BIT
9		7	0010011110100011110 + 8	19 BIT + 8 BIT
9		8	0010011110100000001 + 8	18 BIT + 8 BIT
9	>	9	0010011110100000110 + 14	18 BIT + 14 BIT
END OF BLOCK :			10	2 BIT

APPENDIX B

AMPLITUDE- AND RUN-LENGTH LOOKUP TABLES DERIVED FROM TAB. 1

AMPLITUDE LOOKUP TABLE
(THE SIGN-BIT WHICH IS REQUIRED FOR THE FIRST NINE ENTRIES OF THE AMPLITUDE LOOKUP TABLE IS NOT SHOWN)

MAGNITUDE	HUFFMAN CODE	LENGTH
1	11	2 BIT
2	1011	4 BIT
3	10100	5 BIT
4	101010	6 BIT
5	10101111	8 BIT
6	10101101	8 BIT
7	101011001	9 BIT
8	101011000	9 BIT
>9	10101110 + 8	8 BIT + 8 BIT
SINGLE ZERO	100	3 BIT
R.L. PREFIX	01	2 BIT
END OF BLOCK	00	2 BIT

RUN-LENGTH LOOKUP TABLE

RUN LENGTH	HUFFMAN CODE	LENGTH	
1	01000	5 BIT	(DOES NOT APPEAR)
2	10	2 BIT	
3	110	3 BIT	
4	011	3 BIT	
5	1111	4 BIT	
6	1110	4 BIT	
7	0101	4 BIT	
8	01001	5 BIT	
>9	00 + 6	2 BIT + 6 BIT	

EXHIBIT 13

United States Patent [19]

Pirsch

[11] **4,420,771**

[45] **Dec. 13, 1983**

[54] **TECHNIQUE FOR ENCODING MULTI-LEVEL SIGNALS**

[75] Inventor: **Peter Pirsch, Hanover, Fed. Rep. of Germany**

[73] Assignee: **Bell Telephone Laboratories, Incorporated, Murray Hill, N.J.**

[21] Appl. No.: **232,701**

[22] Filed: **Feb. 9, 1981**

[51] Int. Cl.³ **H04L 3/00; H04N 7/12**

[52] U.S. Cl. ..... **358/261; 340/347 DD; 358/133**

[58] Field of Search ... 340/347 DD, 347 M, 347 AD; 358/133, 260, 261, 135

[56] **References Cited**

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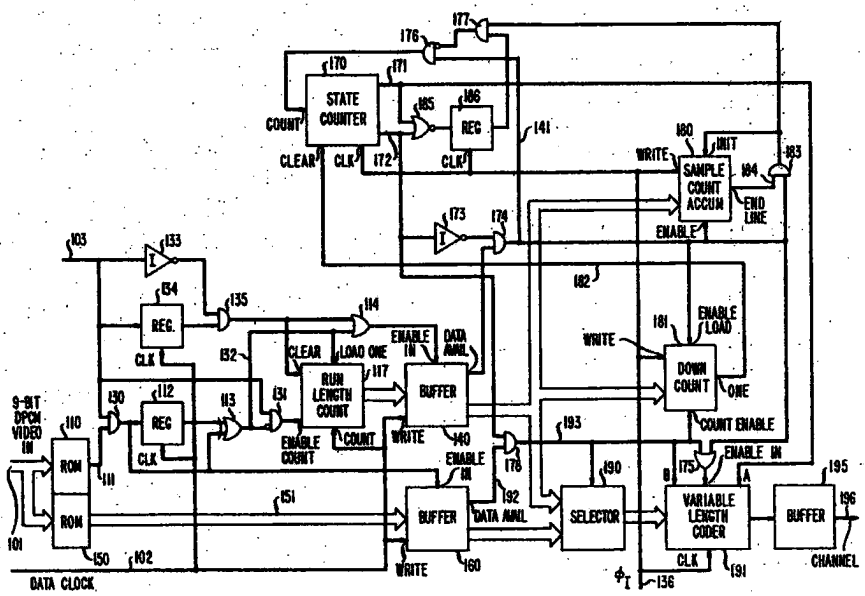
Primary Examiner—T. J. Sloyan

Attorney, Agent, or Firm—Barry H. Freedman

[57] **ABSTRACT**

A series of words each representing one of at least M ($M \geqq 3$) different values is encoded by grouping the words into alternate runs of (1) a first, frequently occurring value, and (2) all other values. A coded representation of each run length as well as a representation of the non-frequent values which make up every other run are then combined in a predetermined sequence. Different code tables may be used to generate code words for each type of information.

17 Claims, 3 Drawing Figures



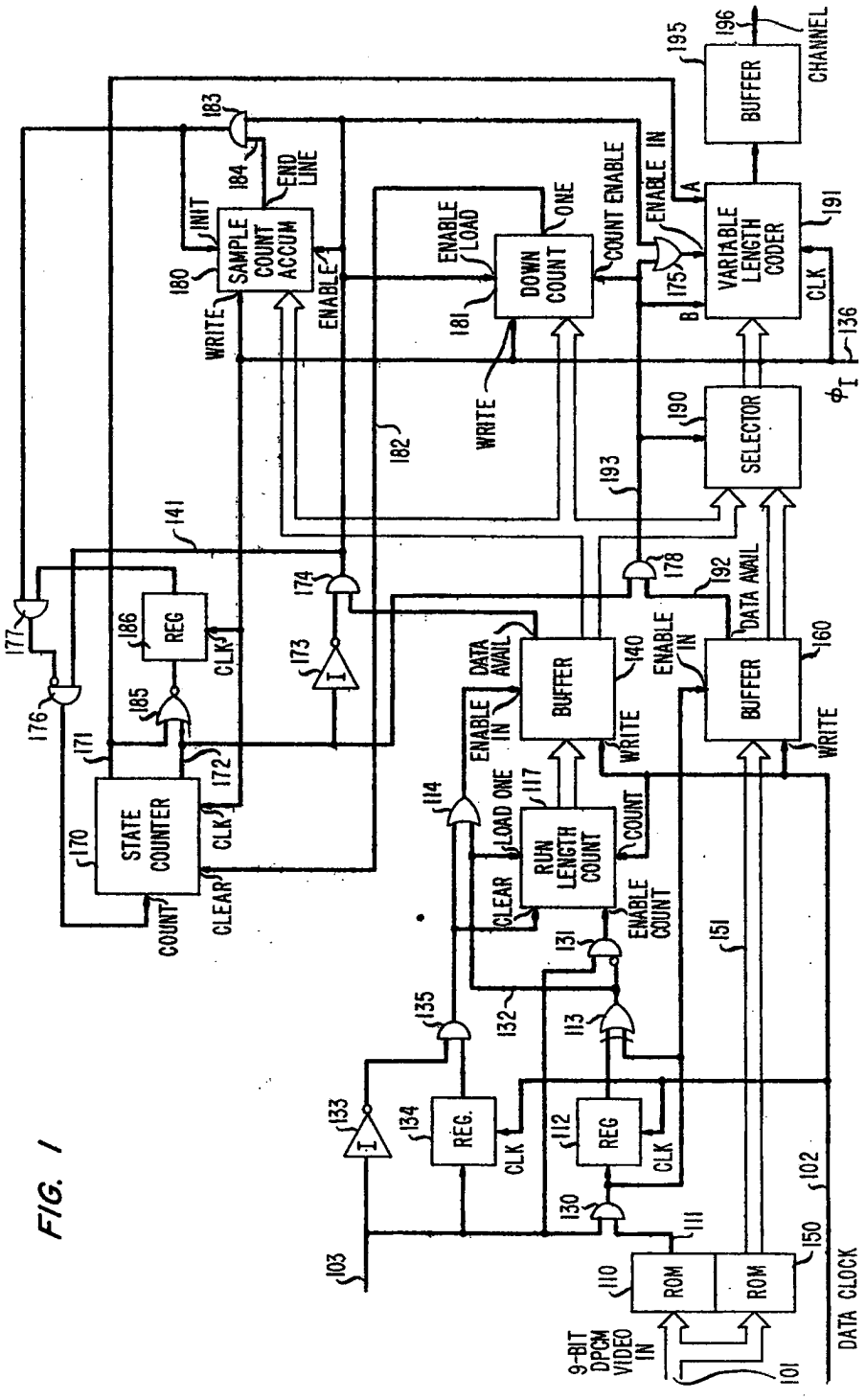

BUFFER
CHANNEL
VARIABLE LENGTH CODER
CLK
SELECTOR
DOWN COUNT
ENABLE LOAD
ONE
COUNT ENABLE
ENABLE IN
WRITE
SAMPLE COUNT ACCUM
INIT
END LINE
ENABLE
DATA AVAIL
REG
STATE COUNTER
CLEAR
COUNT
LOAD ONE
RUN LENGTH COUNT
ENABLE COUNT
ROM
9-BIT DPCM VIDEO IN
DATA CLOCK

FIG. 1

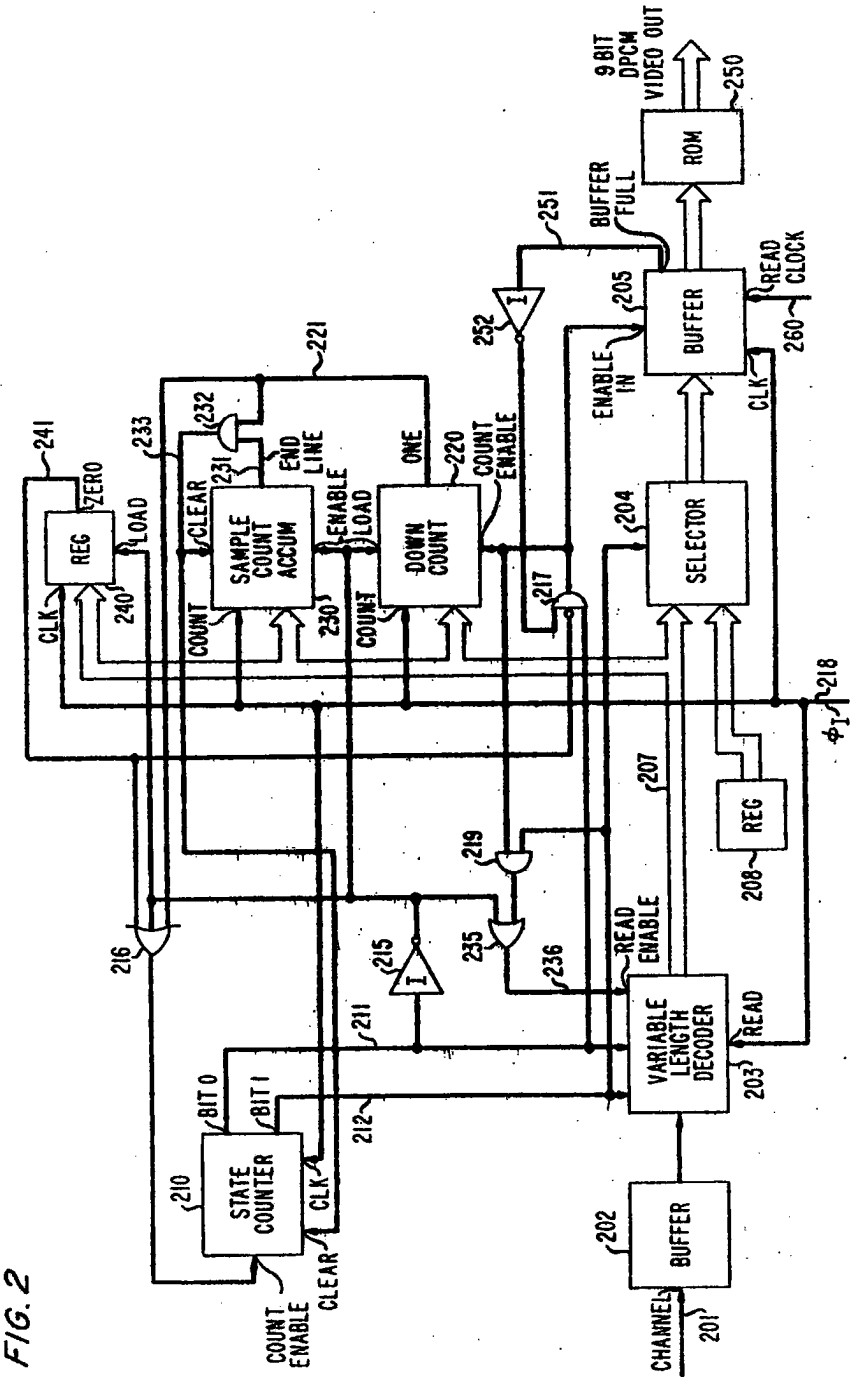
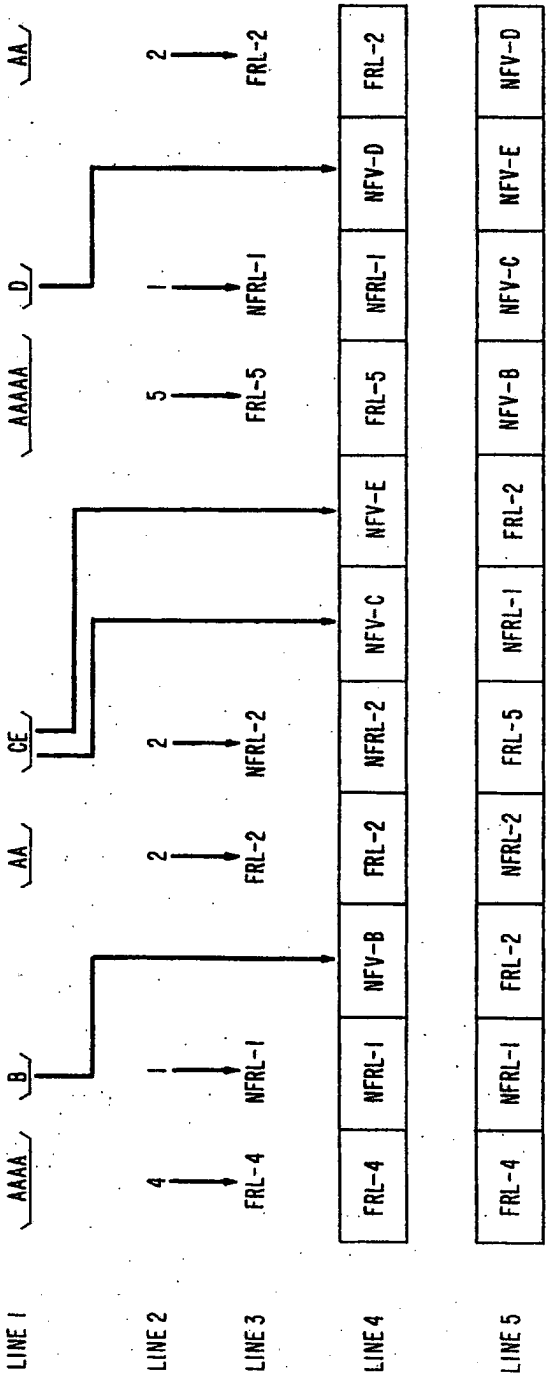

9 BIT DPCM VIDEO OUT
250
ROM
BUFFER FULL
251
BUFFER
READ CLOCK
260
ENABLE IN
205
CLK
252
221
232
233
241
ZERO
REG
LOAD
CLEAR
SAMPLE COUNT ACCUM
231
END LINE
ENABLE LOAD
ONE
DOWN COUNT
220
COUNT ENABLE
204
SELECTOR
CLK
240
COUNT
230
COUNT
217
218
Φ1
207
REG
208
219
216
215
235
236
READ ENABLE
211
VARIABLE LENGTH DECODER
READ
203
BIT 0
BIT 1
212
210
STATE COUNTER
CLK
CLEAR
COUNT ENABLE
202
BUFFER
CHANNEL
201

FIG. 2

FIG. 3


LINE 1
LINE 2
LINE 3
LINE 4
LINE 5
AAAA
B
AA
CE
AAAAA
D
AA
4
FRL-4
NFRL-1
2
FRL-2
NFRL-2
5
FRL-5
NFRL-1
2
FRL-2
FRL-4
NFRL-1
NFV-B
FRL-2
NFRL-2
NFV-C
NFV-E
FRL-5
NFRL-1
NFV-D
FRL-2
FRL-4
NFRL-1
FRL-2
NFRL-2
FRL-5
NFRL-1
FRL-2
NFV-B
NFV-C
NFV-E
NFV-D

TECHNIQUE FOR ENCODING MULTI-LEVEL SIGNALS

TECHNICAL FIELD

The present invention relates generally to a technique for encoding multi-level signals and, in particular, to a form of run-length coding of such signals when one of the levels occurs much more frequently than all of the other possible levels.

BACKGROUND OF THE INVENTION

Numerous advances have been made in the efficiency with which still or moving picture information may be encoded, based upon the recognition that much information represented in a scene, in graphics or in text, is highly correlated. For example, it is possible to very accurately predict the intensity value (or other characteristics) of a particular portion of a picture, based perhaps upon spatial or temporal relationships, or other known properties of pictures, such as luminance/chrominance relations or by using velocity/displacement compensation. These predictions, in turn, are usually compared with the actual picture signal, so that only the error values need be encoded. With more sophisticated predictions, the error values statistically tend to be smaller, allowing further processing which takes advantage of the increased entropy; numerous techniques have been developed for this purpose. For example, the error signal can be non-uniformly quantized, so that inconsequential values are discarded or de-emphasized and important values emphasized. Since errors usually occur in spurts (near "non-predictable" edges, for example) various adaptive techniques can also be used, depending upon which area of the picture is being processed. Alternatively, the error signal can be processed to take advantage of spatial redundancy by a technique known as bit-plane encoding, wherein one or more of the most significant bits of each error sample, representing a group of contiguous picture elements, are coded as a series of run lengths, rather than individually. However, it is noted that the lower order bits of each error value are not usually highly correlated, reducing the effectiveness of the bit-plane approach.

Despite the improvements which the foregoing techniques provide, it nevertheless remains that the efficiency with which multi-level signals having a statistically "preferred" value are encoded may be increased, by reducing redundancy still further and thus reducing the amount of data needed to represent the signal. Accordingly, the broad object of the present invention is to enable more efficient encoding of a multi-level signal wherein one particular level or value occurs much more frequently than any other value. One such multi-level signal very well suited for encoding in accordance with the present invention is an error signal derived from a predictive picture encoder.

SUMMARY OF THE INVENTION

In accordance with the present invention, a series of words which represent samples of a multi-level signal to be encoded are first processed or grouped so as to form run length code words which indicate the sequence of occurrence of (1) words of a first frequently occurring predetermined value and (2) words of all remaining, less frequent values. The lengths of each type of run, called "frequent value" runs and "non-frequent value" runs, respectively, are preferably encoded using a variable length code. The magnitudes or values of words which make up the "non-frequent value" runs are also encoded, again preferably using variable length coding. However, a different code assignment can be used, if desired. The run-length codes and the non-frequent value codes are then combined in a predetermined sequence for transmission to a remote location where the original signal can be recovered.

BRIEF DESCRIPTION OF THE DRAWING

The present invention will be more fully understood from the following detailed description when read in light of the accompanying drawing in which:

FIG. 1 is a block diagram of an encoder for multi-level input signals constructed in accordance with the present invention;

FIG. 2 is a block diagram of a decoder arranged to recover the original signal encoded by the apparatus of FIG. 1; and

FIG. 3 is a diagram illustrating possible sequences for the code words generated in accordance with the invention.

