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(54) **Title**: APPARATUS AND METHOD FOR LOW DELAY OBJECT METADATA CODING

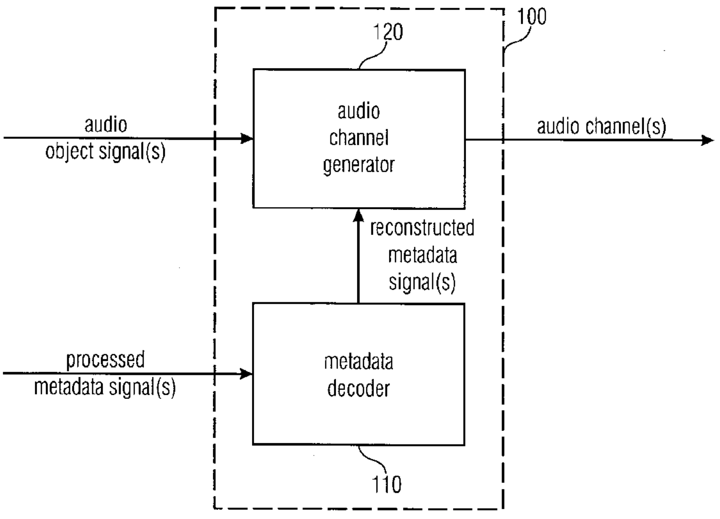

FIGURE 1

(57) **Abstract**: An apparatus (100) for generating one or more audio channels is provided. The apparatus comprises a metadata decoder (110) for generating one or more reconstructed metadata signals $(x_1',\dots x_N')$ from one or more processed metadata signals $(z_1,\dots,z_N)$ depending on a control signal (b), wherein each of the one or more reconstructed metadata signals $(\chi_1',\dots,\chi_N')$ indicates information associated with an audio object signal of one or more audio object signals, wherein the metadata decoder (110) is configured to generate the one or more reconstructed metadata signals $(X_1 ',\dots,X_N')$ by determining a plurality of reconstructed metadata samples $(x_1'(n),\dots,x_N'(n))$ for each of the one or more reconstructed metadata signals $(x_1'\ x_N')$. Moreover, the apparatus comprises an audio channel generator (120) for generating the one or more audio channels depending on the one or more audio object signals and depending on the one or more reconstructed metadata signals $(X_1',\dots,\chi_N')$. The metadata decoder (110) is configured to receive a plurality of processed metadata samples $(z_1(n),\dots,z_N(n))$ of each of the one or more processed metadata signals $(z_1,\dots,z_N)$. Moreover, the metadata decoder (110) is configured to receive the control signal (b). Furthermore, the metadata decoder (110) is configured to determine each reconstructed metadata sample $(\chi_i,'(n))$ of the plurality of reconstructed metadata samples $(X_i'(1),\dots X_i'(n-1), X_i'(n))$ of each reconstructed metadata signal (χ_i') of the one or more reconstructed metadata signals $(x_1',\dots x_N')$, so that, when the control signal (b) indicates a first state $(b(n)=0)$, said reconstructed metadata sample $(X_i'(n))$ is a sum of one of the processed metadata samples $(z,(n))$ of one of the one or more processed metadata signals (z_i) and of another already generated reconstructed metadata sample $(X_i'(n-1))$ of said reconstructed

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metadata signal (X_i'), and so that, when the control signal indicates a second state (b(n)=1) being different from the first state, said reconstructed metadata sample ($X_i'(n)$) is said one (z_i,(n)) of the processed metadata samples (z_i,(1),..., z_i(n)) of said one (Z_i) of the one or more processed metadata signals (z_1,...,z_N). Moreover, an apparatus (250) for generating encoded audio information is provided.

Apparatus and Method for Low Delay Object Metadata Coding

Description

The present invention is related to audio encoding/decoding, in particular, to spatial audio coding and spatial audio object coding, and, more particularly, to an apparatus and method for efficient object metadata coding.

Spatial audio coding tools are well-known in the art and are, for example, standardized in the MPEG-surround standard. Spatial audio coding starts from original input channels such as five or seven channels which are identified by their placement in a reproduction setup, i.e., a left channel, a center channel, a right channel, a left surround channel, a right surround channel and a low frequency enhancement channel. A spatial audio encoder typically derives one or more downmix channels from the original channels and, additionally, derives parametric data relating to spatial cues such as interchannel level differences in the channel coherence values, interchannel phase differences, interchannel time differences, etc. The one or more downmix channels are transmitted together with the parametric side information indicating the spatial cues to a spatial audio decoder which decodes the downmix channel and the associated parametric data in order to finally obtain output channels which are an approximated version of the original input channels. The placement of the channels in the output setup is typically fixed and is, for example, a 5.1 format, a 7.1 format, etc.

Such channel-based audio formats are widely used for storing or transmitting multi-channel audio content where each channel relates to a specific loudspeaker at a given position. A faithful reproduction of these kind of formats requires a loudspeaker setup where the speakers are placed at the same positions as the speakers that were used during the production of the audio signals. While increasing the number of loudspeakers improves the reproduction of truly immersive 3D audio scenes, it becomes more and more difficult to fulfill this requirement – especially in a domestic environment like a living room.

The necessity of having a specific loudspeaker setup can be overcome by an object-based approach where the loudspeaker signals are rendered specifically for the playback setup.

For example, spatial audio object coding tools are well-known in the art and are standardized in the MPEG SAOC standard (SAOC = spatial audio object coding). In contrast to spatial audio coding starting from original channels, spatial audio object coding starts from audio objects which are not automatically dedicated for a certain rendering reproduction setup. Instead, the placement of the audio objects in the reproduction scene is flexible and can be determined by the user by inputting certain rendering information into a spatial audio object coding decoder. Alternatively or additionally, rendering information, i.e., information at which position in the reproduction setup a certain audio object is to be placed typically over time can be transmitted as additional side information or metadata. In order to obtain a certain data compression, a number of audio objects are encoded by an SAOC encoder which calculates, from the input objects, one or more transport channels by downmixing the objects in accordance with certain downmixing information. Furthermore, the SAOC encoder calculates parametric side information representing inter-object cues such as object level differences (OLD), object coherence values, etc. As in SAC (SAC = Spatial Audio Coding), the inter object parametric data is calculated for individual time/frequency tiles, i.e., for a certain frame of the audio signal comprising, for example, 1024 or 2048 samples, 24, 32, or 64, etc., frequency bands are considered so that, in the end, parametric data exists for each frame and each frequency band. As an example, when an audio piece has 20 frames and when each frame is subdivided into 32 frequency bands, then the number of time/frequency tiles is 640.

In an object-based approach, the sound field is described by discrete audio objects. This requires object metadata that describes among others the time-variant position of each sound source in 3D space.

A first metadata coding concept in the prior art is the spatial sound description interchange format (SpatDIF), an audio scene description format which is still under development [1]. It is designed as an interchange format for object-based sound scenes and does not provide any compression method for object trajectories. SpatDIF uses the text-based Open Sound Control (OSC) format to structure the object metadata [2]. A simple text-based representation, however, is not an option for the compressed transmission of object trajectories.

Another metadata concept in the prior art is the Audio Scene Description Format (ASDF) [3], a text-based solution that has the same disadvantage. The data is structured by an extension of the Synchronized Multimedia Integration Language (SMIL) which is a sub set of the Extensible Markup Language (XML) [4,5].

A further metadata concept in the prior art is the audio binary format for scenes (AudioBIFS), a binary format that is part of the MPEG-4 specification [6,7]. It is closely related to the XML-based Virtual Reality Modeling Language (VRML) which was developed for the description of audio-visual 3D scenes and interactive virtual reality applications [8]. The complex AudioBIFS specification uses scene graphs to specify routes of object movements. A major disadvantage of AudioBIFS is that is not designed for real-time operation where a limited system delay and random access to the data stream are a requirement. Furthermore, the encoding of the object positions does not exploit the limited localization performance of human listeners. For a fixed listener position within the audio-visual scene, the object data can be quantized with a much lower number of bits [9]. Hence, the encoding of the object metadata that is applied in AudioBIFS is not efficient with regard to data compression.

It would therefore be highly appreciated, if improved, efficient object metadata coding concepts would be provided.

The object of the present invention is to provide improved concepts for object metadata coding. The object of the present invention is solved by an apparatus according to claim 1, by an apparatus according to claim 6, by a system according to claim 12, by a method according to claim 13, by a method according to claim 14 and by a computer program according to claim 15.

An apparatus for generating one or more audio channels is provided. The apparatus comprises a metadata decoder for generating one or more reconstructed metadata signals (x_1',...,x_N') from one or more processed metadata signals (z_1,...,z_N) depending on a control signal (b), wherein each of the one or more reconstructed metadata signals (x_1',...,x_N') indicates information associated with an audio object signal of one or more audio object signals, wherein the metadata decoder is configured to generate the one or more reconstructed metadata signals (x_1',...,x_N') by determining a plurality of reconstructed metadata samples (x_1'(n),...,x_N'(n)) for each of the one or more reconstructed metadata signals (x_1',...,x_N'). Moreover, the apparatus comprises an audio channel generator for generating the one or more audio channels depending on the one or more audio object signals and depending on the one or more reconstructed metadata signals (x_1',...,x_N'). The metadata decoder is configured to receive a plurality of processed metadata samples (z_1(n),...,z_N(n)) of each of the one or more processed metadata signals

$(z_1,\ldots,z_N)$. Moreover, the metadata decoder is configured to receive the control signal (b). Furthermore, the metadata decoder is configured to determine each reconstructed metadata sample $(x_i'(n))$ of the plurality of reconstructed metadata samples $(x_i'(1),\ldots\ x_i'(n-1),\ x_i'(n))$ of each reconstructed metadata signal (x_i') of the one or more reconstructed metadata signals $(x_1',\ldots,x_N')$, so that, when the control signal (b) indicates a first state $(b(n)=0)$, said reconstructed metadata sample $(x_i'(n))$ is a sum of one of the processed metadata samples $(z_i(n))$ of one of the one or more processed metadata signals (z_i) and of another already generated reconstructed metadata sample $(x_i'(n-1))$ of said reconstructed metadata signal (x_i'), and so that, when the control signal indicates a second state $(b(n)=1)$ being different from the first state, said reconstructed metadata sample $(x_i'(n))$ is said one $(z_i(n))$ of the processed metadata samples $(z_i(1),\ldots,z_i(n))$ of said one (z_i) of the one or more processed metadata signals $(z_1,\ldots,z_N)$.

Moreover, an apparatus for generating encoded audio information comprising one or more encoded audio signals and one or more processed metadata signals is provided. The apparatus comprises a metadata encoder for receiving one or more original metadata signals and for determining the one or more processed metadata signals, wherein each of the one or more original metadata signals comprises a plurality of original metadata samples, wherein the original metadata samples of each of the one or more original metadata signals indicate information associated with an audio object signal of one or more audio object signals.

Moreover, the apparatus comprises an audio encoder for encoding the one or more audio object signals to obtain the one or more encoded audio signals.

The metadata encoder is configured to determine each processed metadata sample $(z_i(n))$ of a plurality of processed metadata samples $(z_i(1),\ldots\ z_i(n-1),\ z_i(n))$ of each processed metadata signal (z_i) of the one or more processed metadata signals $(z_1,\ldots,z_N)$, so that, when the control signal (b) indicates a first state $(b(n)=0)$, said reconstructed metadata sample $(z_i(n))$ indicates a difference or a quantized difference between one of a plurality of original metadata samples $(x_i(n))$ of one of the one or more original metadata signals (x_i) and of another already generated processed metadata sample of said processed metadata signal (z_i), and so that, when the control signal indicates a second state $(b(n)=1)$ being different from the first state, said processed metadata sample $(z_i(n))$ is said one $(x_i(n))$ of the original metadata samples $(x_i(1),\ldots,x_i(n))$ of said one of the one or more processed metadata signals (x_i), or is a quantized representation $(q_i(n))$ said one $(x_i(n))$ of the original metadata samples $(x_i(1),\ldots,x_i(n))$.

According to embodiments, data compression concepts for object metadata are provided, which achieve efficient compression mechanism for transmission channels with limited data rate. No additional delay is introduced by the encoder and decoder, respectively. Moreover, a good compression rate for pure azimuth changes, for example, camera rotations, is achieved. Furthermore, the provided concepts support discontinuous trajectories, e.g., positional jumps. Moreover, low decoding complexity is realized. Furthermore, random access with limited reinitialization time is achieved.

Moreover, a method for generating one or more audio channels is provided. The method comprises:

- Generating one or more reconstructed metadata signals (x_1',...,x_N') from one or more processed metadata signals (z_1,...,z_N) depending on a control signal (b), wherein each of the one or more reconstructed metadata signals (x_1',...,x_N') indicates information associated with an audio object signal of one or more audio object signals, wherein generating the one or more reconstructed metadata signals (x_1',...,x_N') is conducted by determining a plurality of reconstructed metadata samples (x_1'(n),...,x_N'(n)) for each of the one or more reconstructed metadata signals (x_1',...,x_N'). And:

- Generating the one or more audio channels depending on the one or more audio object signals and depending on the one or more reconstructed metadata signals (x_1',...,x_N').

Generating the one or more reconstructed metadata signals (x_1',...,x_N') is conducted by receiving a plurality of processed metadata samples (z_1(n),...,z_N(n)) of each of the one or more processed metadata signals (z_1,...,z_N), by receiving the control signal (b), and by determining each reconstructed metadata sample (x_i'(n)) of the plurality of reconstructed metadata samples (x_i'(1),... x_i'(n-1), x_i'(n)) of each reconstructed metadata signal (x_i') of the one or more reconstructed metadata signals (x_1',...,x_N'), so that, when the control signal (b) indicates a first state (b(n)=0), said reconstructed metadata sample (x_i'(n)) is a sum of one of the processed metadata samples (z_i(n)) of one of the one or more processed metadata signals (z_i) and of another already generated reconstructed metadata sample (x_i'(n-1)) of said reconstructed metadata signal (x_i'), and so that, when the control signal indicates a second state (b(n)=1) being different from the first state, said reconstructed metadata sample (x_i'(n)) is said one (z_i(n)) of the processed metadata samples (z_i(1),...,z_i(n)) of said one (z_i) of the one or more processed metadata signals (z_1,...,z_N).

Furthermore, a method for generating encoded audio information comprising one or more encoded audio signals and one or more processed metadata signals is provided. The method comprises:

- Receiving one or more original metadata signals.

- Determining the one or more processed metadata signals. And:

- Encoding the one or more audio object signals to obtain the one or more encoded audio signals.

Each of the one or more original metadata signals comprises a plurality of original metadata samples, wherein the original metadata samples of each of the one or more original metadata signals indicate information associated with an audio object signal of one or more audio object signals. Determining the one or more processed metadata signals comprises determining each processed metadata sample ($z_i(n)$) of a plurality of processed metadata samples ($z_i(1),\ldots$ $z_i(n-1)$, $z_i(n)$) of each processed metadata signal (z_i) of the one or more processed metadata signals ($z_1,\ldots,z_N$), so that, when the control signal (b) indicates a first state ($b(n)=0$), said reconstructed metadata sample ($z_i(n)$) indicates a difference or a quantized difference between one of a plurality of original metadata samples ($x_i(n)$) of one of the one or more original metadata signals (x_i) and of another already generated processed metadata sample of said processed metadata signal (z_i), and so that, when the control signal indicates a second state ($b(n)=1$) being different from the first state, said processed metadata sample ($z_i(n)$) is said one ($x_i(n)$) of the original metadata samples ($x_i(1),\ldots,x_i(n)$) of said one of the one or more processed metadata signals (x_i), or is a quantized representation ($q_i(n)$) said one ($x_i(n)$) of the original metadata samples ($x_i(1),\ldots,x_i(n)$).

Moreover, a computer program for implementing the above-described method when being executed on a computer or signal processor is provided.

In the following, embodiments of the present invention are described in more detail with reference to the figures, in which:

Fig. 1 illustrates an apparatus for generating one or more audio channels according to an embodiment, Fig. 2 illustrates an apparatus for generating encoded audio information according to an embodiment,

Fig. 3 illustrates a system according to an embodiment,

Fig. 4 illustrates the position of an audio object in a three-dimensional space from an origin expressed by azimuth, elevation and radius,

Fig. 5 illustrates positions of audio objects and a loudspeaker setup assumed by the audio channel generator,

Fig. 6 illustrates a Differential Pulse Code Modulation encoder,

Fig. 7 illustrates a Differential Pulse Code Modulation decoder,

Fig. 8a illustrates a metadata encoder according to an embodiment,

Fig. 8b illustrates a metadata encoder according to another embodiment,

Fig. 9a illustrates a metadata decoder according to an embodiment,

Fig. 9b illustrates a metadata decoder subunit according to an embodiment,

Fig. 10 illustrates a first embodiment of a 3D audio encoder,

Fig. 11 illustrates a first embodiment of a 3D audio decoder,

Fig. 12 illustrates a second embodiment of a 3D audio encoder,

Fig. 13 illustrates a second embodiment of a 3D audio decoder,

Fig. 14 illustrates a third embodiment of a 3D audio encoder, and

Fig. 15 illustrates a third embodiment of a 3D audio decoder.

Fig. 2 illustrates an apparatus 250 for generating encoded audio information comprising one or more encoded audio signals and one or more processed metadata signals according to an embodiment.

The apparatus 250 comprises a metadata encoder 210 for receiving one or more original metadata signals and for determining the one or more processed metadata signals, wherein each of the one or more original metadata signals comprises a plurality of original metadata samples, wherein the original metadata samples of each of the one or more original metadata signals indicate information associated with an audio object signal of one or more audio object signals.

Moreover, the apparatus 250 comprises an audio encoder 220 for encoding the one or more audio object signals to obtain the one or more encoded audio signals.

