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Shimizu et al.

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(45) **Date of Patent: Feb. 23, 2016**

(54) **VIDEO ENCODING APPARATUS AND METHOD, VIDEO ENCODING PROGRAM, AND STORAGE MEDIUM WHICH STORES THE PROGRAM**

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PCT Pub. Date: **Jan. 22, 2009**

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H04N 19/137 (2014.01)
(Continued)

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CPC ***H04N 19/436*** (2014.11); ***H04N 19/124*** (2014.11); ***H04N 19/137*** (2014.11); ***H04N 19/149*** (2014.11); ***H04N 19/15*** (2014.11); ***H04N 19/152*** (2014.11); ***H04N 19/61*** (2014.11)

(58) **Field of Classification Search**
None
See application file for complete search history.

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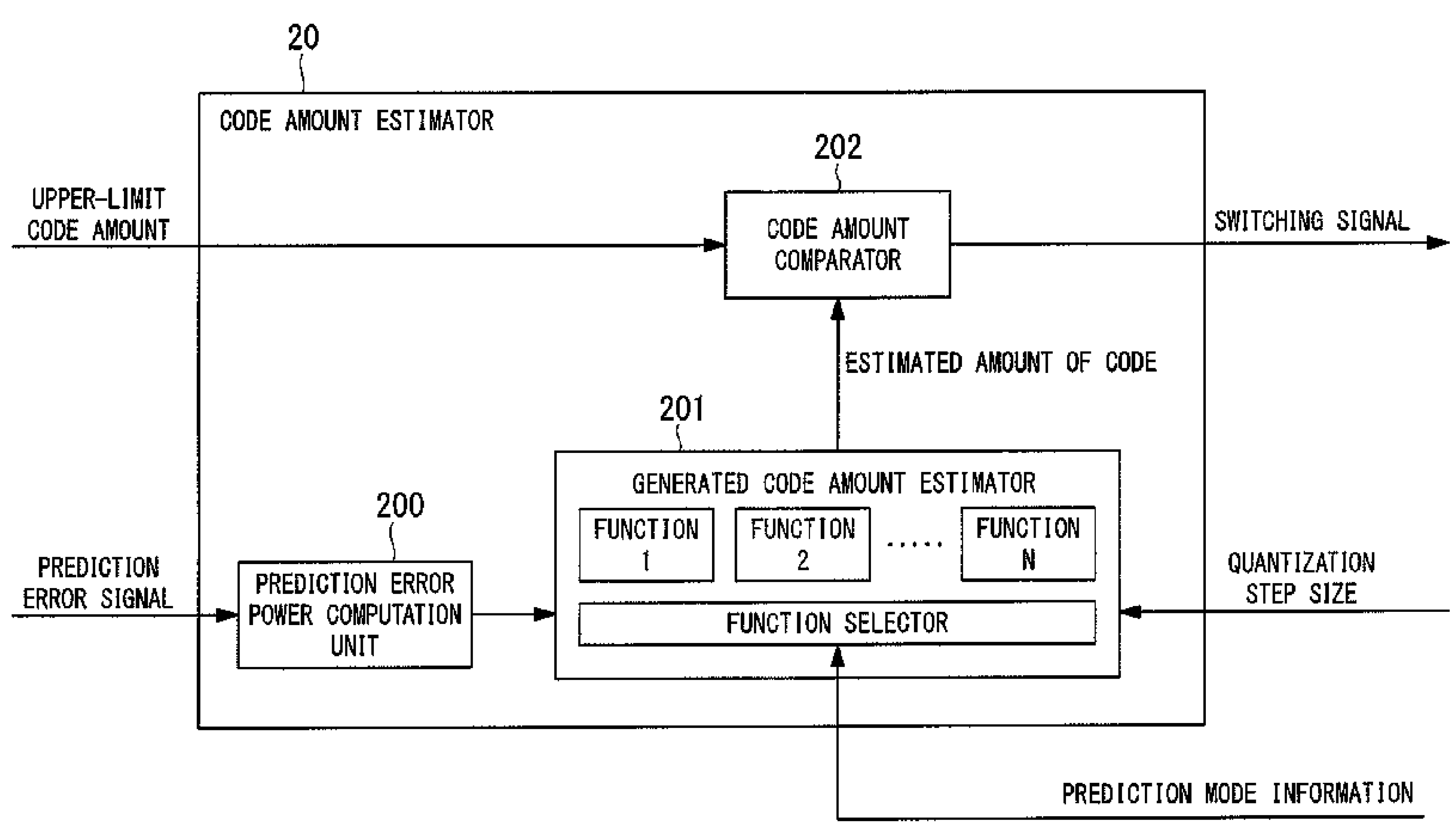
(57) **ABSTRACT**

A video encoding apparatus and a corresponding method for applying orthogonal transformation to a prediction error signal between a video signal of an encoding target area and a predicted signal for the video signal, and quantizing an obtained orthogonal transformation coefficient by using a preset quantization step size so as to encode the coefficient. A prediction error power which is a power of the prediction error signal is computed. For input information such as the computed prediction error power, the preset quantization step size, and an upper limit of an amount of code generated for the encoding target area, it is determined whether or not an amount of code generated when performing quantization using the preset quantization step size exceeds the upper limit. An encoding process is changed based on a result of the determination.