DETAILED DESCRIPTION

The present invention is, in effect, a hybrid technique allowing the advantages of run-length encoding usually used only in conjunction with binary signals, to be achieved with a multi-level signal. It is most effective when the signal to be encoded contains a significant proportion (say >50%) of words of a single value called the "frequent" value, which statistically is expected to occur most often. All other values are referred to collectively as "non-frequent" values. A particularly suitable application of the invention is in processing the output of a video encoder in which the value of each picture element is predicted using previously encoded information, and in which each prediction is compared with the true value to yield an error value. This type of predictive video encoder produces a large number of predictions which will be accurate, and thus a large number of error values will have values at or near ZERO. These form the "frequent value" inputs to the encoder of the present invention, while remaining error values form the "non-frequent" values. However, it is to be clearly understood that multi-level signals derived from other sources may be processed in accordance with the instant invention, and that advantageous results will be achieved as long as a heavy bias exists in favor of a given most frequent value.

FIG. 1 is a block diagram showing an encoder arranged to encode a multi-level input signal in accordance with the present invention. A multi-level input signal such as a multibit digital signal in parallel format is applied simultaneously on line **101** to first and second read-only memories (ROM's) **110** and **150**, which are shown and may be implemented as portions of a signal ROM. A clock pulse is provided on line **102** at the occurence of each input word on line **101**, and a blanking signal provided on line **103** remains high during the entire period (e.g., the active portion of each line interval) when input signals are being processed. ROM **110** is arranged to provide a one-bit output on line **11**, indicating whether each input word has a "frequent" value, on the one hand, or any of a plurality of remaining possible "non-frequent" values, on the other hand. Continuing the example of an input signal derived from a predictive video encoder, each word may contain 9 bits

which can have only a limited number (say 16) of possible values. This limitation occurs because a quantizer is typically included within the video encoder in order to associate different groups of error values with a small number of corresponding representative values. The nine-bit word length used in the quantizer is one bit longer than the 8 bit word length typical of each input to the video encoder, to provide a sign indication, since each error can be positive or negative. The quantizer output is used in forming succeeding predictions (usually represented as 8 bit words) which in turn are compared with the corresponding 8 bit input word to yield the next 9-bit error value. A particular one of the nine-bit quantizer output words, representing the group of smallest error values, may be the "frequent value" that occurs most often, and ROM **110** may be arranged to generate a "0" (ZERO) in response to this input. On the other hand, all of the remaining 15 possible 9-bit words cause ROM **110** to generate an output of "1" (ONE). indicating a "non-frequent" value.

As long as a high blanking signal is maintained on line **103**, the output of ROM **110** on line **111** is applied via AND gate **130** to a one-bit shift register **112** and to the first input of an exclusive OR gate **113** which receives its second input from the output side of register **112**. The purpose of gate **113** is to signal the end of each "run" of bits output from ROM **110** by detecting a difference between its present output and the immediately preceding output stored in registor **112** at the occurence of each clock pulse on line **102**. When the inputs to exclusive OR gate **113** are the same, its low output is applied to an inverting input of AND gate **131**, the output of which is high provided that the input on line **103** is high. The output of gate **131** in turn enables a run-length counter **117** to count clock pulses on line **102**, so as to accumulate an indication of the length of each run of line values output from ROM **110**. Counter **117** must have a capacity sufficient to count the number of words contained in each interval during which the blanking signal is high. For a typical line interval, a 9-bit capacity would be appropriate.

At the transition point between runs, the inputs to exclusive OR gate **113** are different, whereupon the output of gate **113** goes high. A logic signal is thus applied via OR gate **114** to the enable input of a run-length buffer **140** which is now ready to receive the run length stored in counter **117** at the instant that a clock pulse is applied to the write input of the buffer via line **102**. The high output of gate **113** on line **132** also causes a "ONE" to be loaded in counter **117**, so that the next run of input words may be processed.

When the blanking signal on line **103** goes low, indicating that active input signals are no longer present (at the end of each line, for example), inverter **133** and one-bit register **134** both provide high outputs, enabling AND gate **135**. Its output, in turn, is passed through OR gate **114** and used to enable transfer of the multi-bit run length accumulated in counter **117** to buffer **140** when a clock pulse is received at the write input via line **102**. The high output of AND gate **135** also clears counter **117** in preparation for the next series of input words.

When the output of ROM **110** is a ONE, indicating an input with a non-frequent value, the high output of AND gate **130** enables a code word output from ROM **150** to be entered in a non-frequent value buffer **160** when a clock pulse is applied to the write input of the buffer via line **102**. ROM **150** is arranged to code the input word applied on line **101** by generating a fixed length (say 4-bit) code word on line **151** to represent each possible non-frequent input value. This coding removes the redundancy introduced in the input signal by virtue of the previously described quantization process. However, the code conversion performed in ROM **150** is not an essential feature of the present invention. If an input signal derived from other sources is to be encoded, ROM **150** may be eliminated and the input words applied directly to line **151**. In either event, the capacity of buffer **160** must be sufficient to store the number of code words (or input words) expected in each active interval, until the blanking signal on line **103** goes low.

Information in buffers **140** and **160** is read out and encoded, on a first-in/first-out basis, under control of internal timing pulses ϕ_f input on line **136**. These pulses are provided by an internal clock circuit, not shown, which preferably operates at a rate somewhat higher than the data clock on line **102**, so that information can be encoded at least as fast as it is received in the encoder of FIG. **1**. The protocol or sequence of encoding the run length information in buffer **140** and the non-frequent value information in buffer **160** must be preselected and thus known at both the encoder and decoder. For purposes of explanation, it is assumed that the desired sequence is (1) run lengths of frequent values, followed by (2) run lengths of non-frequent values, followed by (3) the non-frequent values themselves.

Supervision of the encoding sequence is provided by a two-bit state counter **170** which is initialized to provide a low output on both lines **171** and **172** at the beginning of each active interval. In this state, called the **0—0** state, the frequent value run length is to be coded. To accomplish this, the low output on line **172** is inverted in an inverter **173**, and used to raise the output of AND gate **174** as long as buffer **140** has available data, as indicated by a high output on line **141**. The high output of AND gate **174** serves several purposes: first, a sample count accumulator **180** is enabled to accept and accumulate the run length stored in buffer **140** at the occurrence of a ϕ_f pulse at its write input. Simultaneously, the same run length is entered in a down counter **181**, but this counter is not otherwise used during the **0—0** state. Second, a high logic signal is applied to the "enable input" terminal of a variable length encoder **191** via OR gate **175**, so that the run length held in buffer **140** may be passed through a selector switch **190** and applied to that encoder, which will be described more fully hereinafter. Finally, the high output of gate **174** enables the output of AND gate **176** to go high, causing state counter **170** to advance to its next state, called the **0–1** state, in which the run length of non-frequent values is to be encoded.

In the **0–1** state, the output of counter **170** on line **171** is high while its output on line **172** remains low. When the logic level of line **171** is raised, variable length coder **191** is signalled, enabling a change in the coding assignment used to encode the run length information. This aspect of the invention will be discussed more fully below. Since the logic level on line **172** remains low in the **0–1** state, the output of AND gate **174** remains high. In this condition, the length of the non-frequent value run is added to the previous count in accumulator **180** and also entered in down counter **181**, overwriting the previous count stored therein. The high output of gate **174** again causes counter **170** to advance, this time to the third state, called the **1–0** state, in which line **172** goes high while line **171** goes low.

In the 1–0 state, the non-frequent value code words stored in buffer 160 are to be encoded. When the logic level on line 172 goes high, the output of AND gate 178 likewise goes high, since at least one non-frequent value code word has been entered in buffer 160 so as to raise the logic level on its data available output (line 192). The high output of gate 178 is passed through OR gate 175 and, as in the 0–1 state, enables coder 191 to receive inputs. However, the high output from gate 178 causes switch 190 to reposition itself so as to apply the non-frequent value codes in buffer 160 to coder 191.

While state counter 170 is in the 1–0 state allowing read out of the non-frequent value codes held in buffer 160, the outputs of AND gates 174 and 176 are low, keeping the counter from changing state. Down counter 181, which has received the run length indicating the number of non-frequent words that must be applied to coder 191 now supervises circuit operation, and the count contained therein is decreased by one each time a ϕ_1 clock pulse is applied on line 136, indicating that another non-frequent value word has been processed. When the count in counter 181 is decreased to ONE, the logic level on line 182 rises, resetting state counter 170 to its 0—0 state with the next ϕ_1 clock pulse, so that the entire cycle described above may be repeated.

Accumulator 180 is used to indicate the end of a processing interval which can include words derived from a single video scan line in the example given above. At the end of such a processing interval, it may be the case that the last information being processed is a frequent value run length; since it is desired that the next processing interval also start in the same state, it is thus necessary to inhibit the advancement of state counter 170. Inhibition is accomplished if counter 170 was most recently in its 0—0 state, since both inputs to NOR gate 185 are then low, producing a high output which sets a register 186 at the next ϕ_1 pulse. This clock pulse advances counter 170 to its 0–1 state. Now, both inputs to AND gate 174 (which is high in the 0–1 state) and the other (on line 184) being high when the count in accumulator 180 indicates that the end of the processing interval has been reached. The high outputs of AND gate 183 and register 186 serve to produce a high output from AND gate 177, which is inverted, keeping the output of AND gate 176 low. This assures that counter 170 will not advance, but will remain in the 0–1 state at the beginning of the next processing interval.

When counter 170 is in a state other than the 0—0 state at the instant when accumulator 180 indicates the end of a processing interval by a high output on line 184, the inhibition mentioned above does not occur. In such case, the outputs of OR gate 185 and thus register 186 are low, so that the output of AND gate 177 is also low. This allows the output of gate 176 to go high and thus advance counter 170 as appropriate.

The output of AND gate 183 is also used to raise the logic level at the "initialize" input to accumulator 180 at the end of each processing interval. In this condition, the next run length output from buffer 140 is loaded directly into accumulator 180, rather than being added to the previous accumulator contents.

As mentioned previously, variable length encoder 191 may comprise a read-only memory capable of storing three complete sets of code words, two for representing the run lengths accumulated in buffer 140 and the third for representing the non-frequent value words accumulated in buffer 160. The particular code set or dictionary used depends upon the type of information (i.e., run length or value) that is being encoded, and for the run lengths, which type of run, i.e., frequent or non-frequent values, is involved. The actual selection of a code table or dictionary depends upon a two-bit code word coupled to coder 191 on lines 171 and 193. For convenience, the bit derived from state counter 170 on line 171 is called the "A" bit, while the bit derived from the output of AND gate 178 on line 193 is called the "B" bit. With bits A and B low, coder 191 is arranged to code frequent value run lengths, while with bit A high and bit B low, non-frequent value run lengths are coded. Finally, with bit B high and bit A low, the non-frequent value words themselves are encoded. For each case, a different code dictionary may be constructed using statistics derived from expected or typical signals. In general, short codes are assigned to most frequent expected values, and longer codes are used for less frequent values. Since the length and rate of the code words output from encoder 191 varies, its output is entered in a first in-first out buffer 195 prior to transmission to a remote location or a storage medium via line 196.

The encoding sequence just described will be more fully appreciated by consideration of the following example. In Table 1 below, a 9-bit multi-level input as might be applied on line 101 is shown in column 1. Each word can assume any of 16 possible values, determined by the characteristics of the quantizer contained in the predictive video encoder which is the source of the input signal. Each non-frequent 9-bit word is quantized or converted to a corresponding 4-bit word in ROM 150, as shown in column 2 of Table 1, using a quantizing strategy which forms no part of the present invention. In this example, input value 000000000 is the frequent value which is not quantized or encoded. This input value causes ROM 110 to produce a ZERO output, while all other input values produce a ONE output from ROM 110, as shown in column 3.

TABLE 1

Input (Line 101)	Output Of ROM 150	Output Of ROM 110	output of Counter 117	Output of Coder 191 Using Table 2	Table 3	Table 4
000000000		0	1	110		
000011001	0010	1				000
000101010	0011	1	2		10	011
000000000		0				
000000000		0				
000000000		0	3	10		
000000101	0001	1				10
000011001	0010	1				000
010110111	1010	1	3		011	01001
000000000		0				
000000000		0	2	000		
000000101	0001	1	1		000	000
000000000		0	1	111		
000000101	0001	1	1		000	10
000000000		0				
000000000		0				
000000000		0				
000000000		0				
000000000		0	5	0101		

The output of ROM 110 is assembled into runs by counter 117, which essentially counts consecutive like outputs from ROM 110. Each multibit word (shown in decimal form in column 4) output from counter 117 is applied to buffer 140. In the example of Table 1, the output of ROM 110 begins with a run of value 0 and

length 1, and is followed by a run of value 1 and length 2. The values of succeeding runs must, by definition, alternate, the run lengths being 3, 3, 2, 1, 1, 1, and 5 as seen from column 4.

The code word assignments used by coder **191** to represent the run lengths in column 4 can be different variable length codes for runs of value ZERO and runs of value ONE, and this arrangement is particularly useful when the run length statistics for the two values are likely to be different. However, the totality of code words used must be such that the receiver can distinguish each word from the next word. Examples of code dictionaries for ZERO and ONE run lengths are given in Tables 2 and 3 below, in which it is seen that the code words are the same but the assignments are different. The appropriate code words determined by using Tables 2 and 3 have been entered in columns 5 and 6 of Table 1. It is to be noted that a code must be provided for a run length of ZERO in Table 2 (for frequent value runs) to account for the possibility that a series of input words will begin with a non-frequent value run. In that event, the first frequent value run is assigned the code representing the ZERO length.

TABLE 2

"ZERO" RUNS

Run Length	Code
0	111
1	110
2	000
3	10
4	011
5	0101
.	
.	
.	

TABLE 3

"ONE" RUNS

Run Length	Code
1	000
2	10
3	011
4	0101
5	110
.	
.	
.	

The code words generated by coder **191** to represent each non-frequent value are also selected using a variable length Huffman code, another example of which is shown in Table 4 below. Appropriate code words for the example in Table 1 generated using Table 4 have been entered in column 7.

TABLE 4

Value	Code
0001	10
0010	000
0011	011
0100	110
0101	111
0110	0101
0111	00100
1000	00101
1001	01000
1010	01001
1011	00110
1100	001110
1101	00111101
1110	00111110

TABLE 4-continued

Value	Code
1111	00111111

From columns 5, 6 and 7 of Table 1, it will be seen that the input words of column 2, which contain a total of 76 bits, are represented by code words having a total of 47 bits, for a compression ratio of approximately 3:2. Where the present invention is used for coding actual error value sequences generated using a predictive video encoder, a compression ratio of approximately 5:2 can be expected. The compression ratio depends upon the type of input sequence.

A multi-valued digital signal encoded with the apparatus of FIG. **1** may be returned to its original form using the decoder shown in block diagram form in FIG. **2**. Incoming code words received from the transmission channel **201** are entered in a first-in, first-out buffer **202** which equalizes the transmission channel rate with the processing rate of the decoder circuitry. Data stored in buffer **202** is applied to a variable length decoder **203** which recognizes words from the serial data stream and, like encoder **191** of FIG. **1**, contains a read-only memory. Decoder **203** advantageously is arranged to perform run length and value decoding under control from a state counter **210**, which insures that the same protocol used in the encoder is used to recover the original signal.

Upon initialization, counter **210** is in the first of four possible states, called the **0—0** state. In this state, the outputs on lines **211** and **212** are both low, and the frequent value run length code word applied to decoder **203** is converted to the corresponding run length output on lines **207** using, for example, the code word to run length conversion in Table 2. The low output from counter **210** on line **211** is inverted by an inverter **215**, and applied to the enable inputs of a down counter **220** and a sample count accumulator **230** each of which receives the frequent value run length. A register **240**, for purposes described below, is also enabled to load the frequent value run length. The high output of inverter **215** is also passed through OR gate **216** to the count input of state counter **210**, advancing it to its second state, called the **0–1** state, upon the ocurrence of a clock pulse ϕ_I applied on line **218**. In this state, the output on line **211** is high while the output on line **212** stays low.

Decoder operation is now controlled by down counter **220**, which enables assembly of the desired number of words each having the frequent value stored in register **208**, in a second buffer **205**. Entry into the buffer is enabled by a high output from an AND gate **217**. Clocking is again provided by a series of clock pulses ϕ_I applied on line **218**, generated by an internal clock not shown, which is also used to synchronize various other circuit elements.

At each occurrence of a ϕ_I pulse on line **218**, the count in down counter **220** is decreased by one, provided that the count enable input received from AND gate **217** is high. Concurrently, a word representing the frequent value, permanently held in a register **208**, is passed through selector switch **204** and entered in buffer **205**. This procedure is repeated until the count in counter **221** decreases to ONE, at which time the last frequent value word is being processed, and the last such word is input to buffer **205**.

When the count in counter 220 reaches ONE, a high output on line 221 is passed through OR gate 216, enabling state counter 210 to advance to its third state, called the 1–0 state, in which line 212 is high and line 211 is low. In this state, a non-frequent value run length code word is taken from buffer 202 and applied to variable length decoder 203. The corresponding run length, obtained from Table 3, is entered in down counter 220. Concurrently, the run length on line 207 is added to the count in accumulator 230.

As the run length is entered, the high output of inverter 215 is passed through OR gate 216, causing state counter 210 to advance to its final state (called the 1—1 state) in which both outputs on lines 211 and 212 are high. In the 1—1 state, the code words representing the non-frequent values are output from buffer 202 and applied to decoder 203. The non-frequent values are recovered, using the code conversion of Table 4, and applied to buffer 205 via selector switch 204, which has been repositioned by virtue of the high signal on line 212. Down counter 220 again decrements at each occurrence of an internal clock pulse on line 218, signifying entry of a non-frequent value word into buffer 205. When the count in counter 220 again reaches one, indicating that the last non-frequent value word is about to be processed, the output on line 221 goes high, resetting counter 210 to its initial 0—0 state so that the cycle described above can be repeated.

When the count in accumulator 230 indicates that the number of words processed is equal to the number of words contained in one processing interval, the output on line 231 goes high. This enables the output of AND gate 232 to go high when down counter 220 has completed its cycle and its output on line 221 also goes high. The output from AND gate 232 on line 233 is used to clear state counter 210, whereupon the entire decoding cycle will be repeated for the next processing interval. It is noted that the arrangement described starts counter 210 in its 0–0 state independent of the preceding state just completed. The output of AND gate 232 also serves to clear accumulator 230 in preparation for the next processing interval.

Register 240 is provided in the decoder of FIG. 2 in order to take account of a special situation in which the length of the first frequent value run is zero, i.e., when the first run in a processing interval is a run of non-frequent values. In this case, entry of frequent values into buffer 205 must be inhibited, and state counter 210 must be advanced. When register 240 receives the value ZERO, state counter 210 is advanced to the 0–1 state and the zero output of register 240 on line 241 goes high. This changes the state of counter 210 to the 1–0 state, since the count enable input from OR gate 216 is thus high. The high output on line 241 also serves to disable AND gate 217, preventing data from entering buffer 205 under the conditions specified above.

Variable length decoder 203 is arranged to provide the next output word each time the level on an output enable lead 236 is raised to indicate that another word is needed. Thus, each time a run length code is loaded in counter 220 and accumulator 230 using an enable input from inverter 215, the same signal is passed from inverter 215 through OR gate 235 to provide a high input on line 236. Each time a non-frequent value is entered in buffer 205, enable line 236 is raised by the action of AND gate 219. One input of gate 219 is high in the 1–0 or 1—1 state; its second input is controlled by the output of AND gate 217, which output is also used to enable buffer 205 to receive the frequent or non-frequent value. If buffer 205 becomes full, it is desirable that the operation of the decoder circuit be temporarily halted. Upon such an occurrence, a "buffer full" output on line 251 goes high, whereupon the low output of an inverter 252 acts to disable AND gate 217. Otherwise, the output of gate 217 is high in the 1—1 and 0–1 states, as desired.