The metadata encoder 210 is configured to determine each processed metadata sample ($z_i(n)$) of a plurality of processed metadata samples ($z_i(1),\ldots$ $z_i(n-1)$, $z_i(n)$) of each processed metadata signal (z_i) of the one or more processed metadata signals ($z_1,\ldots,z_N$), so that, when the control signal (b) indicates a first state ($b(n)=0$), said reconstructed metadata sample ($z_i(n)$) indicates a difference or a quantized difference between one of a plurality of original metadata samples ($x_i(n)$) of one of the one or more original metadata signals (x_i) and of another already generated processed metadata sample of said processed metadata signal (z_i), and so that, when the control signal indicates a second state ($b(n)=1$) being different from the first state, said processed metadata sample ($z_i(n)$) is said one ($x_i(n)$) of the original metadata samples ($x_i(1),\ldots,x_i(n)$) of said one of the one or more processed metadata signals (x_i), or is a quantized representation ($q_i(n)$) said one ($x_i(n)$) of the original metadata samples ($x_i(1),\ldots,x_i(n)$).

Fig. 1 illustrates an apparatus 100 for generating one or more audio channels according to an embodiment.

The apparatus 100 comprises a metadata decoder 110 for generating one or more reconstructed metadata signals ($x_1',\ldots,x_N'$) from one or more processed metadata signals ($z_1,\ldots,z_N$) depending on a control signal (b), wherein each of the one or more reconstructed metadata signals ($x_1',\ldots,x_N'$) indicates information associated with an audio object signal of one or more audio object signals, wherein the metadata decoder 110 is configured to generate the one or more reconstructed metadata signals ($x_1',\ldots,x_N'$) by determining a plurality of reconstructed metadata samples ($x_1'(n),\ldots,x_N'(n)$) for each of the one or more reconstructed metadata signals ($x_1',\ldots,x_N'$).

Moreover, the apparatus 100 comprises an audio channel generator 120 for generating the one or more audio channels depending on the one or more audio object signals and depending on the one or more reconstructed metadata signals (x_1',...,x_N').

The metadata decoder 110 is configured to receive a plurality of processed metadata samples (z_1(n),...,z_N(n)) of each of the one or more processed metadata signals (z_1,...,z_N). Moreover, the metadata decoder 110 is configured to receive the control signal (b).

Furthermore, the metadata decoder 110 is configured to determine each reconstructed metadata sample (x_i'(n)) of the plurality of reconstructed metadata samples (x_i'(1),... x_i'(n-1), x_i'(n)) of each reconstructed metadata signal (x_i') of the one or more reconstructed metadata signals (x_1',...,x_N'), so that, when the control signal (b) indicates a first state (b(n)=0), said reconstructed metadata sample (x_i'(n)) is a sum of one of the processed metadata samples (z_i(n)) of one of the one or more processed metadata signals (z_i) and of another already generated reconstructed metadata sample (x_i'(n-1)) of said reconstructed metadata signal (x_i'), and so that, when the control signal indicates a second state (b(n)=1) being different from the first state, said reconstructed metadata sample (x_i'(n)) is said one (z_i(n)) of the processed metadata samples (z_i(1),...,z_i(n)) of said one (z_i) of the one or more processed metadata signals (z_1,...,z_N).

When referring to metadata samples, it should be noted, that a metadata sample is characterised by its metadata sample value, but also by the instant of time, to which it relates. For example, such an instant of time may be relative to the start of an audio sequence or similar. For example, an index n or k might identify a position of the metadata sample in a metadata signal and by this, a (relative) instant of time (being relative to a start time) is indicated. It should be noted that when two metadata samples relate to different instants of time, these two metadata samples are different metadata samples, even when their metadata sample values are equal, what sometimes may be the case.

The above embodiments are based on the finding that metadata information (comprised by a metadata signal) that is associated with an audio object signal often changes slowly.

For example, a metadata signal may indicate position information on an audio object (e.g., an azimuth angle, an elevation angle or a radius defining the position of an audio object). It may be assumed that, at most times, the position of the audio object either does not change or only changes slowly.

Or, a metadata signal may, for example, indicate a volume (e.g., a gain) of an audio object, and it may also be assumed, that at most times, the volume of an audio object changes slowly.

For this reason, it is not necessary to transmit the (complete) metadata information at every instant of time.

Instead, the (complete) metadata information, may, for example, according to some embodiments, only be transmitted at certain instants of time, for example, periodically, e.g., at every N-th instant of time, e.g., at point in time 0, N, 2N, 3N, etc.

For example, in embodiments, three metadata signals specify the position of an audio object in a 3D space. A first one of the metadata signals may, e.g., specify the azimuth angle of the position of the audio object. A second one of the metadata signals may, e.g., specify the elevation angle of the position of the audio object. A third one of the metadata signals may, e.g., specify the radius relating to the distance of the audio object.

Azimuth angle, elevation angle and radius unambiguously define the position of an audio object in a 3D space from an origin. This is illustrated with reference to Fig. 4.

Fig. 4 illustrates the position 410 of an audio object in a three-dimensional (3D) space from an origin 400 expressed by azimuth, elevation and radius.

The elevation angle specifies, for example, the angle between the straight line from the origin to the object position and the normal projection of this straight line onto the xy-plane (the plane defined by the x-axis and the y-axis). The azimuth angle defines, for example, the angle between the x-axis and the said normal projection. By specifying the azimuth angle and the elevation angle, the straight line 415 through the origin 400 and the position 410 of the audio object can be defined. By furthermore specifying the radius, the exact position 410 of the audio object can be defined.

In an embodiment, the azimuth angle is defined for the range: $-180° < \text{azimuth} \leq 180°$, the elevation angle is defined for the range: $-90° \leq \text{elevation} \leq 90°$ and the radius may, for example, be defined in meters [m] (greater than or equal to 0m).

In another embodiment, where it, may, for example, be assumed that all x-values of the audio object positions in an xyz-coordinate system are greater than or equal to zero, the azimuth angle may be defined for the range: $-90° \leq \text{azimuth} \leq 90°$, the elevation angle may be defined for the range:-90° ≤ elevation ≤ 90°, and the radius may, for example, be defined in meters [m].

In a further embodiment, the metadata signals may be scaled such that the azimuth angle is defined for the range: -128° < azimuth ≤ 128°, the elevation angle is defined for the range: -32° ≤ elevation ≤ 32° and the radius may, for example, be defined on a logarithmic scale. In some embodiments, the original metadata signals, the processed metadata signals and the reconstructed metadata signals, respectively, may comprise a scaled representation of a position information and/or a scaled representation of a volume of one of the one or more audio object signals.

The audio channel generator 120 may, for example, be configured to generate the one or more audio channels depending on the one or more audio object signals and depending on the reconstructed metadata signals, wherein the reconstructed metadata signals may, for example, indicate the position of the audio objects.

Fig. 5 illustrates positions of audio objects and a loudspeaker setup assumed by the audio channel generator. The origin 500 of the xyz-coordinate system is illustrated. Moreover, the position 510 of a first audio object and the position 520 of a second audio object is illustrated. Furthermore, Fig. 5 illustrates a scenario, where the audio channel generator 120 generates four audio channels for four loudspeakers. The audio channel generator 120 assumes that the four loudspeakers 511, 512, 513 and 514 are located at the positions shown in Fig. 5.

In Fig. 5, the first audio object is located at a position 510 close to the assumed positions of loudspeakers 511 and 512, and is located far away from loudspeakers 513 and 514. Therefore, the audio channel generator 120 may generate the four audio channels such that the first audio object 510 is reproduced by loudspeakers 511 and 512 but not by loudspeakers 513 and 514.

In other embodiments, audio channel generator 120 may generate the four audio channels such that the first audio object 510 is reproduced with a high volume by loudspeakers 511 and 512 and with a low volume by loudspeakers 513 and 514.

Moreover, the second audio object is located at a position 520 close to the assumed positions of loudspeakers 513 and 514, and is located far away from loudspeakers 511 and 512. Therefore, the audio channel generator 120 may generate the four audio channels such that the second audio object 520 is reproduced by loudspeakers 513 and 514 but not by loudspeakers 511 and 512.

In other embodiments, audio channel generator 120 may generate the four audio channels such that the second audio object 520 is reproduced with a high volume by loudspeakers 513 and 514 and with a low volume by loudspeakers 511 and 512.

In alternative embodiments, only two metadata signals are used to specify the position of an audio object. For example, only the azimuth and the radius may be specified, for example, when it is assumed that all audio objects are located within a single plane.

In further other embodiments, for each audio object, only a single metadata signal is encoded and transmitted as position information. For example, only an azimuth angle may be specified as position information for an audio object (e.g., it may be assumed that all audio objects are located in the same plane having the same distance from a center point, and are thus assumed to have the same radius). The azimuth information may, for example, be sufficient to determine that an audio object is located close to a left loudspeaker and far away from a right loudspeaker. In such a situation, the audio channel generator 120 may, for example, generate the one or more audio channels such that the audio object is reproduced by the left loudspeaker, but not by the right loudspeaker.

For example, Vector Base Amplitude Panning (VBAP) may be employed (see, e.g., [11]) to determine the weight of an audio object signal within each of the audio channels of the loudspeakers. E.g., with respect to VBAP, it is assumed that an audio object relates to a virtual source.

In embodiments, a further metadata signal may specify a volume, e.g., a gain (for example, expressed in decibel [dB]) for each audio object.

For example, in Fig. 5, a first gain value may be specified by a further metadata signal for the first audio object located at position 510 which is higher than a second gain value being specified by another further metadata signal for the second audio object located at position 520. In such a situation, the loudspeakers 511 and 512 may reproduce the first audio object with a volume being higher than the volume with which loudspeakers 513 and 514 reproduce the second audio object.

Embodiments also assume that such gain values of audio objects often change slowly. Therefore, it is not necessary to transmit such metadata information at every point in time.

Instead, metadata information is only transmitted at certain points in time. At intermediate points in time, the metadata information may, e.g., be approximated using the preceding metadata sample and the succeeding metadata sample, that were transmitted. For example, linear interpolation may be employed for approximation of intermediate values. E.g., the gain, the azimuth, the elevation and/or the radius of each of the audio objects may be approximated for points in time, where such metadata was not transmitted.

By such an approach, considerable savings in the transmission rate of metadata can be achieved.

Fig. 3 illustrates a system according to an embodiment.

The system comprises an apparatus 250 for generating encoded audio information comprising one or more encoded audio signals and one or more processed metadata signals as described above.

Moreover, the system comprises an apparatus 100 for receiving the one or more encoded audio signals and the one or more processed metadata signals, and for generating one or more audio channels depending on the one or more encoded audio signals and depending on the one or more processed metadata signals as described above.

For example, the one or more encoded audio signals may be decoded by the apparatus 100 for generating one or more audio channels by employing a SAOC decoder according to the state of the art to obtain one or more audio object signals, when the apparatus 250 for encoding did use a SAOC encoder for encoding the one or more audio objects.

Embodiments are based on the finding, that concepts of the Differential Pulse Code Modulation may be extended, and, such extended concepts are then suitable to encode metadata signals for audio objects.

The Differential Pulse Code Modulation (DPCM) method is an established method for slowly varying time signals that reduces irrelevance via quantization and redundancy via a differential transmission [10]. A DPCM encoder is shown in Fig. 6.

In the DPCM encoder of Fig. 6, an actual input sample x(n) of an input signal x is fed into a subtraction unit 610. At the other input of the subtraction unit, another value is fed into the subtraction unit. It may be assumed that this other value is the previously received sample x(n-1), although quantization errors or other errors may have the result that the value at other input is not exactly identical to the previous sample x(n-1). Because of such possible deviations from x(n-1), the other input of the subtractor may be referred to as x^*(n-1) The subtraction unit subtracts x^*(n-1) from x(n) to obtain the difference value d(n).

d(n) is then quantized in quantizer 620 to obtain another output sample y(n) of the output signal y. In general, y(n) is either equal to d(n) or a value close to d(n).

Moreover, y(n) is fed into adder 630. Furthermore, x^* (n-1) is fed into the adder 630. As d(n) results from the subtraction d(n) = x(n) – x^* (n-1), and as y(n) is a value equal to or at least close to d(n), the output x^* (n) of the adder 630 is equal to x(n) or at least close to x(n).

x^* (n) is held for a sampling period in unit 640, and then, processing is continued with the next sample x(n+1).

Fig. 7 shows a corresponding DPCM decoder.

In Fig. 7, a sample y(n) of the output signal y from the DPCM encoder is fed into adder 710. y(n) represents a difference value of the signal x(n) that shall be reconstructed. At the other input of the adder 710, the previously reconstructed sample x'(n-1) is fed into the adder 710. Output x'(n) of the adder results from the addition x'(n) = x'(n-1) + y(n). As x'(n-1) is, in general, equal to or at least close to x(n-1), and as y(n) is, in general, equal to or close to x(n) - x(n-1), the output x'(n) of the adder 710 is, in general, equal to or close to x(n).

x'(n) is hold for a sampling period in unit 740, and then, processing is continued with the next sample y(n+1).

While a DPCM compression method fulfills most of the previously stated required features, it does not allow for random access.

Fig. 8a illustrates a metadata encoder 801 according to an embodiment.

The encoding method employed by the metadata encoder 801 of Fig. 8a is an extension of the classical DPCM encoding method.

The metadata encoder 801 of Fig. 8a comprises one or more DPCM encoder 811, ..., 81N. For example, when the metadata encoder 801 is configured to receive N original metadata signals, the metadata encoder 801 may, for example, comprise exactly N DPCM encoder. In an embodiment, each of the N DPCM encoders is implemented as described with respect to Fig. 6.

In an embodiment, each of the N DPCM encoders is configured to receive the metadata samples $x_i(n)$ of one of the N original metadata signals $x_1, \ldots, x_N$, and generates a difference value as difference sample $y_i(n)$ of a metadata difference signal y_i for each of the metadata samples $x_i(n)$ of said original metadata signal x_i, which is fed into said DPCM encoder. In an embodiment, generating the difference sample $y_i(n)$ may, for example, be conducted as described with reference to Fig. 6.

The metadata encoder 801 of Fig. 8a further comprises a selector 830 ("A"), which is configured to receive a control signal b(n).

The selector 830 is moreover, configured to receive the N metadata difference signals $y_1 \ldots y_N$.

Furthermore, in the embodiment of Fig. 8a, the metadata encoder 801 comprises a quantizer 820 which quantizes the N original metadata signals $x_1, \ldots, x_N$ to obtain N quantized metadata signals $q_1, \ldots, q_N$. In such an embodiment, the quantizer may be configured to feed the N quantized metadata signals into the selector 830.

The selector 830 may be configured to generate processed metadata signals z_i from the quantized metadata signals q_i and from the DPCM encoded difference metadata signals y_i depending on the control signal b(n).

For example, when the control signal b is in a first state (e.g., b(n) = 0), the selector 830 may be configured to output the difference samples $y_i(n)$ of the metadata difference signals y_i as metadata samples $z_i(n)$ of the processed metadata signals z_i.

When the control signal b is in a second state, being different from the first state (e.g., b(n) = 1), the selector 830 may be configured to output the metadata samples $q_i(n)$ of the quantized metadata signals q_i as metadata samples $z_i(n)$ of the processed metadata signals z_i.

Fig. 8b illustrates a metadata encoder 802 according to another embodiment.

In the embodiment of Fig. 8b, the metadata encoder 802 does not comprise the quantizer 820, and, instead of the N quantized metadata signals $q_1, \ldots, q_N$, the N original metadata signals $x_1, \ldots, x_N$ are directly fed into the selector 830.

In such an embodiment, when, for example, the control signal b is in a first state (e.g., b(n) = 0), the selector 830 may be configured to output the difference samples $y_i(n)$ of the metadata difference signals y_i as metadata samples $z_i(n)$ of the processed metadata signals z_i.

When the control signal b is in a second state, being different from the first state (e.g., b(n) = 1), the selector 830 may be configured to output the metadata samples $x_i(n)$ of the original metadata signals x_i as metadata samples $z_i(n)$ of the processed metadata signals z_i.

Fig. 9a illustrates a metadata decoder 901 according to an embodiment. The metadata encoder according to Fig. 9a corresponds to the metadata encoders of Fig. 8a and Fig. 8b.

The metadata decoder 901 of Fig. 9a comprises one or more metadata decoder subunits 911, ..., 91N. The metadata decoder 901 is configured to receive one or more processed metadata signals $z_1, \ldots, z_N$. Moreover, the metadata decoder 901 is configured to receive a control signal b. The metadata decoder is configured to generate one or more reconstructed metadata signals $x_1', \ldots x_N'$ from the one or more processed metadata signals $z_1, \ldots, z_N$ depending on the control signal b.

In an embodiment, each of the N processed metadata signals $z_1, \ldots, z_N$ is fed into a different one of the metadata decoder subunits 911, ..., 91N. Moreover, according to an embodiment, the control signal b is fed into each of the metadata decoder subunits 911, ..., 91N. According to an embodiment, the number of metadata decoder subunits 911, .., 91N is identical to the number of processed metadata signals $z_1, \ldots, z_N$ that are received be the metadata decoder 901.

Fig. 9b illustrates a metadata decoder subunit (91i) of the metadata decoder subunits 911, ..., 91N of Fig. 9a according to an embodiment. The metadata decoder subunit 91i is configured to conduct decoding for a single processed metadata signal z_i. The metadata decoder subunit 91i comprises a selector 930 ("B") and an adder 910.

The metadata decoder subunit 91i is configured to generate the reconstructed metadata signal x_i' from the received processed metadata signal z_i depending on the control signal b(n).

This may, for example, be realized as follows:

The last reconstructed metadata sample x_i'(n-1) of the reconstructed metadata signal x_i' is fed into the adder 910. Moreover, the actual metadata sample z_i(n) of the processed metadata signal z_i is also fed into the adder 910. The adder is configured to add the last reconstructed metadata sample x_i'(n-1) and the actual metadata sample z_i(n). to obtain a sum value s_i(n) which is fed into the selector 930.

Moreover, the actual metadata sample z_i(n) is also fed into the adder 930.

The selector is configured to select either the sum value s_i(n) from the adder 910 or the actual metadata sample z_i(n) as the actual metadata sample x_i'(n) of the reconstructed metadata signal x_i'(n) depending on the contral signal b.

When, for example, the control signal b is in a first state (e.g., b(n) = 0), the control signal b indicates that the actual metadata sample z_i(n) is a difference value, and so, the sum value s_i(n) is the correct actual metadata sample x_i'(n) of the reconstructed metadata signal x_i'. The selector 830 is configured to select the sum value s_i(n) as the actual metadata sample x_i'(n) of the reconstructed metadata signal x_i', when the control signal is in the first state (when b(n) = 0).

