

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HISENSE USA CORPORATION; and
HISENSE ELECTRONICA MEXICO S.A. de C.V.

Petitioner,

v.

VIDEOLABS, INC.,
Patent Owner.

U.S. Patent No. 7,769,238

Original Issue Date: August 3, 2010

Title: PICTURE CODING METHOD AND PICTURE DECODING METHOD

Case No. IPR2025-01329

DECLARATION OF DR. KANNAN RAMCHANDRAN

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CHALLENGED CLAIM LISTING

Claim	Limitation No.	Limitation
1	[1-PRE]	A receiving apparatus which receives multiplexed data which is obtained by multiplexing coded audio data and coded picture data, said receiving apparatus comprising:
	[1-A]	a demultiplexing unit configured to separate the multiplexed data into the coded audio data and the coded picture data;
	[1-B]	an audio processing unit configured to decode the separated coded audio data; and
	[1-C]	a picture decoding unit configured to decode the separated coded picture data,
	[1-D]	wherein said picture decoding unit includes a block decoding unit configured to decode coded block data included in the coded picture data, the coded block data being obtained by dividing a picture signal into plural blocks, generating a residual block image from a block image of the respective blocks and a predictive block image obtained by intra-picture prediction or inter-picture prediction, and coding, on a block basis, coefficients obtained by performing orthogonal transformation and quantization on the residual block image
	[1-E]	said block decoding unit includes: a coefficient number decoding unit configured to decode the coded block data to obtain the number of non-zero coefficients which are coefficients included in a current block to be decoded and having a value other than “0”;
	[1-F]	a unit configured to obtain coefficients corresponding to a residual block image of the current block by decoding the coded block data;

Claim	Limitation No.	Limitation
	[1-G]	a unit configured to obtain the residual block image of the current block by performing inverse quantization and inverse orthogonal transformation on the coefficients corresponding to the residual block image of the current block; and
	[1-H]	a reproducing unit configured to reproduce a block image of the current block, from the obtained residual block image and a predictive block image obtained by intra-picture prediction or inter-picture prediction,
	[1-I]	said coefficient number decoding unit includes: a determining unit configured to determine a predictive value for the number of non-zero coefficients included in the current block based on the number of non-zero coefficients included in a decoded block located on a periphery of the current block;
	[1-J]	a selecting unit configured to select a variable length code table based on the determined predictive value; and
	[1-K]	a variable length decoding unit configured to perform variable length decoding on a coded stream which is generated by coding the number of the non-zero coefficients included in the current block, by using the selected variable length code table.

I. INTRODUCTION

I, Kannan Ramchandran, declare as follows:

1. My name is Kannan Ramchandran. I am a Professor of Electrical Engineering and Computer Science at the University of California Berkeley.
2. I have been retained as an expert in this proceeding by counsel for Hisense USA Corporation, and Hisense Electronica Mexico S.A. de C.V. (“Hisense”) in the above-captioned *inter partes* review as an independent consultant to offer opinions regarding the validity of the challenged claims in U.S. Patent No. 7,769,238 (the “’238 Patent”).
3. I am being compensated at my usual consulting rate for my work, plus reimbursement for any reasonable expenses. My compensation is based solely on the amount of time that I devote to activity related to this case and is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other financial interest in this proceeding.
4. In the preparation of this Declaration, I have confined my analysis to the materials and opinions that were available at the time of the preparation of this Declaration, supplemented with my own knowledge and experience in the field. Should new materials, analyses, or opinions be introduced after the filing of this

Declaration, I reserve the right to supplement this Declaration to the extent necessary to address any such newly introduced items.

5. If requested, I am prepared to explain in a deposition or at a trial before the Patent Trial and Appeal Board (the “Board”) the technology disclosed in the ’238 Patent, including the state of the art around April 15, 2002—the earliest alleged priority date of the ’238 Patent. Similarly, I am prepared to explain the technology disclosed in the prior art references cited herein. This may include, among other things, background information on the fields of video coding and compression.

6. My qualifications are stated more fully in my *curriculum vitae*, which is attached as Appendix A. Below is a summary of my education, work experience, and other qualifications.

7. I received my M.S. in electrical engineering in 1984 and my Ph.D. in electrical engineering in 1993, both from Columbia University. After receiving my undergraduate degree and while studying for my Ph.D., I served on the Technical Staff of AT&T Bell Labs as an R&D Design Engineer, from 1984-1990.

8. I have been an Assistant Professor, or Professor, of electrical engineering since 1993. First, I was an Assistant Professor in the Electrical & Computer Engineering Department at the University of Illinois at Urbana-Champaign (“UIUC”) from 1993-1999. While at UIUC, I taught undergraduate

and graduate classes in, among other subjects, digital signal and image processing.

I also served as Research Assistant Professor at the Beckman Institute and Coordinated Science Laboratory, and as the Associate Director of Multimedia Laboratory at the Beckman Institute.

9. I have been a Professor of Electrical Engineering and Computer Science (EECS) at UC Berkeley since 1999. I currently hold the Gilbert Henry Gates Endowed Chair in EECS. At UC Berkeley, I teach undergraduate and graduate-level classes in, among other subjects, digital signal and image processing, data compression and information theory, and digital communication systems. I am also the Director of the Berkeley Audiovisual Signal Processing and Communication Systems (“BASiCS”) Research Group, and Co-Director of the Wireless Foundations Research Center.

10. I have been a Fellow of the Institute of Electrical and Electronics Engineers (“IEEE”) since 2005. I have also served as a technical consultant in media compression and networking over several decades, consulting for both established entities like Microsoft, Hewlett-Packard, Intel, Texas Instruments, Lucent Technologies, and AT&T Research Laboratories, as well as smaller ventures such as PictureTel Corporation, Aware Inc., and numerous media-related startups in Silicon Valley.

11. My primary research focus has been in the field of video compression and multimedia networking over wired and wireless networks. I hold several patents in the field of image and video compression and transmission, and my work on rate-distortion optimization in image and video compression has contributed to the evolution of video compression standards, such as the H.264 standard. Further, a modified version of one of my patents on multi-resolution video broadcast is currently used in the Digital Audio Broadcast standard in Europe.

12. I have published over 700 refereed journal and conference publications, including many articles related to image and video compression and transmission. I have also given several keynote addresses and invited talks at conferences in the fields of image processing, multimedia signal processing, wireless sensor networks and information theory.

13. I have received a number of research accolades in the field of video compression. These include the IEEE Kobayashi Computers and Communications Award in 2017 for my contributions to compression and storage systems, two Best Paper Awards from the IEEE Signal Processing Society, and several conference best paper awards. Other awards include an IEEE Information Theory Society and Communication Society Joint Best Paper award for 2012, an IEEE Communication Society Data Storage Best Paper award in 2010, an Okawa Foundation Prize for

outstanding research at Berkeley in 2001, and an Outstanding Teaching Award at Berkeley in 2009, and a Hank Magnuski Scholar award at Illinois in 1998. I have received several grant awards from the National Science Foundation and the Department of Defense, in which I have been the primary investigator on multi-year multi-million dollar projects related to media transmission and compression.

II. MATERIALS CONSIDERED

14. In preparing this declaration, I reviewed and considered the following materials, along with any others referenced in the body of my declaration:

- The '238 Patent (Ex. 1001) and its file history (Ex. 1002).
- International Publication No. WO03063501A1 ("**Karczewicz**") (Ex. 1004)
- Karczewicz Priority Application No. 10/054,610 (Ex. 1005)
- Karczewicz Priority Provisional Application No. 60/369,500 (Ex. 1006)
- ITU-T Recommendation H.324 ("**H.324**") (Ex. 1007)
- ITU-T Recommendation H.263 ("**H.263**") (Ex. 1008)
- Chart Comparing disclosures from Karczewicz (Ex. 1004) and the corresponding disclosures from Karczewicz 60/369,500 Provisional Application (Ex. 1006) (Ex. 1009)
- JVT-B045 ("Improved Low Complexity Entropy Coding for Transform Coefficients," Bjontegaard, Gisle (Ex. 1010)
- U.S. Patent No. 7,099,387 ("Bjontegaard") (Ex. 1011)
- IPR2018-00658, Paper 14 (Ex. 1012)

- IPR2022-00628, Paper 10 (Ex. 1013)
- IEEE Publication “Scene adaptive coder,” IEEE Transactions on Communications, 1984, by W. Chen, C. H. Hsia, and W.K. Pratt (Ex. 1014)
- IEEE Publication “Motion-compensation prediction with fractional-pel accuracy,” IEEE Transactions on Communications, April 1993, by Bernd Girod (Ex. 1015)

15. I may use these documents and information, or other information obtained during the course of this proceeding, as well as representative charts, graphs, schematics and diagrams, animations, and models based on those documents and information, to support and to explain my testimony.

16. My opinions are based in part on a review and analysis of the above-mentioned documents and materials. I have also drawn on my education, experience, and knowledge of basic engineering and scientific principles in forming my opinions.

III. UNDERSTANDING OF THE LAW

A. Legal Standards

17. I am not an attorney, but I have been informed of several legal principles, which I have employed in forming my opinions in this declaration. I have been informed and understand that each patent claim is considered separately for purposes of validity and that a dependent claim that depends from another claim includes all of the limitations of the claim it depends from.

18. ***Claim Construction.*** I have been informed and understand that the claims of the challenged patents in this proceeding are to be construed using the same claim construction standard applied in district court. I have been informed and understand the claim construction analysis begins with the ordinary meaning of a claim term, and there is a presumption that the term carries its plain and ordinary meaning to persons of ordinary skill in the art as of the effective filing date of the patent. I have also been informed and understand that the most important sources for determining the meaning of a claim term are the claims, the specification, and the prosecution history of the patent at issue, which collectively is called “intrinsic evidence.” I have been further informed and understand that the meaning of a claim term may also be guided by “extrinsic evidence,” such as contemporaneous dictionaries and treatises.

19. ***Burden of Proof.*** I have been informed and understand that the petitioner in an *inter partes* review bears the burden of establishing invalidity by “a preponderance of the evidence.” I have been further informed and understand that, to prove an assertion by “a preponderance of the evidence,” the party with the burden of proof must demonstrate that it is more likely than not that the assertion is true.

20. ***Obviousness.*** I have been informed and understand that a patent claim is invalid if it would have been obvious to a person of ordinary skill in the art

at the time of the claimed invention. I have been further informed and understand that a claimed invention is not patentable if differences between it 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 pertinent art. I have been informed and understand that factors relevant to the determination of obviousness include the scope and content of the prior art, the level of ordinary skill in the art at the time of the invention, differences between the claimed invention and the prior art, and “secondary considerations” or objective indicia of non-obviousness.

21. I have been informed that a single reference alone can render a patent claim obvious, if any differences between the reference and the claim would have been known or obvious to a POSITA at the time of the invention. That is, if the POSITA could have adapted the reference to meet the claims of the patent by applying known concepts to achieve expected results, then the patent claims are rendered obvious by that reference.

22. I have been informed and understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I have been further informed and understand that when a patent claim simply arranges old elements with each performing the same

function it had been known to perform and yields no more than one of ordinary skill would expect from such an arrangement, the combination is obvious.

23. I have been informed and understand that a patent claim composed of several limitations is not obvious merely because each limitation was independently known in the prior art. Hindsight reasoning is not an appropriate basis for combining references to form an obviousness combination. I have been further informed and understand that it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine multiple prior art references.

24. I have been informed that various “secondary considerations” (sometimes referred to as objective indicia of non-obviousness) may support a determination of non-obviousness and that such secondary considerations must be considered as part of an obviousness analysis. I have been informed that even strong evidence of secondary considerations may not be sufficient to rebut a strong showing of obviousness. I have been informed that the patentee bears the burden of showing the existence and effect of secondary considerations of non-obviousness, after which the burden of coming forward with rebuttal evidence shifts to the party arguing obviousness. I have been informed that the following secondary considerations may indicate non-obviousness:

- Copying: evidence that others, including the accused infringer,

copied the patented invention.

- Long-standing problem or need: evidence of a persistent problem or need in the art that was resolved by the patented invention.
- Prior failure: evidence that others have tried and failed to solve the problem or failed to provide the need resolved by the claimed invention.
- Commercial acquiescence of competitors: the willingness of industry to license the patent at issue.
- Skepticism: evidence that those of ordinary skill in the art were skeptical as to the merits of the invention.
- Praise: evidence of praise directed to an invention by others in the field.
- Unexpected results: evidence that those of ordinary skill in the art were surprised by the capabilities of the claimed invention.

25. I have also been informed that the near-simultaneous invention by others can be evidence that a claimed invention is obvious. I have further been informed and understand that the patentee bears the burden of showing a “nexus” between the claimed invention and the evidence proffered on secondary considerations (*e.g.*, proof of commercial success of a product that practices the claimed invention is not enough; there must be evidence that the commercial success resulted, at least in part, from the claimed invention).

B. Priority Date

26. I have been informed and understand that a U.S. patent may claim “priority” to the filing date of one or more earlier filed applications. I have been

informed that the priority date, also called the “effective filing date,” is the earliest filing date to which a claim is entitled and that such date is relevant for determining what qualifies as prior art. I understand that a claim must have written description support in the application(s) to which it claims priority to be entitled to an earlier effective filing date. I have been informed that the priority date determination is done on a claim-by-claim basis and that claims in the same patent may have different priority dates.

27. For purposes of this declaration, I have been instructed to use April 15, 2002, as the priority date of the '238 Patent.

28. I have also been informed that a published patent application that claims priority to a provisional application can be considered prior art as of its provisional filing date. Specifically, I understand that a published patent application can claim the priority date of its provisional application as a prior art reference if (1) at least one claim in the published application is supported by the provisional application; and also (2) that the specific content in the published application relied on in this IPR has written description support in the provisional application.

C. Level of Skill in the Art

29. I have been informed and understand that the level of ordinary skill in the relevant art at the time of the invention is relevant to inquiries such as the

meaning of claim terms, the meaning of disclosures found in the prior art, and the reasons one of ordinary skill in the art may have for combining references.

30. I have been informed and understand that factors that may be considered in determining the level of ordinary skill include: (1) the type of problems encountered in the art; (2) prior art solutions to those problems; (3) the rapidity with which innovations are made; (4) the sophistication of the technology; and (5) the education level of active workers in the relevant field. I have been further informed and understand that a person of ordinary skill in the art is also a person of ordinary creativity.

31. The challenged patent pertains generally to the fields of video coding and compression. A person of ordinary skill in the art (“POSITA”) at the time of the alleged invention would have had at least a Bachelor’s degree in computer science, computer engineering, electrical engineering, or a similar discipline, along with at least 2 years of experience with audio, image, and / or video coding. Relevant experience can substitute for education and *vice versa*. I was at all relevant times at least a POSITA in the art relevant to the challenged patents.

IV. SUMMARY OF OPINIONS

32. I have been asked to compare various prior art references to Claim 1 of the ’238 Patent (the “Challenged Claim”). In my opinion, the Challenged Claim

is unpatentable as obvious – based on these prior art references, combined with the knowledge of a POSITA.

33. My substantive analysis in Section VIII provides examples of why these prior art references render the Challenged Claim unpatentable. I reserve the right to cite and rely on additional portions of these references in any future declarations or depositions.

V. TECHNOLOGY BACKGROUND

34. Before considering the '238 Patent in detail, some background on the technology of the '238 Patent should be considered.

A. Video Compression

35. By April 2002, the field of video compression was well established and built upon the decades of understanding of video encoding principles. The '238 patent explains that a video can be encoded by compressing each frame (picture) separately by leveraging redundancy within single frames and among sequential frames. Specifically, the '238 patent describes the well-known process by which a video encoder divides a picture into blocks and applies block-based coding and compression techniques (*e.g.*, inter- or intra-picture prediction, orthogonal transformation, quantization, and so on) to each block. Ex. 1001, 1:19-27, Figs. 1, 4. The '238 acknowledges, as it must, that these techniques (described further below) were implemented in various video coding standards by the 1990s.

Id. In other words, the exemplary environment for the VLC entropy coding described by the '238 disclosure is the standard late 1990s video encoding process, as described below.

36. **Blocks:** Video comprises a series of frames (pictures). An encoder subdivides each frame into blocks (*e.g.*, 16 x 16 pixels) that are processed individually. Ex. 1008, Section 4.2.1. Often, coding is also described from the perspective of a decoder, which performs the reverse process, aggregating the blocks to recreate the original picture. *Id.*

37. **Prediction and Residual Block Image:** Prediction is used to achieve enhanced coding efficiency. Two types of common prediction are *inter*-picture prediction, which predicts the block based on a prior frame, and *intra*-picture prediction, which predicts the block based on neighboring blocks. Ex. 1008, Section 4.2.2. But prediction will not be perfect. Quality encoding is maintained, despite the imperfection of the prediction, by capturing and transmitting a “residual image” that represents the difference between the predicted and actual block data. *Id.* H.263 supports both inter-picture and intra-picture prediction. Ex. 1008, 11-12. In Figure 3 of H.263 (shown below in Section VII.B.2), the circle with a negative sign (representing the subtraction of the prediction from the actual block data) illustrates a unit for creating the residual image. Ex. 1008, 9. The decoder

performs the same prediction and adds (versus subtracts) the difference (residual) to recreate the current block.