The code table or dictionary used by decoder 203 is directly determined by the state of counter 210. In the 0—0 state, frequent value run-length code words are decoded using Table 2, while in the 1–0 state, non-frequent value run length code words are decoded in accordance with Table 3. The non-frequent value codes are decoded using Table 4 when counter 210 is in its 1—1 state. It is to be noted that decoder 203 does not operate in state 0–1, at which time the frequent value word held in register 208 is being entered in buffer 205.

Read-only memory 250, like read-only memory 150 of FIG. 1, is simply a digital code translator arranged, for example, to re-expand the code words output from buffer 205 to match the word length used in the display connected to the decoder output. Continuing the example discussed above, ROM 250 would be arranged to convert each 4-bit word output from buffer 205 to a corresponding 9-bit word to be applied to a DPCM decoder. Data is read out of buffer 205 by clock pulses applied on line 260 at a suitable rate.

Selector switch 204, like switch 190 of FIG. 1, may be a conventional series of semiconductor logic gates arranged to couple a selector and pass to its output one of two multibit input words, depending upon the logic state of a control input. For switch 204, the control input is derived from the output of counter 210 on line 212, and the input on line 207 is coupled to its output when the control input is high. The switch is repositioned to couple the input received from register 208 to its output when the control input is low.

The coding sequence used in the encoder and decoder of FIGS. 1 and 2, respectively, is illustrated in FIG. 3. A series of multibit input words having values A, B, C, D or E is input to the encoder, as shown in line 1. The words in a processing interval are grouped into runs, as shown in line 2, to separate the most frequent value A from all other less frequent values B-E. The run lengths for both frequent and non-frequent values are next coded (line 3), where FRL-n represents a code word for run length "n" derived from a first (frequent value) conversion table, while NFRL-n represents a code word for a run of length "n" derived from a second (non-frequent value) conversion table. Each set of run length codes is followed, as shown, on line 4, by a code word NFV-x, which represents the value of word "x" using yet a third conversion table.

If desired, a different order for the code words on line 4 of FIG. 3 can be used. However, the run length code words which indicate the sequence of occurrence of frequent and non-frequent values in the signal being encoded should usually precede the code words which specify the particular non-frequent values in the signal. For example, all of the run length code words for an entire processing interval can precede the non-frequent value code words for the interval, as shown in line 5 of FIG. 3. In this example, the frequent and non-frequent run length code words alternate, and are decoded at the receiver to give a count of the number of words that have been processed. When codes representing the number of words in each active interval have been

accumulated, the receiver is then switched so as to decode the non-frequent value codes which follow the run length codes for that interval. These changes in the encoding protocol may necessitate corresponding changes in both the encoder and decoder circuitry, such as an increase in the buffer storage capacity. For this reason, the encoding order described above in connection with FIGS. 1 and 2 is preferred.

While the encoder and decoder in the above examples processed an input signal derived from a predictive video encoder, it is to be clearly understood that the present invention is useful with any series of input samples or words capable of having at least M different values, where M≧3. Where a binary (M=2) signal is to be encoded, numerous prior art run length coding techniques are available. To obtain the maximum advantage, the statistical likelihood that one of the M values will occur should be significantly greater than the statistical likelihood that any other of the values will be present. It is also to be observed that a multiplicity of code assignments can be used for the different run lengths and non-frequent values, other than the codes in Tables 2, 3 and 4.

The definition of a "run" stated previously, namely, a series of consecutive inputs having the same value, can also be modified, if desired, without diminishing the advantages of the present invention. Specifically, an alternative definition of a run may be a series of consecutive words of like value as well as the next (subsequent) word of different value. For example, for a binary input of ONE's and ZERO's, a run of ZERO's would include the ONE bit following any group of successive ZERO's, and a run of ONE bits would include the ZERO bit immediately following the successive ONE's. This alternate definition is to be understood to be within the scope of the present invention, and the means used to determine the length of successive runs including exclusive OR gate 113 and run length counter 117 of FIG. 1 would be modified accordingly. If such a different definition were used, variable length encoder 191 and decoder 203 would also be modified appropriately.

What is claimed is:

1. Apparatus for compressing samples of a multilevel communication signal, each sample having one of at least M (M≧3) different values, wherein the statistical likelihood of occurrence of a particular one of said values is much greater than the statistical likelihood of occurrence of any other of said values, including

means for grouping said samples in runs of a first or a second type, wherein said first type runs include one or more samples of said particular value and said second type runs include one or more samples of said other values, and

means for encoding the lengths of said runs and a representation of said other values.

2. The invention defined in claim 1 wherein said encoding means includes means for assigning a code word to each run length of said first type run using a different code dictionary than used to code the run lengths of said second type runs.

3. The invention defined in claim 2 wherein said encoding means is arranged to encode a representation of said other values using a variable length code wherein the shortest code word is associated with the most frequently occurring one of said other values.

4. Apparatus for encoding a series of samples of a multilevel communication signal each having one of at least three different values, including:

means for generating a first series of run length code words which indicate the sequence of occurrence of (1) ones of said samples having a first one of said different values which occurs more frequently than any other of said different values, and (2) other ones of said samples having other ones of said values, and for generating a second series of code words indicating the values of said other ones of said samples, and

means for combining said first and second series of code words.

5. The invention defined in claim 4 wherein said multilevel communication signal is an error signal derived from a predictive encoder.

6. The invention defined in claim 5 wherein run length code words in said first series which represent runs of samples of said first value are derived from a different code table than run length code words which represent samples of said other values.

7. The invention defined in claim 6 wherein said generating means is arranged to generate a variable length code word to represent the value of each of said other ones of said samples, such that the shortest code word is representative of the most frequently occurring one of said samples.

8. Apparatus for encoding a series of samples of a multi-level error signal derived from a predictive encoder, including

means for grouping said samples so as to form alternate runs of (1) samples having the most frequently occurring predetermined value and (2) samples having all remaining, less frequently occurring values, and

means for encoding (a) the length of each of said runs, and (b) the values of only said samples having said remaining, less frequently occurring values.

9. The invention defined in claim 8 wherein said grouping means includes (1) means for generating a one-bit code indicating the occurrence of samples with said predetermined values, and (2) means responsive to said generating means for counting consecutive like occurrences of said one-bit code.

10. A method of encoding samples of a multilevel communication signal, each sample having one of at least M (M≧3) different values, wherein the statistical likelihood of a particular one of said values is much greater than the statistical likelihood of any other of said values, including the steps of:

grouping said samples in runs of a first or a second type, wherein said first type runs include one or more consecutive samples of said particular value and said second type runs include one or more consecutive samples of said other values, and

generating an output signal representing said multilevel signal by encoding the lengths of said runs and a representation of said other values.

11. The method defined in claim 10 wherein said encoding step includes assigning a code word to each run length of said first type run using a different code dictionary than used to code the run lengths of said second type runs.

12. The method defined in claim 11 wherein said encoding step further includes the step of encoding a representation of said other values using a variable length code wherein the shortest code word is associ-

ated with the most frequently occurring one of said other values.

13. The method of encoding a series of samples of a multilevel communication signal, each sample having one of at least three different values, including the steps of:

generating a first series of run length code words which indicate the sequence of occurrence of (1) ones of said multilevel samples having a first one of said different values which occurs more frequently than any other of said different values, and (2) other ones of said samples, and generating a second series of code words indicating the values represented by said other ones of said samples, and

generating an output signal by combining said first and second series of code words.

14. The method defined in claim 13 wherein said multilevel signal is an error signal derived from a predictive encoder.

15. A method of encoding a series of words which represent samples of a multi-level signal representing pictorial information, including the steps of:

grouping said words so as to form alternate runs of (1) words having the most frequently occurring predetermined value and (2) words having all remaining, less frequently occurring value, and

generating an output signal which represents said pictorial information by encoding (a) the length of each of said runs, and (b) the values of only said words having said remaining, less frequently occurring values.

16. The invention defined in claim 1 wherein said multilevel communication signal is an error signal derived from a predictive encoder.

17. The method defined in claim 10 wherein said multilevel communication signal is an error signal derived from a predictive encoder.

* * * * *

EXHIBIT 14

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Scene Adaptive Coder

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Abstract—**An efficient single-pass adaptive bandwidth compression technique using the discrete cosine transform is described. The coding process involves a simple thresholding and normalization operation on the transform coefficients. Adaptivity is achieved by using a rate buffer for channel rate equalization. The buffer status and input rate are monitored to generate a feedback normalization factor. Excellent results are demonstrated for coding of color images at 0.4 bits/pixel corresponding to real-time color television transmission over a 1.5 Mbit/s channel.**

I. Introduction

TRANSFORM image coding, developed about 15 years ago, has been proven to be an efficient means of image coding [1]–[6]. In the basic transform image coding concept, an image is divided into small blocks of pixels, and each block undergoes a two-dimensional transformation to produce an equal-sized array of transform coefficients. Among various transforms investigated for image coding applications, the cosine transform has emerged as the best candidate from the standpoint of compression factor and ease of implementation [7]–[11]. With the basic system, the array of transform coefficients is quantized and coded using a zonal coding strategy [3]; the lowest spatial frequency coefficients, which generally possess the greatest energy, are quantized most finely, and the highest spatial frequency coefficients are quantized coarsely. Binary codes are assigned to the quantization levels, and the code words are assembled in a buffer for transmission. At the receiver, inverse processes occur to decode the received bit stream, and to inverse transform the quantized transform coefficients to reconstruct a block of pixels.

The basic transform image coding concept, previously described, performs well on most natural scenes. A pixel coding rate of about 1.5 bits/pixel is achievable, with no apparent visual degradation. To achieve lower coding rates, without increasing coding error, it is necessary to adaptively quantize transform coefficients so that those blocks of coefficients containing large amounts of energy are allocated more quantization levels and code bits than low energy blocks. In almost all adaptive transform coding designs to date, transforms are computed, and transform energy is measured or estimated on a first pass through the image. This information is then utilized to determine the quantization levels and code words for a second pass [9]. With this scheme, compression factors can be reduced by a factor of two or more as compared to nonadaptive coding. The practical difficulties are the memory required for the second pass and the complexity of the quantization algorithm. Both these problems are eliminated in the scene adaptive coder described in this paper.

The scene adaptive coder is a single-pass adaptive coder of relative simplicity. The following sections describe the coding scheme and present subjective and quantitative performance evaluations.

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II. Cosine Transform Representation

The two-dimensional discrete cosine transform of a sequence $f(j, k)$ for $j, k = 0, 1, \cdots, N-1$, can be defined as [6]

$$F(u,v) = \frac{4C(u)C(v)}{N^2} \sum_{j=0}^{N-1} \sum_{k=0}^{N-1} f(j,k) \cdot \cos\left[\frac{(2j+1)u\pi}{2N}\right] \cos\left[\frac{(2k+1)v\pi}{2N}\right] \quad (1)$$

for $u, v = 0, 1, \cdots, N-1$, where

$$C(w) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } w = \phi \\ 1 & \text{for } w = 1, 2, \cdots, N-1. \end{cases}$$

The inverse transform is given by

$$f(j,k) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} C(u)C(v)F(u,v) \cdot \cos\left[\frac{(2j+1)u\pi}{2N}\right] \cos\left[\frac{(2k+1)v\pi}{2N}\right] \quad (2)$$

for $j, k = 0, 1, \cdots, N-1$. Among the class of transform possessing fast computational algorithms, the cosine transform has a superior energy compaction property [6]–[9]. The following sections present some other properties of the cosine transform, which are useful to the subsequent discussion.

A. Statistical Description of DCT Coefficients

Let the pixel array $f(j, k)$ represent a sample of a random process with zero mean represented in two's complement format over an integer range $-M \leqslant f(j, k) \leqslant (M-1)$. The probability density of the cosine transform coefficients $F(u, v)$ has been modeled by a number of functions [3], [12]. Among them, the Laplacian density has been shown to provide the best fit [12]. This function can be written as

$$p(x; u, v) = \frac{1}{\sqrt{2}\,\sigma(u,v)} \exp\left\{\frac{\sqrt{2}\,|x|}{\sigma(u,v)}\right\} \quad (3)$$

where $\sigma(u, v)$ denotes the standard deviation of a coefficient.

B. Coefficient Bound

The maximum coefficient value for the cosine transform can be derived from (1) as

$$F_{\max}(0,0) = 2f_{\max} \quad (4a)$$

and

$$\frac{16}{\pi^2} f_{\max} \leqslant F_{\max}(u,v) \leqslant 2f_{\max} \quad (4b)$$

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where f_{max} is the maximum value of the discrete array $f(j, k)$ and F_{max} is the maximum value for the coefficient $F(u, v)$. If the transform is performed in a vector length of $N = 16$, then

$$F_{max}(0, 0) = 2f_{max} \tag{5a}$$

$$F_{max}(u, v) = 1.628\, f_{max}. \tag{5b}$$

C. Mean Square Error Representation

The mean square quantization error between an original image $f(j, k)$ and its reconstructed image $\hat{f}(j, k)$ can be written as

$$\text{MSE} = \frac{1}{N^2} \sum_{j=0}^{N-1} \sum_{k=0}^{N-1} E\{[f(j, k) - \hat{f}(j, k)]^2\}. \tag{6}$$

The unitary property of the cosine transform allows one to express the MSE in the transform domain as

$$\text{MSE} = \frac{1}{4} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} E\{[F(u, v) - \hat{F}(u, v)]^2\} \tag{7}$$

which reduces to

$$\text{MSE} = \frac{1}{4} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} \sum_{n=-\infty}^{\infty} \int_{Dn-1}^{D_n} (x - x_n)^2 \cdot p(x; u, v)\, dx \tag{8}$$

where $p(x; u, v)$ is the probability density function, D_n is a set of decision levels, and x_n is a set of reconstruction levels. With Laplacian modeling of the probability density function, as represented in (3), the MSE becomes

$$\text{MSE} = \frac{1}{4} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} \left\{ \sigma^2(u, v) - \sum_{k=1}^{\infty} \left[(2x_n D_{n-1} + \sqrt{2}\sigma(u, v)x_n - x_n^2) \exp\left(\frac{-\sqrt{2}D_{n-1}}{\sigma(u, v)}\right) - (2x_n D_n + \sqrt{2}\sigma(u, v)x_n - x_n^2) \cdot \exp\left(\frac{-\sqrt{2}D_n}{\sigma(u, v)}\right) \right] \right\}. \tag{9}$$

This result has been verified by computer simulation.

III. Scene Adaptive Coder

Fig. 1 contains a block diagram of the scene adaptive coder. In operation, the input image undergoes a cosine transform in 16 X 16 pixel blocks. An initial threshold is established, and those transform coefficients whose magnitudes are greater than the threshold are scaled according to a feedback parameter from the output rate buffer. The scaled coefficients are quantized, Huffman coded, and fed into the rate buffer. The rate buffer operates with a variable rate input, dependent upon the instantaneous image energy, and a constant channel output rate. The buffer status (fullness) and input rate are monitored to generate the coefficient scaling factor. At the receiver, the received fixed rate data are fed to a rate buffer that generates Huffman code words at a variable rate to the decoder. The decoded transform coefficients are then inverse normalized by the feedback parameter, added to the threshold, and inverse transformed to reconstruct the output pixel block. The following sections describe the coding algorithm in greater detail.

A. Cosine Transform

Referring to the block diagram in Fig. 1, the original image is first partitioned into 16 X 16 pixel blocks. Each block of data is then cosine transformed as defined by (1). The resultant transform coefficients $F(u, v)$ are stored in a register according to the zigzag scan of Fig. 2. Scanning the data in this fashion minimizes the usage of runlength codes during the subsequent coding process.

B. Thresholding

The transform coefficients in the register undergo a threshold process in which all the coefficients, except $F(0, 0)$, that are below the threshold are set to zero, and those coefficients above the threshold are subtracted by the threshold. This results in

$$F_T(u, v) = \begin{cases} F(u, v) - T & \text{if } F(u, v) > T \\ 0 & \text{if } F(u, v) \leqslant T \end{cases} \tag{10}$$

where T is the threshold. Fig. 3 shows a plot of the percentage of coefficients below a threshold versus the threshold for the original images exhibited in Figs. 8(a) and 9(a). As demonstrated, more than 90 percent of the coefficients have absolute magnitude of less than a value of 3, even though the maximum coefficient value could be as large as $1.628\, f_{max}$ [see 5(b)]. Therefore, the thresholding process indicated in (10) will set a major portion of coefficients to zero, and thereby limit the number of coefficients to be quantized. The value of the threshold varies with respect to the globally desired bit rate. However, it can be adjusted locally on a block-to-block basis if desired.

C. Normalization and Quantization

The threshold subtracted transform coefficients $F_T(u, v)$ are scaled by a feedback normalization factor D from the output rate buffer according to the relation

$$F_{TN}(u, v) = \frac{F_T(u, v)}{D}. \tag{11}$$

The scaling process adjusts the range of the coefficients such that a desired number of code bits can be used during the coding process.

The quantization process is simply a floating point to integer roundoff conversion. No decision and reconstruction tables are required. Therefore, there is a significant simplification and saving for a hardware implementation. Because many of the threshold subtracted coefficients are of fractional value, the roundoff process will set some of the coefficients to zero and leave only a limited number of significant coefficients to be amplitude coded. The quantized coefficients can now be represented as

$$\hat{F}_{TN}(u, v) = \text{integer part of } [F_{TN}(u, v) + 0.5]. \tag{12}$$

It should be noted that a lower bound has to be set for the normalization factor in order to introduce meaningful transform coefficients to the coder. This lower bound is dependent upon how accurately the cosine transform is computed. Generally speaking, setting the minimum value of D to unity is sufficient for most of the compression applications. In this case, the worst-case quantization error can be obtained from (9) by letting $D_{n-1} = n - 0.5$, $D_n = n + 0.5$, and $x_n = n$.

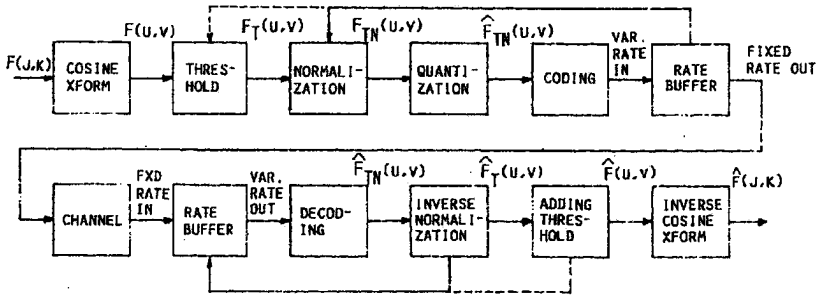

Fig. 1. Block diagram of scene adaptive coding/decoding system.

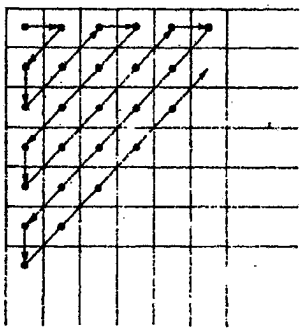

Fig. 2. Zigzag scan of cosine transform coefficients.

Thus

$$\mathrm{MSE} = \frac{1}{4} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} e(u, v) \tag{13}$$

where

$$e(u,v) = \sigma^2(u,v) - (1/2) \sum_{n=1}^{\infty} \left\{ [n^2 + (\sqrt{2}\sigma(u,v) - 1)n] \cdot \exp\left[\frac{-\sqrt{2}(n-0.5)}{\sigma(u,v)}\right] - [n^2 + (\sqrt{2}\sigma(u,v) + 1)n] \exp\left[\frac{-\sqrt{2}(n+0.5)}{\sigma(u,v)}\right] \right\}.$$

Fig. 4 shows the functional relationship between $e(u, v)$ and $\sigma(u, v)$. As can be seen, $e(u, v)$ is always less than 1/12. (Note: 1/12 is the quantization error for a uniform density.) Therefore, the MSE represented by (13) is always less than $N^2/48$. For $N = 16$, this MSE is less than 16/3, which corresponds to a normalized error of 0.0082 percent. This MSE also corresponds to a peak-to-peak signal-to-quantization-noise ratio of more than 40.9 dB, which is relatively insignificant.