When the control signal b is in a second state, being different from the first state (e.g., b(n) = 1), the control signal b indicates that the actual metadata sample z_i(n) is not a difference value, and so, the actual metadata sample z_i(n) is the correct actual metadata sample x_i'(n) of the reconstructed metadata signal x_i'. The selector 830 is configured to select the actual metadata sample z_i(n) as the actual metadata sample x_i'(n) of the reconstructed metadata signal x_i', when the control signal is in the second state (when b(n) = 1).

According to embodiments, the metadata decoder subunit 91i' further comprises a unit 920. Unit 920 is configured to hold the actual metadata sample x_i'(n) of the reconstructed metadata signal for the duration of a sampling period. In an embodiment, this ensures, that when x_i'(n) is being generated, the generated x'(n) is not fed back too early, so that when z_i(n) is a difference value, x_i'(n) is really generated based on x_i'(n-1).

In an embodiment of Fig. 9b, the selector 930 may generate the metadata samples xi'(n) from the received signal component $z_i(n)$ and the linear combination of the delayed output component (the already generated metadata sample of the reconstructed metadata signal) and the received signal component $z_i(n)$ depending on the control signal b(n).

In the following, the DPCM encoded signals are denoted as $y_i(n)$ and the second input signal (the sum signal) of B as $s_i(n)$. For output components that only depend on the corresponding input components, the encoder and decoder output is given as follows:

$$z_i(n) \quad = \quad A(x_i(n),\ v_i(n),\ b(n))$$

$$x_i'(n) \quad = \quad B(z_i(n),\ s_i(n),\ b(n))$$

A solution according to an embodiment for the general approach sketched above is to use b(n) to switch between the DPCM encoded signal and the quantized input signal. Omitting the time index n for simplicity reasons, the function blocks A and B are then given as follows:

In the metadata encoders 801, 802, the selector 830 (A) selects:

$$A:\ z_i(x_i,\ y_i,\ b) = y_i, \quad \text{if } b = 0 \qquad (z_i \text{ indicates a difference value})$$

$$A:\ z_i(x_i,\ y_i,\ b) = x_i, \quad \text{if } b = 1 \qquad (z_i \text{ does not indicate a difference value})$$

In the metadata decoder subunits 91i, 91i', the selector 930 (B) selects:

$$B:\ x_i'(z_i,\ s_i,\ b) = s_i, \quad \text{if } b = 0 \qquad (z_i \text{ indicates a difference value})$$

$$B:\ x_i'(z_i,\ s_i,\ b) = z_i, \quad \text{if } b = 1 \qquad (z_i \text{ does not indicate a difference value})$$

This allows to transmit the quantized input signal whenever b(n) is equal to 1 and to transmit a DPCM signal whenever b(n) is 0. In the latter case, the decoder becomes a DPCM decoder.

When applied for the transmission of object metadata, this mechanism is used to regularly transmit uncompressed object positions which can be used by the decoder for random access.

In preferred embodiments, fewer bits are used for encoding the difference values than the number of bits used for encoding the metadata samples. These embodiments are based on the finding that (e.g., N) subsequent metadata samples in most times only vary slightly. For example, if one kind of metadata samples is encoded, e.g., by 8 bits, these metadata samples can take on one out of 256 different values. Because of the, in general, slight changes of (e.g., N) subsequent metadata values, it may be considered sufficient, to encode the difference values only, e.g., by 5 bits. Thus, even if difference values are transmitted, the number of transmitted bits can be reduced.

In an embodiment, the metadata encoder 210 is configured to encode each of the processed metadata samples ($z_i(1),\ldots,z_i(n)$) of one z_i () of the one or more processed metadata signals ($z_1,\ldots,z_N$) with a first number of bits when the control signal indicates the first state (b(n)=0), and with a second number of bits when the control signal indicates the second state (b(n)=1), wherein the first number of bits is smaller than the second number of bits.

In a preferred embodiment, one or more difference values are transmitted, each of the one or more difference values is encoded with fewer bits than each of the metadata samples, and each of the difference value is an integer value.

According to an embodiment, the metadata encoder 110 is configured to encode one or more of the metadata samples of one of the one or more processed metadata signals with a first number of bits, wherein each of said one or more of the metadata samples of said one of the one or more processed metadata signals indicates an integer. Moreover metadata encoder (110) is configured to encode one or more of the difference values with a second number of bits, wherein each of said one or more of the difference values indicates an integer, wherein the second number of bits is smaller than the first number of bits.

Consider, for example, that in an embodiment, metadata samples may represent an azimuth being encoded by 8 bits. E.g., the azimuth may be an integer between $-90 \leq$ azimuth ≤ 90. Thus, the azimuth can take on 181 different values. If however, one can assume that (e.g. N) subsequent azimuth samples only differ by no more than, e.g., ± 15, then, 5 bits ($2^5 = 32$) may be enough to encode the difference values. If difference values are represented as integers, then determining the difference values automatically transforms the additional values, to be transmitted, to a suitable value range.

For example, consider a case where a first azimuth value of a first audio object is 60° and its subsequent values vary from 45° to 75°. Moreover, consider that a second azimuth value of a second audio object is -30° and its subsequent values vary from -45° to -15°. By determining difference values for both the subsequent values of the first audio object and for both the subsequent values of the second audio object, the difference values of the first azimuth value and of the second azimuth value are both in the value range from -15° to +15°, so that 5 bits are sufficient to encode each of the difference values and so that the bit sequence, which encodes the difference values, has the same meaning for difference values of the first azimuth angle and difference values of the second azimuth value.

In the following, object metadata frames according to embodiments and symbol representation according to embodiments are described.

The encoded object metadata is transmitted in frames. These object metadata frames may contain either intracoded object data or dynamic object data where the latter contains the changes since the last transmitted frame.

Some or all portions of the following syntax for object metadata frames may, for example, be employed:

	No. of bits	Mnemonic
object_metadata()		
{		
has_intracoded_object_metadata;	**1**	**bslbf**
if (has_intracoded_object_metadata) {		
intracoded_object_metadata ();		
}		
else {		
dynamic_object_metadata();		
}		
}		

In the following, intracoded object data according to an embodiment is described.

Random access of the encoded object metadata is realized via intracoded object data ("I-Frames") which contain the quantized values sampled on a regular grid (e.g. every 32 frames of length 1024). These I-Frames may, for example, have the following syntax, where *position_azimuth*, *position_elevation*, *position_radius*, and *gain_factor* specify the current quantized values:

	No. of bits	Mnemonic
intracoded_object_metadata()		
{		
if (num_objects>1) {		
fixed_azimuth;	**1**	**bslbf**
if (fixed_azimuth) {		
default_azimuth;	**8**	**tcimsbf**
}		
else {		
common_azimuth;	**1**	**bslbf**
if (common_azimuth) {		
default_azimuth;	**8**	**tcimsbf**
}		
else {		
for (o=1:num_objects) {		
position_azimuth[o];	**8**	**tcimsbf**
}		
}		
}		
fixed_elevation;	**1**	**bslbf**
if (fixed_azimuth) {		
default_elevation;	**6**	**tcimsbf**
}		
else {		
common_ elevation;	**1**	**bslbf**
if (common_azimuth) {		
default_elevation;	**6**	**tcimsbf**
}		
else {		
for (o=1:num_objects) {		
position_azimuth[o];	**6**	**tcimsbf**
}		
}		
}		
fixed_radius;	**1**	**bslbf**
if (fixed_azimuth) {		
default_radius;	**4**	**tcimsbf**
}		
else {		
common_ radius;	**1**	**bslbf**
if (common_azimuth) {		
default_radius;	**4**	**tcimsbf**
}		
else {		
for (o=1:num_objects) {		
position_ radius [o];	**4**	**tcimsbf**
}		
}		

}		
fixed_gain;	**1**	**bslbf**
if (fixed_azimuth) {		
default_gain;	**7**	**tcimsbf**
}		
else {		
common_ gain;	**1**	**bslbf**
if (common_azimuth) {		
default_gain;	**7**	**tcimsbf**
}		
else {		
for (o=1:num_objects) {		
gain_factor [o];	**7**	**tcimsbf**
}		
}		
}		
}		
else {		
position_azimuth;	**8**	**tcimsbf**
position_elevation;	**6**	**tcimsbf**
position_radius;	**4**	**tcimsbf**
gain_factor;	**7**	**tcimsbf**
}		
}		

In the following, dynamic object data according to an embodiment is described.

DPCM data is transmitted in dynamic object frames which may, for example, have the following syntax:

	No. of bits	Mnemonic
dynamic_object_metadata()		
{		
flag_absolute;	**1**	**bslbf**
for (o=1:num_objects) {		
has_object_metadata;	**1**	**bslbf**
if (has_object_metadata) {		
single_dynamic_object_metadata(flag_absolute);		
}		
}		
}		

	No. of bits	Mnemonic
single_dynamic_object_metadata (flag_absolute) {		
if (flag_absolute) {		
if (!fixed_azimuth*) {		

```
            position_azimuth;                         8                 tcimsbf
        }
        if (!fixed_elevation*) {
            position_elevation;                       6                 tcimsbf
        }
        if (!fixed_radius*) {
            position_radius;                          4                 tcimsbf
        }
        if (!fixed_gain*) {
            gain_ factor;                             7                 tcimsbf
        }
    }
    else {
        nbits;                                        3                 uimsbf
        if (!fixed_azimuth*) {
            flag_azimuth;                             1                 bslbf
            if (flag_azimuth) {
                position_azimuth_difference ;         num_bits          tcimsbf
            }
        }
        if (!fixed_elevation*) {
            flag_elevation;                           1                 bslbf
            if (flag_elevation) {
                position_elevation_difference ;       min(num_bits,7)   tcimsbf
            }
        }
        if (!fixed_radius*) {
            flag_radius;                              1                 bslbf
            if (flag_radius) {
                position_radius_difference ;          min(num_bits,5)   tcimsbf
            }
        }
        if (!fixed_gain*) {
            flag_gain;                                1                 bslbf
            if (flag_gain) {
                gain_factor_difference ;              min(num_bits,8)   tcimsbf
            }
        }
```

Note: num_bits = nbits + 2;
Footnote *: Given by the preceding intracoded_object_data()-frame

In particular, in an embodiment, the above macros may, e.g., have the following meaning:

Definition of object_data() payloads according to an embodiment:

has_intracoded_object_metadata	indicates whether the frame is intracoded or differentially coded.

Definition of intracoded_object_metadata() payloads according to an embodiment:

fixed_azimuth	flag indicating whether the azimuth value is fixed for all object and not transmitted in case of dynamic_object_metadata()
default_azimuth	defines the value of the fixed or common azimuth angle
common_azimuth	indicates whether a common azimuth angle is used is used for all objects
position_azimuth	if there is no common azimuth value, a value for each object is transmitted
fixed_elevation	flag indicating whether the elevation value is fixed for all object and not transmitted in case of dynamic_object_metadata()
default_elevation	defines the value of the fixed or common elevation angle
common_elevation	indicates whether a common elevation angle is used for all objects
position_elevation	if there is no common elevation value, a value for each object is transmitted
fixed_radius	flag indicating whether the radius is fixed for all object and not transmitted in case of dynamic_object_metadata()
default_radius	defines the value of the common radius
common_radius	indicates whether a common radius value is used for all objects
position_radius	if there is no common radius value, a value for each object is transmitted

fixed_gain flag indicating whether the gain factor is fixed for all object and not transmitted in case of dynamic_object_metadata()

default_gain defines the value of the fixed or common gain factor

common_gain indicates whether a common gain value is used for all objects

gain_factor if there is no common gain value, a value for each object is transmitted

position_azimuth if there is only one object, this is its azimuth angle

position_elevation if there is only one object, this is its elevation angle

position_radius if there is only one object, this is its radius

gain_factor if there is only one object, this is its gain factor

Definition of dynamic_object_metadata() payloads according to an embodiment:

flag_absolute indicates whether the values of the components are transmitted differentially or in absolute values

has_object_metadata indicates whether there are object data present in the bit stream or not

Definition of single_dynamic_object_metadata() payloads according to an embodiment:

position_azimuth the absolute value of the azimuth angle if the value is not fixed

position_elevation the absolute value of the elevation angle if the value is not fixed

position_radius the absolute value of the radius if the value is not fixed

gain_factor	the absolute value of the gain factor if the value is not fixed
nbits	how many bits are required to represent the differential values
flag_azimuth	flag per object indicating whether the azimuth value changes
position_azimuth_difference	difference between the previous and the active value
flag_elevation	flag per object indicating whether the elevation value changes
position_elevation_difference	value of the difference between the previous and the active value
flag_radius	flag per object indicating whether the radius changes
position_radius_difference	difference between the previous and the active value
flag_gain	flag per object indicating whether the gain radius changes
gain_factor_difference	difference between the previous and the active value

In the prior art, no flexible technology exists combining channel coding on the one hand and object coding on the other hand so that acceptable audio qualities at low bit rates are obtained.

This limitation is overcome by the 3D Audio Codec System. Now, the 3D Audio Codec System is described.

Fig. 10 illustrates a 3D audio encoder in accordance with an embodiment of the present invention. The 3D audio encoder is configured for encoding audio input data 101 to obtain audio output data 501. The 3D audio encoder comprises an input interface for receiving a plurality of audio channels indicated by CH and a plurality of audio objects indicated by OBJ. Furthermore, as illustrated in Fig. 10, the input interface 1100 additionally receives metadata related to one or more of the plurality of audio objects OBJ. Furthermore, the 3D audio encoder comprises a mixer 200 for mixing the plurality of objects and the plurality of channels to obtain a plurality of pre-mixed channels, wherein each pre-mixed channel comprises audio data of a channel and audio data of at least one object.

Furthermore, the 3D audio encoder comprises a core encoder 300 for core encoding core encoder input data, a metadata compressor 400 for compressing the metadata related to the one or more of the plurality of audio objects.

Furthermore, the 3D audio encoder can comprise a mode controller 600 for controlling the mixer, the core encoder and/or an output interface 500 in one of several operation modes, wherein in the first mode, the core encoder is configured to encode the plurality of audio channels and the plurality of audio objects received by the input interface 1100 without any interaction by the mixer, i.e., without any mixing by the mixer 200. In a second mode, however, in which the mixer 200 was active, the core encoder encodes the plurality of mixed channels, i.e., the output generated by block 200. In this latter case, it is preferred to not encode any object data anymore. Instead, the metadata indicating positions of the audio objects are already used by the mixer 200 to render the objects onto the channels as indicated by the metadata. In other words, the mixer 200 uses the metadata related to the plurality of audio objects to pre-render the audio objects and then the pre-rendered audio objects are mixed with the channels to obtain mixed channels at the output of the mixer. In this embodiment, any objects may not necessarily be transmitted and this also applies for compressed metadata as output by block 400. However, if not all objects input into the interface 1100 are mixed but only a certain amount of objects is mixed, then only the remaining non-mixed objects and the associated metadata nevertheless are transmitted to the core encoder 300 or the metadata compressor 400, respectively.

In Fig. 10, the meta data compressor 400 is the metadata encoder 210 of an apparatus 250 for generating encoded audio information according to one of the above-described embodiments. Moreover, in Fig. 10, the mixer 200 and the core encoder 300 together form the audio encoder 220 of an apparatus 250 for generating encoded audio information according to one of the above-described embodiments.

Fig. 12 illustrates a further embodiment of an 3D audio encoder which, additionally, comprises an SAOC encoder 800. The SAOC encoder 800 is configured for generating one or more transport channels and parametric data from spatial audio object encoder input data. As illustrated in Fig. 12, the spatial audio object encoder input data are objects which have not been processed by the pre-renderer/mixer. Alternatively, provided that the pre-renderer/mixer has been bypassed as in the mode one where an individual channel/object coding is active, all objects input into the input interface 1100 are encoded by the SAOC encoder 800.

Furthermore, as illustrated in Fig. 12, the core encoder 300 is preferably implemented as a USAC encoder, i.e., as an encoder as defined and standardized in the MPEG-USAC standard (USAC = unified speech and audio coding). The output of the whole 3D audio encoder illustrated in Fig. 12 is an MPEG 4 data stream having the container-like structures for individual data types. Furthermore, the metadata is indicated as “OAM” data and the metadata compressor 400 in Fig. 10 corresponds to the OAM encoder 400 to obtain compressed OAM data which are input into the USAC encoder 300 which, as can be seen in Fig. 12, additionally comprises the output interface to obtain the MP4 output data stream not only having the encoded channel/object data but also having the compressed OAM data.

In Fig. 12, the OAM encoder 400 is the metadata encoder 210 of an apparatus 250 for generating encoded audio information according to one of the above-described embodiments. Moreover, in Fig. 12, the SAOC encoder 800 and the USAC encoder 300 together form the audio encoder 220 of an apparatus 250 for generating encoded audio information according to one of the above-described embodiments.

Fig. 14 illustrates a further embodiment of the 3D audio encoder, where in contrast to Fig. 12, the SAOC encoder can be configured to either encode, with the SAOC encoding algorithm, the channels provided at the pre-renderer/mixer 200not being active in this mode or, alternatively, to SAOC encode the pre-rendered channels plus objects. Thus, in Fig. 14, the SAOC encoder 800 can operate on three different kinds of input data, i.e., channels without any pre-rendered objects, channels and pre-rendered objects or objects alone. Furthermore, it is preferred to provide an additional OAM decoder 420 in Fig. 14 so that the SAOC encoder 800 uses, for its processing, the same data as on the decoder side, i.e., data obtained by a lossy compression rather than the original OAM data.

The Fig. 14 3D audio encoder can operate in several individual modes.

In addition to the first and the second modes as discussed in the context of Fig. 10, the Fig. 14 3D audio encoder can additionally operate in a third mode in which the core encoder generates the one or more transport channels from the individual objects when the pre-renderer/mixer 200 was not active. Alternatively or additionally, in this third mode the SAOC encoder 800 can generate one or more alternative or additional transport channels from the original channels, i.e., again when the pre-renderer/mixer 200 corresponding to the mixer 200 of Fig. 10 was not active.

Finally, the SAOC encoder 800 can encode, when the 3D audio encoder is configured in the fourth mode, the channels plus pre-rendered objects as generated by the pre-renderer/mixer. Thus, in the fourth mode the lowest bit rate applications will provide good quality due to the fact that the channels and objects have completely been transformed into individual SAOC transport channels and associated side information as indicated in Figs. 3 and 5 as "SAOC-SI" and, additionally, any compressed metadata do not have to be transmitted in this fourth mode.