38. **Transformation:** After creating a residual block, the encoder applies an “orthogonal transformation” (*e.g.*, a Discrete Cosine Transform) to transform the block’s spatial data to frequency data. Ex. 1008, Section 6.2.4, 48 (Annex A). The result of the orthogonal transformation is a matrix of numbers, referred to as “coefficients.” *Id.*

39. **Quantization:** The encoder “quantizes” the data by dividing each element of the matrix by a predetermined value and rounding the result to the nearest integer to remove insignificant values. Ex. 1008, Sections 4.2.4, 6.2. Because some coefficients will round to zero, the output is a set of fewer non-zero coefficients than the transformed residual block image. *Id.* This is a lossy form of compression, such that the coarser the quantization the fewer the number of bits used to represent the coefficients, but the lower the quality of the encoded file.

40. **Entropy Coding / Variable Length Coding:** The encoder finally applies “entropy coding” to convert the quantized coefficients into codewords (*i.e.*, bit representations). Ex. 1008, Section 4.2.1. This process is lossless but still obtains a smaller file size. *Id.* For example, variable length coding (“VLC”) maps frequently occurring coefficients to shorter codewords and less frequently occurring coefficients to longer codewords to achieve compression. *Id.* To

provide a sense of the process, if one were using VLC to code an English language text, compression could be achieved by varying the number of bits used to represent letters such that more common letters, such as the vowels are coded with fewer bits, while uncommon consonants and symbols, such as “z,” are coded with more bits. This would be in contrast to a coding scheme that uses the same number of bits (*e.g.*, 8-bits) to code each letter and symbol in used in the text. Similar to the different frequencies at which English letters appear in a text, a typical set of quantized coefficient residual data will often have the decimal values “0” and “1” occur more frequently than other values and, therefore, their values would be mapped to shorter binary codewords compared to other values. *Id.* These mappings from values to codewords can be stored in a look-up-table.

B. Standards for Video Coding

41. Before the filing of the '238 patent, video coding was largely driven by the activities of international standards organizations that sought to standardize multimedia coding techniques. These standardization groups included International Standards Organization (ISO), the International Telecommunications Union (ITU), and the Joint Video Group.

42. By the early 1990s, the Video Coding Expert Group (VCEG) of ITU-T had developed several multimedia coding standards (*e.g.*, H.324) that focused on videoconferencing over a network. Ex. 1007. As part of this effort, the ITU-T

developed standards for video coding, including H.261 in 1990 and H.263 in 1996. Ex. 1008. The H.263 standard included the above-described, well-known steps of blocking, prediction, generating residuals, orthogonal transforms, quantization, and variable length coding.

43. The ISO/IEC also develops standards through its Moving Pictures Expert Group (MPEG), which has promulgated several well-known standards for video coding. For example, MPEG-1 was the standard in 1991 for storing movies on disk. The MPEG-2 standard, released in 1996, further defined coding for broadcast and storing digital video on DVD. And MPEG-4, released in 1999, defines standards that are still in use for Internet streaming, interactive video, and mobile video communications. For example, ISO/IEC 14496-2:1999, is a standard document for MPEG-24 Part 2.

44. In December 2001, the VCEG of ITU-T and MPEG of ISO/IEC joined to form the Joint Video Team (JVT) to work on a successor to H.263 and further enhancement to MPEG-4. During the early phases of development, the project was known as H.26L. As the JVT finalized their work it was promulgated as the H.264 standard and MPEG-4 Part 10 in 2003. In practice, H.264 was an evolution of H.263 built on the same basic block-based coding structure, but including a variety of refinements to improve coding efficiency. These refinements included, among other things, changes to the VLC coding process.

45. During JVT meetings in late 2001 and early 2002, several members submitted proposals for improved VLC entropy coding techniques, including the use of multiple VLC look-up-tables and prediction of how to know which table to use for encoding. These proposals allowed the VLC to be better optimized to the content being encoded, such as the methods disclosed by Karczewicz.

VI. THE '238 PATENT

46. U.S. Patent No. 7,769,238 (“the '238 Patent” or “the Challenged Patent”) is entitled “Picture Coding Method and Picture Decoding Method.” The '238 patent claims priority to a Japanese application (No. 2002-112665), which was filed on April 15, 2002.

47. For purposes of this declaration, I have been instructed to use April 15, 2002 as the priority date of the '238 Patent, which is its earliest possible priority date. My opinions in this declaration were formed from the perspective of a POSITA as of April 15, 2002, including both the knowledge of a POSITA at that time as well as how a POSITA would have understood the prior art.

48. The '238 patent states that the prior art commonly used a single variable length code (VLC) table to encode the values of each quantized coefficient in a current block. Ex. 1001, 1:28-44. According to the '238, the efficiency of this technique could be improved. *Id.*

49. To improve efficiency, the '238 patent proposes a system that separately encodes a value representing the total number of non-zero coefficients in a block (in addition to the values of the coefficients themselves). For transmission, this count of non-zero coefficients is itself encoded using a VLC table that is selected from a plurality of VLC tables. *Id.* This presents a further challenge because the decoder must know which VLC table is used to encode this value. While the selected VLC table could be expressly included in the transmitted data, that additional data would cut against the efficiencies obtained. Thus, the '238 patent proposes selecting the specific VLC table used to encode the number of non-zero coefficients based on the number of non-zero coefficients in a block located on the periphery of the block being encoded. *Id.*, 1:45-62, 2:11-14, 37:53-57. This process of selecting the VLC table used to encode the number of non-zero coefficients in a block is the detail claimed by the '238 patent. This is the same solution, however, was earlier described by Karczewicz as discussed in further detail below.

50. While the '238 patent describes and claims this concept in the context of a block-based video coding system, it readily admits that fundamental video coding concepts recited in claim 1 were known in the art, including dividing a picture into blocks, creating a residual block image through inter- or -intra-picture prediction, performing orthogonal transformation and quantization of the residual

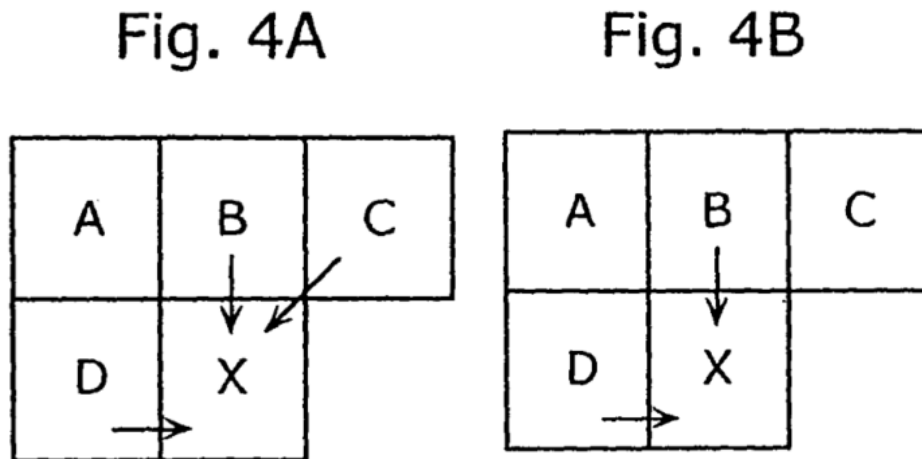
block image, and performing variable length coding (VLC) on the transformed, quantized coefficients representing the residual block image. Ex. 1001, 1:19-27.

51. To improve coding efficiency, because a single VLC table cannot be optimized for all blocks in a frame, the '238 patent proposes using multiple VLC tables for coding the **coefficients**, which can be selected to suit different blocks. *Id.*, 1:42-52. Again, the idea of using multiple VLC tables to code the actual data in the blocks, was known in the art. And it was also known that a good way to organize the various VLC tables used to code block data was based on the number of non-zero coefficients in that block. *Id.*, and 11:25-40, Chart 5. Because this value comes up often, the number of non-zero coefficients for each block will be referred to as " N_C " in this declaration. To correctly decode a block, one will need to know N_C to select the correct VLC table. This metadata is expressly signaled by separately coding N_C and transmitting it with the block's coefficient data. *Id.*, 11:57-60. The '238 patent proposes coding the N_C value itself with one of multiple VLC tables tailored for that purpose. *Id.*, 11:25-60. This requires a mechanism to signal which VLC table was used to code each block's specific instance of N_C . *Id.*, 11:25-60. Rather than expressly providing further metadata identifying the VLC table used in the data stream, the '238 patent proposes picking the VLC table to use for coding based on a prediction of the number of non-zero coefficients in the block to be coded. *Id.*, 1:45-52, 3:25-29. This prediction is made based on the N_C

value of one or more blocks located on the periphery of the current block to be coded. *Id.* This is a subtle point that bears further explanation. The prediction of N_C for a block is used only to select the VLC table used to code the actual N_C value for that block. In other words, the '238 patent teaches that in a table-selecting step, the VLC table for coding N_C is selected based on the predicted value, and in the variable length coding step, the actual N_C contained in the current block is transformed into a variable length code with reference to the VLC table selected. *Id.*, 2:18-24. Then the coefficients themselves are VLC coded with a table selected by that actual N_C .

52. Also, for predicting N_C , the '238 patent discloses that its prediction value is calculated based on an average value of the numbers of the coefficients other than 0 contained in one or more adjacent coded blocks. Ex. 1001, 2:15-17, 39-3:20. Note, while this is a “prediction” of the N_C value for a block, the average value calculation is deterministically provided based on the already decoded actual N_C values of the neighboring blocks. This detail of how the prediction is calculated is not recited in the claims. Nevertheless, as discussed below, Karczewicz describes a very similar, and deterministic function, for its N_C prediction.

53. Figures 4A and B illustrate exemplary embodiments of the relationship between the current block to be coded “X” and the blocks located on the periphery used for prediction “A, B, C, D”:



54. As shown, block “X” is the block currently being coded while blocks B, C, and D are reference blocks that have already been coded. *Id.*, 13:23-26. The encoder predicts the number of non-zero coefficients that will be in block X by considering the number of non-zero coefficients in neighboring blocks B, C, and D (Figure 4A) or in neighboring blocks B, and D (Figure 4B). *Id.*, 13:23-51. The predicted value is used to select a particular VLC table from a plurality of VLC tables and used to code the **actual** number of non-zero coefficients for the block to be coded. *Id.*, 11:22-49. Chart 5, below, shows an exemplary relationship between the predicted value and selected table. *Id.*

CHART 5	
Predictive value	Reference table
0~1	VLC table 1
2~3	VLC table 2
4~6	VLC table 3
7~16	VLC table 4

55. The selected VLC table is used to code the number of non-zero coefficients. *Id.*, 1:45-52. In other words, once the actual number of non-zero coefficients in the block X is determined, that value is coded using the previously selected VLC table. *Id.*, 3:33-37. This is because the decoder will not know the actual number of non-zero coefficients in a block until the block is decoded. But the decoder will know the number of non-zero coefficients that were previously decoded in neighboring blocks.

56. The only claim of the '238 patent recites a receiving apparatus configured to decode picture data using this technique. *Id.*, 38:47-60 (Claim 1). Generally, the '238 patent describes the decoding process as reversing the steps performed by the encoder. *Id.*, 3:21-42, 22:43-58, 27:18-33. The picture data is otherwise coded and decoded using well-known concepts (*e.g.*, block coding, orthogonal transformation, and quantization). *Id.*, 38:20-29.

A. Prosecution History

57. The '238 patent, application No. 11/976,758, claims priority to foreign application JP 2002-112665.

58. The applicant added the single claim, as issued, via a September 29, 2008, preliminary amendment. Ex. 1002, 215-218. The '238 patent issued on August 3, 2010, without any substantive Office Action rejections or amendments to the claims. Ex. 1002, 496-504.

B. Prior IPR Challenges

59. I understand that the '238 patent was previously involved in two IPR challenges: IPR2018-00658 and IPR2022-00628.

60. The PTAB denied institution of IPR2018-00658 because the applied prior art (JVT-B045) allegedly did not disclose '238 patent element [1-I]. Ex. 1012 (IPR2018—00658, Paper 14), pp. 16-19, 29-32. The Board reasoned that “JVT-B045 determines the number of non-zero coefficients in the ‘*last* coded block,’ which is a temporal relationship,” whereas the claim “recites determining a predictive value based on a ‘spatial relationship’—the current block ‘located on a periphery of the current block’.” *Id.*, p. 17. This spatial relationship is shown in Figures 4A and B of the '238 patent.

61. The Patent Owner did not dispute that the proposed combination of H.324, H.263, and JVT-B045 taught all remaining claim elements of the '238 patent. Ex. 1012 (IPR2018—00658, Paper 14), p. 10.

62. The PTAB rejected IPR2022-00628 because the Patent Owner successfully established the effective filing date of the '238 patent extended to the

filing date of its foreign application, thereby antedating the asserted prior art necessary to the grounds in that petition. Ex. 1013 (IPR2022-00628, Paper 10), p. 2.

C. Claim Construction

63. I am not a legal expert or an attorney and offer no opinions on the law. I understand that claim construction is a matter of law. However, I have been informed by counsel of the legal standards that apply to claim construction in an *inter partes* review, and I have applied them in forming my opinions. I understand that during an *inter partes* review, the same claim construction standard used in federal district court is applied when addressing the meaning of claim terms.

64. I have been informed that the words of a claim are generally given the ordinary and customary meaning that the term or phrase would have to POSITA at the time of the invention in view of the surrounding claim language, the specification and the file history (collectively, the “intrinsic evidence” or “intrinsic record”).

65. I also understand that courts may consider extrinsic evidence, such as expert and inventor testimony, dictionaries, and learned treatises (collectively, the “extrinsic evidence” or the “extrinsic record”), but that such extrinsic evidence should be given less weight than the intrinsic evidence.

66. In my opinion, the terms of Claim 1 of the '238 patent do not require further construction and can be interpreted according to its ordinary meaning for purposes of the analysis of the prior art that I am conducting in this declaration.

VII. THE PRIOR ART

A. Karczewicz

67. International Publication No. WO 03/063501 (hereinafter “Karczewicz”) is entitled “Coding Transform Coefficients in Image/Video Encoders and/or Decoders.” Ex. 1004, (54). Karczewicz’ first priority claim, application No. 10/054,610, was filed on January 22, 2002. Ex. 1005; Ex. 1004, (30). Karczewicz’ second priority claim, application No. 60/369,500, was filed on April 2, 2002. Ex. 1006; Ex. 1004, (30).

68. In International Publication No. WO 03/063501, Marta Karczewicz—who is a named inventor on nearly 700 patents in the video encoding space—describes conventional methods of VLC and recognizes that there is a continuing desire to improve data compression efficiency. Ex. 1004, 1:14-26:13. Specifically, Karczewicz describes the benefits of new methods of VLC that are adaptable to the statistical properties of the data to be coded, while maintaining low computational complexity, low memory requirements, and good error resilience. Ex. 1004, 26:13-17, 22-26.

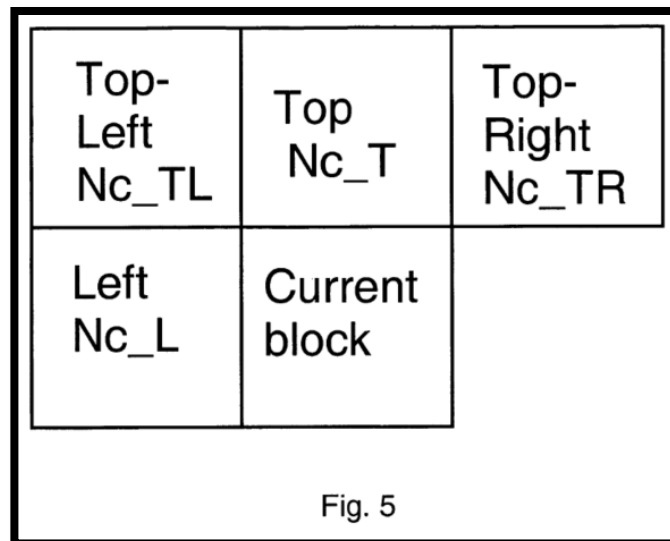
69. Karczewicz proposes a method of variable length coding of quantized transform coefficients produced from block-based transform coding in a video encoder. Ex. 1004, 2:18-3:3, 19:9-20:29, 26:13-17, 22-26, 28-30. Indeed, Karczewicz expressly identifies the ITU H.26L coder development as the background that the disclosed system is improving. *Id.* 2:18-3:3, 19:9-20:29, 26:13-17, 22-26; *see also* Ex. 1006, p. 1:4-10, 2:21-3:23, 4:14-30, 7:1-28, Appendix 1 (ITU Question Q.15/SG16), Appendix 2 (JVT-B072), Appendix 3 (JVT-B118), p. 10.