D. Coding

The coefficient $F(0, 0)$ in the upper left-hand corner of each luminance transform block is proportional to the average luminance of that block. Because block-to-block luminance variations resulting from quantization of $F(0, 0)$ are easily discerned visually, $F(0, 0)$ is linearly quantized and coded with a 9 bit code. As for the other nonzero coefficients, their magnitudes are coded by an amplitude lookup table, and the addresses of the coefficients are coded using a runlength lookup table. The amplitude and runlength lookup tables are simply Huffman codes derived from the histograms of typical transform coefficients. As demonstrated by the histograms of Fig. 5, the domination of low amplitudes and short runs of zero-valued coefficients indicates that both Huffman tables are relatively insensitive to the type of input images and the de-

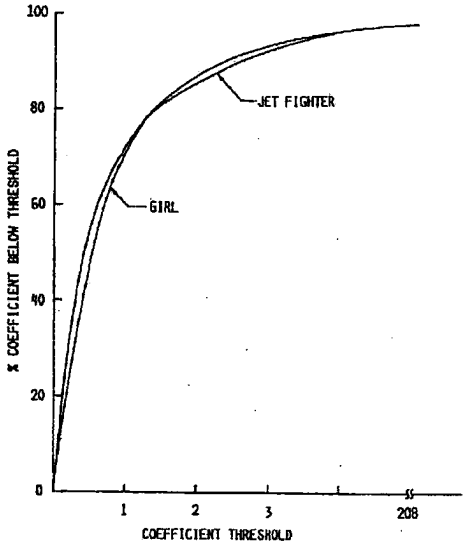

Fig. 3. Distribution of cosine transform coefficients.

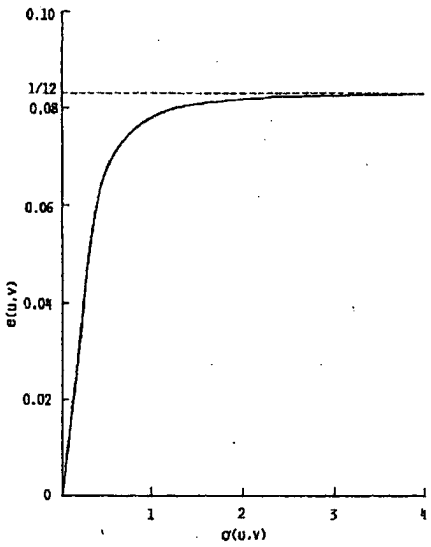

Fig. 4. Quantization error $e(u, v)$ versus coefficient standard deviation $\sigma(u, v)$ at normalization factor of unity and coding threshold of zero. (Probability density function of the coefficient is assumed to be Laplacian.)

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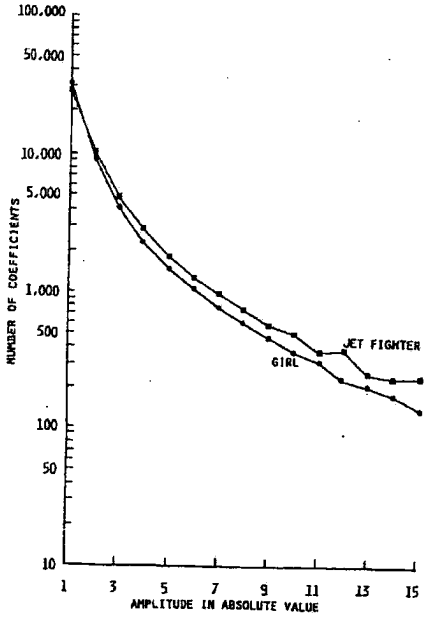
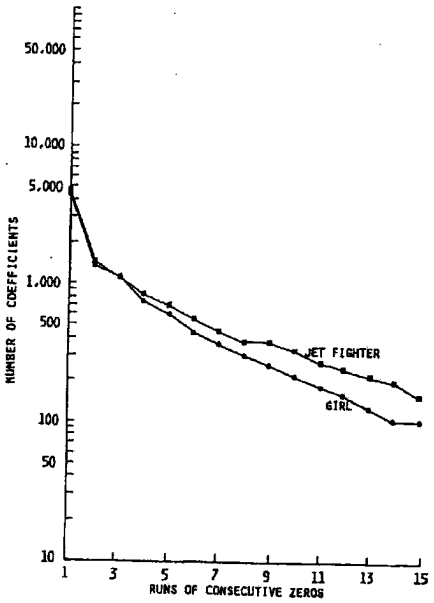


(a)



(b)

Fig. 5. (a) Histogram of cosine transform coefficients obtained with threshold of zero and normalization factor of one. (b) Histogram of runs of consecutive zero counts obtained with threshold of zero and normalization factor of one.

sired bit rate. This suggests that only two predetermined tables are needed for the coding process.

The length of the Huffman table for the amplitude codes is a function of the normalization factor and the transform bound represented by (5b). For a two-dimensional cosine transform of 16 X 16 pixels, the maximum length is

$$L_A = \frac{1.628|f_{\max}|}{D_{\min}} \tag{14}$$

where $D_{\min}$ is the minimum allowable normalization factor. For $|f_{\max}|$ and $D_{\min}$ equal to 128 and 1, respectively, the length will be 208. As for the runlength of zero counts, the

TABLE I
HUFFMAN CODE TABLE FOR COEFFICIENT AMPLITUDE IN ABSOLUTE VALUE

AMPLITUDE	NUMBER OF CODE BITS	HUFFMAN CODES
1	1	1
2	3	001
3	4	0111
4	5	00001
5	5	01101
6	6	011001
7	7	0000001
8	7	0110001
9	8	00000000
10	8	01100000
11	8	00000001
12	8	01100001
13	6+8	000001+8 BITS
EOB	4	0001
RL PREFIX	3	010

length of the table can be represented by

$$L_R = (N^2 - 1) \tag{15}$$

where N is the transform block size. The subtraction of unity is because the dc coefficient in individual blocks is separately encoded. For a transform block size of 16 X 16 pixels, the length is 255. In practice, the length of both tables can be shortened to less than 30 entries by assigning Huffman codes to only the low amplitude coefficients and short runlengths (using a fixed length code elsewhere). Again, due to the domination of the low amplitude coefficients and short runlengths, the loss of coding efficiency is insignificant.

Tables I and II show typical truncated Huffman code tables for the amplitude and runlength, respectively. It should be noted that the amplitude codes in Table I include an "end of block (EOB)" code and a "runlength prefix" code. The EOB code is used to terminate coding of the block as soon as the last significant coefficient of the block is coded. The runlength prefix code is required in order to distinguish the runlength code from the amplitude code.

It should be noted that there are many ways to improve the coding efficiency of the coder. One way is to cut down the number of runs in the runlength coder. This can be accomplished by skipping single isolated coefficients with absolute magnitude of one, or by introducing an amplitude code for the isolated coefficients with zero amplitude. The coding improvement is generally quite significant; this is especially true if the average coding rate is low.

E. Rate Buffer

The rate buffer in the SAC performs channel rate equalization. The buffer has a variable rate data input and a constant data output. The differentials are monitored from block to block, and the status is converted into a scaling factor that is fed back to the normalizer. The buffer always forces the coder to adjust to the local coding variations, while ensuring global performance at a desired level. The general operation of a rate buffer is well documented [13], [14]. The specific method used in this paper is described as follows.

Let $B(m)$ represent the number of bits into the rate buffer for the mth block and let $S(m)$ represent the normalized buffer status at the end of the mth block ($-0.5 < S(m) < 0.5$). Then, $B(m)$ and $S(m)$ can be written as

$$B(m) = \sum_{\substack{u=0 \\ (u,v)\neq(0,0)}}^{15} \sum_{v=0}^{15} H\{[\hat{F}_{TN}(u,v)]_m\} + 9 \tag{16}$$

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TABLE II
HUFFMAN CODE TABLE FOR THE NUMBER OF CONSECUTIVE ZERO-VALUED COEFFICIENTS

RUN-LENGTH	NUMBER OF CODE BITS	HUFFMAN CODE
1	2	11
2	3	101
3	3	011
4	4	0101
5	4	0011
6	5	01000
7	5	10010
8	5	01001
9	5	10001
10	5	10011
11	6	001000
12	6	100000
13	6	001010
14	6	001001
15	6	100001
16	6	000011
17	6	001011
18	7	0000000
19	7	0000100
20	7	0000010
21	7	0001110
22	7	0000001
23	7	0000101
24	7	0000011
25	7	0001111
26	8	00011000
27	8	00011010
28	8	00011001
29	8	00011011
30	5+8	00010+8 BITS

$$S(m) = S(m-1) + \frac{[B(m) - 256R]}{L} \tag{17}$$

where

$[\hat{F}_{TN}(u,v)]_m$	quantized coefficients of the mth block, as defined in (12)
$H\{\cdot\}$	Huffman coding function
R	average coding rate
L	rate buffer size.

The buffer status $S(m)$ is used to select an instantaneous normalization factor $\hat{D}(m)$ according to an empirically determined "normalization factor versus status" curve. This relationship is described by

$$\hat{D}(m) = \Phi\{S(m)\}. \tag{18}$$

In order to smooth out this instantaneous normalization factor such that the desired normalization factor does not fluctuate too much, a recursive filtering process is applied to generate

$$D(m) = cD(m-1) + (1-c)\hat{D}(m) \tag{19}$$

where c is a constant with value less than unity.

The desired operating conditions for the rate buffer algorithm are: a) the feedback normalization factor is as stable as possible; b) the buffer status is able to converge rapidly and stay as close to the half full position ($S(m) = 0$) as possible. Both these conditions may be satisfied using the above set of equations. Fig. 6 shows typical values of the normalization factor and buffer status as a function of block indexes for the images shown in Figs. 8(a) and 9(a).

The rate buffer can be guaranteed not to overflow. This is because the normalization factor can get very large within a few blocks of operation, and effectively limit the data going into the buffer. However, there is no guarantee that the buffer will not underflow if a minimum allowable normalization factor is set to a fixed value. Therefore, the buffer status has to be constantly monitored and, if the status is closer to -0.5, fill bits must be introduced into the channel.

IV. Scene Adaptive Coding of Color Images

Fig. 7 contains a block diagram of a color image coding system based on the scene adaptive coder. In this system, a color image, represented by tristimulus signals $R(j,k)$, $G(j,k)$, $B(j,k)$, is first converted to a new three-dimensional space defined by

$$\begin{bmatrix} Y(j,k) \\ I(j,k) \\ Q(j,k) \end{bmatrix} = \begin{bmatrix} 0.299 & 0.589 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.253 & 0.312 \end{bmatrix} \begin{bmatrix} R(j,k) \\ G(j,k) \\ B(j,k) \end{bmatrix} \tag{20}$$

where $Y(j,k)$ is the luminance signal and $I(j,k)$ and $Q(j,k)$ are chrominance signals. This conversion compacts most of the signal energy into the Y plane such that more efficient coding can be accomplished [15]. The I and Q chrominance planes are spatially averaged and subsampled by a factor of 4 to 1 in both the horizontal and vertical directions. The luminance and subsampled chrominance images are then partitioned into 16 X 16 pixel blocks and coded by the SAC in the order of 32 Y, two I, and two Q sequences. At the receiver, the received code bits are decoded. Inverse cosine transform and inverse coordinate conversions are then performed to reconstruct the source tristimulus signals. The inverse coordinate conversion is described by

$$\begin{bmatrix} R(j,k) \\ G(j,k) \\ B(j,k) \end{bmatrix} = \begin{bmatrix} 1.000 & 0.956 & 0.621 \\ 1.000 & -0.272 & -0.647 \\ 1.000 & -1.106 & 1.703 \end{bmatrix} \begin{bmatrix} Y(j,k) \\ I(j,k) \\ Q(j,k) \end{bmatrix}. \tag{21}$$

V. Simulation Results

Computer simulations have been conducted to evaluate the performance of the scene adaptive coder. The original test images shown in Figs. 8(a) and 9(a) are of size 512 X 512 pixels with each red, green, and blue tristimulus value uniformly quantized to 8 bits/pixel. Figs. 8(b) and 9(b) show the reconstructed images at a combined average bit rate of 0.4 bits/pixel. This rate corresponds to a channel bandwidth of 1.5 Mbits for a 15 frame/s intraframe coding system. The excellent reconstruction of the images is clearly demonstrated. Table III tabulates the average mean square error between the original and the reconstructed images. Also included in the table is the peak signal-to-noise ratio for the reconstructed image.

VI. Summary

The scene adaptive coder described herein encodes cosine transform coefficients in a simple manner. The coding process involves only thresholding, normalization, roundoff, and rate buffer equalization. The performance of the coder is quite good in terms of mean square error and subjective evaluation. Because the coding process is dependent upon the instantaneous coefficient content inside the block and the accumulated rate buffer content, it is well suited for intraframe coding of moving images. At Compression Labs, Inc., the coder has been implemented with real-time hardware to code NTSC color video at a channel rate of 1.5 Mbits/s.

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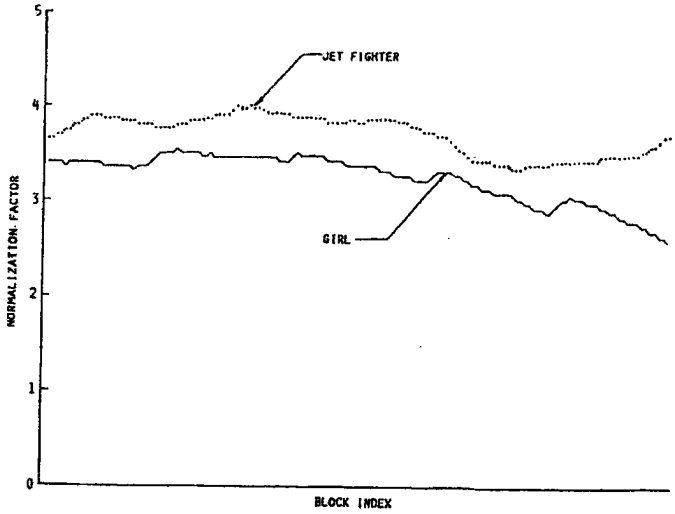
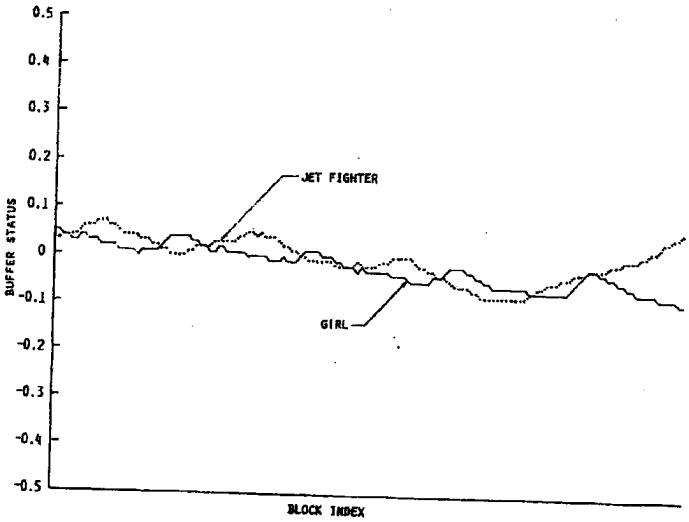


(a)



(b)

Fig. 6. Buffer status for the last 114 blocks of images shown in Figs. 8(a) and 9(a).

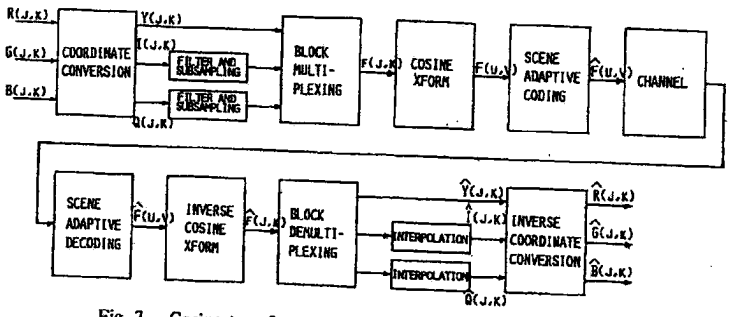


Fig. 7. Cosine transform color image coding/decoding system.



(a)



(b)

Fig. 8. Cosine transform scene adaptive coding. (a) Original. (b) Reconstructed image at 0.4 bits/pixel.



(a)



(b)

Fig. 9. Cosine transform scene adaptive coding. (a) Original. (b) Reconstructed image at 0.4 bits/pixel.

TABLE III
MEAN SQUARE ERROR BETWEEN ORIGINAL AND RECONSTRUCTED IMAGES AT 0.4 BITS/PIXEL; MEAN SQUARE ERROR IS COMPUTED AT THE INPUT OF CODER AND THE OUTPUT OF DECODER WITH $f_{max}(j, k)$ NORMALIZED TO 1

IMAGES	MEAN SQUARE ERROR	SNR
GIRL	0.0359%	34.45 DB
JET	0.0521%	32.84 DB

ACKNOWLEDGMENT

The authors wish to express their sincere gratitude to Dr. A. Tescher for his valuable discussions and suggestions in the area of rate buffer stabilizations.

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From 1966 to 1968 he was employed with the Allis-Chalmers Company, Harvey, IL, responsible for solid-state circuitry development. He was a Teaching and Research Assistant and Research Associate at the Department of Electrical Engineering, University of Southern California, from 1968 to 1973. In 1973 he joined Ford Aerospace and Communications Corporation, Palo Alto, CA, to work on communication systems analysis and digital image processing. In 1977 he left to help form Compression Labs, Inc., San Jose, CA, where he developed the combined symbol matching coder for coding facsimile images, the intraframe coder for coding NTSC color video at 1.5 Mbits, and the combined intraframe and interframe coder for coding color video at less than 750 kbits. As Chief Scientist of the company, he is responsible for research and development work in digital image processing.

★



William K. Pratt (S'57–M'61–SM'75) received the B.S. degree in electrical engineering from Bradley University, Peoria, IL, in 1959 and the M.S. and Ph.D. degrees in electrical engineering from the University of Southern California, Los Angeles, in 1961 and 1965, respectively.

He received Master's and Doctoral Fellowships from Hughes Aircraft Company and was employed there from 1959 to 1965. He became an Assistant Professor of Electrical Engineering at the University of Southern California in 1965, an Associate Professor in 1969, and a Full Professor in 1975. At U.S.C. he was the Director of the Image Processing Institute and of the Engineering Computer Laboratory. He is now the President and Chairman of the Board of Vicom Systems, Inc., San Jose, CA.

In 1976 Dr. Pratt was awarded a Gugenheim Fellowship for research and image analysis techniques. He is a member of Sigma Tau, Omicron Delta Kappa, and Sigma Xi.

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EXHIBIT 15

REDACTED

EXHIBIT 16

UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF DELAWARE

U.S. PHILIPS CORPORATION,)

Plaintiff,)

vs.) No. 06-00251-GMS

EASTMAN KODAK COMPANY,)

Defendant.)

VIDEOTAPED DEPOSITION OF BERND GIROD, Ph.D.

WEDNESDAY, JANUARY 30, 2008

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EXCERPTS

THE WITNESS: I don't see a Huffman code table included in document 10A or the translation of 10; however, there is a table with frequencies of occurrence. So that would enable one of ordinary skill in the art to come up with a Huffman code table which has the same performance as that that Dr. Vogel used. 17:00:25 17:00:43

MR. KINTON: Ask the court reporter to mark as Girod Exhibit 11 U.S. Patent No. 4,698,672 to Chen et al. 17:01:10

(Girod Exhibit No. 11 was marked for identification)

MR. DeCOSTA: Do you want your break?