In Fig. 14, the OAM encoder 400 is the metadata encoder 210 of an apparatus 250 for generating encoded audio information according to one of the above-described embodiments. Moreover, in Fig. 14, the SAOC encoder 800 and the USAC encoder 300 together form the audio encoder 220 of an apparatus 250 for generating encoded audio information according to one of the above-described embodiments.

According to an embodiment, an apparatus for encoding audio input data 101 to obtain audio output data 501 is provided. The apparatus for encoding audio input data 101 comprises:

- an input interface 1100 for receiving a plurality of audio channels, a plurality of audio objects and metadata related to one or more of the plurality of audio objects,

- a mixer 200 for mixing the plurality of objects and the plurality of channels to obtain a plurality of pre-mixed channels, each pre-mixed channel comprising audio data of a channel and audio data of at least one object, and

- an apparatus 250 for generating encoded audio information which comprises a metadata encoder and an audio encoder as described above.

The audio encoder 220 of the apparatus 250 for generating encoded audio information is a core encoder (300) for core encoding core encoder input data.

The metadata encoder 210 of the apparatus 250 for generating encoded audio information is a metadata compressor 400 for compressing the metadata related to the one or more of the plurality of audio objects.

Fig. 11 illustrates a 3D audio decoder in accordance with an embodiment of the present invention. The 3D audio decoder receives, as an input, the encoded audio data, i.e., the data 501 of Fig. 10.

The 3D audio decoder comprises a metadata decompressor 1400, a core decoder 1300, an object processor 1200, a mode controller 1600 and a postprocessor 1700.

Specifically, the 3D audio decoder is configured for decoding encoded audio data and the input interface is configured for receiving the encoded audio data, the encoded audio data comprising a plurality of encoded channels and the plurality of encoded objects and compressed metadata related to the plurality of objects in a certain mode.

Furthermore, the core decoder 1300 is configured for decoding the plurality of encoded channels and the plurality of encoded objects and, additionally, the metadata decompressor is configured for decompressing the compressed metadata.

Furthermore, the object processor 1200 is configured for processing the plurality of decoded objects as generated by the core decoder 1300 using the decompressed metadata to obtain a predetermined number of output channels comprising object data and the decoded channels. These output channels as indicated at 1205 are then input into a postprocessor 1700. The postprocessor 1700 is configured for converting the number of output channels 1205 into a certain output format which can be a binaural output format or a loudspeaker output format such as a 5.1, 7.1, etc., output format.

Preferably, the 3D audio decoder comprises a mode controller 1600 which is configured for analyzing the encoded data to detect a mode indication. Therefore, the mode controller 1600 is connected to the input interface 1100 in Fig. 11. However, alternatively, the mode controller does not necessarily have to be there. Instead, the flexible audio decoder can be pre-set by any other kind of control data such as a user input or any other control. The 3D audio decoder in Fig. 11 and, preferably controlled by the mode controller 1600, is configured to either bypass the object processor and to feed the plurality of decoded channels into the postprocessor 1700. This is the operation in mode 2, i.e., in which only pre-rendered channels are received, i.e., when mode 2 has been applied in the 3D audio encoder of Fig. 10. Alternatively, when mode 1 has been applied in the 3D audio encoder, i.e., when the 3D audio encoder has performed individual channel/object coding, then the object processor 1200 is not bypassed, but the plurality of decoded channels and the plurality of decoded objects are fed into the object processor 1200 together with decompressed metadata generated by the metadata decompressor 1400.

Preferably, the indication whether mode 1 or mode 2 is to be applied is included in the encoded audio data and then the mode controller 1600 analyses the encoded data to detect a mode indication. Mode 1 is used when the mode indication indicates that the encoded audio data comprises encoded channels and encoded objects and mode 2 is applied when the mode indication indicates that the encoded audio data does not contain any audio objects, i.e., only contain pre-rendered channels obtained by mode 2 of the Fig. 10 3D audio encoder.

In Fig. 11, the meta data decompressor 1400 is the metadata decoder 110 of an apparatus 100 for generating one or more audio channels according to one of the above-described embodiments. Moreover, in Fig. 11, the core decoder 1300, the object processor 1200 and the post processor 1700 together form the audio decoder 120 of an apparatus 100 for generating one or more audio channels according to one of the above-described embodiments.

Fig. 13 illustrates a preferred embodiment compared to the Fig. 11 3D audio decoder and the embodiment of Fig. 13 corresponds to the 3D audio encoder of Fig. 12. In addition to the 3D audio decoder implementation of Fig. 11, the 3D audio decoder in Fig. 13 comprises an SAOC decoder 1800. Furthermore, the object processor 1200 of Fig. 11 is implemented as a separate object renderer 1210 and the mixer 1220 while, depending on the mode, the functionality of the object renderer 1210 can also be implemented by the SAOC decoder 1800.

Furthermore, the postprocessor 1700 can be implemented as a binaural renderer 1710 or a format converter 1720. Alternatively, a direct output of data 1205 of Fig. 11 can also be implemented as illustrated by 1730. Therefore, it is preferred to perform the processing in the decoder on the highest number of channels such as 22.2 or 32 in order to have flexibility and to then post-process if a smaller format is required. However, when it becomes clear from the very beginning that only small format such as a 5.1 format is required, then it is preferred, as indicated by Fig. 11 or 6 by the shortcut 1727, that a certain control over the SAOC decoder and/or the USAC decoder can be applied in order to avoid unnecessary upmixing operations and subsequent downmixing operations.

In a preferred embodiment of the present invention, the object processor 1200 comprises the SAOC decoder 1800 and the SAOC decoder is configured for decoding one or more transport channels output by the core decoder and associated parametric data and using decompressed metadata to obtain the plurality of rendered audio objects. To this end, the OAM output is connected to box 1800.

Furthermore, the object processor 1200 is configured to render decoded objects output by the core decoder which are not encoded in SAOC transport channels but which are individually encoded in typically single channeled elements as indicated by the object renderer 1210. Furthermore, the decoder comprises an output interface corresponding to the output 1730 for outputting an output of the mixer to the loudspeakers.

In a further embodiment, the object processor 1200 comprises a spatial audio object coding decoder 1800 for decoding one or more transport channels and associated parametric side information representing encoded audio signals or encoded audio channels, wherein the spatial audio object coding decoder is configured to transcode the associated parametric information and the decompressed metadata into transcoded parametric side information usable for directly rendering the output format, as for example defined in an earlier version of SAOC. The postprocessor 1700 is configured for calculating audio channels of the output format using the decoded transport channels and the transcoded parametric side information. The processing performed by the post processor can be similar to the MPEG Surround processing or can be any other processing such as BCC processing or so.

In a further embodiment, the object processor 1200 comprises a spatial audio object coding decoder 1800 configured to directly upmix and render channel signals for the output format using the decoded (by the core decoder) transport channels and the parametric side information

Furthermore, and importantly, the object processor 1200 of Fig. 11 additionally comprises the mixer 1220 which receives, as an input, data output by the USAC decoder 1300 directly when pre-rendered objects mixed with channels exist, i.e., when the mixer 200 of Fig. 10 was active. Additionally, the mixer 1220 receives data from the object renderer performing object rendering without SAOC decoding. Furthermore, the mixer receives SAOC decoder output data, i.e., SAOC rendered objects.

The mixer 1220 is connected to the output interface 1730, the binaural renderer 1710 and the format converter 1720. The binaural renderer 1710 is configured for rendering the output channels into two binaural channels using head related transfer functions or binaural room impulse responses (BRIR). The format converter 1720 is configured for converting the output channels into an output format having a lower number of channels than the output channels 1205 of the mixer and the format converter 1720 requires information on the reproduction layout such as 5.1 speakers or so.

In Fig. 13, the OAM-Decoder 1400 is the metadata decoder 110 of an apparatus 100 for generating one or more audio channels according to one of the above-described embodiments. Moreover, in Fig. 13, the Object Renderer 1210, the USAC decoder 1300 and the mixer 1220 together form the audio decoder 120 of an apparatus 100 for generating one or more audio channels according to one of the above-described embodiments.

The Fig. 15 3D audio decoder is different from the Fig. 13 3D audio decoder in that the SAOC decoder cannot only generate rendered objects but also rendered channels and this is the case when the Fig. 14 3D audio encoder has been used and the connection 900 between the channels/pre-rendered objects and the SAOC encoder 800 input interface is active.

Furthermore, a vector base amplitude panning (VBAP) stage 1810 is configured which receives, from the SAOC decoder, information on the reproduction layout and which outputs a rendering matrix to the SAOC decoder so that the SAOC decoder can, in the end, provide rendered channels without any further operation of the mixer in the high channel format of 1205, i.e., 32 loudspeakers.

the VBAP block preferably receives the decoded OAM data to derive the rendering matrices. More general, it preferably requires geometric information not only of the reproduction layout but also of the positions where the input signals should be rendered to on the reproduction layout. This geometric input data can be OAM data for objects or channel position information for channels that have been transmitted using SAOC.

However, if only a specific output interface is required then the VBAP state 1810 can already provide the required rendering matrix for the e.g., 5.1 output. The SAOC decoder 1800 then performs a direct rendering from the SAOC transport channels, the associated parametric data and decompressed metadata, a direct rendering into the required output format without any interaction of the mixer 1220. However, when a certain mix between modes is applied, i.e., where several channels are SAOC encoded but not all channels are SAOC encoded or where several objects are SAOC encoded but not all objects are SAOC encoded or when only a certain amount of pre-rendered objects with channels are SAOC decoded and remaining channels are not SAOC processed then the mixer will put together the data from the individual input portions, i.e., directly from the core decoder 1300, from the object renderer 1210 and from the SAOC decoder 1800.

In Fig. 15, the OAM-Decoder 1400 is the metadata decoder 110 of an apparatus 100 for generating one or more audio channels according to one of the above-described embodiments. Moreover, in Fig. 15, the Object Renderer 1210, the USAC decoder 1300 and the mixer 1220 together form the audio decoder 120 of an apparatus 100 for generating one or more audio channels according to one of the above-described embodiments.

An apparatus for decoding encoded audio data is provided. The apparatus for decoding encoded audio data comprises:

- an input interface 1100 for receiving the encoded audio data, the encoded audio data comprising a plurality of encoded channels or a plurality of encoded objects or compress metadata related to the plurality of objects, and

- an apparatus 100 comprising a metadata decoder 110 and an audio channel generator 120 for generating one or more audio channels as described above.

The metadata decoder 110 of the apparatus 100 for generating one or more audio channels is a metadata decompressor 400 for decompressing the compressed metadata.

The audio channel generator 120 of the apparatus 100 for generating one or more audio channels comprises a core decoder 1300 for decoding the plurality of encoded channels and the plurality of encoded objects.

Moreover, the audio channel generator 120 further comprises an object processor 1200 for processing the plurality of decoded objects using the decompressed metadata to obtain a number of output channels 1205 comprising audio data from the objects and the decoded channels.

Furthermore, the audio channel generator 120 further comprises a post processor 1700 for converting the number of output channels 1205 into an output format.

Although some aspects have been described in the context of an apparatus, it is clear that these aspects also represent a description of the corresponding method, where a block or device corresponds to a method step or a feature of a method step. Analogously, aspects described in the context of a method step also represent a description of a corresponding block or item or feature of a corresponding apparatus.

The inventive decomposed signal can be stored on a digital storage medium or can be transmitted on a transmission medium such as a wireless transmission medium or a wired transmission medium such as the Internet.

Depending on certain implementation requirements, embodiments of the invention can be implemented in hardware or in software. The implementation can be performed using a digital storage medium, for example a floppy disk, a DVD, a CD, a ROM, a PROM, an EPROM, an EEPROM or a FLASH memory, having electronically readable control signals stored thereon, which cooperate (or are capable of cooperating) with a programmable computer system such that the respective method is performed.

Some embodiments according to the invention comprise a non-transitory data carrier having electronically readable control signals, which are capable of cooperating with a programmable computer system, such that one of the methods described herein is performed.

Generally, embodiments of the present invention can be implemented as a computer program product with a program code, the program code being operative for performing one of the methods when the computer program product runs on a computer. The program code may for example be stored on a machine readable carrier.

Other embodiments comprise the computer program for performing one of the methods described herein, stored on a machine readable carrier.

In other words, an embodiment of the inventive method is, therefore, a computer program having a program code for performing one of the methods described herein, when the computer program runs on a computer.

A further embodiment of the inventive methods is, therefore, a data carrier (or a digital storage medium, or a computer-readable medium) comprising, recorded thereon, the computer program for performing one of the methods described herein.

A further embodiment of the inventive method is, therefore, a data stream or a sequence of signals representing the computer program for performing one of the methods described herein. The data stream or the sequence of signals may for example be configured to be transferred via a data communication connection, for example via the Internet.

A further embodiment comprises a processing means, for example a computer, or a programmable logic device, configured to or adapted to perform one of the methods described herein.

A further embodiment comprises a computer having installed thereon the computer program for performing one of the methods described herein.

In some embodiments, a programmable logic device (for example a field programmable gate array) may be used to perform some or all of the functionalities of the methods described herein. In some embodiments, a field programmable gate array may cooperate with a microprocessor in order to perform one of the methods described herein. Generally, the methods are preferably performed by any hardware apparatus.

The above described embodiments are merely illustrative for the principles of the present invention. It is understood that modifications and variations of the arrangements and the details described herein will be apparent to others skilled in the art. It is the intent, therefore, to be limited only by the scope of the impending patent claims and not by the specific details presented by way of description and explanation of the embodiments herein.

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Claims

1. An apparatus (100) for generating one or more audio channels, wherein the apparatus comprises:

a metadata decoder (110; 901) for generating one or more reconstructed metadata signals (x_1',...,x_N') from one or more processed metadata signals (z_1,...,z_N) depending on a control signal (b), wherein each of the one or more reconstructed metadata signals (x_1',...,x_N') indicates information associated with an audio object signal of one or more audio object signals, wherein the metadata decoder (110; 901) is configured to generate the one or more reconstructed metadata signals (x_1',...,x_N') by determining a plurality of reconstructed metadata samples (x_1'(n),...,x_N'(n)) for each of the one or more reconstructed metadata signals (x_1',...,x_N'), and

an audio channel generator (120) for generating the one or more audio channels depending on the one or more audio object signals and depending on the one or more reconstructed metadata signals (x_1',...,x_N'),

wherein the metadata decoder (110; 901) is configured to receive a plurality of processed metadata samples (z_1(n),...,z_N(n)) of each of the one or more processed metadata signals (z_1,...,z_N),

wherein the metadata decoder (110; 901) is configured to receive the control signal (b),

wherein the metadata decoder (110; 901) is configured to determine each reconstructed metadata sample (x_i'(n)) of the plurality of reconstructed metadata samples (x_i'(1),... x_i'(n-1), x_i'(n)) of each reconstructed metadata signal (x_i') of the one or more reconstructed metadata signals (x_1',...,x_N'), so that, when the control signal (b) indicates a first state (b(n)=0), said reconstructed metadata sample (x_i'(n)) is a sum of one of the processed metadata samples (z_i(n)) of one of the one or more processed metadata signals (z_i) and of another already generated reconstructed metadata sample (x_i'(n-1)) of said reconstructed metadata signal (x_i'), and so that, when the control signal indicates a second state (b(n)=1) being different from the first state, said reconstructed metadata sample (x_i'(n)) is said one (z_i(n)) of the processed metadata samples (z_i(1),...,z_i(n)) of said one (z_i) of the one or more processed metadata signals (z_1,...,z_N).

2. An apparatus (100) according to claim 1,

wherein the metadata decoder (110; 901) is configured to receive two or more of the processed metadata signals ($z_1,\ldots,z_N$), and is configured to generate two or more of the reconstructed metadata signals (x_1', ..., x_N'),

wherein the metadata decoder (110; 901) comprises two or more metadata decoder subunits (911, ..., 91N),

wherein each (91i; 91i') of the two or more metadata decoder subunits (911, ..., 91N) is configured comprises an adder (910) and a selector (930),

wherein each (91i; 91i') of the two or more metadata decoder subunits (911, ..., 91N) is configured to receive the plurality of processed metadata samples ($z_i(1),\ldots z_i(n-1)$, $z_i(n)$) of one (z_i) of the two or more processed metadata signals ($z_1,\ldots,z_N$), and is configured to generate one (z_i) of the two or more reconstructed metadata signals (z_1, ..., z_N),

wherein the adder (910) of said metadata decoder subunit (91i; 91i') is configured to add one ($z_i(n)$) of the processed metadata samples ($z_i(1),\ldots z_i(n)$) of said one (z_i) of the two or more processed metadata signals ($z_1,\ldots,z_N$) and another already generated reconstructed metadata sample ($x_i'(n-1)$) of said one (z_i) of the two or more reconstructed metadata signals (z_1, ..., z_N), to obtain a sum value ($s_i(n)$), and

wherein the selector (930) of said metadata decoder subunit (91i; 91i') is configured to receive said one of the processed metadata samples ($z_i(n)$), said sum value ($s_i(n)$) and the control signal, and wherein said selector (930) is configured to determine one of the plurality of metadata samples ($x_i'(1),\ldots x_i'(n-1)$, $x_i'(n)$) of said reconstructed metadata signal (x_i') so that, when the control signal (b) indicates the first state ($b(n)=0$), said reconstructed metadata sample ($x_i'(n)$) is the sum value ($s_i(n)$), and so that, when the control signal indicates the second state ($b(n)=1$), said reconstructed metadata sample ($x_i'(n)$) is said one ($z_i(n)$) of the processed metadata samples ($z_i(1),\ldots,z_i(n)$).

3. An apparatus (100) according to claim 1 or 2,

wherein at least one of the one or more reconstructed metadata signals (x_1',...,x_N') indicates position information on one of the one or more audio object signals, and

wherein the audio channel generator (120) is configured to generate at least one of the one or more audio channels depending on said one of the one or more audio object signals and depending on said position information.

4. An apparatus (100) according to one of the preceding claims,

wherein at least one of the one or more reconstructed metadata signals (x_1',...,x_N') indicates a volume of one of the one or more audio object signals, and

wherein the audio channel generator (120) is configured to generate at least one of the one or more audio channels depending on said one of the one or more audio object signals and depending on said volume.