70. Karczewicz recognized that the data in different blocks might have different statistical properties that would result in one VLC table being more efficient than another. Ex. 1004, 10:1-11, 19:9-22, 23:21-32. For example, because in image coding, the frequency of occurrence (*i.e.*, probability) of different transform coefficients, and hence the probability of different (run, level) pairs, changes depending on the image content and the type of image being encoded. *Id.* Thus, if a single set of variable length codewords is used and only a single mapping between data symbols to be encoded/decoded and VLCs is provided, optimum coding efficiency cannot be achieved. *Id.* Thus, tailoring the VLC table to the data would gain coding efficiency. *Id.*

71. Karczewicz, thus, proposes a method of VLC coding using multiple VLC tables for coding. Ex. 1004, 33:29-34:9. The particular table used to code a

block is based on the number of non-zero-value coefficients, N_C , in a block of quantized transform coefficients, which is signaled explicitly in the bit-stream transmitted to a corresponding decoder. Ex. 1004, 27:1-5. Karczewicz further teaches that N_C is itself VLC coded, which “provides a still greater improvement in coding efficiency.” Ex. 1004, 27:7-10. The method involves the use of at least two sets of VLC codewords (i.e., VLC tables) to encode N_C and defines rules for switching between the VLC tables based on the number of non-zero-valued coefficients in a block (or blocks) neighboring the block whose N_C value is to be coded. Ex. 1004, 27:12-16.

72. Figure 5 of Karczewicz shows a current image block to be coded and the N_C values for its immediately neighboring, previously encoded image blocks:



Ex. 1004, 31:28-29, 34: 11-14, Fig. 5. The terms N_{C_L} , N_{C_TL} , N_{C_T} , and N_{C_TR} denote respectively the number of non-zero quantized coefficients in the blocks to

the left, top-left, top, and top-right of the current image block to be encoded. Ex. 1004, 34: 11-14, Fig. 5. The N_C value for the current image block is variable length encoded using a codeword from one of the available sets of VLC codes, chosen by considering the already coded N_C value(s) of immediately neighboring block(s). Ex. 1004, 34: 11-14, Fig. 5.

73. Karczewicz describes an exemplary procedure for assigning a variable length code to an N_C value, taking into account the N_C values of the previously encoded neighboring blocks on the periphery of the current block:

$$\text{VLC_N} = N_{c_map}[fn(N_{c_L}, N_{c_TL}, N_{c_T}, N_{c_TR})]$$

$$\text{VLC_N} = N_{c_map}[fn(N_{c_L}, N_{c_TL}, N_{c_T}, N_{c_TR})] \quad (1)$$

Ex. 1004, 34:16-35:10. In the above expression, fn is a function that can be represented as:

$$\text{VLC_N} = N_{c_map}[(N_{c_L} + N_{c_T})/2]$$

$$\text{VLC_N} = N_{c_map}[(N_{c_L} + N_{c_T}) / 2] \quad (2)$$

Id. N_{c_map} is an array that maps integer values to different available VLC codes and VLC_N indicates the number of the table from which the codewords are to be selected. Examples of fn include “average” or “median.” *Id.*

74. Karczewicz represents one of several disclosures directed to the use of multiple VLC tables. For example, in the prior IPR challenges against the '238 Patent, both of JVT-B-45 (Ex. 1010) and U.S. Patent No. 7,099,387 (Ex. 1011) to Bjontegaard disclose the use of multiple VLC tables to encode values of coefficients in a current block. However, I understand that, despite acknowledging that the use of multiple VLC tables was known, Patent Owner made the slight distinction that Bjontegaard instead taught a predictive value (for selecting a particular VLC table) that was based on a temporal relationship (*e.g.*, determines prediction based on a last coded block) rather than the claimed spatial relationship (*i.e.*, "located on a periphery of the current block"). Ex. 1012 (IPR2018—00658, Paper 14), pp. 16-19, 29-32.

75. As discussed above in Sections V.B and V.C, the '238 patent's prosecution history and subsequent IPR challenges show the only concept claimed in the '238 patent that the standards documents (discussed below) do not allegedly teach is the determination of a predictive value for the number of non-zero coefficients in a current block based on the number of non-zero coefficients included in decoded blocks located on a periphery of the current block. However, Karczewicz disclosed this predictive relationship before the '238 patent.

1. **Karczewicz Provisional Application No. 60/369,500**

76. As mentioned above, Karczewicz claims priority to two applications. Karczewicz' first priority claim, application No. 10/054,610, was filed on January 22, 2002. Ex. 1005; Ex. 1004, (30). Karczewicz' second priority claim, application No. 60/369,500, was filed on April 2, 2002. Ex. 1006; Ex. 1004, (30). I understand that for Karczewicz to claim the benefit of a provisional application, the provisional application must provide written support for both at least one of the claims of the publication and the subject matter relied upon in the invalidity analysis.

77. It is my opinion that at least the provisional application No. 60/369,500, which was filed on April 2, 2002 (Ex. 1006), provides written description support for both at least one of the claims of the Karczewicz publication (Ex. 1004) and the publication's subject matter relied upon in the petition.

78. Claim 1 of Karczewicz reads as follows:

1. A method of encoding a set of data symbols

comprising a certain first number of data symbols having a first value and a certain second number of data symbols having values other than said first value, in which a set of symbols to be variable-length encoded is formed from said set of data symbols, and variable-length encoding is applied to said set of symbols to be variable-length encoded,

characterised in that at least one characteristic of the variable length encoding applied to the set of symbols to be variable-length encoded is adapted according to the number of the symbols to be variable-length encoded and that an indication of the number of variable-length encoded symbols is provided, said indication being a variable length codeword representative of said number of symbols to be variable length encoded selected from one of at least two alternative sets of variable length codewords according to said number of symbols to be variable length encoded.

79. This claim is fully supported by Karczewicz 60/369,500 provisional patent application (“Karczewicz ’500 Provisional”). The Karczewicz ’500 Provisional discloses “a method of encoding a set of data symbols.” Of course, video coding is a process for encoding data symbols. Consistent with this, the Karczewicz ’500 Provisional specifically states that its “invention relates to a method, a system and a device for the coding of digital video. More specifically, the invention concerns the coding of quantised transform coefficients produced as a result of block-based transform coding in a video/image encoder/decoder using Variable Length Coding (VLC).” *Id.* at p. 1:12-14; *see also* 8:5-11 (“The invention relates to the variable length coding of the quantized transform coefficients produced as a result of block-based transform coding in a video encoder. The method according to the present invention seeks to address the aforementioned problems relating to improving the adaptability of variable length coding methods

to the type and statistical properties of the data symbols to be coded while maintaining low computational complexity and good error resilience. One aim of the invention is to provide new and more efficient schemes for coding of (*run*, *level*) pairs representing non-zero-valued quantized transform coefficients.”).

80. The method disclosed comprises “a certain first number of data symbols having a first value and a certain second number of data symbols having values other than said first value.” This limitation reflects quantised transform coefficients have a certain first number of zero value coefficients and a certain second number of non-zero value coefficients. Karczewicz 60/369,500 Provisional Application, 1:20-2:5. The coefficient values are categorized into zero and non-zero groups to allow (run, level) encoding. Run, Level encoding involves a “run,” representing the number consecutive zeros valued coefficients before a non-zero coefficient. The claim represents this concept as “a certain first number of data symbols having a first value”. The “level” is non-zero and represents “a certain second number of data symbols having values other than said first value”). Karczewicz 60/369,500 Provisional Application, 1:20-2:5 (“Typically, each non-zero quantised coefficient in the one dimensional array is represented by two values, referred to as level and run. Level is the value of the quantised coefficient and run is the number of consecutive zero-valued coefficients preceding the coefficient in question. A level value equal to zero is used to indicate that there are

no more non-zero coefficient values in the block. This 0-level value is referred to as an EOB (end-of-block) symbol.”); *see also* 7:1-28. Run, Level coding has the advantage of not having to separately code each zero valued coefficient. Instead, you merely record the number of zeros in a row before the next non-zero coefficient. The Karczewicz system separately encodes the number of non-zero coefficients in a block. N_c is assigned to that number and is used to signal explicitly the number of non-zero coefficient values in the array, then N_c reflects the claimed certain second number and $16 - N_c$ reflects the claimed certain first number. Karczewicz 60/369,500 Provisional Application, 10:1-28.

81. Karczewicz’s ’500 Provisional further discloses “in which a set of symbols to be variable-length encoded is formed from said set of data symbols, and variable-length encoding is applied to said set of symbols to be variable-length encoded.” Karczewicz 60/369,500 Provisional Application, 9:11-13 (“The invention proposes a method of VLC coding of the number of non-zero coefficients in the block. **We also propose a method of VLC coding of (run, level) pair corresponding to the non-zero coefficients within the block.**”) (emphasis added). *See also* Karczewicz 60/369,500 Provisional Application, 2:1-3 (“Typically, each non-zero quantised coefficient in the one dimensional array is represented by two values, referred to as level and run [**a set of symbols**]. Level is the value of the quantised coefficient and run is the number of consecutive zero-

valued coefficients preceding the coefficient in question.”). Karczewicz further discloses that multiple different tables, *i.e.*, mappings, are used to to encode the run, level symbols. Karczewicz 60/369,500 Provisional Application, 9:19-23 (“At least two sets of mappings are provided for relating the (run,level) pairs to the code numbers. Each (run, level) pair is first mapped to a code number using the mapping table selected from one of the at least two sets of mappings responsive to the value of max_run, defined to be the maximum value that a run can take. Max_run is initialized by considering the number of non-zero coefficients within the block and is updated after encoding of each (run, level) pair.”).

82. The Karczewicz '500 Provisional's method is “characterised in that at least one characteristic of the variable length encoding applied to the set of symbols to be variable- length encoded is adapted according to the number of the symbols to be variable-length encoded.” Given the use of multiple VLC mappings to encode the coefficient data, a mechanism must be provided to choose which mapping to use for a given set of coefficients. Karczewicz, thus, discloses that the mapping between VLC codewords and values, *i.e.*, one characteristic of the VLC applied, is based on, or adapted according to, the number of non-zero valued data symbols to be encoded. Karczewicz 60/369,500 Provisional Application, 8:25-34 (“Another aim of the invention provides improved coding performance for encoding of non-zero quantised transform coefficients. The invention establishes a

relationship between the number of non-zero-valued data symbols, the codewords used to represent the (run, level) pairs and the mappings between the (run, level) pairs and the codewords. ***The mapping between codewords and (run,level) is also dependent on the number of non-zero-valued data symbols***). Karczewicz explains its reasoning for using the N_C value to select the VLC mapping used for coding the coefficients. Karczewicz 60/369,500 Provisional Application, 10:19-12:1 (“When the number of nonzero coefficients is large, say close to the total size of the array, it is observed that (run,level) pairs with small value of run and high value of level have higher probability.”).

83. The Karczewicz '500 Provisional's method discloses that “an indication of the number of variable-length encoded symbols is provided, said indication being a variable length codeword representative of said number of symbols to be variable length encoded.” This is the N_C value representing the number of non-zero encoded coefficients in the block. And the Karczewicz '500 Provisional describes VLC encoding N_C . Karczewicz 60/369,500 Provisional Application, 9:12-17 (“At least two sets of variable length codewords are provided for variable length coding the number of non-zero coefficients in the block, denoted by the N_C symbol.”). The Karczewicz '500 Provisional provides examples of how the N_C symbol is encoded. Karczewicz 60/369,500 Provisional Application, 10:14-18.

84. The Karczewicz '500 Provisional further discloses that the VLC table used to encode the N_C symbol is “selected from one of at least two alternative sets of variable length codewords according to said number of symbols to be variable length encoded.” Karczewicz expressly states “[a]t least two sets of variable length codewords are provided for variable length coding the number of non-zero coefficients in the block, denoted by the N_C symbol.” Karczewicz 60/369,500 Provisional Application, 9:10-18 (“An N_C symbol is variable length coded using a codeword selected from one of the at least two sets of variable length codewords responsive to the values of previously coded N_C symbols. The previously coded N_C symbols that are used to assign VLC codewords could be advantageously chosen from the blocks that reside close to the block in question.”). I note that there appear to be a couple of minor typos in the Karczewicz 60/369,500 Provisional Application (Ex. 1006). However, neither of these simple typographical errors would affect a POSITA’s understanding of the reference nor my analysis of this prior art reference. For example, in Karczewicz 60/369,500 Provisional Application (Ex. 1006) at 10:14-18, Karczewicz explains that “[u]sing equation (2), VLC_N becomes 2. Then $N_C=3$ will be encoded as 0100 using Table 5 with $VLC2$.” However, a POSITA would readily understand that using equation (2), VLC_N becomes 1, because the average of N_{C_L} and N_{C_T} is $(4+2)/2=3$. Then the 4th place (index=3) of N_C_map is “1”. Therefore, $N_C=3$ will be encoded as

00100 using VLC1(Table2). Similarly, in Karczewicz 60/369,500 Provisional Application (Ex. 1006) at 10:19-12:1, Karczewicz assumes 5 non-zero coefficients in a block with run-level pairs (2,1),(3,2),(4,3),(2,3),(1,2). Karczewicz then explains that “[a]t the beginning of encoding of the block, since there are 5 non-zero coefficients and there can be at most 16 non-zero coefficients, run could take a value at most 11 [denoted as max_run]. After encoding the first pair, that is (2,1), max_run will decrease, precisely it will become 12.” However, a POSITA would readily recognize based on the surrounding disclosure that the max-run should be decremented to 10 rather than increased to 12 in this example. Again, these minor typos do not affect my analysis of the relevant sections of the prior art, nor would they affect a POSITA’s understanding of the teachings of Karczewicz’s provisional.

85. To show that Karczewicz captured the relevant concepts of the ’238 patent claims from its earliest provisional, in Section VIII below, for every disclosure relied upon in the Petition from Karczewicz (Ex. 1004), I provide corresponding citations to the disclosures from the Karczewicz 60/369,500 Provisional Application (Ex. 1006). For ease of reference, this is also attached as Ex. 1009, which compares the disclosures relied upon in the Petition from Karczewicz (Ex. 1004) in the left column and the corresponding disclosures from the Karczewicz 60/369,500 Provisional Application (Ex. 1006) in the right column.

As the chart and my corresponding citations show, the Karczewicz 60/369,500 Provisional Application discloses all of the concepts relied on in Karczewicz. Again, this list is not exhaustive, and any absences from the chart should not be taken as indicative of any material difference between the references.

86. As shown above, the Karczewicz 60/369,500 Provisional fully supports Karczewicz' disclosure of at least Claim 1. Thus, I understand that Karczewicz is entitled to a priority date earlier than its January 22, 2003 filing date, namely an effective filing date of at least April 2, 2002. And the disclosure of the April 2, 2002, provisional renders obvious the '238 patent as discussed at length below.

87. I have only been asked to address the priority claim to the April 2, 2002, Provisional Application No. 60/369,500, which sufficiently predates the priority of the '238 patent. Although Karczewicz additionally claims priority to an earlier filed January 22, 2002, non-provisional, the subject matter relied on herein is fully supported by the Karczewicz 60/399,500 Provisional Application. I reserve the right to rely on the earlier filed non-provisional priority should Patent Owner claim an earlier priority date.

B. Multimedia and Coding Standards

88. Significant advancements in multimedia compression in the 1990s were driven by international standards organizations, who sought to standardize

multimedia coding techniques. For example, the ITU-T developed each of H.323 and H.324 with a focus on videoconferencing over a network. The ITU-T also developed the prior art H.261 and H.263 for video coding. Together, the H.324 and H.263 standards collectively define the basic elements of a multimedia coding system, including a demultiplexer, an audio codec, a video codec that implements block-based coding, prediction, transformation, quantization, and variable length coding.

1. H.324 (Ex. 1007)

89. The ITU-T developed an international standard for videoconferencing over a General Switch Telephone Network (GSTN). GSTN was designed for both audio and video. As such, it includes features related to the coding of audio and networking. This standard was presented in the initial publication of H.324 in March 1996, with a revision published in February 1998. Ex. 1007.