THE WITNESS: Oh, that's right. I forgot about the break we want to take. 17:01:32

MR. DeCOSTA: You requested one.

MR. KINTON: Why don't we take a break.

THE WITNESS: Let's take a break.

THE VIDEOGRAPHER: The time is 5:01 p.m. We're off the record. 17:01:40

(Recess taken)

THE VIDEOGRAPHER: The time is 5:10 p.m. and we are on the record.

BY MR. KINTON:

Q. I'd like you to look at page 18 of Girod 17:10:20

Exhibit 7 for me. 17:10:24

A. Okay.

Q. And above the 10.1.3 COST document, you have a paragraph that starts "Therefore, the Chen Patent." 17:10:41

Do you see that?

A. I see that.

Q. Girod Exhibit 11 is the Chen patent you're referring to there, right?

A. Yes, it is. 17:10:52

Q. What is the basis for your statement that "the Chen patent does not derive events comprising a run of zero coefficients and preceded or followed by at least one non-zero coefficient... from a sequence of transform coefficients, as required by the claim language"? 17:11:06

A. Well, the Chen patent discloses run length coding of zero coefficients and that's very similar to that particular mode of the Widcom VTC-56 that we previously discussed. 17:11:35

Go through in a little more detail in the paragraph before that of what's -- what's in the Chen patent. But as a quick summary, it's basically the same distinctions that apply to the technique in the Widcom VTC that we previously discussed that 17:12:06

distinguished the Chen patent from the Vogel claims. 17:12:14

Q. Is that because the only -- and, again, I'll put quotes around it-- "non-zero coefficient" that is joint coded with a run of zero coefficients, the only value that is jointly coded in the Chen patent is 1? 17:12:27

A. Exactly.

Q. You can set that aside.

Did you attend COST 211 bis?

A. I attended some of the COST 211 bis meetings, that's correct. 17:12:54

Q. In what capacity?

A. I was a invited expert, brought in by the -- by -- I think it was called Deutsche Bundespost at the time, the German PTT. 17:13:15

Q. And did you have to sign a nondisclosure agreement when you came into that meeting?

A. Not that I recall. Wouldn't have been -- nondisclosure agreements are something very specifically American. 17:13:36

Q. Did you have to sign a confidentiality agreement --

A. No.

Q. -- when you went to those meetings as a visiting expert? 17:13:43

A. Even today, if meetings are confidential, it's understood that you stick to it and people don't sign papers. 17:13:44

Q. How often are invited experts -- or how often do invited experts attend COST 211 bis meetings? 17:14:03

A. In these working meetings of the so-called simulation subgroup, which I attended, I would think that probably every meeting was also attended by at least some invited experts, in addition to the representatives of the core members of the COST 211 bis project. 17:14:24

Q. And who were the core members of the COST 211 bis project?

A. This is a long time ago, but to the best of my recollection, these were all European -- let me back up. All the members were European PTTs. 17:14:43

Q. What's a PTT?

A. It's the state organization that is in charge of postal services telephony and telegraph in the countries. This is prederegulation in Europe. So these services were provided by government organizations. 17:15:08

Q. As opposed to AT&T -- actually, more like AT&T, prebreak up? 17:15:33

A. Right. The breakups or the privatization of these organizations and breakups that would often occur in this context in Europe, you know, followed the corresponding -- what's after the corresponding development in the United States. 17:15:35 17:15:56

Q. Now, did you ever make any technical presentations to COST 211 bis meetings that you attended?

A. I think I did, yes.

Q. Did you receive any presentations made by others at COST 211 bis meetings that you attended? 17:16:08

A. Yes, certainly.

Q. Now, when you attended the COST 211 bis meetings as an invited expert, were you invited for a discreet meeting or did you attend a series of meetings that you recall? 17:16:25

A. The invitation in my case was I think on a meeting-by-meeting basis, and, in fact, I'm not sure how many meetings I attended.

Q. In addition to the PTTs were there any educational institutions that were members of COST bis 211? 17:17:07

A. Again, this is a long time ago. Again, to the best of my recollection, people that -- like myself, at that time, came from universities, I 17:17:27

think were all invited through the PTTs as experts. 17:17:31

Q. When you made presentations to the meetings that you attended, did you distribute copies of your presentation?

A. To the best of my recollection, it wasn't customary to actually hand out copies of the presentation, except that instead there would usually be a technical document submitted. 17:18:02

Q. Was that submitted to, for lack of a better word, a secretary at the meetings, or was it distributed to the attendees; do you recall? 17:18:27

MR. DeCOSTA: Objection; foundation.

THE WITNESS: You know, I don't recall the exact mode of operation for the document submittal at that time, so I would have to speculate about that. 17:19:06

BY MR. KINTON:

Q. Do you know if the documents that were presented at meetings were kept by any members of COST 211 bis for purposes of archiving? 17:19:27

MR. DeCOSTA: Objection; calls for speculation.

THE WITNESS: Yeah, undoubtedly some of these members, may be all of them, would archive the documents. 17:19:50

BY MR. KINTON: 17:19:51

Q. I'm thinking more of an official function within the COST 211 bis group. Are you aware of whether or not there was somebody who was responsible for, you know, keeping an archive of the papers that were presented? 17:20:01

A. I'm not aware --

MR. DeCOSTA: Objection; foundation.

THE WITNESS: I'm not aware of any particular party being responsible to maintain an archive. 17:20:09

BY MR. KINTON:

Q. Do you know if it was possible for members to get access to papers that had been previously presented at earlier meetings? 17:20:23

MR. DeCOSTA: Same objection.

THE WITNESS: Well, members would presumably have -- have a representative at every one of those meetings, and, therefore, have documents from these meetings. 17:20:47

BY MR. KINTON:

Q. Do you know if it was possible for the invited experts to get -- obtain copies of previously presented technical documents that maybe related to somebody that they are going to be 17:21:02

presenting to the COST 211 bis group? 17:21:04

A. I'm not aware of an official way of getting access for the invited experts to documents from previous meetings. So unless they would know a person who would, you know, hand this document to them, you know, in an informal manner, maybe the original author, I wouldn't know of a -- of a formal procedure to gain access to these documents. 17:21:31

Q. Do you know if there were minutes of the COST 211 bis meetings? 17:21:57

A. I would assume so. I think there must have been minutes of every meeting.

Q. Do you know -- happen to know where those minutes are kept?

A. You know, because of the lack of an archive, you know, what one could only -- if one needed those minutes, only hope to find a pack rat who has kept all this, all these materials for, you know, over 20 years. 17:22:15

Q. Now, you say "the lack of an archive." Do you know for a fact that there is not an archive or do you know -- 17:22:40

A. I don't --

Q. -- whether there is one?

A. I don't know that for a fact. 17:22:48

Q. Has -- 17:22:51
A. Since these are, you know, projects under the umbrella of the European community, it's quite possible that at least some of their materials are kept in European community archives, maybe as part 17:23:05 of final project reports submitted. But I don't know that.
Q. Have you ever seen any minutes from a COST 211 bis meeting?
A. You know, again, that is a -- that's a very 17:23:26 long time ago, so I don't recall any specific instance of seeing minutes of a meeting. My best guess -- you know, I'm speculating here, sorry -- would be that I have probably seen minutes of COST 211 bis meetings. 17:23:45
Q. Do you have any understanding as to whether or not the minutes of the COST 211 bis meetings would identify the documents that were presented at the meeting?
MR. DeCOSTA: Objection; foundation. 17:24:06
THE WITNESS: Yeah, I don't know one way or another.
BY MR. KINTON:
Q. Fair enough.
If you look at page 18 of your expert 17:24:27

report, you have a Section 10.1.3 related to the 17:24:29 COST document.
Do you see that?
A. Yes.
Q. Your basic opinion is that Mr. Vogel's 17:24:48 providing the document to the COST 211 bis project was not a publication; is that correct?
A. Correct. Doesn't -- it does not appear to meet the criteria for a publication.
Q. You don't opine that it doesn't provide an 17:25:16 adequate written description of the invention, correct?
A. I haven't performed that analysis.
Q. Do you expect to provide that analysis at trial? 17:25:27
A. Sitting here today, I haven't carried out this analysis, and I also don't expect to provide it at trial.
Q. So you, as you sit here today, don't expect to offer an opinion at trial that the COST document 17:26:43 referenced on page 18 to 19 of your expert report does not provide an adequate written description in enabling disclosure of the claims of the '075 patent, correct?
A. That's correct. 17:27:20

MR. KINTON: Why don't we take a break. 17:27:21
THE VIDEOGRAPHER: The time is 5:27 p.m. and we are off the record.
(Recess taken)
THE VIDEOGRAPHER: The time is 5:34 p.m. 17:34:00 and we are on the record.
MR. KINTON: Thank you, Dr. Girod. I have no more questions.
MR. DeCOSTA: We have no questions and reserve our right under the rules. 17:34:07
MR. KINTON: Off the record.
THE VIDEOGRAPHER: This marks the end of videotape No. 4 in the deposition of Bernd Girod -- Girod, pardon me. The time is 4:34 {sic} p.m. and we are off the record. 17:34:23
(TIME NOTED: 5:34 P.M.)

STATE OF CALIFORNIA)
:ss
COUNTY OF SAN MATEO)

I, CYNTHIA MANNING, CSR No. 7645, a Certified Shorthand Reporter of the State of California, do hereby certify:
That the foregoing proceedings were taken before me at the time and place herein set forth; that any witnesses in the foregoing proceedings, prior to testifying, were placed under oath; that a verbatim record of the proceedings was made by me using machine shorthand which was thereafter transcribed under my direction; further, that the foregoing is an accurate transcription thereof.
I further certify that I am neither financially interested in the action, nor a relative or employee of any attorney of any of the parties.
IN WITNESS WHEREOF, I have this date subscribed my name.

DATED: February 4, 2008

_____
CYNTHIA MANNING, CSR No. 7645

EXHIBIT 17

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

EXPERT REPORT OF CHARLES J. NEUHAUSER, PH.D. ON BEHALF OF DEFENDANT EASTMAN KODAK COMPANY

Expert Report of Charles J. Neuhauser, Ph.D.

Introduction

My name is Charles J. Neuhauser. I am the owner and principal consultant of Neuhauser Associates, Inc. located at 525 West Remington Drive, Suite 126, Sunnyvale, California. I have been retained in this matter by DLA Piper US LLP on behalf of the Eastman Kodak Company to provide engineering opinions about the operation of the Widcom VTC-56 Coder Board (the "Coder Board").

Summary of Opinions

- I have developed a Verilog simulation based directly on the schematics of the Coder Board and the data values and logic contained in programmable devices in that schematic.
- The simulator correctly represents the functional operation of a section of the Coder Board.
- When provided with input data values, the Coder Board simulation produces outputs that include two distinct run length encoding techniques.
- The simulator output correctly represents what the actual Coder Board would produce if presented with these inputs.

Personal Background

I am an electrical engineer by training with specific education and experience in the operation of logic circuits and systems built from those circuits. My current *curriculum vita*, attached as Exhibit A to this report, outlines my general qualifications as an engineer. Below I will describe my specific qualifications and experience with respect to this matter.

This particular matter relates to the operation of the Widcom VTC-56 Coder Board. This board makes use of design techniques and circuit technology from the early to mid 1980s (I will explain this technology in detail below). From approximately 1970 to 1990 I worked actively in the field of logic and system design. My responsibilities covered the specification, selection of technology, design, simulation, debugging and validation of systems similar in structure and design to the Coder Board. During this period I participated directly in the design activities described and I also supervised other engineers undertaking similar activities. My experience with designs includes processors, communications interfaces, printer controllers and similar systems.

In particular I have designed a number of systems based on the logic families used in the Widcom Coder Board. The techniques used in the Coder Board design were widely known in the early 1980s because the particular logic families and components used were standards within the semiconductor industry.

In evaluating the Coder Board operation I have made use of certain simulation techniques (that I shall explain in detail below). Many of the systems I designed and worked with during the 1980s required extensive use of simulation systems similar to the system used in this project. Therefore, I am very familiar with the strengths and limitations of these systems.

Materials Considered

- Mentor Graphics, ModelSim 6.1c Simulation System.
- "A Verilog HDL Primer"; Second Edition; J. Bhasker; Star Galaxy Publishing; 1999.
- Various data sheets (Exhibit J)
- CD titled "Widcom Technical Documentation for Neuhauser" (3/17/06). The contents of the CD are listed in Exhibit B.
- "VTC-56B Coder Theory of Operation; Widcom Inc.; Draft 11-1-86 (WID0100264-314) from the CD mentioned above. (Exhibit C).
- "VTC-56B Theory of Operation: A System Overview: Widcom, Inc.; Draft 11-1-86 (WID0100475-490) from the CD mentioned above. (Exhibit D)
- Schematics titled "VTC-56 Coder" (WID 01002144-149) from the CD mentioned above (Exhibit R).
- CD labeled CLI351725 containing inspection photographs of the VTC-56. The contents of this CD are listed in Exhibit E.
- "Widcom VTC-56 Video Coder/Decoder Data Extraction Report"; Chipworks Inc.; July 16, 2004 from the Widcom Technical Documentation CD mentioned above (Exhibit F).
- Data files associated with the Chipworks report cited above from the CD titled "Widcom Technical Documentation" (3/17/06). (Exhibit K)
- Example DCT files. (Exhibit G)

Technical Background

The Widcom System and Coder Board

The Widcom VTC-56 is a complete teleconferencing system, that is, it provides an end to end system for the transmission of video information. The core of the system is a card rack containing electronic circuitry that processes video images for transmission and receives highly compressed video images and processes them for presentation on a monitor. CLI351725.006.jpg (Exhibit H) is a photograph of a portion of the electronics rack. The rack contains a number of circuit boards, which are electronic assemblies that plug into the rack. The circuit boards in the rack perform different functions. By communicating with each other through electrical conductors at the rear of the rack, the circuit boards, as an assembly, perform the overall teleconferencing function of the VTC-56. The Coder board, which is the subject of this report, is located in the fourth slot from the top in the photograph.

The Coder Board is a component of the Widcom VTC-56 system. My understanding based on the documents I have reviewed is that the VTC-56 is a videoconferencing terminal designed to enable the transmission of video signals over telephone lines. Because video signals contain more information content than can be passed over the telephone line to the remote video conferencing terminal it is necessary to reduce the amount of information content using certain computational techniques. This is referred to technically as *compression*. The VTC-56 uses several compression techniques in series. The Coder Board represents the last step in the chain of video information content compression. The Coder Board actually performs two main functions. About half the circuitry on the board is dedicated to encoding data and the other half is associated with serializing and buffering the data for transmission. Encoding is a process by which a representation of data is transformed into a different (possibly more compact) representation. My discussion and investigation is concerned only with the circuitry related to encoding. I will not be concerned with this serialization and buffering circuitry because no encoding takes place in that circuitry. Thus, the opinions expressed here are only related to the encoding circuitry of the Coder Board.

Design of an electronic system, such as the Coder Board, begins with a conceptual design. Engineers then refine the conceptual design into a detailed design that embodies all the critical elements related to the functioning of the circuitry. In the time frame when the VTC-56 was designed, engineers typically carried out the detailed design step by drafting electrical schematics of the required circuitry. Schematics are diagrams that describe precisely the circuit components required and how they will be interconnected to produce a system that will carry out the desired function, which in the case of the Coder Board includes data encoding. Typically, the schematics and certain other engineering documents provide all the information necessary to construct and produce the circuit board. Therefore, the schematics precisely embody the function of the product. Thus, a skilled engineer using the schematics (and certain additional information that I will describe below) can determine precisely how the device behaves (including the resulting output for a given input).

Technology

The encoding section of the Coder Board is a digital logic design, that is, the circuitry works in a digital or discrete fashion rather than in an analog or continuous manner. Physically, the Coder Board is composed of circuit components that are mounted on a large printed circuit board. The printed circuit board provides electrical pathways between circuit component packages. This general structure can be seen in the photo CLI351725.143.jpg in Exhibit I, to cite one example.

Circuit components in the Coder Board perform well-defined logic functions, such as storage, counting, addition and so forth. Thus, the components are many times referred to a "logic components" and the board and its components are referred to as "logic circuitry". The logic components of the Coder Board were selected from the well-known TTL (for Transistor Transistor Logic) family, an extensive series of logic components widely available at the time the VTC-56 was designed. The Coder Board design makes use of several types of logic components from the TTL family. These include SSI (Small Scale Integration) devices, FPLA (Field Programmable Logic Arrays), PROMs (Programmable Read Only Memories) and PALs (Programmable Array Logic).

SSI devices are fixed purpose devices, that is, they perform a well defined logic function that cannot be altered. Some devices, for example, perform the function of addition in a strictly fixed manner. Thus, if the device identifier is known (either from the schematic or from physical observation) the function of the device can also be determined. This is done by consulting "datasheets" which are standardized documentation provided publicly by device manufacturers. Specifically, the purpose of this documentation is to provide engineers with all the information about a device that they need to make use of it in a design or to determine the function of a design that includes that device. In order to understand the function of logic circuitry on the Coder Board I made use of datasheets for the SSI and other components. These datasheets are attached as Exhibit J. The datasheets I have provided are for specific manufacturers. Because logic devices have a standardized identification scheme (based on a part number such as the '74LS08,' which is an integrated circuit with quad 2-input AND gates) that is related to their function, the data sheet used to determine the function of a particular device on the Coder Board does not need to be from the manufacturer of that device, but may be from any manufacturer.

Programmable Devices

In addition to the fixed function SSI devices, the Coder Board contains a number of "programmable devices", such as, FPLAs, PROMs and PALs. These devices are manufactured with a generic internal function that can be made specific through a programming process that is carried out after device manufacture but before the device is placed on the circuit board. Because of this programmability feature, devices of the same type may be used in different ways in different parts of the design. For example, one PROM might be programmed to encode data and an identical PROM might be programmed to control logic sequencing. PALs and FPLAs may be used in a similar manner.

Generally, a schematic diagram does not include information about the specific programming of such programmable devices. Instead, this information is kept in another form, such as a set of equations or an array of data that is used to program the particular device. Although the Coder Board documentation I reviewed included a complete set of schematics it did not include the programming

information for the programmable devices used in the design. For this I made use of a different source of information derived from readouts of the actual programmable devices.

My understanding is that a complete operating VTC-56 system, S/N 212, which includes a working Coder Board, was obtained. For the particular programmable devices used in the Coder Board it is possible to "read out" of the device the programming that gives the device its particular logic personality. This is done by using well-known engineering techniques and equipment. I have performed such readouts on many occasions with many different types of devices, including devices like those used in the Coder Board design. It is a straight forward process.

I was provided with readouts for all FPLAs, PALs, and PROMs on the Coder Board. My understanding is that the readouts were performed by Chipworks (3685 Richmond Road, Suite 500, Ottawa, ON K2H 5B7 Canada), a well-known reverse engineering company that specializes in semiconductor analysis. Exhibit K contains the files provided to me with the data for the programmable devices. Each type of programmable device has a different internal organization and therefore the files are handled in a different manner. I will discuss this in more detail below under methodology. Chipworks also provided a report that details how they performed their analysis. This is attached as Exhibit F.

Methodology

My primary objective is to determine the precise operation of the encoding section of the Coder Board. To do this I employed a well-known engineering technique called *simulation*. To my knowledge, simulation has been used to evaluate the function of logic circuitry since at least the 1970s. It continues to be widely used today as the primary method of evaluating the operation of logic circuitry before a design is committed to manufacturing.