5. An apparatus for decoding encoded audio data, comprising:

an input interface (1100) for receiving the encoded audio data, the encoded audio data comprising a plurality of encoded channels or a plurality of encoded objects or compress metadata related to the plurality of objects, and

an apparatus (100) according to one of claims 1 to 4,

wherein the metadata decoder (110; 901) of the apparatus (100) according to one of claims 1 to 4 is a metadata decompressor (400) for decompressing the compressed metadata,

wherein the audio channel generator (120) of the apparatus (100) according to one of claims 1 to 4 comprises a core decoder (1300) for decoding the plurality of encoded channels and the plurality of encoded objects,

wherein the audio channel generator (120) further comprises an object processor (1200) for processing the plurality of decoded objects using the decompressed metadata to obtain a number of output channels (1205) comprising audio data from the objects and the decoded channels, and wherein the audio channel generator (120) further comprises a post processor (1700) for converting the number of output channels (1205) into an output format.

6. An apparatus (250) for generating encoded audio information comprising one or more encoded audio signals and one or more processed metadata signals, wherein the apparatus comprises:

a metadata encoder (210; 801; 802) for receiving one or more original metadata signals and for determining the one or more processed metadata signals, wherein each of the one or more original metadata signals comprises a plurality of original metadata samples, wherein the original metadata samples of each of the one or more original metadata signals indicate information associated with an audio object signal of one or more audio object signals, and

an audio encoder (220) for encoding the one or more audio object signals to obtain the one or more encoded audio signals,

wherein the metadata encoder (210; 801; 802) is configured to determine each processed metadata sample ($z_i(n)$) of a plurality of processed metadata samples ($z_i(1),\ldots\ z_i(n-1), z_i(n)$) of each processed metadata signal (z_i) of the one or more processed metadata signals ($z_1,\ldots,z_N$), so that, when the control signal (b) indicates a first state (b(n)=0), said reconstructed metadata sample ($z_i(n)$) indicates a difference or a quantized difference between one of a plurality of original metadata samples ($x_i(n)$) of one of the one or more original metadata signals (x_i) and of another already generated processed metadata sample of said processed metadata signal (z_i), and so that, when the control signal indicates a second state (b(n)=1) being different from the first state, said processed metadata sample ($z_i(n)$) is said one ($x_i(n)$) of the original metadata samples ($x_i(1),\ldots,x_i(n)$) of said one of the one or more processed metadata signals (x_i), or is a quantized representation ($q_i(n)$) said one ($x_i(n)$) of the original metadata samples ($x_i(1),\ldots,x_i(n)$).

7. An apparatus (250) according to claim 6,

wherein the metadata encoder (210; 801; 802) is configured to receive two or more of the original metadata signals ($x_1,\ldots,x_N$), and is configured to generate two or more of the processed metadata signals ($z_1, \ldots, z_N$), wherein the metadata encoder (210; 801; 802) comprises two or more DCPM Encoders (811, ..., 81N),

wherein each of the two or more DCPM Encoders (811, ..., 81N) is configured to determine a difference or a quantized difference between one ($x_i(n)$) of the original metadata samples ($x_i(1),...x_i(n)$) of one (x_i) of the two or more original metadata signals ($x_1,...,x_N$) and another already generated processed metadata sample of one (z_i) of the two or more reconstructed metadata signals (z_1, ..., z_N), to obtain a difference sample ($y_i(n)$), and

wherein metadata encoder (210; 801; 802) further comprises a selector (830) being configured to determine one of the plurality of processed metadata samples ($z_i(1),...\ z_i(n-1),\ z_i(n)$) of said processed metadata signal (z_i) so that, when the control signal (b) indicates the first state (b(n)=0), said processed metadata sample ($y_i(n)$) is the difference sample ($y_i(n)$), and so that, when the control signal indicates the second state (b(n)=1), said processed metadata sample ($z_i(n)$) is said one ($x_i(n)$) of the original metadata samples ($x_i(1),...,z_i(n)$) or a quantized representation ($q_i(n)$) of said one ($x_i(n)$) of the original metadata samples ($x_i(1),...,z_i(n)$).

8. An apparatus (250) according to claim 6 or 7,

wherein at least one of the one or more original metadata signals indicates position information on one of the one or more audio object signals, and

wherein the metadata encoder (210; 801; 802) is configured to generate at least one of the one or more processed metadata signals depending on said at least one of the one or more original metadata signals which indicates said position information.

9. An apparatus (250) according to one of claims 6 to 8,

wherein at least one of the one or more original metadata signals indicates a volume of one of the one or more audio object signals, and

wherein the metadata encoder (210; 801; 802) is configured to generate at least one of the one or more processed metadata signals depending on said at least one of the one or more original metadata signals which indicates said position information.

10. An apparatus (250) according to one of claims 6 to 9, wherein the metadata encoder (210; 801; 802) is configured to encode each of the processed metadata samples ($z_i(1),\ldots,z_i(n)$) of one z_i () of the one or more processed metadata signals ($z_1,\ldots,z_N$) with a first number of bits when the control signal indicates the first state (b(n)=0), and with a second number of bits when the control signal indicates the second state (b(n)=1), wherein the first number of bits is smaller than the second number of bits.

11. An apparatus for encoding audio input data (101) to obtain audio output data (501), comprising:

an input interface (1100) for receiving a plurality of audio channels, a plurality of audio objects and metadata related to one or more of the plurality of audio objects,

a mixer (200) for mixing the plurality of objects and the plurality of channels to obtain a plurality of pre-mixed channels, each pre-mixed channel comprising audio data of a channel and audio data of at least one object, and

an apparatus (250) according to one of claims 6 to 10,

wherein the audio encoder (220) of the apparatus (250) according to one of claims 6 to 10 is a core encoder (300) for core encoding core encoder input data, and

wherein the metadata encoder (210; 801; 802) of the apparatus (250) according to one of claims 6 to 10 is a metadata compressor (400) for compressing the metadata related to the one or more of the plurality of audio objects.

12. A system, comprising:

an apparatus (250) according to one of claims 6 to 10 for generating encoded audio information comprising one or more encoded audio signals and one or more processed metadata signals, and an apparatus (100) according to one of claims 1 to 4 for receiving the one or more encoded audio signals and the one or more processed metadata signals, and for generating one or more audio channels depending on the one or more encoded audio signals and depending on the one or more processed metadata signals.

13. A method for generating one or more audio channels, wherein the method comprises:

generating one or more reconstructed metadata signals (x_1',...,x_N') from one or more processed metadata signals (z_1,...,z_N) depending on a control signal (b), wherein each of the one or more reconstructed metadata signals (x_1',...,x_N') indicates information associated with an audio object signal of one or more audio object signals, wherein generating the one or more reconstructed metadata signals (x_1',...,x_N') is conducted by determining a plurality of reconstructed metadata samples (x_1'(n),...,x_N'(n)) for each of the one or more reconstructed metadata signals (x_1',...,x_N'), and

generating the one or more audio channels depending on the one or more audio object signals and depending on the one or more reconstructed metadata signals (x_1',...,x_N'),

wherein generating the one or more reconstructed metadata signals (x_1',...,x_N') is conducted by receiving a plurality of processed metadata samples (z_1(n),...,z_N(n)) of each of the one or more processed metadata signals (z_1,...,z_N), by receiving the control signal (b), and by determining each reconstructed metadata sample (x_i'(n)) of the plurality of reconstructed metadata samples (x_i'(1),... x_i'(n-1), x_i'(n)) of each reconstructed metadata signal (x_i') of the one or more reconstructed metadata signals (x_1',...,x_N'), so that, when the control signal (b) indicates a first state (b(n)=0), said reconstructed metadata sample (x_i'(n)) is a sum of one of the processed metadata samples (z_i(n)) of one of the one or more processed metadata signals (z_i) and of another already generated reconstructed metadata sample (x_i'(n-1)) of said reconstructed metadata signal (x_i'), and so that, when the control signal indicates a second state (b(n)=1) being different from the first state, said reconstructed metadata sample (x_i'(n)) is said one (z_i(n)) of the processed metadata samples (z_i(1),...,z_i(n)) of said one (z_i) of the one or more processed metadata signals (z_1,...,z_N).

14. A method for generating encoded audio information comprising one or more encoded audio signals and one or more processed metadata signals, wherein the method comprises:

receiving one or more original metadata signals,

determining the one or more processed metadata signals, and

encoding the one or more audio object signals to obtain the one or more encoded audio signals,

wherein each of the one or more original metadata signals comprises a plurality of original metadata samples, wherein the original metadata samples of each of the one or more original metadata signals indicate information associated with an audio object signal of one or more audio object signals, and

wherein determining the one or more processed metadata signals comprises determining each processed metadata sample ($z_i(n)$) of a plurality of processed metadata samples ($z_i(1),...$ $z_i(n-1)$, $z_i(n)$) of each processed metadata signal (z_i) of the one or more processed metadata signals ($z_1,...,z_N$), so that, when the control signal (b) indicates a first state ($b(n)=0$), said reconstructed metadata sample ($z_i(n)$) indicates a difference or a quantized difference between one of a plurality of original metadata samples ($x_i(n)$) of one of the one or more original metadata signals (x_i) and of another already generated processed metadata sample of said processed metadata signal (z_i), and so that, when the control signal indicates a second state ($b(n)=1$) being different from the first state, said processed metadata sample ($z_i(n)$) is said one ($x_i(n)$) of the original metadata samples ($x_i(1),...,x_i(n)$) of said one of the one or more processed metadata signals (x_i), or is a quantized representation ($q_i(n)$) said one ($x_i(n)$) of the original metadata samples ($x_i(1),...,x_i(n)$).

15. A computer program for implementing the method of claim 13 or 14 when being executed on a computer or signal processor.

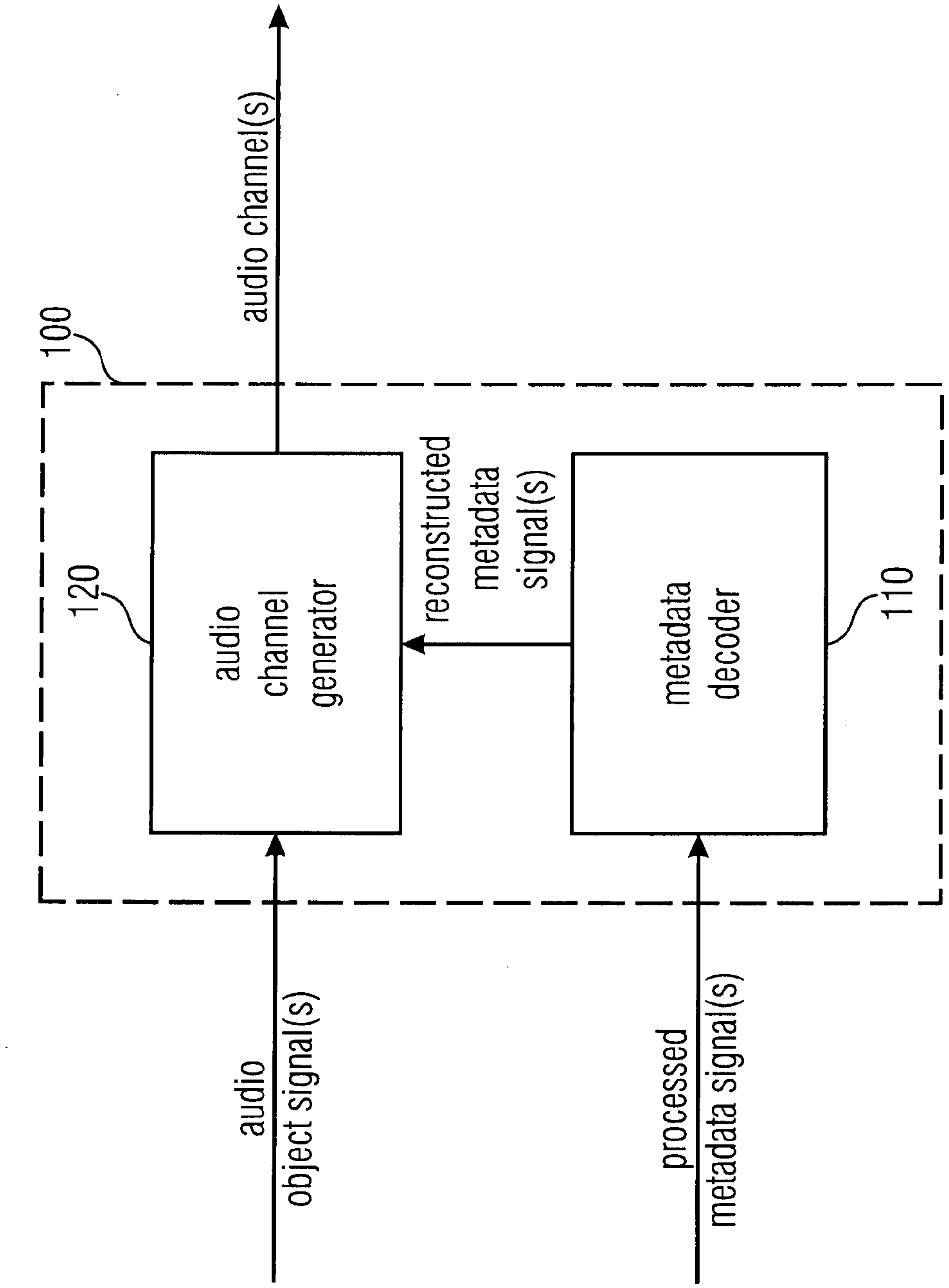

audio object signal(s)
processed metadata signal(s)
100
120
audio channel generator
metadata decoder
110
reconstructed metadata signal(s)
audio channel(s)

FIGURE 1

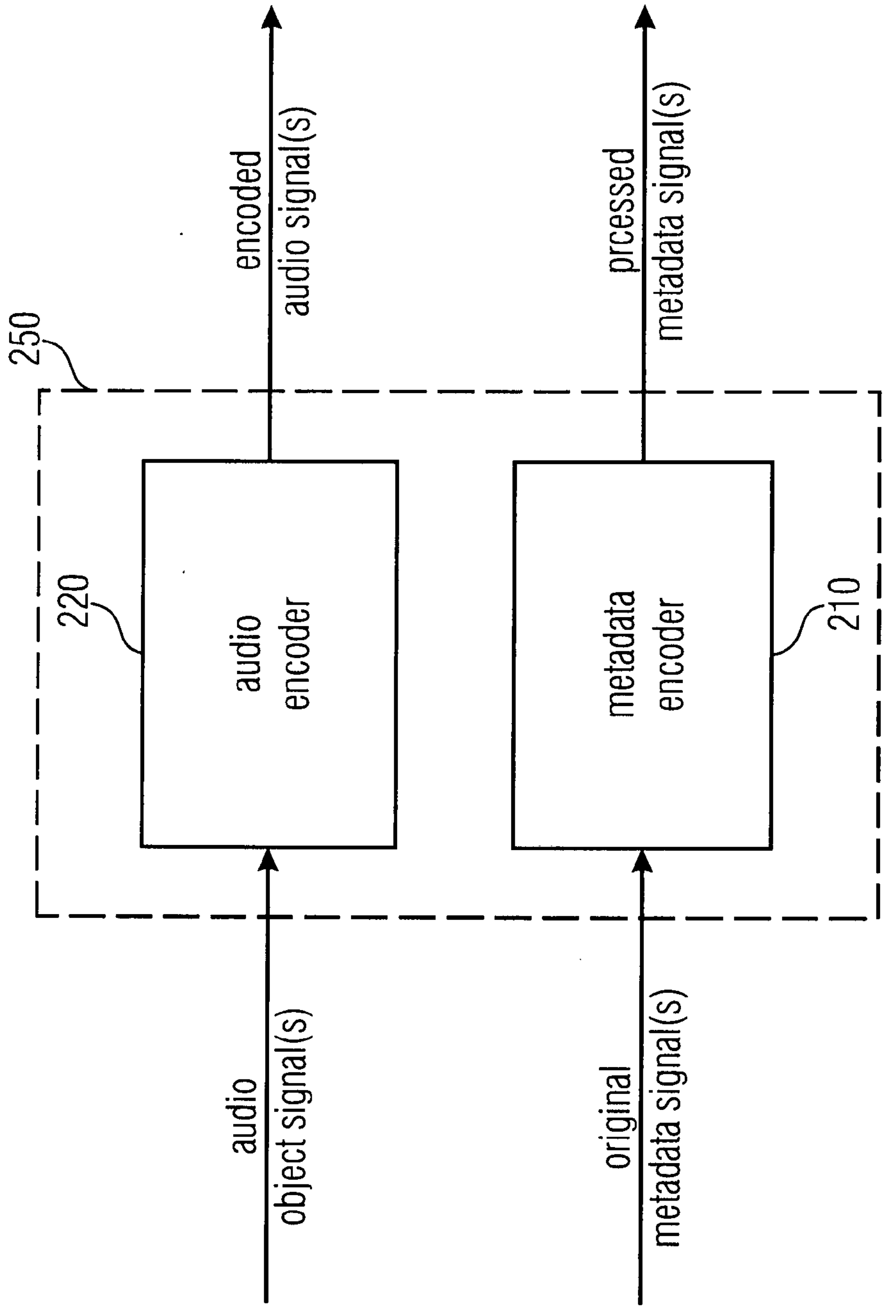

250
encoded
audio signal(s)
prcessed
metadata signal(s)
220
audio
encoder
metadata
encoder
210
audio
object signal(s)
original
metadata signal(s)