90. Terminal devices compatible with H.324 can process real-time voice, data, video, and combinations thereof. Ex. 1007, I (Summary). H.324 further specifies video and audio codecs to perform compression and decompression. Figure 1 (annotated below) of H.324 shows a standard compliant multimedia videophone system:

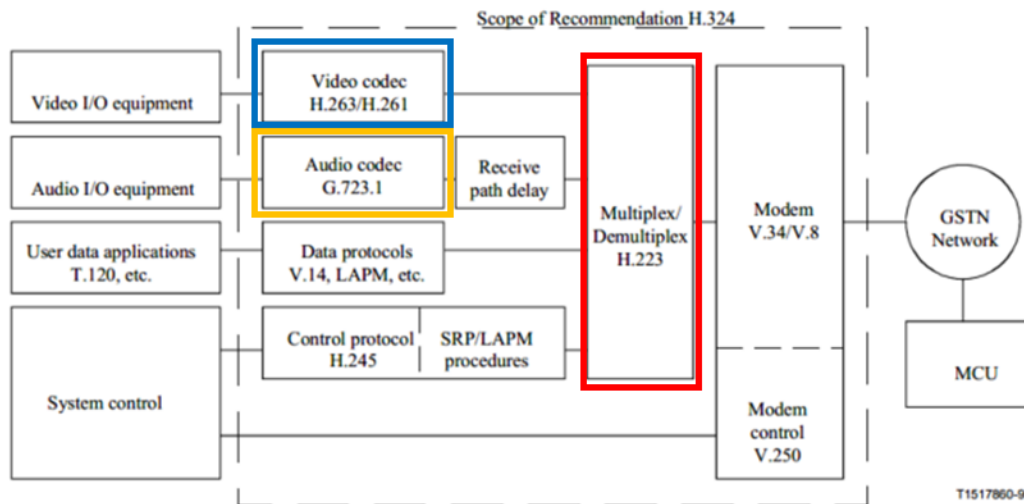


Figure 1/H.324 – Block diagram for H.324 multimedia system

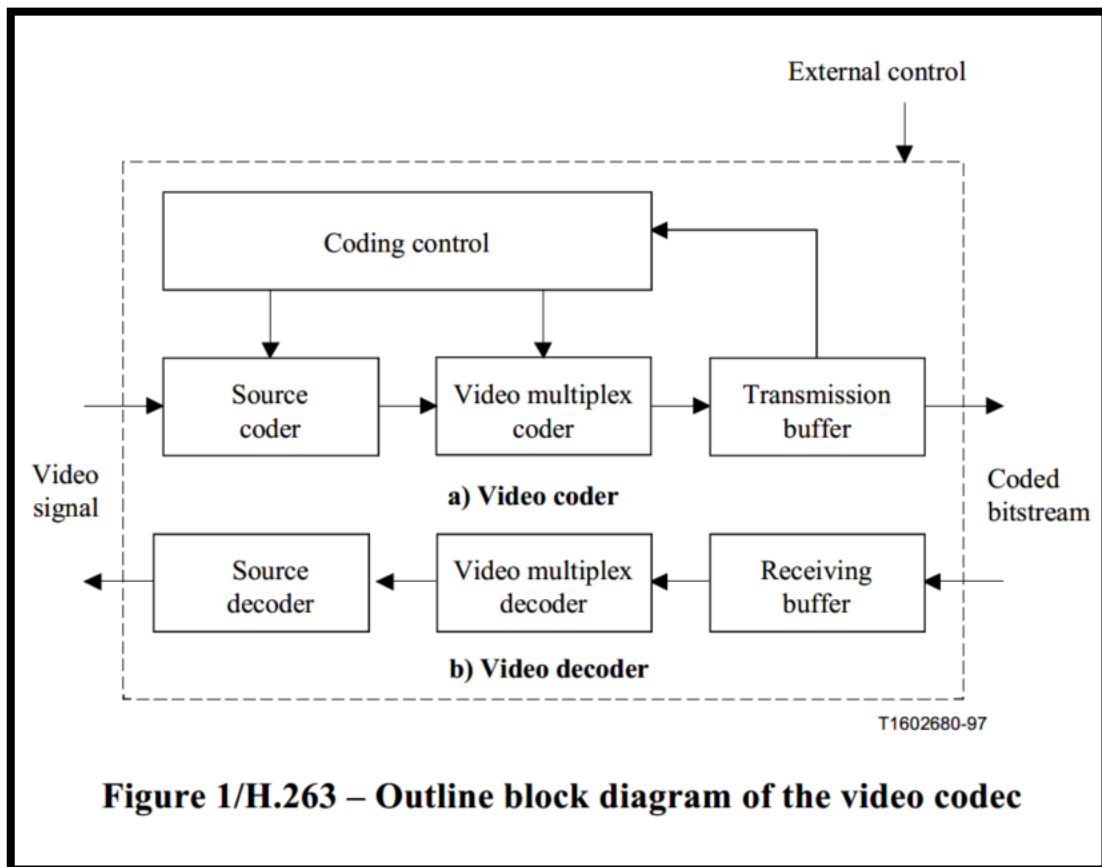
As shown, the system includes a video codec (blue rectangle) and audio codec (orange). The audio codec is described as a dual-rate audio and speech coder for multimedia communications and specifically recommends the use of H.263 as compatible video codcs. Ex. 1007, 2-3. The system also includes a multiplexer/demultiplexer (red) that, based on the H.223 standard, multiplexes transmitted video, audio, data, and control signals into a single bitstream and demultiplexes a received bitstream into its components parts. Ex. 1007, 2, 7.

2. H.263 (Ex. 1008)

91. The ITU-T developed and approved the H.263 standard in March 1996. Ex. 1008. H.263 specifies a video coding scheme for the compression of the moving picture element of audio-visual services at low bit rates. Ex. 1008, i.

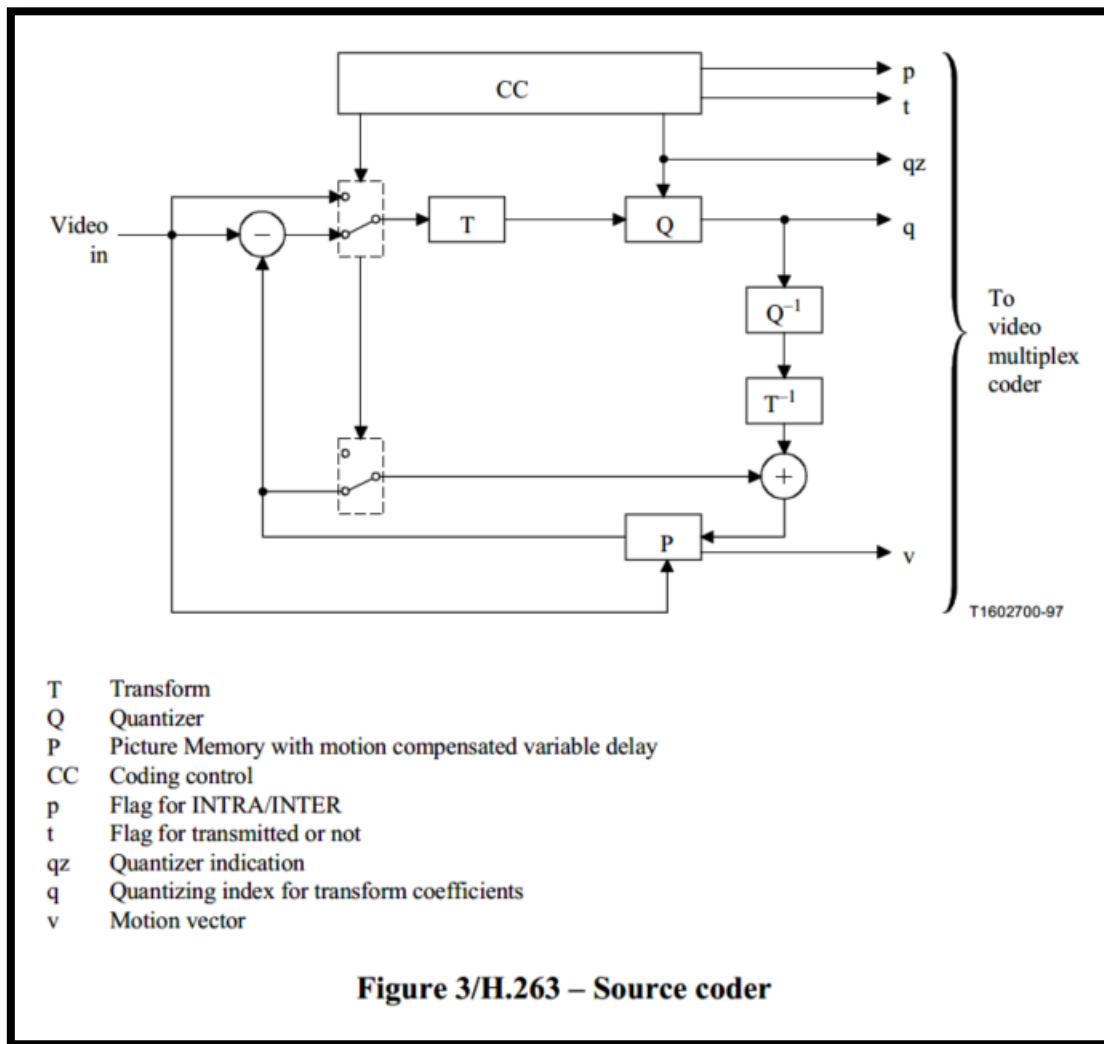
(Summary). A second version of the H.263 standard was released in February 1998, which is fully compatible with the first revision. *Id.*, 1.

92. H.263 discloses a block diagram of a video codec in Figure 1:



93. The video encoder provides a digital bitstream that may be combined with audio signals. Ex. 1008, 2. The video decoder performs the reverse process. *Id.*

94. A detailed diagram of the video encoder of Figure 1 is shown in Figure 3:



C. Motivation to Combine Karczewicz and H.324 and H.263

95. A POSITA would have found it obvious to combine Karczewicz, H.324, and H.263 for many reasons. Multimedia compression was a crowded art, based on concepts that were well understood, predictable, and routinely combined as needed to achieve a POSITA's design goals.

96. First, the POSITA would have been motivated to combine H.324 with H.263. Because H.324 expressly mandates that all compliant terminals offering

video communication shall support H.263 video (Ex. 1007, p. 6 (Clause 6.1 Required Elements)), the H.324 essentially makes the proposed combination itself. Consistent with this, H.263 expressly references H.324 as a compatible standard. Ex. 1008, p. 2 (Clause 2 References).

97. A POSITA would be further motivated to combine Karczewicz's coefficient number coder with the video coding systems and methods described in H.263 to predictably improve coding efficiency. In 1999-2001 timeframe, POSITA's were actively looking for ways to improve on existing ITU and ISO standards. Indeed, the ITU and MPEG formed a joint taskforce, the JVT, expressly for that purpose, which was known as H.26L. The express goal of these efforts was to build upon and improve the basic predictive and block coder framework of the H.263. Indeed, the VLC coding disclosed by Karczewicz simply involves the non-lossy coding improvement of values included the H.263 standard, namely blocks with a certain number of non-zero coefficients.

98. Consistent with this, Karczewicz expressly teaches that its video codec is H.263 compliant. Ex. 1004, Fig. 8. Indeed, Karczewicz expressly frames its disclosure in the context of improvements to these international standards. The combination of Karczewicz, H.324, and H.263 involves the application of a known technique (*i.e.*, encoding the number of non-zero coefficients in a block based on neighboring blocks) to known standards (H.324 and H.263) that were continually

looking for improvements. For example, the proposed solution in Karczewicz expressly references video coding recommendations from the ITU-T and addresses the need to improve methods of variable length coding that provide improved adaptability to the type and statistical properties of the data symbols to be coded while maintaining low computational complexity, low memory requirements, and good error resilience. Ex. 1004, 2:18-3:3, 19:9-20:29, 26:13-17, 22-26; *see also* Ex. 1006, p. 1:4-10, 2:21-3:23, 4:14-30, 7:1-28, Appendix 1 (ITU Question Q.15/SG16), Appendix 2 (JVT-B072), Appendix 3 (JVT-B118), p. 10.

99. I discuss additional details regarding why a POSITA would have been motivated to combine Karczewicz, H.324, and H.263 with respect to the particular claims at issue in Section VIII.A below.

VIII. THE CHALLENGED '238 PATENT CLAIMS ARE UNPATENTABLE OVER THE PRIOR ART

A. GROUND 1: Claim 1 Is Obvious Over Karczewicz In Combination With H.324/H.263

1. Independent Claim 1

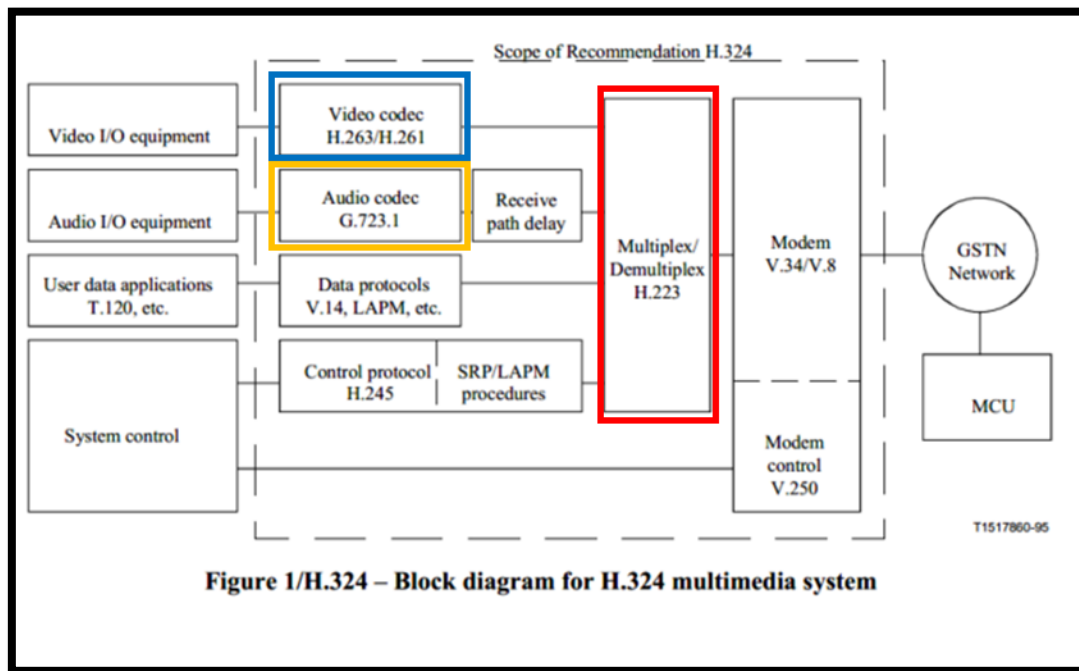
100. In my opinion, Karczewicz alone or in combination with H.324/H.263 renders Claim 1 of the '238 patent obvious.

a) **[1-PRE]**

101. Karczewicz alone or in view of H.324 and H.263 discloses “[a] receiving apparatus which receives multiplexed data which is obtained by multiplexing coded audio data and coded picture data.”

102. As I discussed above, this limitation recites basic coder features. Both Karczewicz and the inventors of the ’238 patent were working on improving existing standards defined encoders, such as those encoders compliant with H.324/H.263. In other words, both Karczewicz and the inventors of the ’238 patent recognized that this element was not only known in the art, but also defined in international standards. Ex. 1012 (IPR2018—00658, Paper 14), p. 10 (“Patent Owner does not dispute Peittioner’s contentions [applying H.324 and H.263] regarding the limitations of claim 1, except for limitation [1j].”). In fact, the Patent Owner—to support its earliest priority claim to a Japanese reference—argued that although the ’238 priority document did not expressly disclose an *audio* coding device, one of ordinary skill in the art would have known that the priority document was improving upon known standards (*e.g.*, H.26L and H.324) that coded both audio and video in multiplexing systems as required by claim 1’s preamble. Ex. 1013 (IPR2022-00628, Paper 10), pp. 11-22.

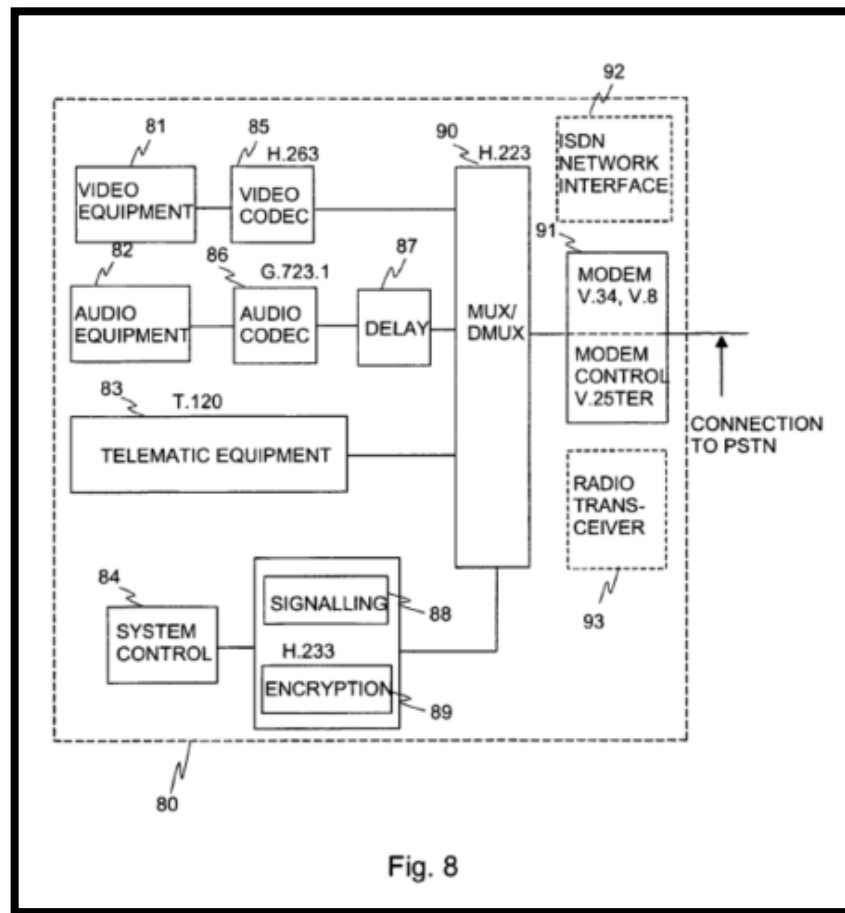
103. Consistent with Patent Owner's admissions, **H.324** discloses multimedia telephone terminals (Ex. 1007, 1), including Figure 1 that shows a generic multimedia videophone system:



104. The system includes a video codec (blue rectangle) and audio codec (orange). The audio codec is described as a dual-rate audio and speech coder for multimedia communications and the video codec uses H.263 or H.261 video coming schemes that share the same basic encoder/decoder structures. Ex. 1007, 2-3. The system also includes a multiplexer/demultiplexer (red) that, based on the H.223 standard, which demultiplexes a received bitstream into video, audio, data, and control signals. Ex. 1007, 2, 7.