Simulations of logic circuit operation can be carried out at a number of levels. One level is functional, that is, the function of the logic is simulated without regard to physical issues such as timing. Many physical issues (such as loading, wire length, voltage and temperature) can influence the speed with which an actual implementation of a certain logic circuit runs when realized physically. Therefore a logic design that works functionally may not work (or may not work at full speed) when actually implemented. To assess this issue engineers make use of another level of logic simulation referred to as "timing" simulation. This type of simulation attempts to include all the timing constraints due to physical factors into the operation of the simulator.

In simulating the encoder logic circuitry of the Coder Board I used only a functional simulation. My reason for doing this was that the VTC-56 is known to be a functioning product, that is, the physical realization of the logic circuitry is

known to work properly. Therefore a timing simulation would not provide any additional information beyond what a functional simulation would.

To perform simulation I made use of the Mentor Graphics ModelSim Designer 6.1c running on a Windows XP platform. This particular simulator is very widely used by design engineers for precisely the purpose I am using it for. I wrote my simulation of the Coder Board encoder logic circuitry in Verilog, a well-known high level simulation language, using MultiEdit 9.0, a text editor, which includes some support for formatting Verilog. I wrote the Verilog code directly in MultiEdit rather than using the graphical interface provided by ModelSim. All simulations were run from the ModelSim command line.

My Verilog simulation was developed directly from the Widcom VTC-56 schematics. In particular, I made use of the following schematic pages (Exhibit R, WID01002144 – 147), which I refer to in the Verilog code as pages 1 through 4, respectively. To develop the simulation I carried out the following steps:

- Step 1: Develop and test device level logic circuitry
- Step 2: Build board level simulation by interconnecting device models
- Step 3: Test and debug the board level model
- Step 4: Develop a driver and formatter for the board level simulation
- Step 5: Run board level simulation on sample data

Step 1: Modeling Device Level Logic Circuitry

There are four general types of logic devices found in the VTC-56:

- SSI devices
- PROMs
- FPLAs
- PALs

Each type of device required different modeling approaches.

Modeling SSI Devices

I developed functional simulation models for each of the following SSI devices:

- 74LS02 – Quad NOR Gate
- 74LS04 – Hex Inverter
- 74LS32 – Quad OR Gate
- 74LS161 – 4-Bit Binary Counter
- 74LS163 – 4-Bit Binary Counter
- 74LS174 – Hex D-Type Flip/Flop
- 74LS244 – Octal Buffer with 3-State Output
- 74LS273 – Octal Register with Clear

- 74LS283 – Four Bit Full Binary Adder
- 74LS374 – Octal D Flip/Flop with Enable
- 74LS377 – Octal D Flip/Flop with Enable

I modeled each device based on datasheets that I obtained from various manufacturers. Because the 7400 series logic family is standardized, a datasheet from any manufacturer is sufficient for functional simulation. The datasheets used to develop the functional simulation models are attached as Exhibit J.

My modeling of SSI devices is functional and does not consider timing for the reason discussed earlier. For each device I also wrote test code to validate the operation of the device. Generally, SSI devices are simple enough that it is possible to verify that the proper output is produced for given inputs. The device models and their associated Verilog test code are provided in Exhibit L.

Modeling PROM Devices

PROMs are memory storage devices that contain permanent data. In the VTC-56 Coder Board design they are used to perform certain types of complex logic functions (such as quantizing and encoding). The use of PROMs in this manner was very common in the 1970s and 1980s. The VTC-56 makes use of the following PROM types:

- 27128 – 16K x 8 bit PROM
- 2764 – 8K x 8 bit PROM
- TBP28S86 – 1K x 8 bit PROM
- TBP24S10 – 256 x 4 bit PROM
- TBP28S42 – 512 x 8 bit PROM
- TBP18S030 – 32 x 8 bit PROM

Each PROM has the same basic function, which is to provide a data output in response to an address input. To implement each PROM model I made use of a Verilog feature known as the "two-dimensional register structure". Basically, this structure acts like an addressable array of storage locations that reflects the same function in the PROM devices. Using this approach requires that the register structure be preloaded with the PROM data at the start of simulation. This data originates with files provided in a specific format to the simulation.

As mentioned above, I was provided with the PROM data as read out of the Coder Board PROMs by Chipworks. These files were in a so called ".LIS" format, which is a simple format for transferring PROM data from the readout equipment. I wrote a simple translation program in Python to convert the ".LIS" files into the format required by Verilog when loading the PROMs. The PROM translation programs are shown in Exhibit M. The resulting Verilog initialization files are provided in Exhibit N. Each PROM used on the Coder Board has a unique program; therefore there is a unique model for each PROM.

Note: it appears that Chipworks read out the Coder Board PROMs properly, but mislabeled two of the files with respect to the schematic. In particular, the file COD-9F.LIS contains the data for the PROM labeled as 10F on the Schematic. This error probably occurred because the PROM spans two columns on the board, one labeled 10 and one labeled 9. (See Exhibit O, CLI351725.150-152.jpg).

A similar situation applies to file COD-15A.LIS which holds the data for the device labeled 16A on the schematic. (See Exhibit P, CLI351725.145.jpg). Although I have referred to the mislabeling of the two files as "errors" they are really only of a clerical nature. Chipworks read the files out properly and I have assigned the data in these files to the proper PROMs identified in the Widcom schematics. Thus, this mislabeling by Chipworks has no effect on the simulation results.

Modeling FPLA Devices

FPLA devices perform logic functions, but do not include internal storage. Such devices were widely used in the 1980s to implement complex random logic. The device is unprogrammed when it is purchased and is then programmed for the specific logic function desired. All FPLAs in the encoder section of the Coder Board are based on the 82S153 device. I was provided with two types of files from the Chipworks readout. One file type (.JED) describes the fuse map, which is a bit by bit description of how the FPLA is programmed. The other file type (.EQN) provides logic equations corresponding to the programmed function performed by the FPLA. My understanding is that these equations were produced by Chipworks from the fuse map file using a custom disassembler tool written by Chipworks for the extraction.

I converted the equations from the Chipworks readout directly to the equivalent Verilog code. This is a straight forward process that is basically mechanical. As a guide I used the datasheet for the 82S153 (Exhibit J). Basically, I turned each equation into a Verilog *assign* statement. Doing this also required a simple replacement of the logic symbols in the .EQN file ("/" becomes "~, "+" becomes "|" and "*" becomes "&"). For each equation a few additional lines of code are necessary to represent the function of the tri-state output driver in the 82S153. I performed the transformation from .EQN equations to Verilog by hand using the MultiEdit text editor. However, the transformation is mechanical and could have been carried out by a program.

For each FPLA, I wrote a simple test to verify the basic operation of the device. Where possible, I attempted to test every input logic combination and verified calculated the results by hand against the original .EQN file. The Verilog code for the models and the tests is provided in Exhibit L.

Modeling PAL Devices

PAL devices are similar to FPLAs except that they contain internal memory in the form of individual D-type flip/flops. Both PALs in the encoder section of the Coder Board are the PAL16R6 type. This is a widely used type of logic device. Chipworks provided both a .JED file for the fuse map and a .EQN file, which is a translation from the fuse map to equations. This was done using the JED2EQN program (version 063) from National Semiconductor. I processed the .EQN file in a manner similar to that I described above for the FPLAs. In addition, I devised a simple model of the D-type flip/flop and tri-state output driver of the PAL16R6 to use with the equations. My procedure for transforming the .EQN file to Verilog is shown in Exhibit Q.

For the two PALs I also wrote test programs to check their operation against the description provided by the VTC-56 documentation in the "Theory of Operation". These tests are shown in Exhibit L.

Step 2: Board Level Modeling

Once I had constructed the basic device models, I proceeded to develop a model of the encoder section of the Coder Board. I did this by incorporating the device models into a Verilog design based on the schematics for the Coder Board (Exhibit R, WID01002144-147). My board level model includes all the logic from the edge of the board (WID01002144) to the input to the FIFO on (WID01002147) as shown in Exhibit R. In Exhibit R, logic that is shaded light gray does not relate to the function under test and was not simulated. By simply observing the data values at the right hand edge of schematic (WID01002146), it is possible to see the entire operation of the encoder. Therefore, my simulation stops at the input to the FIFO because no encoding takes place beyond that point.

In constructing the board level simulation I retained the device identification names and the line names where possible. The device identification follows standard engineering practice in that the identification is based a device's particular placement in a row or column of the physical coder board. For example, the 74LS163 designated 16E in the schematic (Exhibit R, WID01002144) is located at row E, column 16 on the physical board. Thus, for this specific device I used the name "LOC16E". Certain devices, such as the 74LS04, are composed of multiple identical subsections. For these I appended a letter (A, B, C, etc.) to the name to identify the subsection.

Verilog requires that every signal line (i.e., wire) in the simulation have a unique name that meets the Verilog naming convention. I named each signal wire either as they were in the schematics, or if Verilog could not represent that name, a slightly modified name was used (e.g., INC.AC on WID01002146 became INC_AC because Verilog does not allow embedded periods). If the schematic indicated no name for a wire, then I either assigned a sensible name based on the

function of the signal or assigned a name based on the output terminal number of the driving logic device. For example, the output of the device 20C, pin 19 on WID01002145 is named LOC20C19.

For certain specialized lines, such as those that are tied directly to Vcc or to ground (i.e., to 1 or 0 in the simulation), I named the line based on the location of the device appending either HI or LO as required. In some cases, especially where input pins on devices were "open", I defined the pin as 1'b0 (a Verilog logical low) or 1'b1 (a Verilog logical high) as appropriate. Both approaches are equivalent. For device output pins that were not connected, I defined a wire name based on the device location and pin number, such as NC19H19 for the LS377 device in location 19H on page WID01002145. "NC" stands for "no connection". Having a defined wire for unused device outputs is required by Verilog, but serves no function in the simulation and does not affect the resulting output from the simulation.

Finally, I defined a set of input and output pins for the board level design. These were based on the board edge signals as defined in the schematics and the signals to the FIFO on schematic WID01002146.

I have added certain comments and headers to the simulation to make it easier to follow. This comments and headers should be considered ancillary information and do not affect the simulation results in any way. The actual non-commentary Verilog code is the only valid functional description of the Coder Board.

The process of turning a schematic design into Verilog code in the manner I have described above is straight forward and is well understood by logic design engineers who employ these, or similar techniques, on a regular basis. I have used the techniques described above many times on engineering projects.

The simulation is basically functional, that is it does not consider specific device timing. Simulating the Coder Board in this manner is appropriate for at least two reasons. First, the VTC-56 is known to function properly because I am informed that it was a system that was sold to customers and used as a video conferencing system. For example, the VTC-56 was demonstrated on the Today Show on March 22, 1985 in which host Jane Pauley interviewed Robert Widergren, the founder of Widcom, over a VTC-56 in the NBC studio. Thus, the logic being simulated is known to function properly. Second, the encoder logic circuitry on the Coder Board is designed in a completely clock synchronous manner. This widely used engineering technique means that the logic function performed by the board is not dependent upon the speed of the logic. Thus, there is a speed below which the board will always function. In the simulation, I have used a symmetrical clock with a 100 unit period. This number was chosen for convenience and is unrelated to the actual clock in the VTC-56. However, for the reasons discussed above, the value is unimportant to validating the functional operation of the VTC-56 encoder logic on the Coder Board.

Note: Pins 11 and 12 of device 74LS183 (16E) are driving pins 13 and 11 of device 82S153 (16F) (Exhibit R, WID 01002144). Pins 13 and 11 of the 82S153 are programmed to be outputs of 1. This is a double drive situation, which apparently represents an error in the electrical design of the Coder board. However, this situation does not affect the operation of the board because the high bits of the counter are unused. I have not corrected this design artifact in my simulation, but rather have included it exactly as it is implemented on the Coder board. Its presence does not affect the simulation results in any way.

Step 3: Board Level Debugging

Once my board design was completed, I began testing it. I did this by devising a simple set of test driver codes to exercise the input lines in a manner similar to how the upstream Discrete Cosine Transform (DCT) board in the VTC-56 would function. Using "display" and "monitor" statements in the Verilog code for the Coder Board, it was possible to see the value of any internal signal. Most of the errors I uncovered during the debugging phase involved various typographical mistakes I made in translating the schematics to Verilog. These included misnaming of lines, connecting lines to the wrong pins (instead of how the schematic specified) and so forth. I simply fixed these typographical errors by correcting the simulation so that the Verilog code matched the schematic exactly.

I did, however, uncover a mistake in the schematic itself. This involved the identification of the device at location 10E on WID01002144. The schematic identifies this device as a 74LS374, an Octal D Flip/Flop with Enable. The logic will not function correctly with this device, although my understanding, as described above, is that the VTC-56 is known to function. I checked the photographs of the Coder Board (CLI351725.148-149.jpg, see Exhibit S), and determined that the Coder Board actually contained a 74LS273 (Octal Register with Clear) at that location. With this substitution the simulation runs correctly. In this instance I have essentially corrected the schematic (and the simulation) to conform to the circuitry on the actual Coder board.

One issue that arose during testing of the Coder Board simulation in Verilog was power-up initialization. When physical logic is powered up, storage locations (registers, flip/flops and so on) start in a random manner. That is, they may initialize randomly as either a 1 or a 0. In properly designed logic, such as the Coder Board, this does not cause a problem because the hardware initialization sequence ignores these random values. The Verilog simulator, however, is much more stringent in its requirements and if a signal is initially undefined it may remain undefined. This is the case with several signals within the Coder Board simulation. Therefore, I initialized these signals to arbitrary values during the reset phase. This is shown at lines 2202 to 2231 of Exhibit T. I have carefully checked all the areas of the simulation that I initialized in this manner and have determined

that a physical realization would initialize correctly for any arbitrary value. Additionally, the VTC-56 Coder Board is known to power up properly.

The problems that I encountered in debugging the board level simulation are similar to those I have encountered in the past when building a simulation from a schematic.

Step 4: Driver and Formatter Modeling

Driver

Once I had debugged the board level simulation I devised a complete system which included a Verilog Driver to exercise the encoder logic and a Formatter to present the output of the encoder logic in a useful manner. The Driver is Verilog code that provides address delta, distortion factor (DK) and coefficients to the Coder Board module (called "coder").These are the same signals that would be provided to the actual Coder board by the remaining circuit boards in the VTC-56. This logic also handles the handshake signaling that would normally occur between the Coder Board and the DCT board in the VTC-56. This signaling is simple and is outlined in the VTC-56 Theory of Operation (Exhibit C). The driver logic is embodied in the Verilog initialization code for the top-level design (see Exhibit T lines 1925 to 2330).

The Driver code makes use of a memory structure to hold data to be sent to the Coder Board. This memory contains four simple commands and associated data. It is accessed sequentially as the simulation progresses. The four commands are Reset, Present Address, Present Data and Stop. Each memory address contains one command and the associated data. A typical sequence is:

Reset
Present Address
Present Data (0)
Present Data (1)
:
:
Present Data (63)
Present Address
Present Data (0)
Present Data (1)
:
:
<as required until complete>
:
:
Present Data (63)
Stop

When an address or data is presented, the Driver places the appropriate data signals on the input lines to the Coder Board and then lowers a handshake signal (Data Ready [/CA+D RDY] or Coefficient Ready [/COEFF RDY]). The Coder Board logic then responds with either an Address Accept [CA+D] or Data Accept [COEFF UNLK] signal. These are also Coder Board input signal, similar to the signals discussed above. The Coder Board processes the input data in an asynchronous manner (although synchronized internally with the system clock) and then raises either the Address Accept or Data Accept signals as appropriate to obtain another set of input data. The Driver then fetches the next command from memory and either presents data or address or stops the simulation.

Formatter

To present the output of the Coder board simulation in a more human readable manner I devised a simple Verilog module called FMT whose purpose is to reorganize the output of the Coder Board (Exhibit T, lines 1694-1924). This logic takes the 16-bit encoded data word (C00-C15) and the four-bit two's complement length (LEN3-LEN0) and presents only those bits of the data word that are valid based on the value of the length. The result is shown in binary. The FMT module also identifies the type of data output (e.g., SYNC1, AC1 etc.) based on the current state of the coder state machine (see WID01000310, Exhibit U).

Step 5: Test Data

I was provided with test data (Exhibit G). My understanding is that the test data is data from an actual television image that has been processed by a discrete cosine transform program. This input data is shown in Exhibit V. I wrote a Python program to format this data for loading into the control memory of the Driver during simulation initialization. The translation program is shown as Exhibit W. Exhibit X provides 1200 blocks (one complete frame) of the input data translated into a form acceptable to the simulation. Although, I was provided with six data files I only made use of one of these, ZigZagDataB.txt, as shown in Exhibit W. I did this because each data file consisted of 1200 blocks, so one data file was more than sufficient to illustrate the operation of the Coder Board.

Description of Coder Board Logic

Exhibit Y is an overall block diagram of the logic of the coder board (WID01000319). I will briefly describe the operation of the section outlined by dashed lines, which is the section of logic that I have simulated. This block diagram is directly related to the logic diagram provided in Exhibit R, WID01002144-149.

The logic I have simulated includes the following sub-sections identified in the block diagram of Exhibit Y,

- ADDRESS, DK and COEFF registers
- Quantizer (and KD, CODRR counter and PROM)
- Isolated Term Eliminator
- Mean Predictor
- Code Tables
- Input State Machine, Block Counter and Coder State Machine

ADDRESS, DK and COEFF Registers -
Input data enters the diagram in Exhibit Y at the left edge. There are two types of write operation. One operation writes new values to the Address Delta, DK and Start of Frame registers (an address delta is an offset from the block number previously transmitted). The other writes new data values to the COEFF (Coefficient) Register. Writes of address and data are coordinated by a logic handshaking arrangement as discussed above in the section on simulation. Coefficients are 10-bit quantities generated by VTC-56 logic external to the Coder Board. (WID01000266)

The Address Delta value indicates the amount by which the address changes for each new set of coefficients. For the input data file I used every block was present so the Address Delta value changed by one. The DK value indicates a distortion factor to be applied during the encoding process. During VTC-56 operation DK may be adjusted to reduce the amount of encoded data produced (with some resulting degradation in picture quality). In the simulation DK is fixed at zero, a value that introduces the least distortion. The Start of Frame (or SOF) signal indicates when a new frame starts. This value is set to a value of one for the first block of the simulation and then is zero for the remaining 1199 block reflecting the fact that every block in the frame is present.

Quantizer –
Every 10-bit coefficient value is converted from a two's complement value into an 8-bit magnitude plus a sign bit. The value on lines Q7-Q0 (see Exhibit R WID01002144) is a quantized value of the input. The amount of quantizing varies depending upon the current DK value. A DK value of zero indicates the lowest level of quantizing. (WID01000266) Quantizing is a process where input values in a certain range are replaced by one representative value. The effect is to reduce the number of bits of information that must be encoded and thus compressing the input data in a simple way. Quantizing is very similar to the ordinary arithmetic practice of rounding numbers.

Isolated Term Eliminator –
The isolated term eliminator identifies short sequences of values with a magnitude of one that are surrounded by zero values. When such a situation is identified the logic converts the sequence to all zeros. Sequences of the form 010, 0110 and 01110 will be converted to 000, 0000 and 00000 respectively. The output of the

isolated term eliminator appears on lines AC7-AC0. (Exhibit C, WID01000266-267, 276)

Mean Predictor –
Mean predictor logic tracks values from the output of the isolated term eliminator and predicts likely successive values. Based on the results the mean predictor coder logic selects a coding table (see below). The mean predictor generates values from 0 to 5 that are output at PM2-PM0. Only the PM value 0 will activate the run length encoding feature. (Exhibit C, WID01000267, 274-277). The mean predictor supplies a value of 6 when a DC coefficient is present. DC coefficients are encoded separately from AC coefficients. (See WID01000302).