FIGURE 2

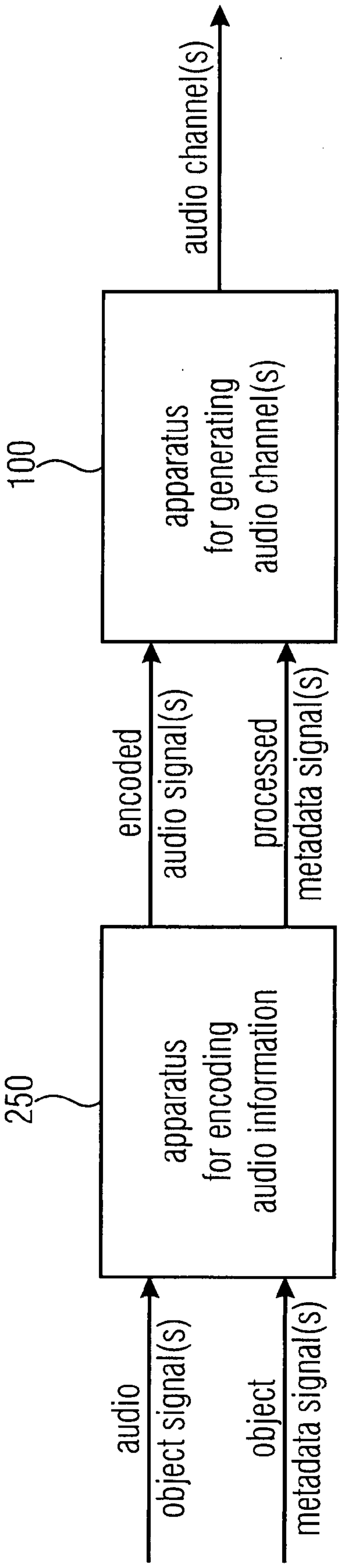

audio
object signal(s)
object
metadata signal(s)
250
apparatus
for encoding
audio information
encoded
audio signal(s)
processed
metadata signal(s)
100
apparatus
for generating
audio channel(s)
audio channel(s)

FIGURE 3

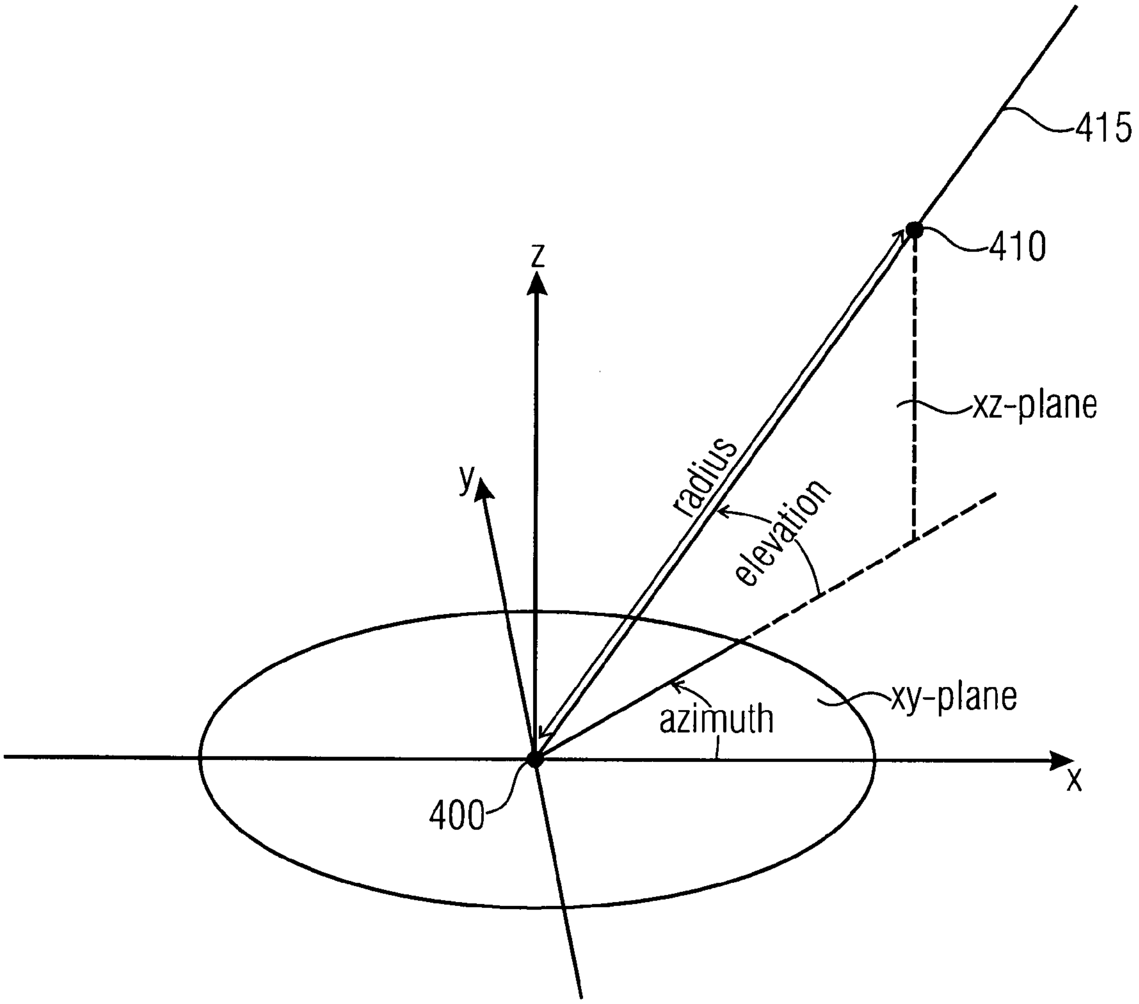


FIGURE 4

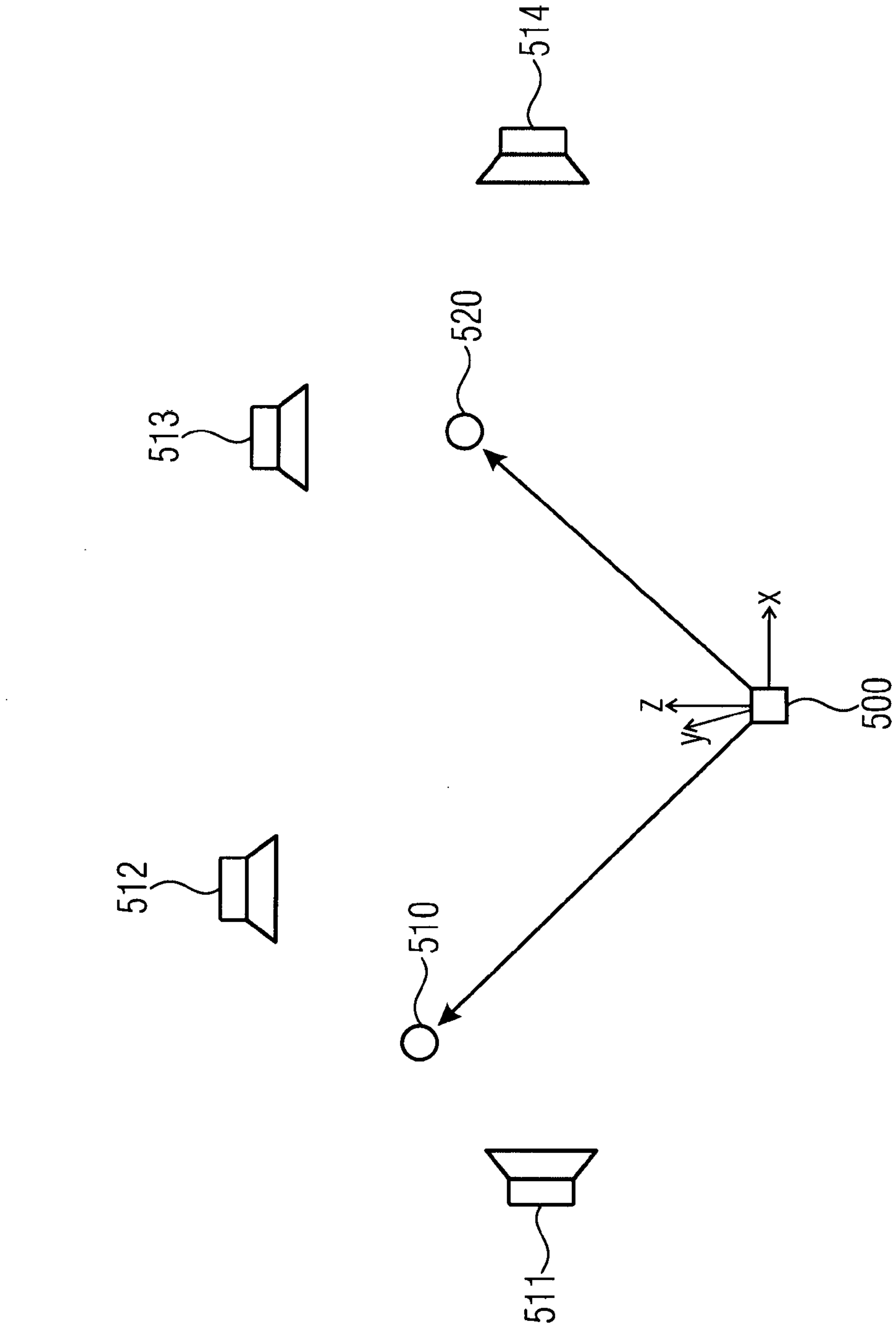


FIGURE 5

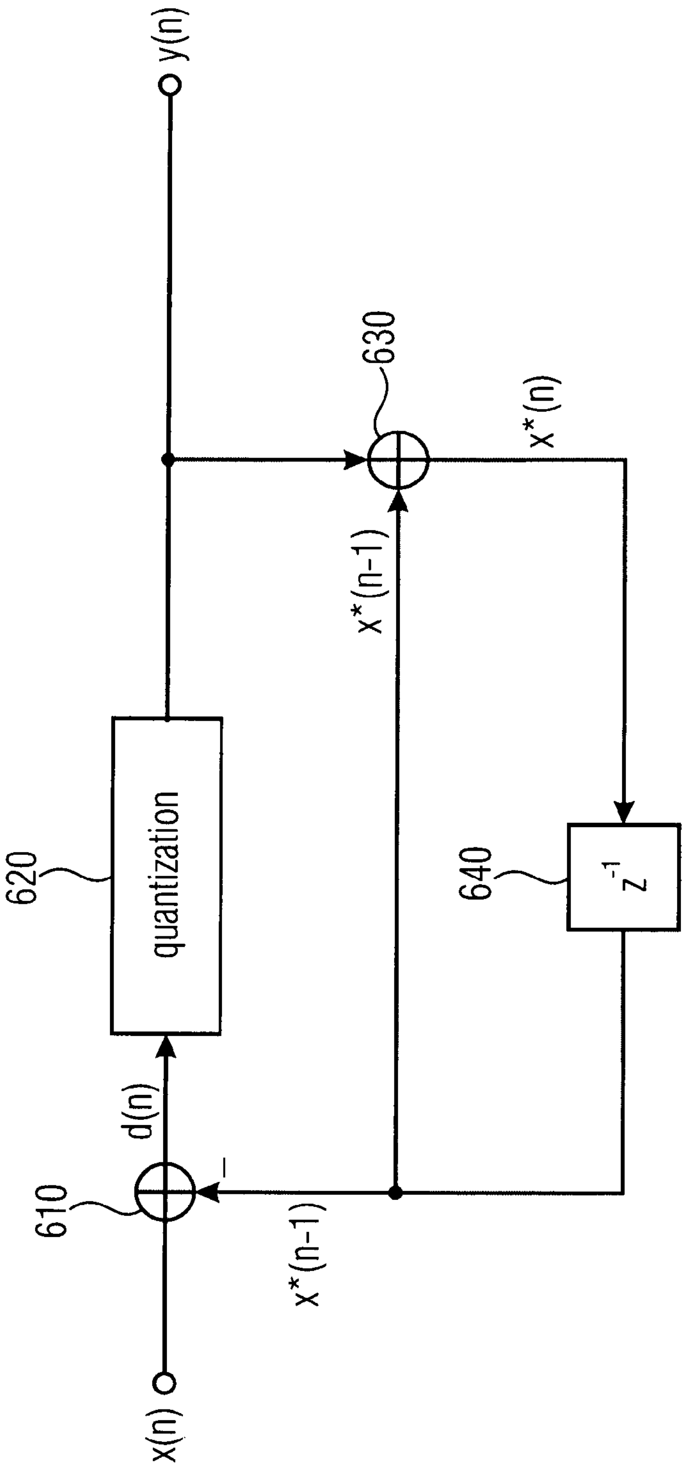


FIGURE 6

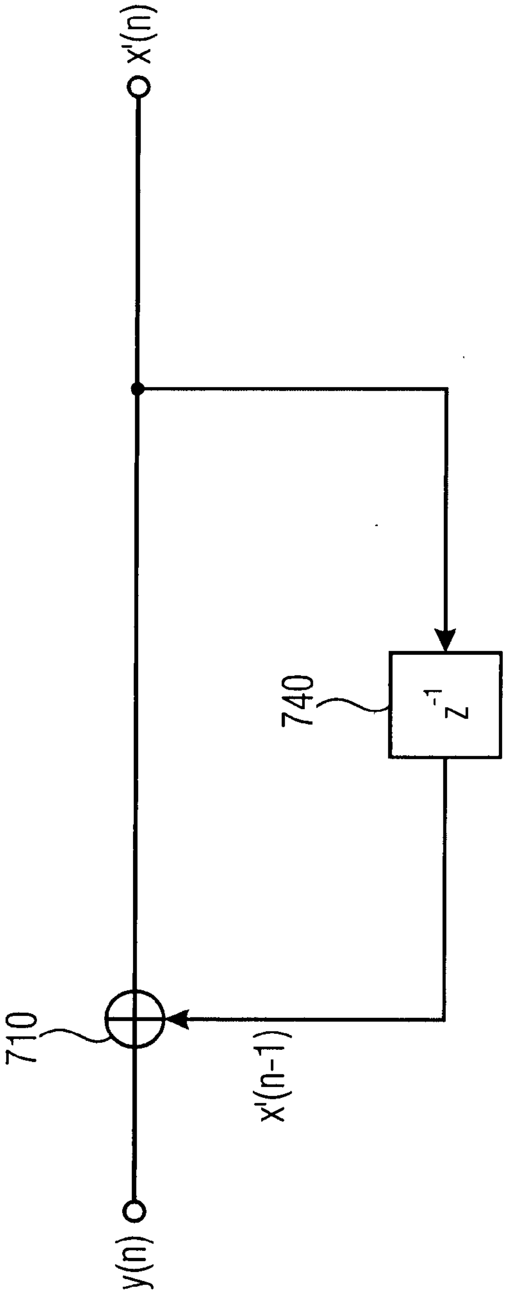


FIGURE 7

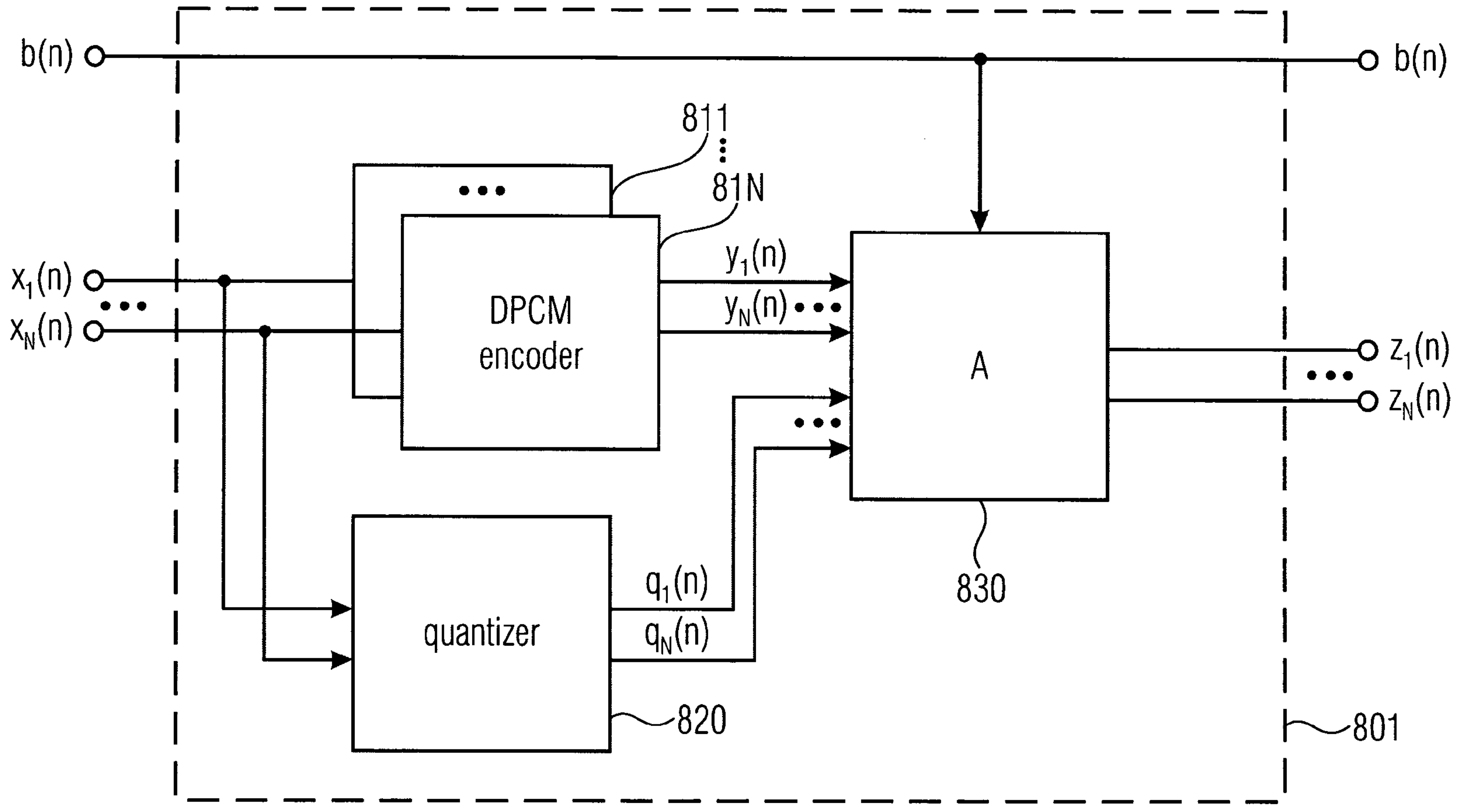

b(n)
b(n)
811
81N
DPCM
encoder
$x_1(n)$
$x_N(n)$
$y_1(n)$
$y_N(n)$
A
$z_1(n)$
$z_N(n)$
quantizer
$q_1(n)$
$q_N(n)$
830
820
801