105. Thus, it is my opinion that **H.324** also teaches a receiving apparatus which receives multiplexed data which is obtained by multiplexing coded audio data and coded picture data.

106. **Karczewicz** confirms its compatibility with a multimedia terminal 80 that includes video equipment 81, audio devices 82, and telematic devices 83 was well known. Ex. 1004, Fig.8 (shown below), p. 44:5-15, 17-27, 29-45:6; *see also* Ex. 1006, p. 1:16-18, 2:21-30, Appendix 3 (JVT-B118), p. 10. The video equipment 81 includes a monitor for displaying received video content and optional video processing equipment. Ex. 1004, p. 44:5-15; *see also* Ex. 1006, p. 1:16-18, 2:21-30, Appendix 3 (JVT-B118), p. 10. The audio equipment 82 typically includes a loudspeaker for reproducing received audio content. Ex. 1004, p. 44:5-15; *see also* Ex. 1006, p. 1:16-18, 2:21-30, Appendix 3 (JVT-B118), p. 10.



107. When a multiplexed and possibly encrypted multimedia bit-stream is being received, MUX/DMUX unit 90 is responsible for decrypting the bit-stream, dividing it into its constituent multimedia components and passing those components to the appropriate codec(s) and/or terminal equipment for decoding and reproduction. *Id.*

b) **Element [1-A]**

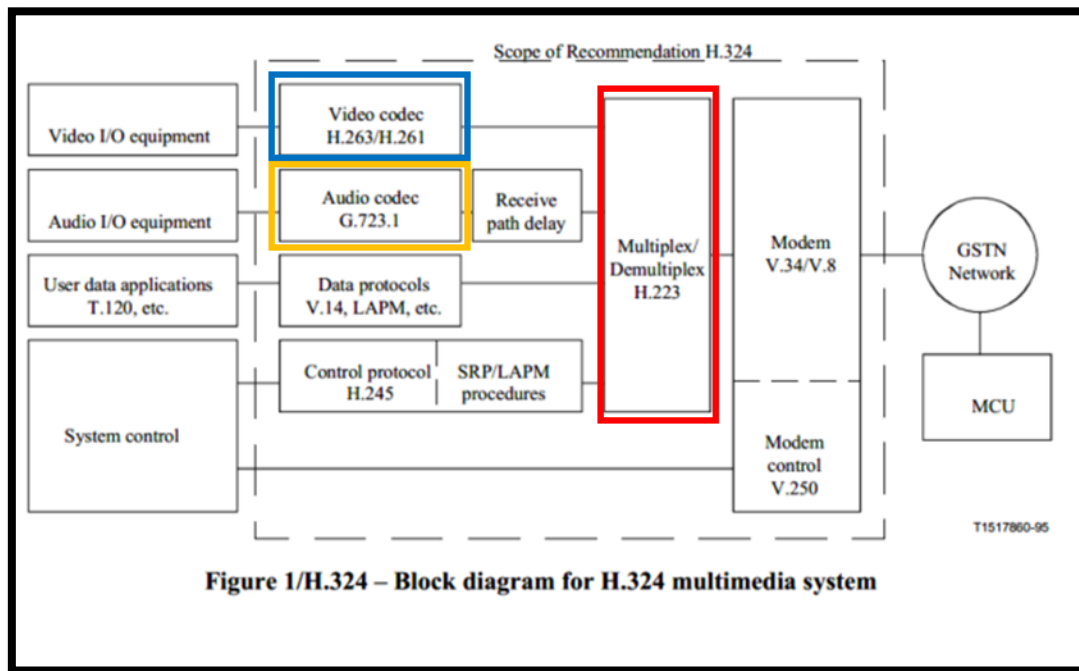
108. In my opinion, Karczewicz alone or in combination with H.324 and H.263 discloses “a demultiplexing unit configured to separate the multiplexed data

into the coded audio data and the coded picture data.” The ’238 patent shows only a block-level functional description of a multiplexing/demultiplexing unit and assumes a POSITA would understand how to implement such a unit. Ex. 1001, 36:23-26; Fig. 29.

109. This limitation recites basic coder features. Again, the inventors of the ’238 patent admitted that this element was not only known in the art, but also defined in international standards. Ex. 1012 (IPR2018—00658, Paper 14), p. 10. To support its earliest priority claim to a Japanese reference, Patent Owner asserted the priority document was improving upon known standards (*e.g.*, H.26L and H.324) that coded both audio and video in multiplexing systems as required by claim 1’s element 1-A. Ex. 1013 (IPR2022-00628, Paper 10), pp. 11-22.

110. I understand that Patent Owner argued **H.324** showed a demultiplexing unit configured to separate the multiplexed data into the coded audio data and the coded picture data. Ex. 1013 (IPR2022-00628, Paper 10), pp. 11-22; Ex. 1012 (IPR2018—00658, Paper 14), p. 10.

111. For example, **H.324** requires a Multiplex Protocol (H.223), which specifies a demultiplexing unit that separates a received multimedia bit stream into video, audio, data, and control streams. Ex. 1007, 2, 6. The demultiplexing unit is shown in Figure 1 in red.



112. **Karczewicz** confirms that its system was compatible with this well-known process and teaches that when a multiplexed and possibly encrypted multimedia bit-stream is being received, the MUX/DMUX unit 90 is responsible for decrypting the bit-stream, dividing it into its constituent multimedia components and passing those components to the appropriate codec(s) and/or terminal equipment for decoding and reproduction. Ex. 1004, Fig. 8, p. 45: 19-28; *see also* Ex. 1006, p. 1:16-18, 2:21-30, Appendix 3 (JVT-B118), p. 10.

113. Karczewicz alone or in combination with H.324 and H.263 thus teaches a demultiplexing unit configured to separate the multiplexed data into the coded audio data and the coded picture data.

c) **Element [1-B]**

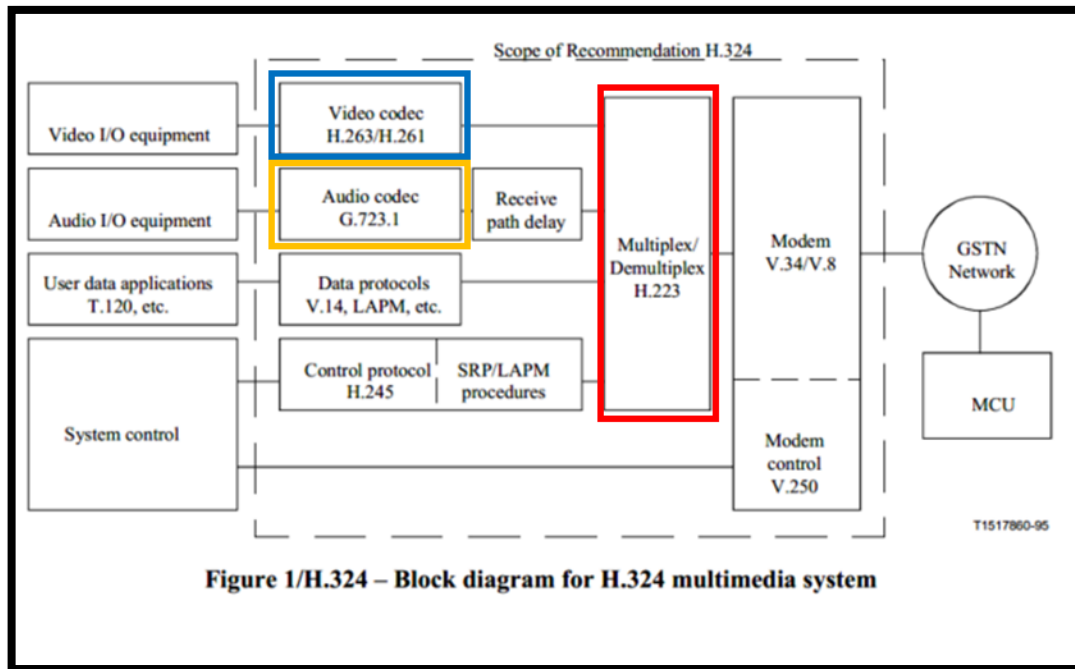
114. In my opinion, Karczewicz in combination with H.324 and H.263 discloses “an audio processing unit configured to decode the separated coded audio data.”

115. This limitation recites basic coder features. Again, the inventors of the '238 patent admitted that this element was not only known in the art, but also defined in international standards. Ex. 1012 (IPR2018—00658, Paper 14), p. 10. To support its earliest priority claim to a Japanese reference, Patent Owner asserted the priority document was improving upon known standards (*e.g.*, H.26L and H.324) that coded both audio and video in multiplexing systems as required by claim 1's element 1-B. Ex. 1013 (IPR2022-00628, Paper 10), pp. 11-22.

116. As with the preamble and element 1A, I understand that Patent Owner argued **H.324** showed an audio processing unit configured to decode the separated coded audio data. Ex. 1013 (IPR2022-00628, Paper 10), pp. 11-22; Ex. 1012 (IPR2018—00658, Paper 14), p. 10.

117. For example, **H.324** requires an Audio Codec (G.273.1), which is an audio processing unit that decodes the audio stream separated from the bit stream by the demultiplexing unit. Ex. 1007, 2, 6. Specifically, H.324 teaches that the Audio Codec “encodes the audio signal from the microphone for transmission, and

decodes the audio code which is output to the speaker.” *Id.*, 2. The audio processing unit is shown in Figure 1 in orange.



118. **Karczewicz** confirms its compatibility with this well known feature and discloses that its terminal’s audio equipment is coupled to an audio codec 86. Ex. 1004, Fig. 8, p. 44: 29-45:6; *see also* Ex. 1006, p. 1:16-18, 2:21-30, Appendix 3 (JVT-B118), p. 10. Karczewicz discloses that “[l]ike the video codec, the audio codec comprises an encoder/decoder pair. It ... transforms encoded audio data received from the network back into a form suitable for reproduction, for example on the terminal's loudspeaker.” Ex. 1004, Fig. 8, p. 44: 29-45:6; *see also* Ex. 1006, p. 1:16-18, 2:21-30, Appendix 3 (JVT-B118), p. 10.

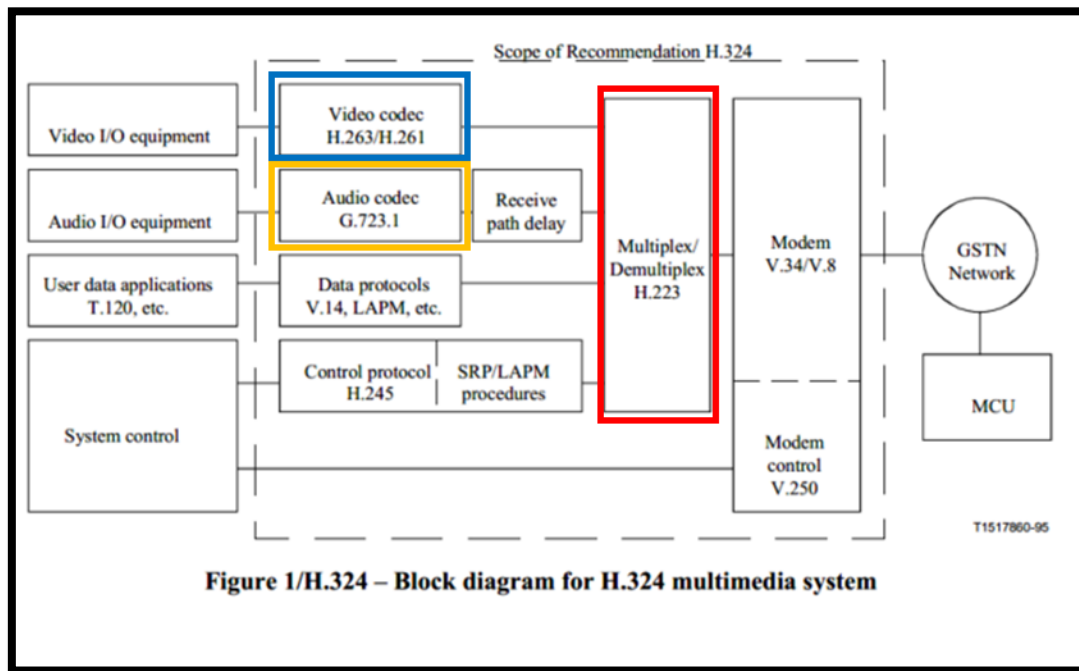
119. Karczewicz alone or in combination with H.324 and H.263 thus teaches an audio processing unit configured to decode the separated coded audio data.

d) **Element [1-C]**

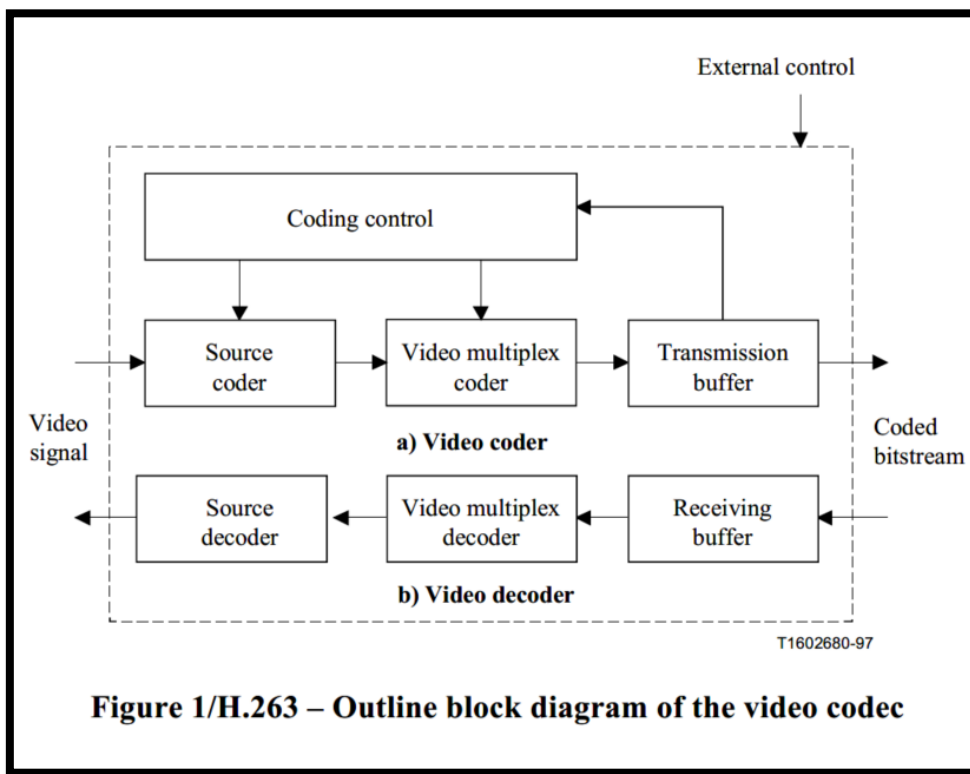
120. Karczewicz in combination with H.324 and H.263 discloses “a picture decoding unit configured to decode the separated coded picture data.”

121. This limitation recites basic coder features. The inventors of the '238 patent admitted that a picture decoding unit configured to decode the separated coded picture data was not only known in the art, but also defined in international standards. Ex. 1012 (IPR2018—00658, Paper 14), p. 10.

122. For example, **H.324** requires a Video Codec (H.263 and H.261), which is a picture decoding unit that decodes the video stream that has been separated by the demultiplexing unit. Ex. 1007, 2, 6. The picture decoding unit is shown in the annotated Figure 1 in blue.



123. **H.263**, which is incorporated by reference in H.324, details video codecs. Ex. 1008, 2. For example, H.263 explains that the video coder provides a self-contained digital bitstream that can be combined with other signals (for example, as defined in Recommendation H.223). Ex. 1008, 2. H.263 explains that the video decoder performs the reverse process. Ex. 1008, 2. Figure 1 of the H.263 shows a video codec that includes a video decoder:



124. **Karczewicz** confirms it is compatible with this well-known feature and discloses that its video equipment 81 is coupled to a video codec 85, which video codec 85 includes a picture coding/decoding device similar to Fig. 15 of the '238 patent. Ex. 1004, Fig. 8, p. 44:17-27; *see also* Ex. 1006, p. 1:16-18, 2:21-30, Appendix 3 (JVT-B118), p. 10. Karczewicz describes that "[t]he video codec 85 comprises a video encoder and a corresponding video decoder both implemented according to the invention.... The video codec 85 is responsible for encoding captured video data in an appropriate form for further transmission over a communications link and decoding compressed video content received from the communications network. In the example illustrated in Figure 8, the video codec is

implemented according to ITU-T recommendation H.26L, with appropriate modifications to implement the adaptive variable length coding method according to the invention in both the encoder and the decoder of the video codec.” Ex. 1004, Fig. 8, p. 44:17-27; *see also* Ex. 1006, p. 1:16-18, 2:21-30, Appendix 3 (JVT-B118), p. 10.