Code Tables –
The processed coefficient value (after quantizing and isolated term elimination) appears on lines AC7-AC0 and the sign appears on the line D-SIGN. The predicted mean table selection value appears on PM2-PM0. These values are used to access a table and determine the encoded value that will be output from the coder logic and a length code indicating how many bits the coded value contains. (Exhibit C, WID01000267-268, 278-279)

A processed coefficient value appearing on lines AC7-AC0 is encoded by tables stored in PROMs 16A, 17A and 19A. The particular output value depends upon the address lines AD12-AD0. The value on these lines depends upon AC7-AC0, the sign, the distortion factor DK, the address delta (A9-A0), the predicted mean value (PM2-PM0) and the current state of the coder state machine.

How the address to the code table PROMs is translated is outlined in Exhibit Z (WID01000302). Exhibit AA expands this table to show every valid code that may be generated by the code tables. I created this exhibit directly from the code table PROMs (16A and 17A) and the length PROM 19A using the data provided by Chipworks. This is the same data that I used in the simulation models of these PROMs. The first column in the table is the 13 bit address used to access the PROMs. I have not included addresses that are not used during encoding. The deleted addresses are indicated by breaks in the address sequence. The second column, labeled 17A, 16A, provides the hexadecimal value of the code table information at the given address. The column labeled "19A" provides the associated length information in hexadecimal. Note that the length is encoded, so that the actual value of the length must be determined by subtracting the given length from 16 (decimal) or 10 (hexadecimal).

The column labeled "Code" presents the binary form of the hexadecimal information read from PROMs 17A and 16A. Adjacent to this column is the actual length of the code in decimal. This length is simply a translation of the length code shown in the column labeled "19A". The column labeled "Code as Sent" shows the code value actually sent in binary and trimmed to the length specified. The left most digit corresponds to the least significant digit of the "Code" column.

In the "Type" column I have shown the particular type of information being encoded based on the encoding table in Exhibit Z (WID01000302). In particular, the Types RL0 and RL1 correspond to the "AC1 Run Length Table "0" and "1" shown in Exhibit Z. The final column, labeled "Value" gives the corresponding value (in decimal) that is being encoded by the given address. For example, address 0004 encodes a value of "4" from the AC1 table. Similarly, address 0304 (see page 9 of Exhibit AA) encodes a run of 4 zeros terminated by a value other than "1".

State Machines –

- The state machines (Input, Block Counter and Coder) control the sequencing of logic. The Coder state machine is responsible for controlling the coding tables based on the current processing state of the logic. The Coder state machine is responsible for detecting runs of zeros which occur when the PM2-PM0 value is zero and implementing the two run length encoding techniques discussed below. (Exhibit C, WID01000267-268, 278-280, 310).

Analysis of Results

The input data file of Exhibit V represents one frame of video data, which consists of 1200 blocks of data in the blue signal channel. Each block represents an 8x8 pixel area of the video image. In the particular case of this data, it represents an image that is 320 x 240 pixels. The data represents discrete cosine transform (DCT) data values that would be expected by the Coder Board of the VTC-56. That is, the magnitude decays from initially large values to small values that are dominated by numbers with magnitude 0 and 1.

The data is presented to the Coder Board in a block of 64 data values. Each data block begins with an address delta, a distortion factor (DK) and a frame sync indication if it is the first block of a frame, that are loaded into the Coder Board. For the simulation I have selected an address delta of 1 (reflecting the fact that each frame is sequentially present) and a distortion factor of zero. A distortion factor of zero indicates the lowest level of quantization. The distortion factor is held constant during simulation. Holding the distortion factor constant does not affect the simulation results.

I ran the simulation based on blocks 1 to 1200 of the input data file corresponding to one complete frame of data. The attached Exhibit X shows the data used to drive the simulation, which was in turn derived from the data in Exhibit V. The results of the Coder Board simulation operating with this data and processed by the Formatter described above are given in Exhibit AB. This represents the encoding of one complete frame. From this simulation I have selected the encoding of one block (block number 8) from Exhibit AC to illustrate the run length encoding

technique implemented by the VTC-56. There are many other blocks in Exhibit AB that show the same run length encoding technique.

Exhibit AC shows the simulator output for block 8 of the input. This block is highlighted in Exhibit AD which shows the first few blocks of input data taken from Exhibit V.

I have annotated a single block of the simulator output in Exhibit AC as follows:

Coefficient Number – indicates the sequence number of the input coefficient. Coefficients are numbered from 0 to 63. Coefficient 0 is the DC coefficient and coefficients 1-63 are AC coefficient values.

Coefficient (Hex) – the hexadecimal value (two's complement) of the coefficient currently being coded. (Note: due to pipelining in the isolated term elimination logic the coefficient is actually presented to the coder board logic three input sequences prior to the generation of the output value. However, for clarity the Formatter logic of the simulator retains a copy of the unprocessed input value so that it may be presented when the output is generated).

- *Coefficient (Decimal)* – this is the sign-magnitude of the input presented in decimal form corresponding to the input data of Exhibit V.

- *Quantized Value* – this is the 8-bit magnitude (in hexadecimal) of the coefficient after it has been quantized based on the current DK value (which is fixed at zero in this simulation). A quantized value is smaller than the input coefficient value because quantizing is a process similar to rounding.

- *PM Value* – the current value of the mean predictor output PM2-PM0. Run length encoding will only occur when this value is zero.

- *Pre-coding Value* – coefficient value for input to the coding tables (in hexadecimal). This value reflects the effects of both quantizer logic and the isolated term elimination logic. In many cases the result is that an input coefficient value is converted to a zero value by the isolated term elimination logic. If the quantized value is not equal to one then the pre-coding value will be the same as the quantized value. Only ones are converted to zeros when they occur in isolated sequences of one, two or three successive ones preceded and followed by a zero value (Exhibit C, WID01000276).

  Note the value being encoded on the AC7-AC0 lines is shown in hexadecimal. The reader may refer to Exhibit AA to interpret value given as a decimal value.

- *Coded Value (Binary)* – this is the encoded value provided by the code tables. The actual output of the code tables is 16 bits in length (CODE15-CODE0), but the length code (LENGTH3-LENGTH0) defines the number of valid bits in the output. The simulator shows only the valid bits, that is, those bits which will actually be transmitted. The first bit to be transmitted is shown on the left, the last bit to be transmitted is shown on the right.

- *Type* – this field indicates what the output of the coder currently represents using the following notation. The type currently being output from the simulation is related to the current state coder state machine. This is shown in the column labeled "State" and relates directly to the state numbers (hexadecimal) in Exhibit U. The relationship of the type code to the state of the coder state machine is shown below. The column labeled Type is the code shown on the simulation. The column labeled State is the corresponding value of the coder state machine (in hexadecimal). A short description of the output is provided in the last column.

Type	**State**	**Description**
SYNC1	x06	First synchronization character
SYNC2	x0A	Second synchronization character
DK	x0E	Encoded Current Distortion Factor – the number following DK is the current distortion factor being used. In this simulation it is always 0.
ADDR	x12	Encoded address delta. The value shown in parentheses is the address delta. In this simulation it is always a 1 because every block of the frame is present.
DC	x16, x26	Magnitude of encoded DC coefficient value
ACx	x16, x26	(AC1-AC6) indicates the particular AC encoding table used to encode the AC coefficient. The table used depends upon the predicted mean value.
SIGN	x2A	Coefficient sign (+ or -). Zero coefficients have no sign.
RL1	x1E	Encoded run length for sequences of zeros terminated by a value of magnitude 1. The number in parentheses shows the number of zeros in the run.
RL0	x22	Encoded run length for sequences of zeros terminated by a non-zero value of magnitude other than 1. The number in parentheses shows the number of zeros in the run.
EOB	x2E	End of Block (Frequently terminates a run of zero values)

Within the simulator output for block 8 (Exhibit AC), I have highlighted two examples of the encoding of runs of zero. The first example (time =1271750-6150) illustrates a run of zeros followed by a coefficient of magnitude 1 that has been assigned the code of 101101. This run results from the input coefficient numbers 6 and 7, which have a value of -1 and +3 respectively. These values become 0 and 1 after quantizing. Because the mean predictor output has a value of 0 the coder state machine implements run length encoding. The run of zeros

terminated by a 1 (in this case, a run of only one zero value) has the encoded value indicated by RL1 and followed by the associated sign value. Exhibit AA at address 0341 (page 11) shows that this code (101101) is assigned to a run of a single zero value terminated by a value of magnitude 1, which is consistent with the simulation results shown in Exhibit AC.

A run of zeros terminated by a value other than a magnitude of one is shown at time = 1284350-1312750. This corresponds to coefficient numbers 10-20. The terminating coefficient value is +5 which is quantized to a value of +2. The result is the sequence is terminated by a coded run length of 10 zeros indicated by RL0 and followed by a coefficient magnitude (for 2) and the corresponding sign (+). The reader may refer to Exhibit AA to see that the value provided by the simulation (10010110) corresponds to a run of 10 zero values terminated by a value other than 1 (see address 030A on page 9).

Thus, according to my analysis, the Widcom VTC-56 Coder Board encodes runs of zeros in two distinct ways, based on whether the terminating coefficient is 1, or some non-zero coefficient other than 1. This is shown concisely in the Coder Board Theory of Operation document (Exhibit C, WID01000268):

CODE WORD	COEFF. = ZERO	NON-ZERO COEFF.	RUN TERMINATED BY non-one	RUN TERMINATED BY one	RUN TERM: BY EOB:
FIRST	0 Coeff.	Coeff.	Run Length	Run Length	EOB
SECOND		Sign	Coeff.	Sign	
THIRD			Sign		

Compensation

I am compensated for my work on this matter at the rate of $300.00 per hour. This rate applies to all work performed including deposition and trial testimony. I am also compensated for my actual expenses. My compensation does not depend in any way upon the outcome of this matter.

Prior Testimony

During the last four years I have provided testimony at deposition or trial on the occasions listed in Exhibit AE.

The opinions expressed in this declaration are based on my current understanding of the facts and the materials cited above. I reserve the right to amend this

declaration should I be presented with new materials or facts relevant to the opinions presented here.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Executed this 13 day of December, 2007, at Sunnyvale, California.

Charles J. Neuhauser

Charles J. Neuhauser, Ph.D.

EXHIBIT 18

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July 16, 2004

Widcom VTC-56B
Video Coder/Decoder
Data Extraction Report

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For questions, comments, or more information about this report, or for any additional technical needs concerning semiconductor technology, please call Sales at Chipworks.

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Rev. F1.0

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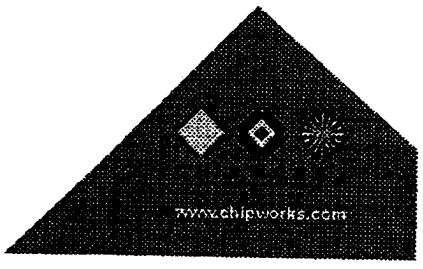

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Summary of Data Extraction Procedure

Contents of the programmable devices on Widcom VTC-56B coder and decoder boards were extracted. The following two boards were used during the data extraction:

Widcom VTC-56B coder board, P/N 1750-10130, S/N 3068C
Widcom VTC-56B decoder board, P/N 1750-10132, S/N 1365A5

All programmable devices including bipolar PROMs, EPROMs and programmable logic devices were sequentially removed from the boards' socket, read using a universal device programmer. The extracted data was saved in a file, and the devices were placed back in the boards sockets.

XELTEK SUPERPRO 680 Universal Programmer and XELTEK SUPERPRO Programmer Version 1.0 software were used for data extraction. Device data was saved as binary file for programmable memory devices (*.BIN), and as JEDEC fuse map file (*.JED) for programmable logic devices.

The JEDEC fuse map files were then disassembled to equation files. A National Semiconductor JED2EQN equation disassembler utility, version V063, was used to produce equation files for all PAL16xx devices. An equation disassembler was developed for the purpose of this project to produce equation files for all 82S153 devices.

The following sections contain:

1. The list of all devices, on coder and decoder boards, for which data extraction and disassembly was performed
2. Programmable memory data listings in hexadecimal format
3. FPLA 82S153 device data listings, including fuse map and corresponding equation file
4. PAL16xx device data listings, including fuse map and corresponding equation file

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List of Extracted Device Data

Widcom VTC-56B coder board, P/N 1750-10130, S/N 3068C

Location#	Part Number	Part Type	Data File Name	EQN File Name
1E	82S153	FPLA 18x42x10	COD-1E.JED	COD-1E.EQN
1H	28S42	512x8 PROM (82S147)	COD1H-.BIN	N/A
2D	PAL16R6	PAL	COD-2D.JED	COD-2D.EQN
2E	82S153	FPLA 18x42x10	COD-2E.JED	COD-2E.EQN
3A	PAL16R8	PAL	COD-3A.JED	COD-.3A.EQN
3E	82S153	FPLA 18x42x10	COD-3E.JED	COD-3E.EQN
4A	PAL16R4	PAL	COD-4A.JED	COD-4A.EQN
6D	28S42	512x8 PROM (82S147)	COD-6D.BIN	N/A
6F	28S22	256x8 PROM	COD-6F.BIN	N/A
7H	18S030	32x8 PROM (82S123)	COD-7H.BIN	N/A
8F	28S42	512x8 PROM (82S147)	COD-8F.BIN	N/A
9B	18S030	32x8 PROM (82S123)	COD-9B.BIN	N/A
9C	28S42	512x8 PROM (82S147)	COD-9C.BIN	N/A
9D	82S153	FPLA 18x42x10	COD-9D.JED	COD-9D.EQN
10B	PAL16R8	PAL	COD-10B.JED	COD-10B.EQN
10C	82S153	FPLA 18x42x10	COD-10C.JED	COD-10C.EQN
10F	28S86	1024x8 PROM (82S181)	COD-9F.BIN	N/A
11C	82S153	FPLA 18x42x10	COD-11C.JED	COD-11C.EQN
11F	28S86	1024x8 PROM (82S181)	COD-11F.BIN	N/A
11H	28S42	512x8 PROM (82S147)	COD-11H.BIN	N/A
12C	82S153	FPLA 18x42x10	COD-12C.JED	COD-12C.EQN
13C	82S153	FPLA 18x42x10	COD-13C.JED	COD-13C.EQN
14C	82S153	FPLA 18x42x10	COD-14C.JED	COD-14C.EQN
14E	28S42	512x8 PROM (82S147)	COD-14E.BIN	N/A
15E	82S153	FPLA 18x42x10	COD-15E.JED	COD-15E.EQN
16A	2764	8Kx8 EPROM	COD-15A.BIN	N/A
16F	82S153	FPLA 18x42x10	COD-16F.JED	COD-16F.EQN

www.chipworks.com

Widcom VTC-56B coder board, P/N 1750-10130, S/N 3068C Continued

Location#	Part Number	Part Type	Data File Name	EQN File Name
16H	18S030	32x8 PROM (82S123)	COD-16H.BIN	N/A
17A	2764	8Kx8 EPROM	COD-17A.BIN	N/A
17C	28S42	512x8 PROM (82S147)	COD-17C.BIN	N/A
18C	28S42	512x8 PROM (82S147)	COD-18C.BIN	N/A
18E	82S153	FPLA 18x42x10	COD-18E.JED	COD-18E.EQN
18F	27128	16Kx8 EPROM	COD-18F.BIN	N/A
19A	2764	8Kx8 EPROM	COD-19A.BIN	N/A
20C	PAL16R6	PAL	COD-.20C.JED	COD-20C.EQN
20D	24S10	256x4 PROM (82S129)	COD-20D.BIN	N/A
20H	PAL16R6	PAL	COD-20H.JED	COD-20H.EQN

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Widcom VTC-56B decoder board, P/N 1750-10132, S/N 1365A5

Location#	Part Number	Part Type	Data File Name	EQN File Name
1C	PAL16R8	PAL	DEC-1C.JED	DEC-1C.EQN
2A	28S42	512x8 PROM (82S147)	DEC-2A.BIN	N/A
3E	2764	8Kx8 EPROM	DEC-3E.BIN	N/A
4E	2764	8Kx8 EPROM	DEC-4E.BIN	N/A
5A	PAL16R8	PAL	DEC-5A.JED	DEC-5A.EQN
5B	28L22	256x8 PROM	DEC-5B.BIN	N/A
5D	2732A	4Kx8 EPROM	DEC-5D.BIN	N/A
5E	2764	8Kx8 EPROM	DEC-5E.BIN	N/A
6D	2732A	4Kx8 EPROM	DEC-6D.BIN	N/A
6E	2764	8Kx8 EPROM	DEC-6E.BIN	N/A
8C	28L22	256x8 PROM	DEC-8C.BIN	N/A
8E	28L22	256x8 PROM	DEC-8E.BIN	N/A
8F	28L42	512x8 PROM	DEC-8F.BIN	N/A
9A	2732A	4Kx8 EPROM	DEC-9A.BIN	N/A
9D	PAL16R4	PAL	DEC-9D.JED	DEC-9D.EQN
10C	2764	8Kx8 EPROM	DEC-10C.BIN	N/A
10F	28L22	256x8 PROM	DEC-10F.BIN	N/A
11C	2764	8Kx8 EPROM	DEC-11C.BIN	N/A
12C	2764	8Kx8 EPROM	DEC-12C.BIN	N/A

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EXHIBIT 19

UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF DELAWARE

- - - - - - - - - - - - - - - - - -x

U.S. PHILIPS CORPORATION, :

Plaintiff, :

vs. : Case No. 06-251-GMS

EASTMAN KODAK COMPANY, :

Defendant. :

- - - - - - - - - - - - - - - - - -x

Palo Alto, California

Wednesday, January 30, 2008

Videotaped Deposition of CHARLES NEUHAUSER, Ph.D., held at the offices of Finnegan, Henderson, Farabow, Garrett & Dunner, 3300 Hill View Avenue, Palo Alto, California, commencing at 9:03 a.m., before Sharon Lancaster, a Certified Shorthand Reporter of the State of California.

EXCERPTS

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ALAN DIAZ, Videographer

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3 Directory of CD "CL1351725 re 5_20 CLI VTC-56 San Diego Inspection for Neuhauser (06/21/06); 8 pages 58
4 Widcom VTC-56B Video Coder/Decoder Data Extraction Report; 191 pages, double-sided 59
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PROCEEDINGS

THE VIDEOGRAPHER: Good morning.
We are on the video record at 9:03 a.m.
I am Alan Diaz, an associate of Henderson Legal Services in Washington, D.C. The phone number is 202-220-4158.
This is a matter pending before the United States District Court, District of Delaware. The case caption is U.S. Philips Corporation vs. Eastman Kodak Company. The case number is 06-251 GMS.
This is the beginning of Tape No. 1, Volume 1, of the deposition of Charles Neuhauser on January 30th, 2008. We are located at 3300 Hillview Avenue, Palo Alto, California.
This is taken on behalf of the plaintiff.
Counsel, would you please identify yourself, starting with the questioning attorney.
MR. CAMPBELL: This is Louis Campbell, representing Philips.
MR. MULLOY: Rick Mulloy with DLA Piper, on behalf of Kodak.
THE VIDEOGRAPHER: Will the Court Reporter

please swear in the witness.

CHARLES NEUHAUSER, Ph.D.,
having been first duly administered the oath, under penalty of perjury, testified as follows:

EXAMINATION

BY MR. CAMPBELL:

Q. Good morning, Dr. Neuhauser.
A. Good morning.
Q. Have you been deposed before?
A. Yes, I have.
Q. How many times?
A. Probably two dozen times.
Q. Okay. So you're fairly familiar with the procedures and everything involved; correct?
A. I'm willing to listen to any advice you have.
Q. Okay. We can move on to the questions.
So, I guess first we'll just start with what you've looked at. I guess maybe we'll start with what you haven't looked at.
Did you look at any deposition testimony in preparing this report?
A. I don't believe so.