FIGURE 8A

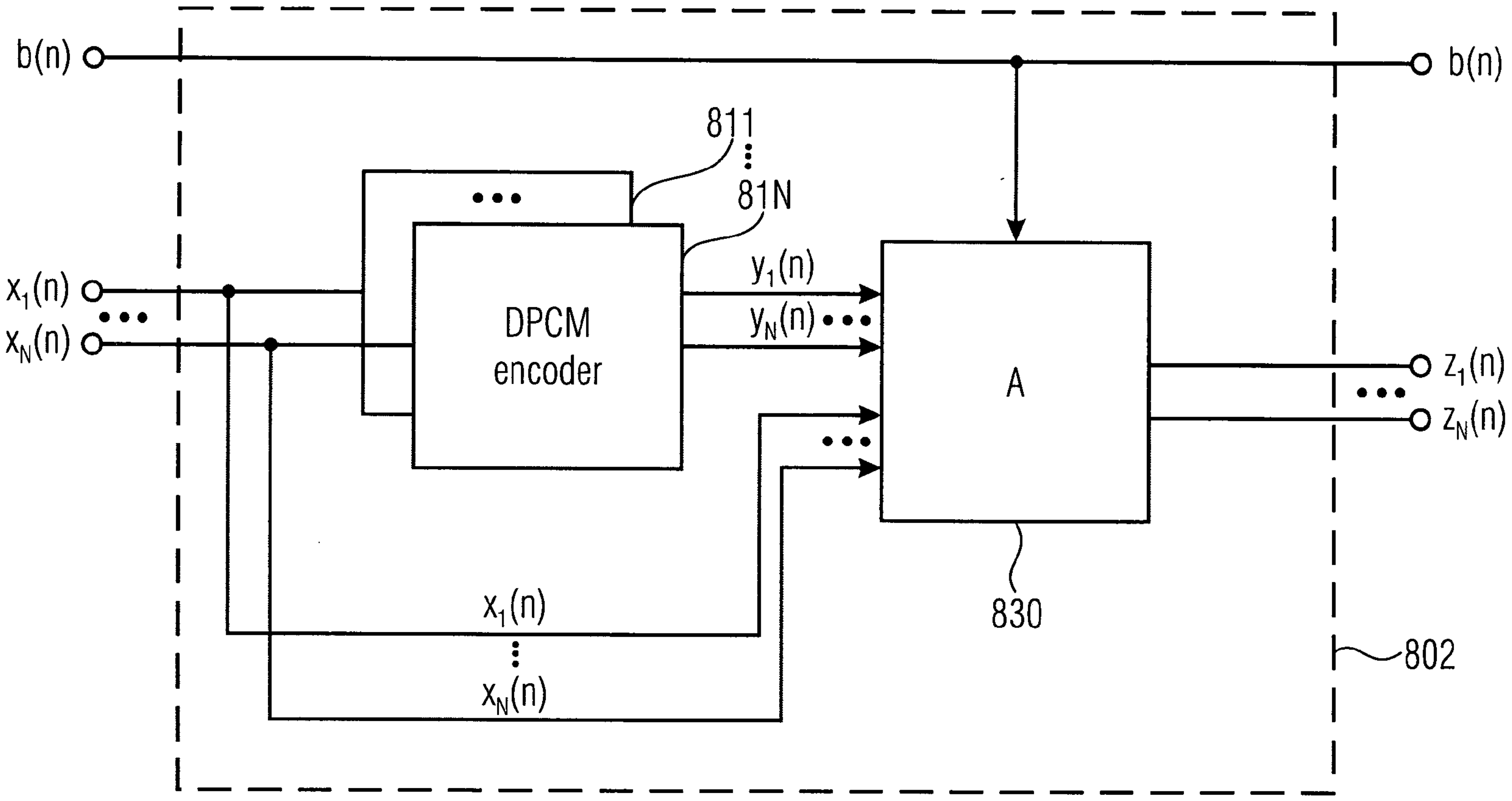

b(n)
$x_1(n)$
$x_N(n)$
811
81N
DPCM encoder
$y_1(n)$
$y_N(n)$
A
830
$x_1(n)$
$x_N(n)$
b(n)
$z_1(n)$
$z_N(n)$
802

FIGURE 8B

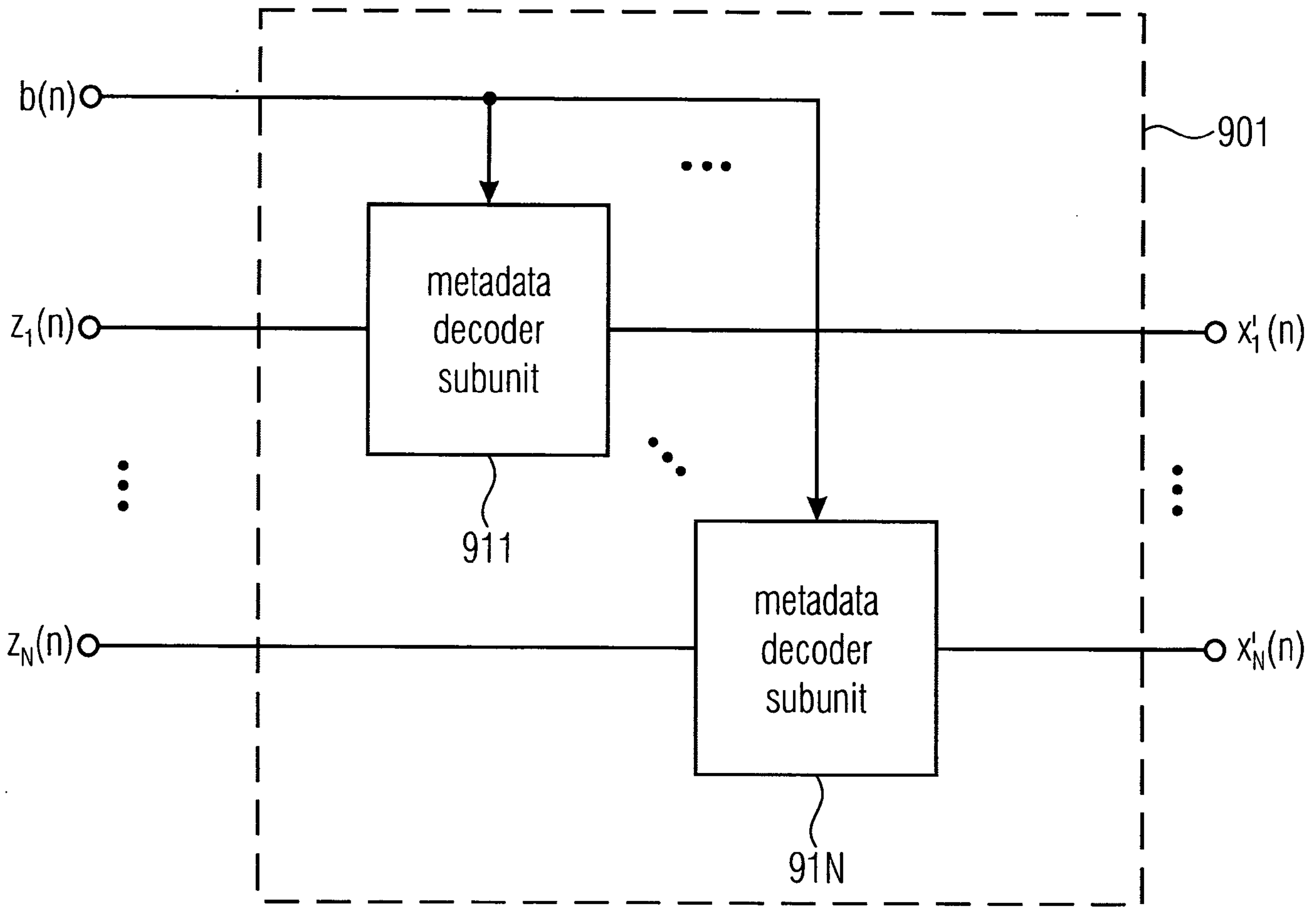

b(n)
$z_1(n)$
$z_N(n)$
metadata decoder subunit
911
metadata decoder subunit
91N
901
$x'_1(n)$
$x'_N(n)$

FIGURE 9A

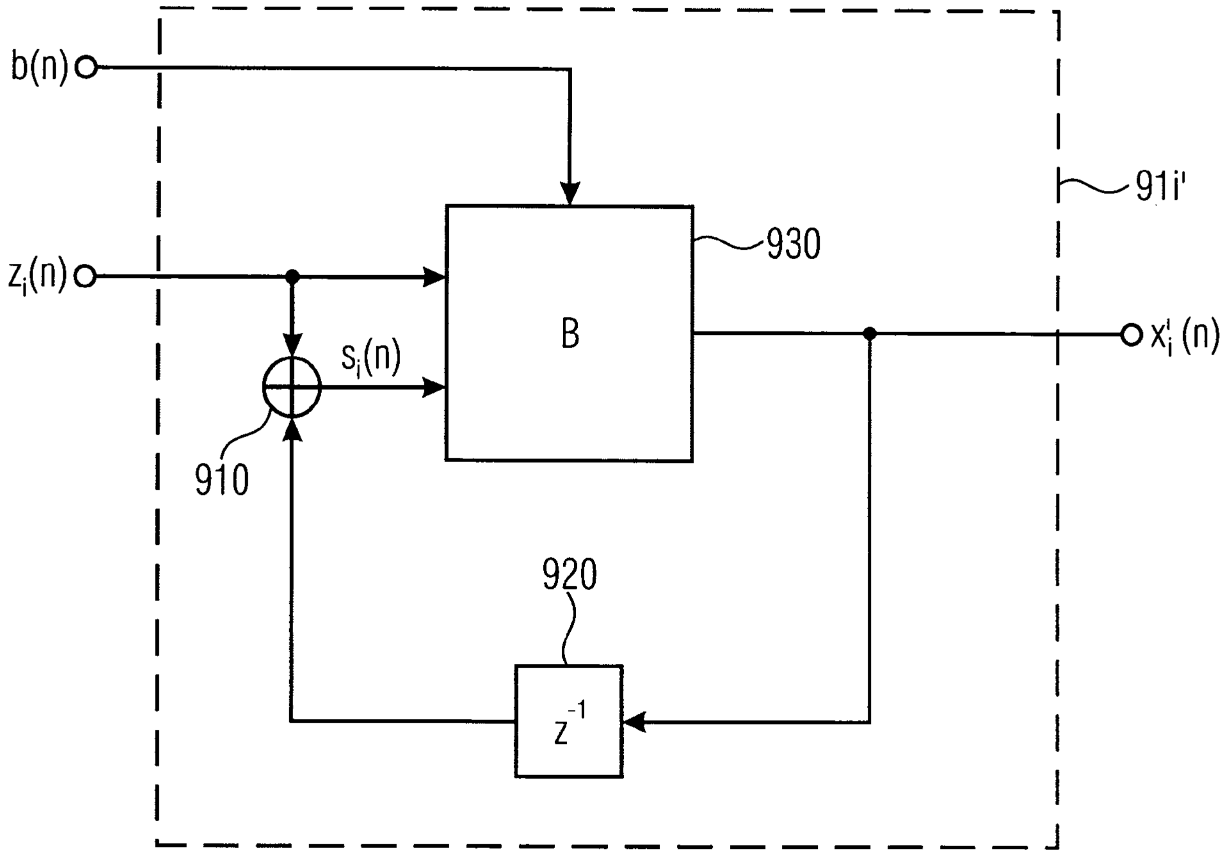
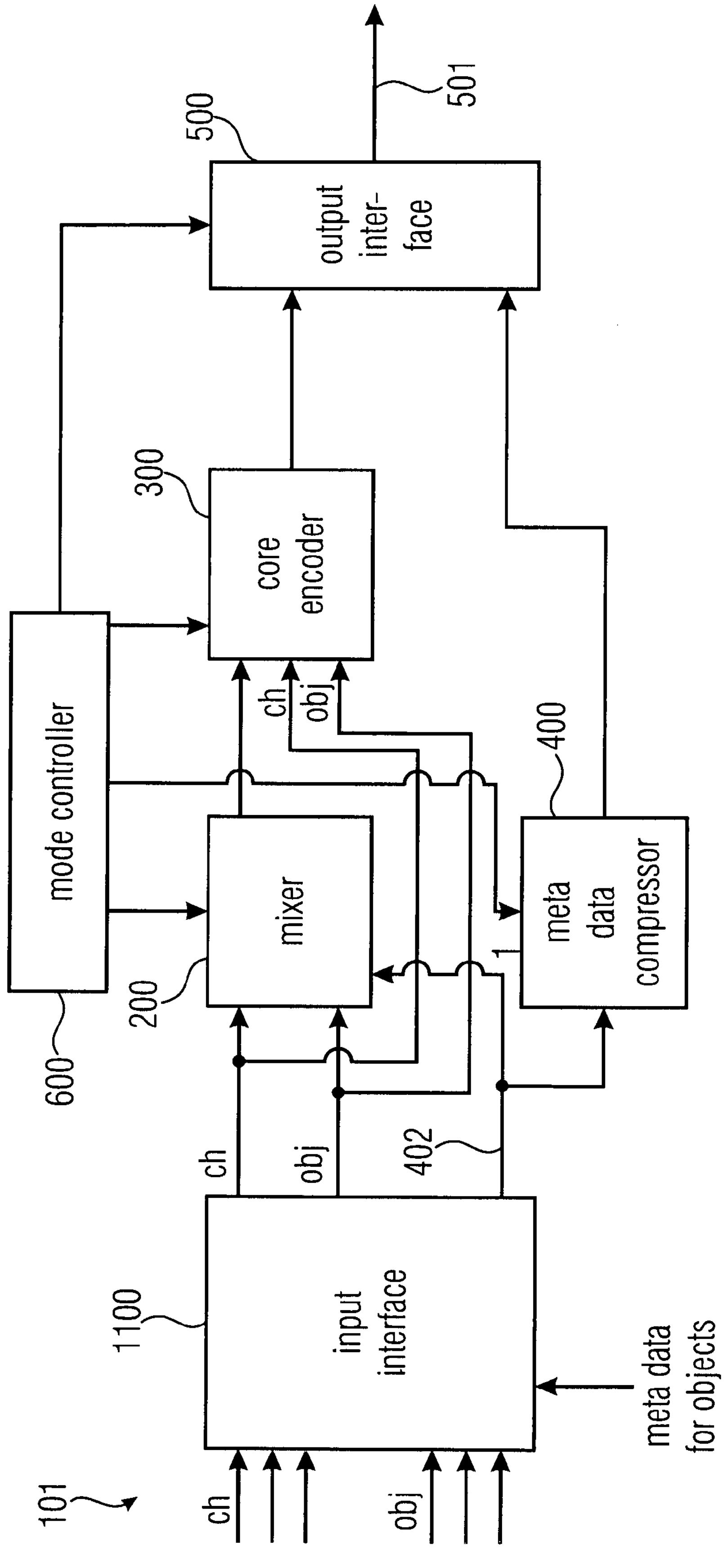
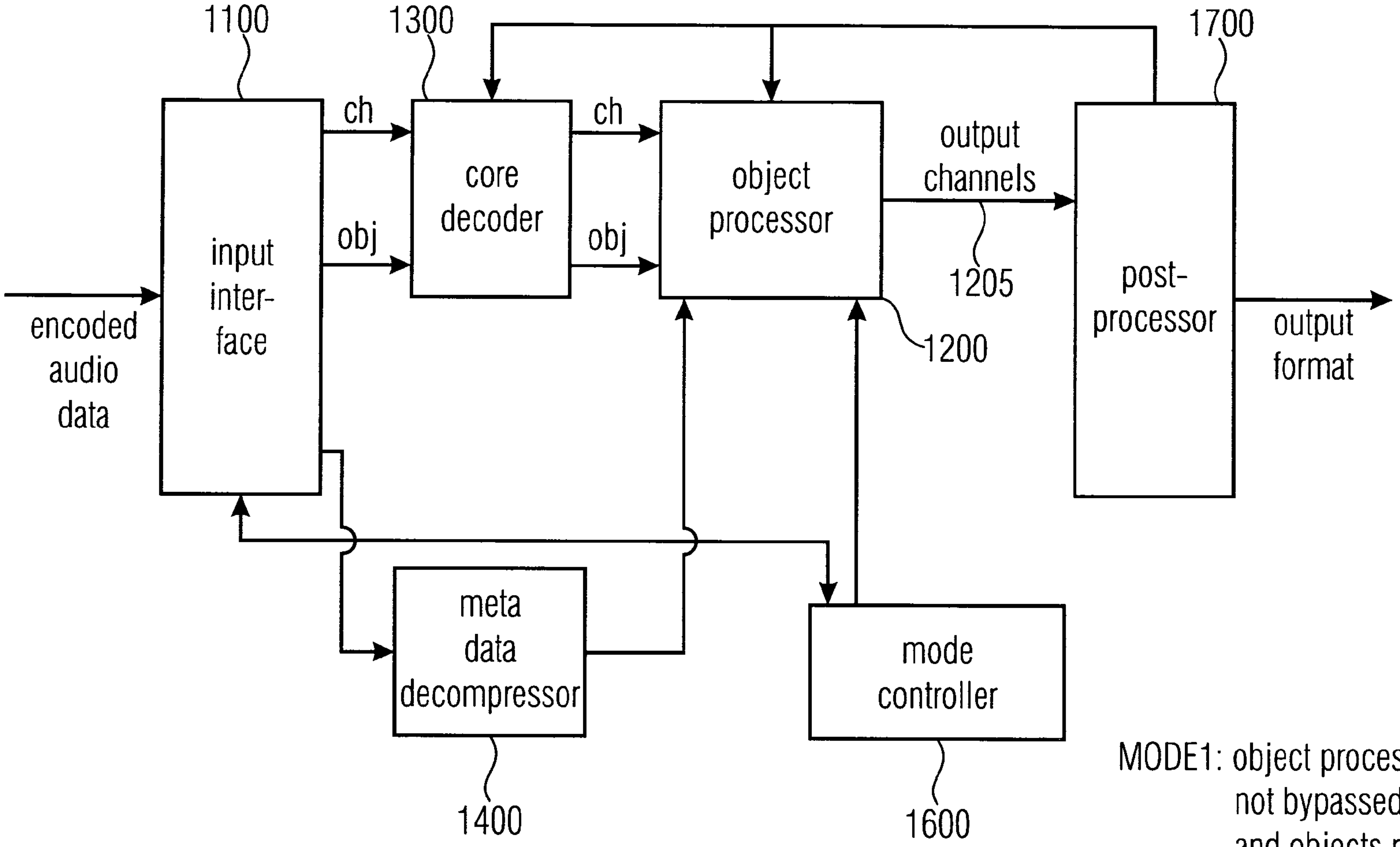