125. Karczewicz in combination with H.324 and H.263 thus teaches a picture decoding unit configured to decode the separated coded picture data.

e) **Element [1-D]**

126. Karczewicz in combination with H.324 and H.263 discloses “wherein said picture decoding unit includes a block decoding unit configured to decode coded block data included in the coded picture data, the coded block data being obtained by dividing a picture signal into plural blocks, generating a residual block image from a block image of the respective blocks and a predictive block image obtained by intra-picture prediction or inter-picture prediction, and coding, on a block basis, coefficients obtained by performing orthogonal transformation and quantization on the residual block image.”

127. This lengthy claim element generally recites the well-known steps of **block-based coding, prediction** (*i.e.*, inter- or intra-prediction), creating a **residual image**, orthogonal **transform**, **quantization**, and **coefficient encoding**. In fact, the majority of this claim merely recites that the exemplary data that the

claimed decoder operates on is “being obtained” by conventional encoding steps.

The '238 patent acknowledges that these steps are known in the background art.

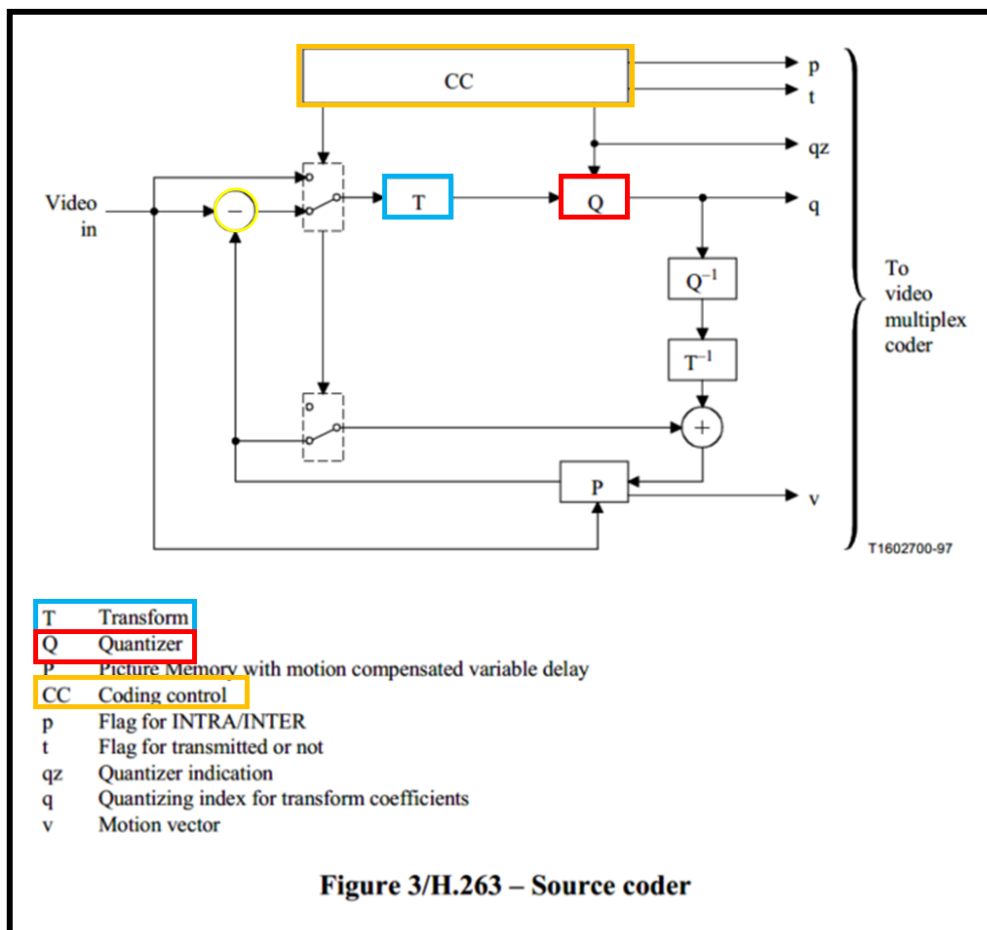
Ex. 1001, 1:19-38. And the Patent Owner did not dispute that **H.263** similarly

taught this element. Ex. 1012 (IPR2018—00658, Paper 14), p. 10. For example,

H.263 illustrates an encoder in Figure 3, which shows logical blocks for generating

a residual image, transformation, and quantization that the claimed decoder

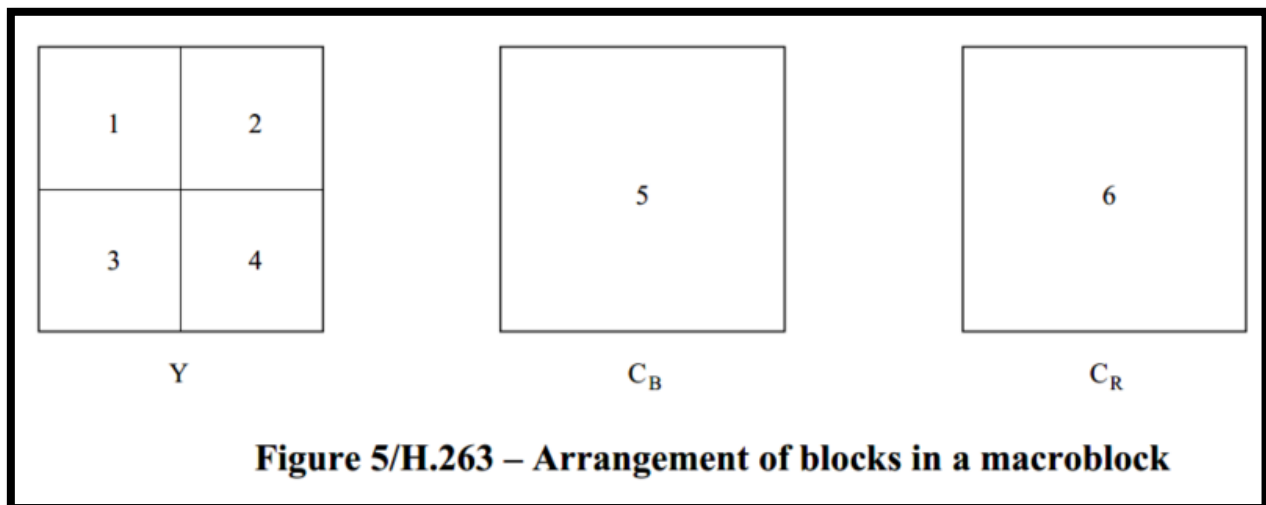
operates on. Ex. 1008, Fig. 3.



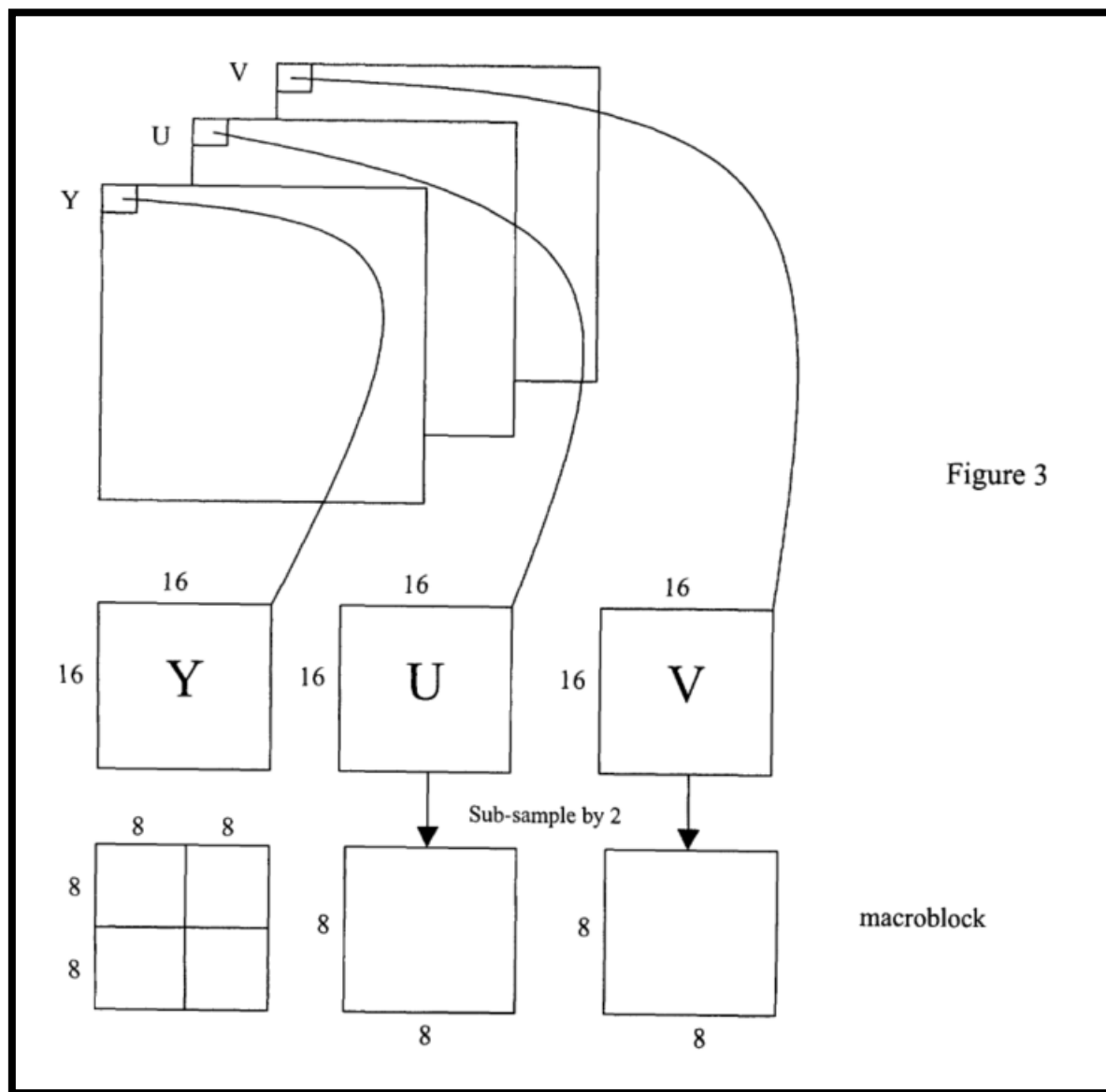
128. Nevertheless, these steps were known in the cited art.

129. **Block-Based Coding** (“wherein said picture decoding unit includes a block decoding unit configured to decode coded block data included in the coded picture data, the coded block data being obtained by dividing a picture signal into plural blocks”)

130. **H.263** discloses dividing a moving picture into blocks. Ex. 1008, Section 4.2.1. “Each picture is divided either into Groups of Blocks (GOBs) or into slices. *Id.*, 9. Each GOB is then further divided into macroblocks. *Id.*, 10. Figure 5 of H.263 shows an exemplary macroblock that relates to 16 pixels by 16 lines of Y and the spatially corresponding 8 pixels by 8 lines of CB and CR. *Id.*, 11, Fig. 5 (below). H.263 describes that each macroblock consists of four luminance blocks and two spatially corresponding color difference blocks. Ex. 1008, 11.



131. **Karczewicz** confirms this was well known and discloses that “each frame of a video sequence is divided into so-called 'macroblocks', which comprise luminance (Y) information and associated chrominance (U, V) information which is spatially sub-sampled.” Ex. 1004, p. 2:18-3:3, 5-16; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70. Figure 3 illustrates one way in which macroblocks can be formed.



132. Figure 3 shows a frame of a video sequence represented using a YUV color model, each component having the same spatial resolution. Ex. 1004, Fig. 3, p. 2:18-3:3; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70. The use of blocks and macroblocks for video coding were well-known in the art (*e.g.*, the paper “Scene adaptive coder,” published in the IEEE Transactions

on Communications, 1984, authored by W. Chen, C. H. Hsia, and W.K. Pratt, or the paper “Motion-compensation prediction with fractional-pel accuracy,” authored by Bernd Girod in the IEEE Transactions on Communications in April 1993.). Macroblocks are formed by representing a region of 16x16 image pixels in the original image as four blocks of luminance information, each luminance block comprising an 8x8 array of luminance (Y) values and two spatially corresponding chrominance components (U and V) which are sub-sampled by a factor of two in the x and y directions to yield corresponding arrays of 8x8 chrominance (U, V) values. Ex. 1004, p. 2:18-3:3; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70. Karczewicz discloses that the International Telecommunications Union (ITU-T) recommendation H.26L defines the fundamental block size used within the macroblocks to be other than 8x8, for example 4x8 or 4x4. Ex. 1004, p. 2:18-3:3; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70.

133. Karczewicz describes that its “decoder 200 comprises a video multiplex decoder 270, which receives an encoded video bit-stream 135 from the encoder 100 and demultiplexes it into its constituent parts, an inverse quantiser 210, an inverse DCT transformer 220, a motion compensated prediction block 240, a frame store 250, a combiner 230, a control manager 260, and an output 280.” Ex.

1004, p. 15:14-19; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70.

134. **Prediction** (“generating ... a predictive block image obtained by intra-picture prediction or inter-picture prediction”)

135. **H.263** teaches the use of both intra- and inter-prediction. Ex. 1008, Section 4.2.2. H.263 describes that a prediction of the block is formed based on previously-coded data, either from frames that have already been coded and transmitted (“inter-prediction”) or from the current frame (“intra-prediction”). Ex. 1008, 11-12. In Figure 3 above, the Coding Control (“CC”) (shown in orange) block controls the modes of prediction. Ex. 1008, 9.

136. **Karczewicz** also confirms the use of both intra- and inter-prediction. Ex. 1004, p. 5:5-23-6:5; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70. For example, Karczewicz teaches that block-based transform coding can be applied to “[f]rames of a video sequence which are compressed using motion- compensated prediction are generally referred to as INTER-coded or P- frames.” Ex. 1004, p. 5:5-23-6:5, 12:9-13 (describing quantization in connection with operation of the encoder in INTRA-coding node); *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70.

137. **Residual Block Image** (“generating a residual block image from a block image of the respective blocks”)

138. **H.263** teaches generating a residual block image to reduce the amount of transmitted data. Ex. 1008, 9. The unit calculates a difference between the current block and the predicted block in the picture to create a “residual picture.” Ex. 1008, 9. In Figure 3 above, the circle with a negative sign (annotated in yellow) shows the unit for creating a residual picture. Ex. 1008, 9.

139. **Karczewicz** discloses generating a “prediction error” (PE) frame, which is done on a block basis, since motion compensation prediction alone rarely provides a sufficiently precise representation of the image content. Ex. 1004, p. 5:5-23-6:5, 12:9-13, 15:1-12; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70. The prediction error block is a residual block image from a respective block. Ex. 1008, p. 5:5-23-6:5; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70. Karczewicz teaches, “[t]he prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two-dimensional array of DCT transform coefficients for each block. DCT transformation block 104 produces an array of coefficient values for each prediction error block, the number of coefficient values depending on the nature of the blocks which make up the macroblock.” Ex. 1004, p. 11:29-12:7; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70.

140. **Transform / Quantization** (“coefficients obtained by performing orthogonal transformation and quantization on the residual block image”)

141. **H.263** teaches “[a] hybrid of inter-picture prediction to utilize temporal redundancy and transform coding of the remaining signal to reduce spatial redundancy.” Ex. 1008, 2. A POSITA would understand that, like the ’238 patent, transform coding includes orthogonal transformation techniques (*e.g.*, Discrete Cosine Transform (“DCT”)). Ex. 1001, 1:19-27 (confirming DCT or the like is an orthogonal transformation). In Figure 3 above, the “Transform” block (“T”) (annotated in blue) shows the unit for transformation to reduce spatial redundancy. Ex. 1008, Fig. 3. The output of the block T is a block of transform coefficients, which are subsequently quantized, such as by dividing each coefficient by an integer value and rounding to the nearest integer. Ex. 1008, Section 4.2.4 (Quantization). In Figure 3 above, the “Quantizer” block (“Q”) (annotated in red) shows the unit for quantization. Ex. 1008, Fig. 3.

142. **Karczewicz** discloses that “[t]he prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two-dimensional array of DCT transform coefficients for each block. DCT transformation block 104 produces an array of coefficient values for each prediction error block, the number of coefficient values depending on the

nature of the blocks which make up the macroblock.” Ex. 1004, p. 11:29-12:7; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 32. Similarly, “[t]he transform coefficients for each prediction error block are passed to quantiser 106 where they are quantised using a quantisation parameter QP.” Ex. 1004, p. 12:9-13; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 12, 16, 28, 32, 42-43, 69-70.

143. **Encoding Coefficients** (“coding, on a block basis, coefficients”)

144. **H.263** teaches that its quantized coefficients are then encoded on a block-by-block basis. Ex. 1008, 11. “Data for the macroblocks is transmitted per macroblock in increasing macroblock number” and “[d]ata for the blocks is transmitted per block in increasing block number.” Ex. 1008, 11. “Transmitted blocks are transformed and resulting coefficients are quantized and entropy coded.” Ex. 1008, 11.

145. **Karczewicz** also discloses that the quantized coefficients are encoded on a block basis. Ex. 1004, p. 12:9-13, 11:29-12:7; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 12, 16, 28, 32, 42-43, 69-70. For example, Karczewicz teaches that “[t]he prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine transform on each block of prediction error values to produce a two- dimensional array of DCT transform coefficients for each block. DCT transformation block 104 produces an array of coefficient values for each

prediction error block, the number of coefficient values depending on the nature of the blocks which make up the macroblock.” Ex. 1004, p. 11:29-12:7; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 12, 16, 28, 32, 42-43, 69-70.