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Q. So you didn't look at the testimony of Eric Hamilton?
A. No, I don't believe so.
Q. Or Stanley Fralick?
A. No. None of these names mean anything to me.
Q. I'll give you a few more names.
Shrikant Acharya. Ever heard of him?
A. No.
Q. Andrew Tescher?
A. No.
Q. So you never interviewed with those gentlemen, either?
A. No.
Q. And did you actually see the Widcom device yourself, or did you just see photographs of it?
A. Just photographs.
Q. And did you see any evidence of sales, like -- for instance, any invoice or receipt, anything like that?
A. No.
Q. And did you see any evidence of prior use, other than the Today Show, for example, that you

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mentioned in your report?
A. I believe that's the only example.
Q. Did you look at the asserted patent in this case?
A. At one point, I read it, yes.
Q. But you're not offering an opinion that maps the device to the patent claims; is that correct?
A. That's correct.
Q. And so you didn't look at the claim construction either; right?
A. I believe I may have seen some part of that order, but I'm not sure.
Q. Do you recall when you saw it?
A. Yesterday.
Q. Okay. Which part did you look at?
A. As I remember, there was a table that just showed the definitions that I believe the judge had accepted. That's what I understood it to be, but it may not have been that.
Q. So do you consider yourself an expert?
MR. MULLOY: Objection. Vague.
THE WITNESS: In what? I mean, in this case?

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BY MR. CAMPBELL:
Q. Well, are there any fields in which you do consider yourself an expert?
A. Yes.
Q. What are those fields?
A. Well, I could probably give you a summary of areas of expertise. I'm an -- basically an expert in system structures, computer architecture, operation, design of systems, testing of those systems. I have done all of these things. I believe that's summarized in my -- at the beginning of my declaration.
Q. So have you had any direct experience in transmission coding protocols?
A. Probably not.
Q. So who wrote your report?
A. I did.
Q. When did you write it?
A. I wrote it about a month ago. You would have to look at the date of the report. I signed it shortly after I finished it, so --
Q. How long do you think you spent on it?
A. Probably several days. I remember part of a

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week. That's just the writing part, you understand.
Q. What else went into the preparation of the report?
A. Well, of course, the testing and the development of the Verilog code and understanding of the system and all of those things went into -- It formed the foundation for the report.
Q. And so you're not offering any opinions on anticipation; is that correct?
MR. MULLOY: Objection. Seeks a legal conclusion.
You can answer.
THE WITNESS: I'm not sure I understand your question completely.
BY MR. CAMPBELL:
Q. Well, are you offering any opinion that the prior use or sale of the Widcom device invalidates the Philips patent?
A. I don't believe I'm offering an opinion about that. I'm just offering an opinion about how this device operates.
Q. And so you're also not offering an opinion on

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found in the Widcom specification?
A. What is the device we're talking about here?
Q. This would be the VTC-56.
Did you simulate the whole VTC-56 or just the encoder board?
A. Just part of the encoder board.
Q. Which part of the encoder board?
A. If you look at the exhibit -- Do you have the exhibits here?
Q. Not all of them, no.
A. I believe it's Exhibit K. If you look at that, it specifically says what part of the Coder Board. But generally it was from the edge of the board to the input to the FIFO.
Q. And a FIFO -- that's a buffer that means first-in/first-out buffer?
A. That's correct.
Q. And that's just where the data is stored to move on to whatever the VTC-56 needed to do next; right?
A. It's an elastic buffer between the end of encoding and the start of serialization.

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Q. So for that section of the encoder board, you started with the specification. If I'm understanding this correctly, you started with the specification to determine what the pieces of that were to input into the simulation software?
A. I'm lost. I'm just -- I'm just lost with the question.
Q. Well, how did you -- I mean, I guess my question is: Did you start with the specification, or did you start with the physical circuit that you had seen pictures of?
A. Just to make sure that we're not talking about different things here. Okay. Specification, I generally -- When I talk about a specification, it's usually a written document. Okay? Which either tells how a device might behave or how a device does behave or how to use a device. Okay?
Then there's schematics, which are descriptions of the circuits and their interconnection. Okay? And then there's datasheets, which are descriptions of the circuit -- individual module operation.

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So we may be confused about -- I think you're putting schematics in with written specifications, which is fine, as long as we both understand that. But --
Q. Okay. Well, there is a list of materials considered in your report on page 2.
A. Mm-hmm.
Q. Were any of these the starting point for what you input into the simulation?
A. Well, I'll just go down this list. I made use of the datasheets to develop the simulation. Okay? I made use of documentation within the Widcom Technical Documentation for Neuhauser CD, specifically the schematics. But probably some other information in there. Like, there was some physical layouts of the board that I made use of.
These Theory of Operation documents, I used those to understand what was going on. But I didn't actually take something from those documents and put it in. Okay? You know? So I would say, in a general sense, I didn't use them to build the specification directly.

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Schematics, I certainly used those. I made use of the photographs, as I discuss in the report, for certain purposes. The Chipworks Extraction Report, which includes the information about the programming of individual programmable devices, I made use of that.
The example DCT files, Exhibit G, and the files associated with the Chipworks report discussed above. So those are the things that I made use of.
And then, of course, ordinary engineering common sense about certain things.
Q. Okay. So was there any other data specific to the Widcom device that is not listed here that went into your simulation?
A. I don't believe so.
Let me just take a break here for a moment.
MR. CAMPBELL: It's probably a good time to take a break. Ten minutes.
THE VIDEOGRAPHER: We are off the record at 10:02 a.m.
(Brief recess taken.)
THE VIDEOGRAPHER: We are back on record at

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10:14 a.m.
You may proceed.
BY MR. CAMPBELL:
Q. Before the break, we were going through the list of materials you considered to see what was the input to your simulation. So I guess we just go through that list in more detail.
So the various datasheets, Exhibit J, those are just datasheets made by the manufacturers of the chips that describe the functionality of the chips that were in the Widcom device; is that correct?
A. In the area that I simulated; that's correct.
Q. Okay. We'll move on to the next one here, which is the CD titled "Widcom Technical Documents for Neuhauser." The contents are listed in Exhibit B. I just printed out a copy of that.
So if we could mark this as Exhibit 2.
(Neuhauser Deposition Exhibit 2 was marked for identification.)
BY MR. CAMPBELL:
Q. Dr. Neuhauser, the Exhibit 2 document, is that the same thing as Exhibit B to your report?

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A. I believe that's correct.
Q. So if we could just go through, in this document, what the various groups are. So this is just a directory listing of -- It looks like a CD; is that correct?
A. That's correct.
Q. First, it starts with the files found on the directory of D. What are the files here, generally speaking?
A. Oh, you mean the top level files?
Q. Yes.
A. I see what you're saying.
Well, these are basically PDF files of copies of Widcom documents of various sorts.
Q. So these are Widcom schematics. "Theory of Operation" I see in here, too. Documents like that?
A. Correct.
Q. Below that, in Exhibit B, we have a group of documents from the directory of Dean, colon, backslash, Chipworks VTC-56 report. What are these documents here?
A. Well, there's two things. I mean, there is a

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Readme. I don't remember what the Readme said. Something like it was confidential or something to that effect.
The main thing is there is this Widcom data extraction report, which is a PDF of their actual report, the process they used -- they used, and actually the data files themselves in PDF form.
And then below this is the extracted files that -- the files that were extracted from the programmable devices by these people at Chipworks in various forms. So sometimes the same files appears in -- in fact, most of the time it appears in two forms.
Q. So in that answer, when you're saying "they," you were referring to Chipworks?
A. That's correct.
Q. Okay. Let's set that aside, for now at least.
Then going back to your report, you said you didn't look at the Theory of Operation as an input, you looked at it more to provide context; is that correct?

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A. That's correct. I don't believe there was anything in the Theory of Operation that I used as input other than -- Let me just qualify that a little.
I don't think I got data from the Theory of Operation. But I did refer to the Theory of Operation to confirm my understanding of how the edges of the board worked so that I could develop my, you know, input process to them. So I didn't get the input data from it, but I did use that to verify how the edge of the board worked.
Q. By "edge of the board," you mean the input and output ports?
A. Mostly the input port on the -- the input to the part of the design that I looked at comes directly from the card edge or edge of the board, if you will.
Q. So then next on the list we have schematics titled "VTC-56 Coder" from the CD mentioned above. So the CD mentioned above is the CD printed out in Exhibit B; is that correct?
A. That's correct.
Q. So what was this document here that is also marked Exhibit R?

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that there was. But I don't know exactly how they -- You know, a schematic can represent something you wish to design, or it can represent something that you did design. Okay?

Because after you finish, sometimes you go back and you correct your schematics to account for all of the prototyping work you did. And so that could explain the situation. I mean, they might have just forgotten to correct this area of the schematic.

Q. And so did you check the photograph in its entirety to make sure it matched up with the schematic?

A. No. I only checked the areas that I mentioned in the report. This area and several others.

Q. And did you ever check the connections on the board between the various chips to be sure they were the same as in the schematic?

A. Well, in a couple of instances, I did look at things. Particularly the other instance I mentioned in here, where it looks like there is probably a design error. I attempted to check the circuitry on

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the board by looking at the photos. But I'm not sure in that case it was possible to make a complete determination.

Q. So the design area you mentioned -- I think it's the note here at the top of page 11. Is that what you were speaking of?

A. Let me see. (Witness reviewing document.)

Yes, that's what I was speaking about a minute ago.

Q. So what is the design error you're describing here?

A. Well, it looks like the two devices are both driving each other. They are both outputs, and the outputs are hooked together. This is not a desirable situation, but it happens in designs, and it doesn't necessarily cause problems.

Q. Now, you found this error in the schematic; is that right?

A. Yes, that's correct.

Q. Did you examine the photographs to see if this error continued on through the actual device?

A. I -- I made an attempt to do that. But the

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photographs don't provide enough detail to -- The problem is that the wires run underneath some of the devices, so you can't necessarily see where they go and what they connect to.

Q. Now, you also mentioned in your report that you performed a functional simulation as opposed to a timing simulation; is that correct?

A. That's correct.

Q. What is the difference between those two?

A. Well, the basic difference is a functional simulation looks at the -- is an attempt to capture the function that the design is intended to perform.

Timing simulation attempts to capture the physical characteristics in addition to the functional characters. Physical characteristics affect time. And so the timing simulation attempts to capture those and put that into the simulation and see if the device will work with those constraints.

Q. And why did you make a decision to only do a functional test here?

A. Well, there were several reasons. I think initially I was not able to find good models of the

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devices that included -- I mean, there's several problems.

First, you have to have good models of the devices that include timing in them. And then you would have to have some understanding of physical electrical characteristics of the board in order to put into the simulation an allowance for wire lengths, for instance, and for other things like capacitance of the lines, how big the lines are, how much resistance they have. You just put that into the simulation.

So those were, you know -- could be done with enough expenditure of time and energy. I think that sort of thing could be done. But I didn't believe it was necessary, because we know that the board works. We know that the design is a synchronous design, and several other things that I mentioned in my report.

So, you know, we know that -- that the -- and the objective of this was to determine the function, not the exact timing. So it was really on the basis of those notions that I mention in the report that I chose to do a functional simulation.

Q. Now, in your work -- In your report, you

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never mentioned that you actually tested the physical device; is that correct?
A. Tested -- What device? You mean the actual board?
Q. The device -- Yes, there's a board shown in the photos. You never actually tested that, did you?
A. No, I did not.
Q. And why not?
A. I wasn't asked to.
Q. But do you know if Chipworks does that kind of test?
MR. MULLOY: Objection. Calls for speculation.
THE WITNESS: I don't know. I can tell you that a competent engineer could do such a test. Chipworks has competent engineers; therefore, they probably could do such a test if they were asked to.
BY MR. CAMPBELL:
Q. So it's physically possible to do such a test?
A. Well, let me put it this way: I believe that it's possible. But I'm giving you my best judgment as

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an engineer. But not having completely thought out the testing issue for this particular board, I can't say for sure that it would be possible. But it seems to me that it would be possible.
Q. And how would you do that? Or at least how would you attempt to do that?
A. Well, I can give you a general outline. It won't be specific to this board.
What you would do is you would construct what some people might call a manufacturing test. Typically, when a board is built -- it depends on a lot of factors. There's different ways of testing the board in manufacturing.
One way that I have used -- and it's not necessarily the only way you can do it -- But one way that I used is you build a jig that holds the board, and then you provide it with inputs that you're interested in. You power it from the jig, of course. And you provide it with inputs that represent what you're interested in finding out about the board. And then you look at the outputs.
And, for instance, one thing you can do is

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compare the outputs back against the simulation to see that, in fact, that what is happening on the board is the same as what was in your simulation, if you did a simulation. Okay?
So, you know, you should -- You know, in theory, you should be able to make a board operate by building an environment around it that is comparable to its native environment.
Q. If I could move back to one other thing.
So we talked about the functional versus the timing simulation. Is it fair to say that the timing simulation is harder to perform?
A. Well, I'm not sure what "harder" means. They are both simulations that simulators are designed to perform. To do a timing simulation requires more information than a functional simulation. You have to have, you know, at least the functional level of simulation, you know, to determine how something works. And timing is an additional thing that you do beyond that to determine whether the physical artifact itself will work.
MR. CAMPBELL: So if we could mark this one

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next, Exhibit 5.
(Neuhauser Deposition Exhibit 5 was marked for identification.)
BY MR. CAMPBELL:
Q. Dr. Neuhauser, any chance you have seen this before?
A. What magazine did it come from?
Q. Well, I found it last night on Chipworks' Web site.
A. Okay. Well, your question is: Is there any chance that I have seen this article before?
Q. I'll rephrase.
Have you seen this article before?
A. I don't recall this article.
Q. I'll show it to you with the understanding that you have never seen it before. But on the second page of this, there is a heading called "System Level Analysis," where it describes how they took apart a digital camera and performed a timing test on the functionality of that camera.
A. The "they" here is Chipworks?
Q. Chipworks. Correct. So there's not really

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verify that your conclusions about encoding were correct?

A. Like I said before -- I mean, you might get some information from that. I'm not sure that it would make the conclusion any stronger. I don't really see -- If I had thought that it would make the conclusion stronger, I would have done it.

Q. But if you had looked at the decoding side, there is at least a chance that you could have found that your conclusions were incorrect; is that right?

MR. MULLOY: Objection. Calls for speculation.

THE WITNESS: I don't -- From an engineering judgment standpoint, I don't think that's correct. I mean, what is said in the specifications, what is shown on the schematic, the programmable devices, the entire simulation works in a certain way. It's all very coherent.

I don't see how -- It would be shocking to find something different someplace else. It just wouldn't make any sense. Especially in a device that is based on an operating physical system. In other

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words, the physical system itself. If the decoder was somehow different from the encoder, it wouldn't work.

BY MR. CAMPBELL:

Q. Okay. The next paragraph here, near the end you say, "Therefore, the schematics precisely embody the function of the product. Thus, a skilled engineer using the schematics" -- and then in parentheses you say, "(and certain additional information that I will describe below)" then out of parentheses, "can determine precisely how the device behaves" and then another parenthetical, "(including the resulting output for a given input)."

I mean, I looked through this. I didn't see additional information that you will describe below. What is that referring to?

A. The programmable device data.

Q. Got it.

So is that the only thing you meant there? Is that all you're referring to there?

A. I believe that's the case, yes. I might have used one other thing. I think I used the -- I think there was a -- that there's a switch setting on the

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board, that I made use of the photograph on the board to determine. I believe that's the case.

Q. What do you mean by that, "switch setting"?

A. There is some jumpers that have to be set. They are options, and I just had them set according to the way they were jumpered on the board. I don't think it would have made any -- quite frankly, any difference how they are set. It's just an option.

Q. Okay. I guess my next question is on the next page. The last paragraph, beginning the last paragraph here, you say, "Generally, the schematic diagram does not include information about the specific programming of such programmable devices."

What kind of documents do contain that information?

A. Well, it could be several different kinds of things. In the case here, the documents were the readouts from the programmable devices. In a production situation, in what is called "forward engineering," the documents would probably be equations or bitmaps for the programmable devices. There's a lot of different ways that information is

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presented.

Q. And you don't -- I think we already asked this. But you never looked at those? You were never at least given those to look -- documents here?

A. If they exist, I was never given them.

Q. All right. So on the next page, page 5, first full paragraph, you say, "My understanding is that a complete operating VTC-56 system, S/N 212, which includes a working Coder Board, was obtained."

What is the basis for that understanding?

A. My discussions with one of the attorneys.

Q. Would this be one of the DLA attorneys?

A. No.

Q. Which attorney was it?

A. It would be Barry Shelton.

Q. What do you mean by "operating"?

A. I believe that this system was functioning, that it was not a defective system. That's just based on what he told me.

Q. And so by "functioning," that means if you attached all the necessary cameras and TV monitors and so forth, it would take a camera image, output it

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to -- I guess it was the phone line, or likewise receive an image off the phone line, decode that for a TV monitor? Is that what you mean?

A. Well, in general, that's what -- you would have to have two of them, really. You would have to have one on the other end to really do a complete test.

Q. Do you know how Barry determined it was an operating system?

A. No, I don't.

Q. So you just took his word for it?

A. I did.

Q. And, likewise, what do you mean by a "working Coder Board"?

A. Where is that?

Q. Same sentence.

A. The same -- the same issue, that this board had functioned at one time --

Q. And again you --

A. -- and probably still did. And that -- it's just on his representation.

Q. So then in the next paragraph, the second

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sentence -- I'll read both of them so it makes more sense. First and second.

"I was provided with readouts for all FPLAs, PALs and PROMS on the Coder Board. My understanding is that the readouts were performed by Chipworks" -- and it lists their address -- "a well-known reverse engineering company that specializes in semiconductor analysis."

So, again, what do you base this understanding on?

A. I've had contacts with Chipworks in the past or had investigated using them in projects. They are a well-known company.

Q. So how do you know they performed the readouts here?

A. Their report. It had their logo on it.

Q. How do you know they didn't make any mistakes?

A. Well, two reasons: One is, is that it's a relatively straightforward engineering task. Okay? And the second thing is, is that the results that were read out, they worked fine in the simulation. So if

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there was a mistake, it would have to be something that didn't affect the simulation in any way.

Q. Well -- now, what do you mean by "they worked fine in the simulation"?

A. The simulation functioned over the input data that I gave it.

Q. So it didn't cause any -- Well, you put input in; you got output out?

A. I put input in. I got output that I expected to get out based on my knowledge of the circuitry and the technical documentation I had from Widcom. I didn't get any anomalies in the simulation that -- that, you know, indicated to me that something was wrong in any of programmable devices.

And then I also looked at each programmable device to see whether the information that was in there -- Remember, I tested these devices after I built up a model, I put I the programming, I tested them. It's not always possible to test them completely. But in the process of doing that, I analyzed what their function was. And their function seemed sensible against the function in the

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schematic -- that was being suggested by the schematic and by the technical documentation and by the fact the system would run with those -- with those particular programmable devices.

Q. You took the data from Chipworks, put it into your system, and then determined that it was what you thought it was going to be; is that right?

A. I'm not sure that's what I -- I'm not sure that's a very good summary of what I just said.

Q. Well, what's wrong with it?

A. It's so vague, I can't -- I mean -- I basically did engineering validation, you know, that I would do on any project to make sure that everything looked consistent. It's an engineering type of process, right, to look at the programming, to look at the intended function of the device, to look at the schematics and to see if all of that seems to be reasonably consistent.

Q. All right. So further on this page in that section, is that starts -- well, it's the Methodology section. You state, "My primary objective is to determine the precise operation of the encoding