FIGURE 9B



MODE1: individual channel/object coding
MODE2: mixing of channels and rendered objects

FIGURE 10
(ENCODER)



MODE1: object processor is not bypassed (channels and objects received)

MODE2: object processor is bypassed (only (pre-rendered) channels received)

FIGURE 11
(DECODER)

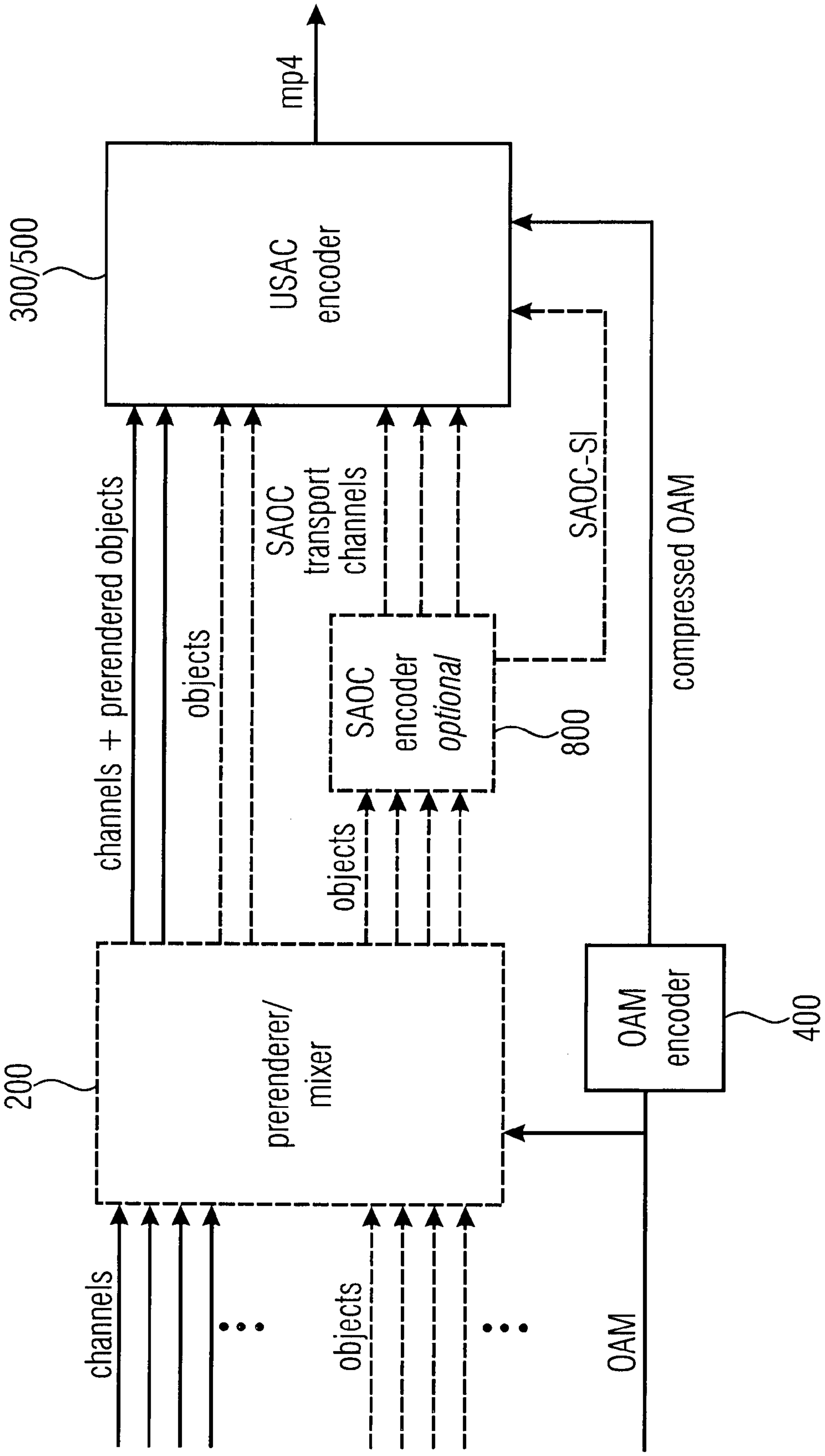
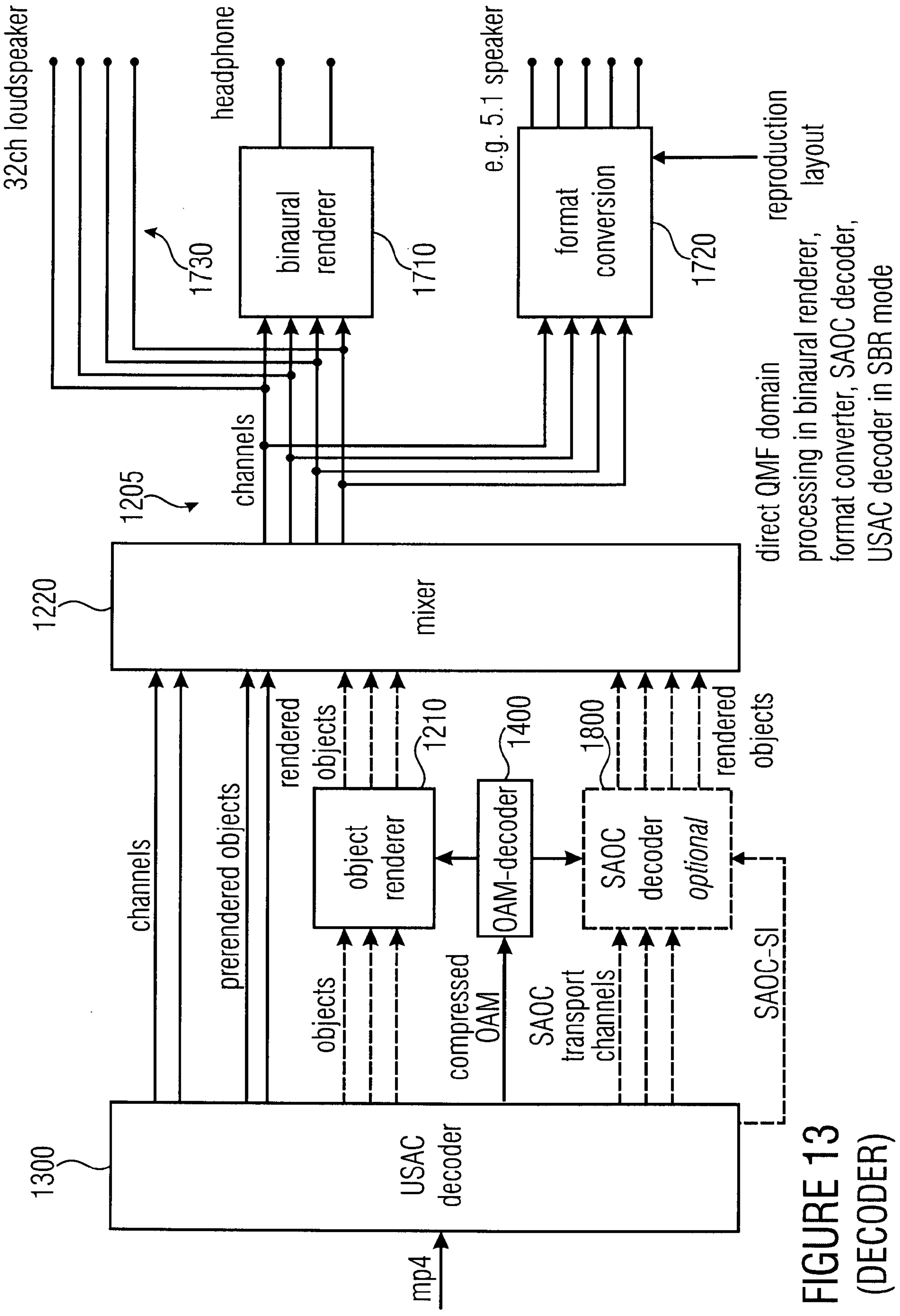


FIGURE 12
(ENCODER)



direct QMF domain processing in binaural renderer, format converter, SAOC decoder, USAC decoder in SBR mode

FIGURE 13
(DECODER)

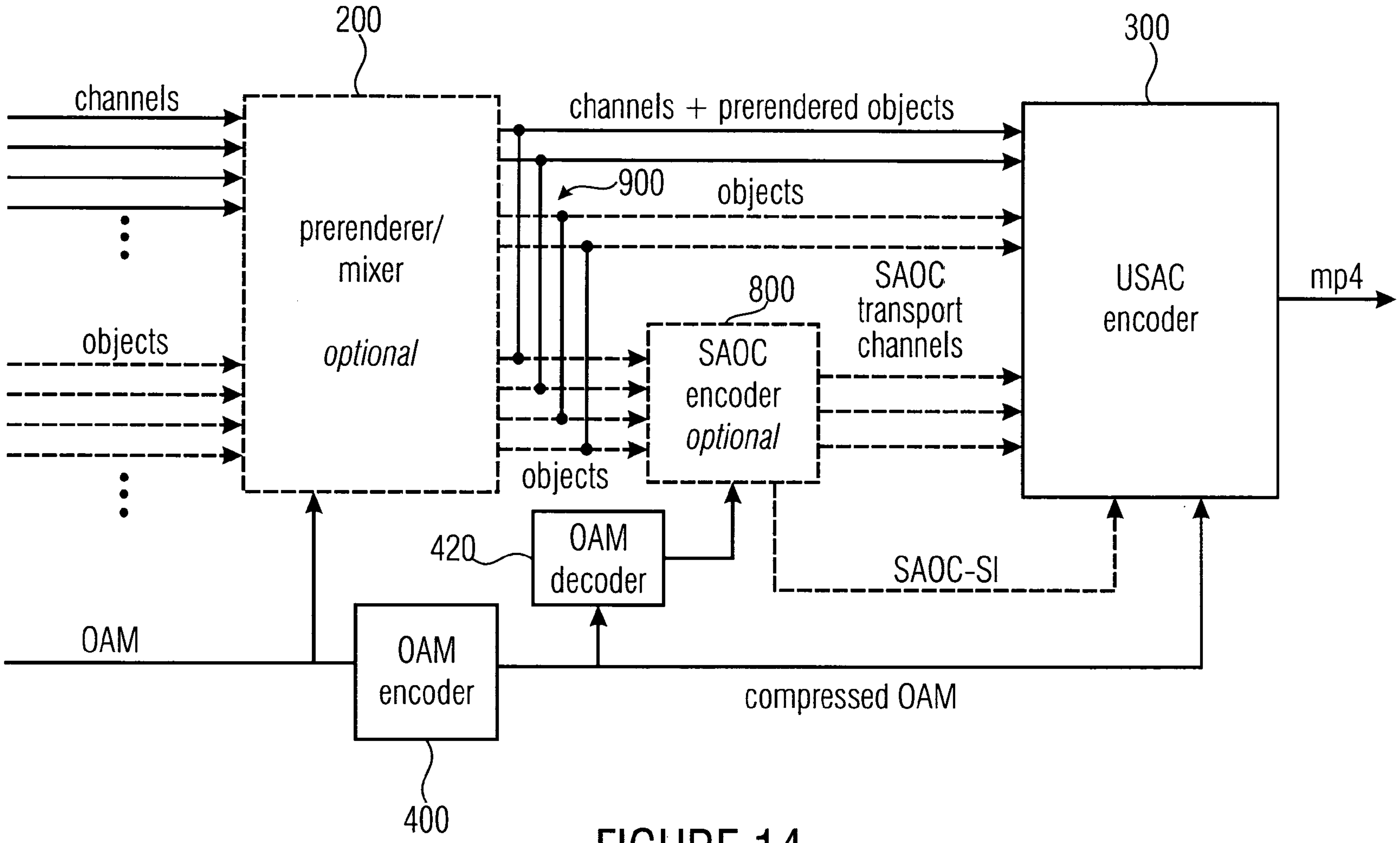


FIGURE 14
(ENCODER)

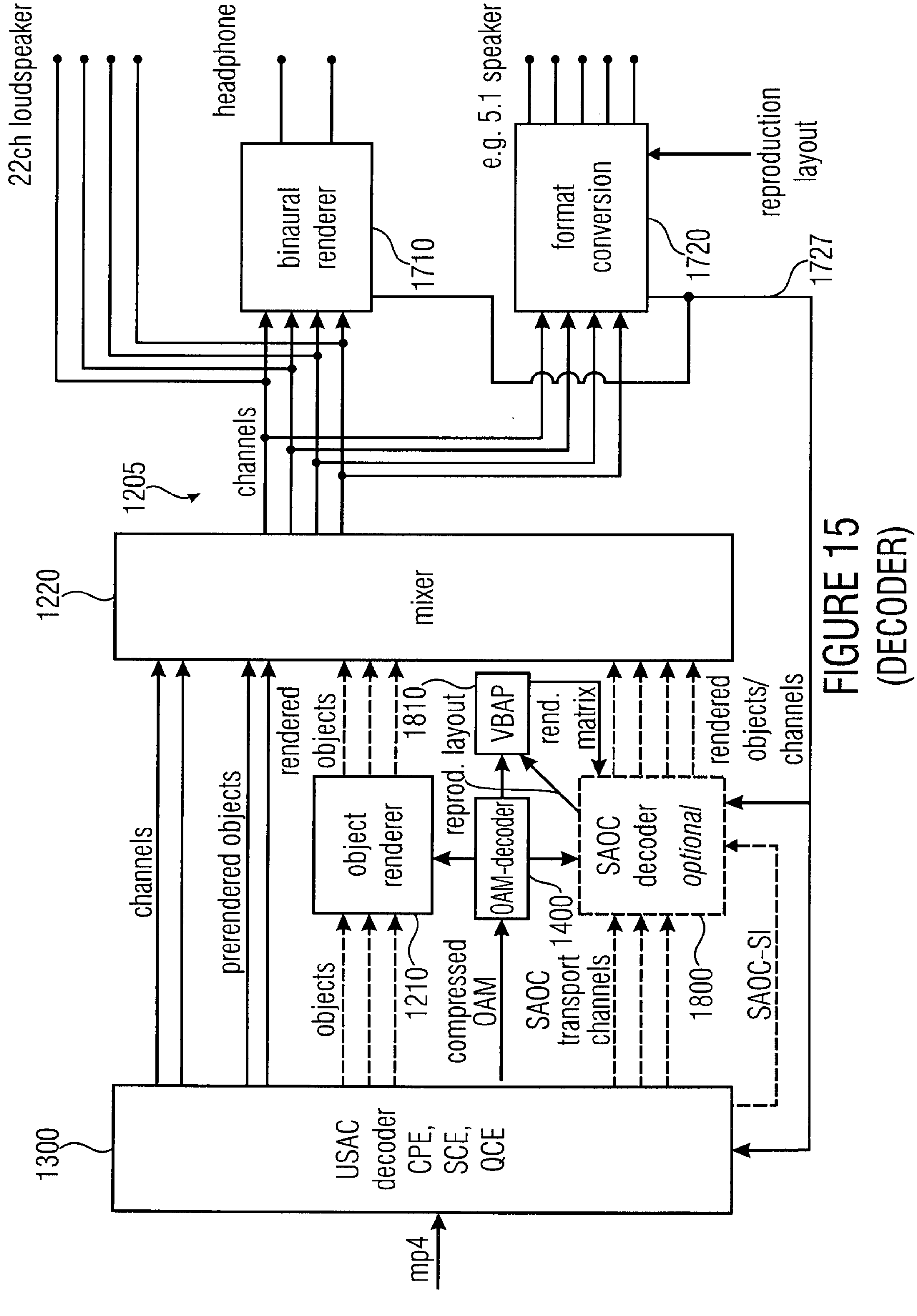


FIGURE 15 (DECODER)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/065283

A. CLASSIFICATION OF SUBJECT MATTER
INV. G10L19/008
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/006325 A1 (DOLBY LAB LICENSING CORP [US]; CHABANNE CHRISTOPHE [US]; ROBINSON CHAR) 10 January 2013 (2013-01-10) page 1, line 9 - line 15 page 2, line 3 - line 32 -----	1-15
X	WO 2013/006330 A2 (DOLBY LAB LICENSING CORP [US]; TSINGOS NICOLAS R [US]; ROBINSON CHARLE) 10 January 2013 (2013-01-10) figures 6A,6B,7,12,14A paragraphs [0009], [0014], [0026], [0076], [0080], [0090], [0105] - [0106], [0134], [0160] ----- -/--	1,6,11, 13,14

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 17 October 2014	Date of mailing of the international search report 23/10/2014
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Taddei, Hervé

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/065283

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Nils Peters ET AL: "The Spatial Sound Description Interchange Format: Principles, Specification, and Examples", Computer Music Journal, 37:1, 3 May 2013 (2013-05-03), pages 11-13, XP055137982, DOI: 10.1162/COMJ_a_00167 Retrieved from the Internet: URL:http://www.mitpressjournals.org/doi/pdfplus/10.1162/COMJ_a_00167 [retrieved on 2014-09-03] abstract page 13, left-hand column, line 7 - line 48 page 15, left-hand column, line 34 - right-hand column, line 4 page 16, left-hand column, line 6 - line 8 -----	1,6,11, 13,14
A	WO 2013/006338 A2 (DOLBY LAB LICENSING CORP [US]; ROBINSON CHARLES Q [US]; TSINGOS NICOLA) 10 January 2013 (2013-01-10) paragraph [0064] -----	7,10

11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/065283

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		US 2014133682 A1	15-05-2014
		WO 2013006325 A1	10-01-2013
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		CA 2837894 A1	10-01-2013
		CN 103650535 A	19-03-2014
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		JP 2014520491 A	21-08-2014
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		TW 201316791 A	16-04-2013
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		EP 2727383 A2	07-05-2014
		JP 2014522155 A	28-08-2014
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		TW 201325269 A	16-06-2013
		US 2014133683 A1	15-05-2014
		WO 2013006338 A2	10-01-2013