146. Karczewicz in combination with H.324 and H.263 thus teaches that the picture decoding unit includes a block decoding unit configured to decode coded block data included in the coded picture data, the coded block data being obtained by dividing a picture signal into plural blocks, generating a residual block image from a block image of the respective blocks and a predictive block image obtained by intra-picture prediction or inter-picture prediction, and coding, on a block basis, coefficients obtained by performing orthogonal transformation and quantization on the residual block image.

f) **Element [1-E]**

147. Karczewicz in combination with H.324 and H.263 discloses “said block decoding unit includes: a coefficient number decoding unit configured to decode the coded block data to obtain the number of non-zero coefficients which are coefficients included in a current block to be decoded and having a value other than ‘0’.”

148. **Karczewicz** discloses a video decoder 700 that includes a variable length decoding unit. Ex. 1004, p. 39:8-19; *see also* Ex. 1006, p. 8:7-27, 9:13-22, Appendix 3 (JVT-B118), pp. 10, 12, 16, 28, 32, 42-43, 69-70. Karczewicz teaches

that “[i]n the decoder, the bit-stream is received and separated into its constituent parts by video multiplex decoder 770.... [T]he compressed video data extracted from the bit-stream is processed on a macroblock-by-macroblock basis. The compressed video data for an INTRA-coded macroblock comprises variable length codewords representing the VLC coded N_c value ... for each block of the macroblock, ... ” Ex. 1004, p. 39:21-40:4; *see also* Ex. 1006, p. 8:7-27, 9:13-22, Appendix 3 (JVT-B118), p. 10.

149. Karczewicz describes that when decoding VLC coded pairs for intra- or inter-coded image blocks, “video multiplex decoder 770 first **determines the number of non-zero-valued quantised transform coefficients in the block**. As previously explained, information relating to the number of non-zero-valued quantised transform coefficients, N_c , is inserted into bit- stream 635 by encoder 600. **Decoder 700 extracts this information from the received bit-stream.** **According to the invention, the N_c value is itself VLC coded and therefore video multiplex decoder 770 performs an appropriate variable length decoding operation to recover the information relating to N_c .**” Ex. 1004, p. 40:11-41:8 (emphasis added); *see also* Ex. 1006, p. 8:7-27, 9:13-22, Appendix 3 (JVT-B118), p. 10.

150. Karczewicz in combination with H.324 and H.263 thus teaches that the block decoding unit includes: a coefficient number decoding unit configured to

decode the coded block data to obtain the number of non-zero coefficients which are coefficients included in a current block to be decoded and having a value other than '0'.

g) **Element [1-F]**

151. Karczewicz in combination with H.324 and H.263 discloses “a unit configured to obtain coefficients corresponding to a residual block image of the current block by decoding the coded block data.”

152. This limitation recites basic coder features. Again, both Karczewicz and the inventors of the '238 patent recognized that a unit configured to obtain coefficients corresponding to a residual block image of the current block by decoding the coded block data was not only known in the art, but also defined in international standards. Ex. 1012 (IPR2018—00658, Paper 14), p. 10.

153. For example, **H.263** teaches that its video decoder includes a unit that extracts quantized transformed coefficients from the coded bitstream. Ex. 1008, Section 6.2 (Coefficients Decoding).

154. **Karczewicz** also discloses a DCT transformation block configured to obtain coefficients corresponding to prediction error information. Ex. 1004, p. 11:29-12:7; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 32. Specifically, “[t]he prediction error information for each block of the macroblock is passed to DCT transformation block 104, which performs a two-dimensional discrete cosine

transform on each block of prediction error values to produce a two- dimensional array of DCT transform coefficients for each block. DCT transformation block 104 produces an array of coefficient values for each prediction error block, the number of coefficient values depending on the nature of the blocks which make up the macroblock.” Ex. 1004, p. 11:29-12:7; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 32.

155. Karczewicz in combination with H.324 and H.263 thus teaches a unit configured to obtain coefficients corresponding to a residual block image of the current block by decoding the coded block data.

h) Element [1-G]

156. Karczewicz in combination with H.324 and H.263 discloses “a unit configured to obtain the residual block image of the current block by performing inverse quantization and inverse orthogonal transformation on the coefficients corresponding to the residual block image of the current block.”

157. This limitation recites basic coder features. Again, both Karczewicz and the inventors of the '238 patent recognized that a unit configured to obtain the residual block image of the current block by performing inverse quantization and inverse orthogonal transformation on the coefficients corresponding to the residual block image of the current block was not only known in the art, but also defined in international standards. Ex. 1012 (IPR2018—00658, Paper 14), p. 10.

158. For example, **H.263** teaches that its video decoder performs inverse quantization and inverse orthogonal transformation on the coefficients to obtain the residual block image of the current block. Ex. 1008, Section 6.2.1 (Inverse Quantization), Section 6.2.4 (Inverse Transform). H.263 discloses that “[a]fter inverse quantization and zigzag of coefficients, the resulting 8 x 8 blocks are processed by a separable two-dimensional inverse discrete cosine transformation of size 8 by 8.” Ex. 1008, 47.

159. **Karczewicz** also discloses that its video multiplex decoder 270 “reconstructs an array of quantised transform coefficient values for each prediction error block and passes them to inverse quantiser 210.” Ex. 1004, p. 17:7-18:4; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 32, 42-43. The “[i]nverse quantiser 210 inverse quantises the quantised DCT coefficients representing the prediction error information for each block of the macroblock according to the control information and provides the now inverse quantised DCT coefficients to inverse DCT transformer 220. The inverse quantised DCT coefficients representing the prediction error information for each block are then inverse transformed in the inverse DCT transformer 220 to yield an array of reconstructed prediction error values for each block of the macroblock.” Ex. 1004, p. 17:7-18:4; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 32, 42-43.

160. Karczewicz in combination with H.324 and H.263 thus teaches a unit configured to obtain the residual block image of the current block by performing inverse quantization and inverse orthogonal transformation on the coefficients corresponding to the residual block image of the current block.

i) **Element [1-H]**

161. Karczewicz in combination with H.324 and H.263 discloses “a reproducing unit configured to reproduce a block image of the current block, from the obtained residual block image and a predictive block image obtained by intra-picture prediction or inter-picture prediction.”

162. This limitation recites basic coder features. Both Karczewicz and the inventors of the '238 patent recognized that a reproducing unit configured to reproduce a block image of the current block, from the obtained residual block image and a predictive block image obtained by intra-picture prediction or inter-picture prediction was not only known in the art, but also defined in international standards. Ex. 1012 (IPR2018—00658, Paper 14), p. 10.

163. For example, **H.263** teaches that for each macroblock, the decoder forms an identical prediction to the one created by the encoder. Ex. 1008, Section 6.3 (Reconstruction of Blocks). H.263 discloses that “[a]fter motion compensation and coefficients decoding (inverse transform included), a reconstruction is formed for each luminance and chrominance block.” Ex. 1008, 47.

164. **Karczewicz** shows a video decoder 200 that includes a video multiplex decoder 270 (for receiving an encoded video bit-stream 135 from the encoder 100 and demultiplexes it into its constituent parts), an inverse quantiser 210, an inverse DCT transformer 220, a motion compensated prediction block 240, a frame store 250, a combiner 230, a control manager 260, and an output 280. Ex. 1004, p. 15:14-19; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 12, 16, 28, 32, 42-43, 69-70.

165. Karczewicz then describes that the motion compensated prediction block 240 uses a reconstructed motion vector to identify the location of a region of reconstructed pixels in a prediction reference frame stored in frame store 250. Ex. 1004, p. 18:6-19:3; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 69-70. Karczewicz teaches that the reference frame can be a previously decoded intra- or inter-coded frame. Ex. 1004, p. 18:6-19:3; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 69-70. In either case, the region of pixels indicated by the reconstructed motion vector is used to form a prediction for the macroblock in question. Ex. 1004, p. 18:6-19:3; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 69-70. “The prediction, that is the blocks of pixel values derived from the reference frame, are passed from motion compensated prediction block 240 to combiner 230 where they are combined with the decoded prediction error information. In practice, the pixel values of each predicted block are added to

corresponding reconstructed prediction error values output by inverse DCT transformer 220. In this way an array of reconstructed pixel values for each block of the macroblock is obtained. The reconstructed pixel values are passed to the video output 280 of the decoder and are also stored in frame store 250.” Ex. 1004, p. 18:6-19:3; *see also* Ex. 1006, Appendix 3 (JVT-B118), pp. 10, 69-70.

166. Karczewicz in combination with H.324 and H.263 thus teaches a reproducing unit configured to reproduce a block image of the current block, from the obtained residual block image and a predictive block image obtained by intra-picture prediction or inter-picture prediction.

j) **Element [1-I]**

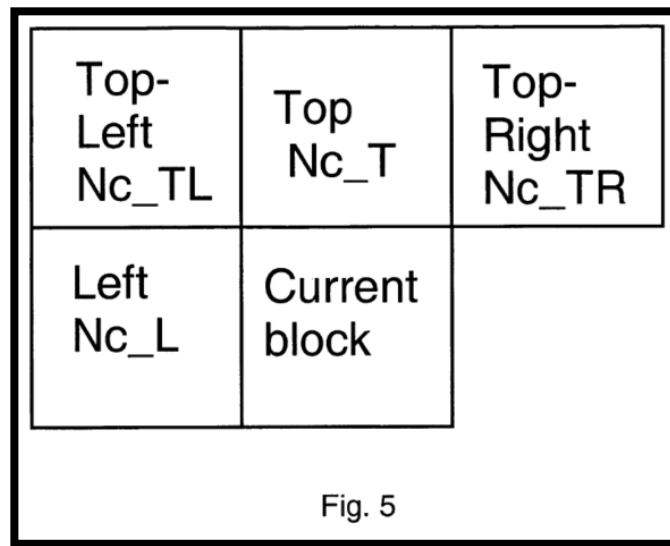
167. Karczewicz in combination with H.324 and H.263 discloses “said coefficient number decoding unit includes: a determining unit configured to determine a predictive value for the number of non-zero coefficients included in the current block based on the number of non-zero coefficients included in a decoded block located on a periphery of the current block.” In prior invalidity challenges against the ’238 patent, I understand that this is the only element that the Patent Owner disputed to be taught by the prior art. Ex. 1012 (IPR2018—00658, Paper 14), p. 10. However, Karczewicz—which has not been considered by the Office or the PTAB—discloses this exact element.

168. **Karczewicz** expressly teaches that its video multiplex coder 670 determines the number of non-zero valued coefficients in a block of quantized transform coefficients by using at least two sets of variable length codewords:

When video multiplex coder 670 receives a block (two-dimensional array) of quantised transform coefficients, ***it determines the number of non-zero-valued coefficients in the array.*** According to the invention, this number, referred to as N_c , is variable length coded and transmitted to the decoder in bit-stream 635. ***At least two sets of variable length codewords are provided for variable length coding of the N_c value.*** In an embodiment of the invention, these are, for example, the VLC codewords defined respectively in Tables 2 and 5, previously described in the text. More specifically, N_c is variable length encoded using a codeword selected from one of the at least two sets of variable length codewords responsive to the values of previously coded N_c symbols. Advantageously, the previously coded N_c symbols used to ***assign the VLC codewords are chosen from blocks that reside close to the block being coded.***

Ex. 1004, p. 33:29-34:9 (emphasis added), 39:8-19; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10.

169. Figure 5 depicts an image block (nearly identical to Figure 4A and 4B of the '238 patent) to be VLC encoded and its neighboring blocks. Ex. 1004, Fig. 5, p. 34:11-14; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10. The terms N_{c_L} , N_{c_TL} , N_{c_T} and N_{c_TR} denote respectively the number of non-zero quantized coefficients in blocks to the Left, Top-Left, Top and Top-Right of the current image block to be encoded:



170. The N_C value for the current image block is variable length encoded using a codeword from one of the available sets of VLC codes, chosen by considering the already coded N_C value(s) of immediately neighboring block(s). Ex. 1004, Fig. 5, p. 34:16-35:10; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10.

171. Other than requiring the determination be based on the number of non-zero coefficients in at least one peripheral coded block, the Challenged Claim does not limit the algorithm used for the prediction. Karczewicz meets this by describing an exemplary procedure for assigning a predicted N_C value, VLC_N in the equation (1) below, taking into account the N_C values of the previously encoded neighboring image blocks (N_{C_L} , N_{C_TL} , N_{C_T} , N_{C_TR}):

172. $VLC_N = N_{C_map}[fn(N_{C_L}, N_{C_TL}, N_{C_T}, N_{C_TR})]$ (Equation 1)

Ex. 1004, 34:16-35:10; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10. In the above expression, fn is a function that can be represented as:

$$173. \text{ VLC_N} = \text{Nc_map}[(\text{Nc_L} + \text{Nc_T})/2] \text{ (Equation 2)}$$

Id. Nc_map is an array that maps integer values to different available VLC codes and VLC_N indicates the number of the table from which the codewords are to be selected. Examples of fn include “average” or “median.” *Id.*

174. Karczewicz specifies that “when decoding the VLC coded (run, level) pairs for an INTRA- or INTER-coded image block, video multiplex decoder 770 first determines the number of non-zero-valued quantised transform coefficients in the block.... Decoder 700 extracts this information from the received bit-stream. According to the invention, the Nc value is itself VLC coded and therefore video multiplex decoder 770 performs an appropriate variable length decoding operation to recover the information relating to Nc . As explained above, the VLC coding table used to encode the Nc value for a particular image block is selected on the basis of the Nc value(s) associated with a previously encoded image block or blocks.” Ex. 1004, 40:11-41:8; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10. For example, in the case that Nc values from blocks to the left, top-left, top and top- right are used to select the VLC table for coding subsequent Nc values and the block scanning (coding) order is from the

top-left of an image, row-by-row, Karczewicz explains that it is advantageous to encode N_c values for blocks in the first row of the image, plus the first block on the second row according to a predetermined scheme. Ex. 1004, 40:11-41:8; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10. Then the N_c values for all subsequent image blocks can be encoded according to the rule described by equation (1) above and can be decoded at the decoder without any explicit indication of the VLC coding table used. Ex. 1004, 40:11-41:8; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10.

175. Karczewicz in combination with H.324 and H.263 thus teaches that the coefficient number decoding unit includes: a determining unit configured to determine a predictive value for the number of non-zero coefficients included in the current block based on the number of non-zero coefficients included in a decoded block located on a periphery of the current block.

k) **Element [1-J]**

176. Karczewicz in combination with H.324 and H.263 discloses “a selecting unit configured to select a variable length code table based on the determined predictive value.”

177. **Karczewicz** discloses a selecting unit configured to select a variable length code table based on the determined predictive value. Table 2 of Karczewicz illustrates an exemplary set of VLC codewords:

Codeword index	VLC Codeword
0	1
1	010
2	011
3	00100
4	00101
5	00110
6	00111
7	0001000
8	0001001
9	0001010
10	000010000
11	000010001
12	000010010
13	000010011
14	000010100
15	000010101
....	

Table 2: The First 16 UVLC Codewords of H.26L Generated According to the Scheme Presented in Table 1

Ex, 1004, p. 20:23-29, 21:Table 2; *see also* Ex. 1006, Fig. 1, Table 2, Table 5, p. 3:11-15, 8:14-30, 10:1-23. Karczewicz recognizes that it can be advantageous to use more than one set of VLC codewords and discloses an exemplary second set of VLC codewords (VLC2). Ex, 1004, p. 24:1-14; *see also* Ex. 1006, Fig. 1, Table 2, Table 5, p. 3:11-15, 8:14-30, 10:1-23. Table 5 shows the first 16 codewords of VLC2.

Codeword Index	VLC2 Codeword
0	10
1	110
2	111
3	0100
4	0101
5	0110
6	0111
7	001000
8	001001
9	001010
10	001011
11	001100
12	001101
13	001110
14	001111
15	00010000

Table 5: The First 16 VLC2 Codewords of Q.15/SG16 Document Q15-K-30, Generated According to the Scheme Presented in Table 4

Ex. 1004, pp. 24-25, Table 5; *see also* Ex. 1006, Fig. 1, Table 2, Table 5, p. 3:11-15, 8:14-30, 10:1-23. Karczewicz describes an exemplary procedure for assigning a variable length code to an N_C value, taking into account the N_C values of the previously encoded neighboring image blocks. Ex. 1004, 34:16-35:10; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10. Examples of the fn include “average” or “median.” *Id.*

178. Assume that the current N_C value to be encoded is 3, the neighboring N_C_L and N_C_T values are given by 4 and 2, respectively and N_C_map is given by $N_C_map=[1\ 1\ 1\ 1\ 1\ 2\ 2\ 2\ 2]$ where VLC1 and VLC2 correspond to the codewords from Table 2 and Table 5, respectively. Ex. 1004, 34:16-35:10; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10. Applying equation (2), VLC_N is equal to 1. In this case $N_C = 3$ is encoded as 00100 using the VLC codewords from Table 2. Ex. 1004, 34:16-35:10; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10.

179. Karczewicz in combination with H.324 and H.263 thus teaches a selecting unit configured to select a variable length code table based on the determined predictive value.

l) **Element [1-K]**

180. Karczewicz in combination with H.324 and H.263 discloses “a variable length decoding unit configured to perform variable length decoding on a coded stream which is generated by coding the number of the non-zero coefficients included in the current block, by using the selected variable length code table.”

181. **Karczewicz** discloses that its variable length decoding unit configured to perform variable length decoding on a coded stream which is generated by coding the number of the non-zero coefficients included in the current block, by using the selected variable length code table. Ex. 1004, p. 33:29-34:9, 39:8-19,

34:11-14, 16-35:10, 40:11-41:8, Fig. 5; *see also* Ex. 1006, Fig. 1, p. 8:7-27, 9:13-22, 10:1-23, Appendix 3 (JVT-B118), p. 10.

182. Although **Karczewicz** expressly teaches a variable length decoding unit configured to perform variable length decoding on a coded stream which is generated by coding the number of the non-zero coefficients included in the current block, by using the selected variable length code table, Patent Owner did not dispute that the prior art taught this element of the '238 patent. Ex. 1012 (IPR2018—00658, Paper 14), p. 10.

183. Karczewicz in combination with H.324 and H.263 thus teaches a variable length decoding unit configured to perform variable length decoding on a coded stream which is generated by coding the number of the non-zero coefficients included in the current block, by using the selected variable length code table.

IX. SECONDARY CONSIDERATIONS

184. I am not aware of secondary considerations of non-obviousness that bear on the challenged claims. If I am made aware in the future of arguments of any secondary consideration, I expressly reserve the right to assess those arguments when they arise in order to form opinions regarding their correctness or incorrectness.

X. CONCLUSION

185. It is my conclusion and opinion that Claim 1 of the '238 Patent is invalid.

I declare under penalty of perjury that the foregoing is true and correct.

Executed this 25th day of July, 2025 in Berkeley, CA.



Dr. Kannan Ramchandran

APPENDIX A

KANNAN RAMCHANDRAN

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A. Professional Preparation:

Ph.D., Elec. Engineering, Columbia University, New York

June 1993

M.S., Elec. Engineering, Columbia University, New York

May 1984

B. Appointments:

University of California at Berkeley

June 1999-Present

Professor, EECS Department:

- Instructor for undergraduate and graduate classes in digital signal and image processing, communication systems, probability, coding, linear systems, and information theory.
- Ph.D. thesis advisor to about 10 post-graduate, graduate and undergraduate research students.
- Director, Berkeley Audiovisual Signal processing and Communication Systems (BASiCS) Research Group
- Co-Director, Berkeley Laboratory for Information Sciences and Systems (BLISS) Center

University of Illinois at Urbana-Champaign

August 1993-May 1999

Assistant Professor, ECE Department:

- Teacher for undergraduate and graduate classes in digital signal and image processing.
- Research Assistant Professor, Beckman Institute and Coordinated Science Laboratory:
- Associate Director of Multimedia Laboratory at the Beckman Institute

AT&T Bell Labs, N.J. (Member of the Technical Staff)

March 1984 – September 1990

R&D Design Engineer

C. Selected awards, honors, professional activities:

- Awarded the Gilbert Henry Gates Endowed Chair in Electrical Engineering and Computer Science at UC Berkeley (2022-27)
- Institute of Electrical and Electronics Engineers (IEEE) Communications Society and Information Theory Society Joint Best Paper Award (2020).
- Selected as the Padovani Lecturer for 2019 by the Institute of Electrical and Electronic Engineers (IEEE) Information Theory Society.
- **Recipient of the 2017 Institute of Electrical and Electronics Engineers (IEEE) Kobayashi Computers and Communications Award** (a Field award in recognition of outstanding contributions to the integration of computers and communications) **for pioneering contributions to the theory and practice of distributed compression and storage coding.**
- **Elected Fellow of the Institute of Electrical and Electronic Engineers (IEEE) in 2005 for contributions to image and video compression and transmission.**
- Best Paper award from Optical Society of America Imaging Systems, July 2014 for paper published in Biomedical Optics Express.

- Best Paper Finalist, IEEE International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunications Systems (MASCOTS), Aug 2013.
- Institute of Electrical and Electronics Engineers (IEEE) Communications Society and Information Theory Society Joint Best Paper Award (2012).
- Selected as one of the six Grand Challenge Winners of the U.S. Department of Transportation's Research and Innovative Technology Administration (RITA) nation-wide competition in 2011 for innovative ideas on the use of wireless technology to enable vehicles to communicate with one another.
- Institute of Electrical and Electronics Engineers (IEEE) 2010 Communication Society Committee on Data Storage Best Paper Award (2010).
- **Outstanding Teaching Award in the EECS Department at UC Berkeley, 2008-2009.**
- Best Paper Award: "Vsync: a novel bi-directional compression protocol for video file synchronization," ACM Multimedia, October 2008, Vancouver.
- Best Paper Award, "Enhancing peer-to-peer live multicast quality using helpers," IEEE International Conference on Image Processing 2008, San Diego.
- Best Paper Award, "Robust distributed multi-view video compression for wireless camera networks," Video Communication and Image Processing Conference 2007, San Jose.
- Best Paper Award, "Ubiquitous access to distributed data in large-scale sensor networks through decentralized erasure codes," Fourth ACM/IEEE Conference on Information Processing for Sensor Networks, April 2005, Los Angeles.
- Okawa Foundation Award at UC Berkeley (2001) chosen to recognize excellence in research
- IEEE Signal Processing Society Best Paper Award for 1999 paper, "Rate-distortion methods in image and video compression."
- Selected as inaugural Henry Magnusky Scholar at the University of Illinois in 1998 chosen to recognize "excellent junior faculty"
- National Science Foundation CAREER Award for 1997.
- Office of Naval Research Young Investigator Award for 1997.
- IEEE Signal Processing Society Best Senior Paper Award for 1996 for paper "Best wavelet packet bases in a rate-distortion sense."
- Army Research Office Young Investigator Award for 1996.
- NSF Research Initiation Award for 1994-1996.
- Elaihu I. Jury Award Best Doctoral Thesis Award in systems and communications at Columbia University for 1993.
- Invited plenary speaker at several conferences and workshops in field.
- Serve actively as industrial technical consultant in image and video processing and wireless networking areas.

D. Litigation Experience

Case: Cloudera vs. Streamscale

Matter: patent infringement contention related to distributed storage systems technology.
 Responsibilities: Expert witness on infringement contentions, wrote expert report, gave deposition testimony, testified in court (2023).

Case: Google vs. Personalized Media Communications (PMC)

Matter: patent infringement contention related to suite of patents on video streaming technology.
 Responsibilities: Expert witness on invalidity contentions, wrote expert report, and gave deposition testimony (2020).

Case: Caltech vs. Apple

Matter: patent infringement contention related to suite of patents on sparse parity check

codes for transmission over Digital Video Broadcast-Satellite (DVB-S) standard.
Responsibilities: Expert witness, involved in the Markman claim construction, wrote expert report (2018)

Case: ViaSat vs. Acacia

Matter: breach of contract dispute related to satellite communications technology.
Responsibilities: Served as expert witness and gave a bunch of tutorials. (Dec. 2016-May 2017).

Case: AT&T Mobility vs Intellectual Ventures

Matter: patent infringement contention related to OFDM and LTE standards.
Responsibilities: Expert witness, studied prior art and OFDM/LTE standards but case was settled (2016).

Case: Kodak vs. Ricoh

Matter: license breach related to digital camera technology
Responsibilities: Wrote expert report and gave expert testimony in district court of New York (lower Manhattan) (October 2013).

Case: Credit Suisse vs. Realtime Data

Matter: patent infringement related to transmission standard for financial data transmission in district court of New York
Responsibilities: Wrote non-infringement expert report and gave deposition testimony (Aug. 2012)

Case: Kodak vs. RIM/Apple

Matter: ITC patent infringement related to digital camera technology
Responsibilities: Studied prior art and related literature, wrote infringement and rebuttal to invalidity reports, was deposed, presented Markman tutorial to ITC judge, and gave expert testimony in court. (September 2010).

Case: Kodak vs. LG/Samsung

Matter: ITC patent infringement related to digital camera technology
Responsibilities: Studied prior art and related literature, wrote infringement and rebuttal to invalidity reports, was deposed, presented tutorial to ITC judge and gave expert testimony in court. (October 2009).

Case: Funai vs. Respondents

Matter: ITC patent infringement related to high-definition digital television apparatus and display technology
Responsibilities: Studied prior art and related literature, wrote infringement and rebuttal to invalidity reports, was deposed, presented tutorial to ITC judge and gave expert testimony in court. (August 2008).

Case: Funai/Sony vs. Amtran

Matter: ITC patent infringement related to high-definition digital television technology.
Responsibilities: Studied prior art and related literature, and did infringement analysis. Case was settled before going to trial. (2008).

Case: Broadcom vs. Qualcomm

Matter: Patent infringement related to video compression technology
Responsibilities: Studied patents and related literature, wrote invalidity and non-infringement expert reports, was deposed twice and gave expert testimony in court. (2007)

E. Patents and invention disclosures:

- K. Ramchandran and K. Javitt, "Circuit for digitally adding loss to a signal". Granted U.S. Patent

Number 5,237,591 (issued Aug. 1993, AT&T).

- K. Ramchandran, K. M. Uz, and M. Vetterli, "Multi-resolution joint source-channel coding and applications to digital broadcast". Granted U.S. Patent Number 5,267,021 (issued Nov. 1993). (*A modified version of the method proposed in this patent was considered for the European Digital Audio and Video Broadcasting Standard.*)
- K. Ramchandran, Y. Yu, M. Vetterli, and D. Anastassiou, "Fast rate-distortion optimal adaptive thresholding for JPEG & MPEG with complete decoder compatibility," Invention report filed, June'93. Granted U.S. Patent Number 5,734,755 (issued March 1998).
- B. Krongold, D. Jones and K. Ramchandran, "Computationally Efficient Optimal Power Allocation Algorithms for Multicarrier Communications Systems". Granted U.S. Patent No. 6,400,773 (issued June 2002).
- K. Ramchandran, J. Chou and I. Kozintsev, "Data transmission using arithmetic coding based continuous error detection". Granted U.S. Patent No. 6,418,549 (issued July 2002).
- S. Ha, S. Han, T. Kim, V. Bharghavan, U. Madhow and K. Ramchandran, "Data transport acceleration and management within a network communication system". Granted U.S. Patent No. 7,099,273 (issued August 2006).
- R. Puri and K. Ramchandran, "Encoding and decoding of digital data using cues derivable at a decoder," Granted U.S. Patent Number 7,400,774 (issued July 2008). Granted U.S. Patent Number 7,400,774 (issued July 2008).
- J. Chou and K. Ramchandran, "Transcoding multimedia information within a network communication system," Granted U.S. Patent Number 7,444,418 (issued Oct. 2008).
- U. Madhow, B. Wild, and K. Ramchandran, "Systems and methods of beamforming in radio frequency identification applications," Granted U.S. Patent Number 7,652,577 (issued Oct. 2008).
- H. Garudadri and K. Ramchandran, "Method, apparatus, and system for encoding and decoding side information for multimedia transmission," Granted U.S. Patent Number 7,643,358 (issued Jan. 2010).
- J. Gilbert, K. Ramchandran, and G. Song, "Mechanism for streaming media data over wideband wireless networks with error concealment," Granted U.S. Patent Number 7,881,258 (issued Feb. 2011).
- P. Ahammad, C. Yeo, K. Ramchandran and S. Sastry, "High-speed video action recognition and localization," Granted U.S. Patent Number 8,027,542 (issued Sept. 2011).
- H. Garudadri, N. Srinivasamurthy, H. Chung, K. Ramchandran and A. Majumdar, "Method, apparatus, and system for enhancing robustness of predictive video codecs using a side channel based on distributed source coding techniques," U.S. patent application 2008/0267288 (filed May 2008).
- J. Chou and K. Ramchandran, "Decoding compressed image data," U.S. patent application 2003/0035586 (filed May 2002).
- K. Ramchandran, B. Wild, A. Tkachenko, and U. Madhow, "Localizing tagged assets using modulated backscatter systems," International patent application number PCT/US2009/0212921 (filed Feb. 2008).
- B. Wild, U. Madhow, K. Ramchandran, R. Barton, and A. Tkachenko, "Applique nodes for performance and functionality enhancement in radio frequency identification systems," U.S. patent application 2010/0013601 (filed March 2009).
- B. Wild, U. Madhow, K. Ramchandran, and A. Tkachenko, "Range extension and multiple access in modulated backscatter systems," U.S. patent application 2010/0060424, Filed March 2009.
- B. Wild, U. Madhow, and K. Ramchandran, "RFID Repeater for range extension in modulated backscatter systems," U.S. patent application 2010/156610 (filed Aug. 2009).

F. Selected talks and visiting appointments:

- Several keynote and invited talks over the past decade at top IEEE conferences in fields of image processing, multimedia signal processing, wireless sensor networks and information theory.
- Invited keynote speaker, IEEE Information Theory Workshop, Brazil (2011), Picture Coding Symposium, San Francisco, California (2004), IEEE International Conference on Video and Image Processing, Switzerland (2004), IEEE Statistical Signal Processing Workshop, St. Louis, Missouri (2003).
- Invited seminar colloquium speaker at several institutions including Stanford, MIT, UIUC, EPFL (Switzerland), Michigan, Wisconsin, Microsoft Research, Indian Institute of Science, Bangalore, HP Research, IBM Research, etc.
- Invited panelist, NSF workshops on the Future of Spectrum (2003), Sensor Networks (2002), Future of Wireless (2001), Joint Source-Channel Coding (2000).
- Institute of Mathematical Applications, Minneapolis, MN (Summer 2001)
- Math. Sciences Research Center, Lucent Technologies, Murray Hill, NJ (*Summer 1998*)
- Visiting Professor, Electrical Engineering Department, Ecole Polytechnique Federal de Lausanne, Lausanne, Switzerland (*Summer 1997* and *Summer 2001*)
- Communications Research Group, AT&T Research Labs, Florham Park, NJ (*Summer 1997*)
- Imaging Technology Dept., Hewlett-Packard Research Labs, Palo Alto, CA (*Summer 1994*)

G. Publications: I have published over 700 refereed journal & conference publications in the broad areas of communications, signal and image processing, machine learning, and information theory. I have served as the doctoral thesis advisor to 30 Ph.D. students, who after graduating, have gone on to become academic and industrial leaders in the field. In addition, I have supervised the M.S. theses of over 25 students, and served as a mentor for about 24 postdoctoral scholars.

- Here is a select list of my publications:

A. Books & Book Chapters

1. Z. Xiong and K. Ramchandran, "Wavelet Image Compression" in "Handbook of Image and Video Processing," editor Alan C. Bovik, Elsevier Publications, 2010.
2. G. Dimakis and K. Ramchandran, "Network Coding for Distributed Storage in Wireless Networks," in V. Saligrama, editor, Networked Sensing Information and Control, Signals and Communication series, Springer Verlag, October 2007.
3. Raouf Hamzaoui, Vladimir Stankovic, Zixiang Xiong, Kannan Ramchandran, Rohit Puri, Abhik Majumdar, and Jim Chou, "Channel Protection Fundamentals, in Multimedia over IP Wired and Wireless Networks" edited by Philip A. Chou and Mihaela van der Schaar, publisher: Elsevier, ISBN-13: 978-0-12-088480-3, ISBN-10: 0-12-088480-1, Publication Date: March 2007.
4. Abhik Majumdar, Rohit Puri, Kannan Ramchandran, and Jim Chou, "Distributed Video Coding and its Applications, in Multimedia over IP Wired and Wireless Networks edited by Philip A. Chou and Mihaela van der Schaar, publisher: Elsevier, ISBN-13: 978-0-12-088480-3, ISBN-10: 0-12-088480-1, Publication Date: March 2002.
5. A. Kumar, P. Ishwar, and K. Ramchandran, "On distributed sampling of smooth non-bandlimited fields," in the Third International Symposium on Information Processing in Sensor Networks, April 26-27, 2004, Berkeley, CA, pp. 89-98, ACM Press, 2004.
6. P. Ishwar, A. Kumar, and K. Ramchandran, "Distributed sampling for dense sensor networks:

- a "bit-observation principle", in Information Processing in Sensor Networks: Second International Workshop, IPSN 2003, Palo Alto, CA, April 22-23, 2003, (Lecture Notes in Computer Science) (L. J. Guibas and F. Zhao, eds.), pp. 17-31, Springer, New York, NY 2003.
7. P. Ishwar, R. Puri, S. S. Pradhan, and K. Ramchandran, "On rate-constrained estimation in unreliable sensor networks," in Information Processing in Sensor Networks: Second International Workshop, IPSN 2003, Palo Alto, CA, April 22-23, 2003, (Lecture Notes in Computer Science) (L. J. Guibas and F. Zhao, eds.), pp. 178-192, Springer, New York, NY 2003.
 8. K. Ramchandran and M. Vetterli, "Multiresolution Joint Source-Channel Coding," in Wireless Communications: Signal Processing Perspectives. Editors: H. Vincent Poor and Gregory W. Wornell. Prentice Publications, 1998.

B. Archived Journal Publications

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