5 Claims, 15 Drawing Sheets



(51) **Int. Cl.**

H04N 19/152	(2014.01)
H04N 19/436	(2014.01)
H04N 19/149	(2014.01)
H04N 19/15	(2014.01)
H04N 19/61	(2014.01)

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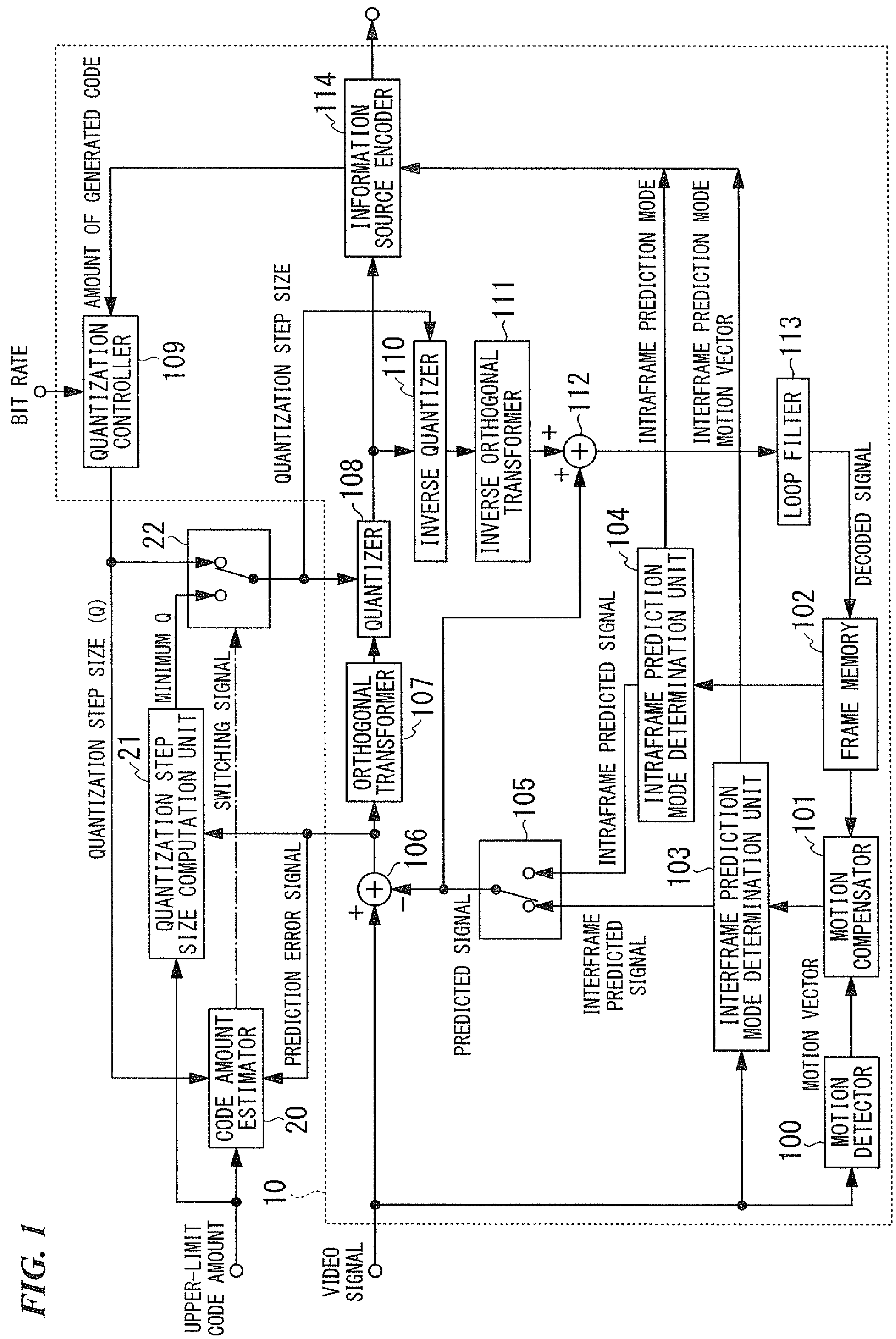

UPPER-LIMIT CODE AMOUNT
VIDEO SIGNAL
10
20
CODE AMOUNT ESTIMATOR
21
QUANTIZATION STEP SIZE COMPUTATION UNIT
MINIMUM Q
SWITCHING SIGNAL
PREDICTION ERROR SIGNAL
QUANTIZATION STEP SIZE (Q)
22
BIT RATE
QUANTIZATION CONTROLLER
109
AMOUNT OF GENERATED CODE
QUANTIZATION STEP SIZE
106
107
ORTHOGONAL TRANSFORMER
108
QUANTIZER
110
INVERSE QUANTIZER
111
INVERSE ORTHOGONAL TRANSFORMER
112
114
INFORMATION SOURCE ENCODER
PREDICTED SIGNAL
105
INTRAFRAME PREDICTED SIGNAL
INTERFRAME PREDICTED SIGNAL
104
INTRAFRAME PREDICTION MODE DETERMINATION UNIT
103
INTERFRAME PREDICTION MODE DETERMINATION UNIT
INTRAFRAME PREDICTION MODE
INTERFRAME PREDICTION MODE
MOTION VECTOR
113
LOOP FILTER
DECODED SIGNAL
102
FRAME MEMORY
101
MOTION COMPENSATOR
100
MOTION DETECTOR

FIG. 1

FIG. 2

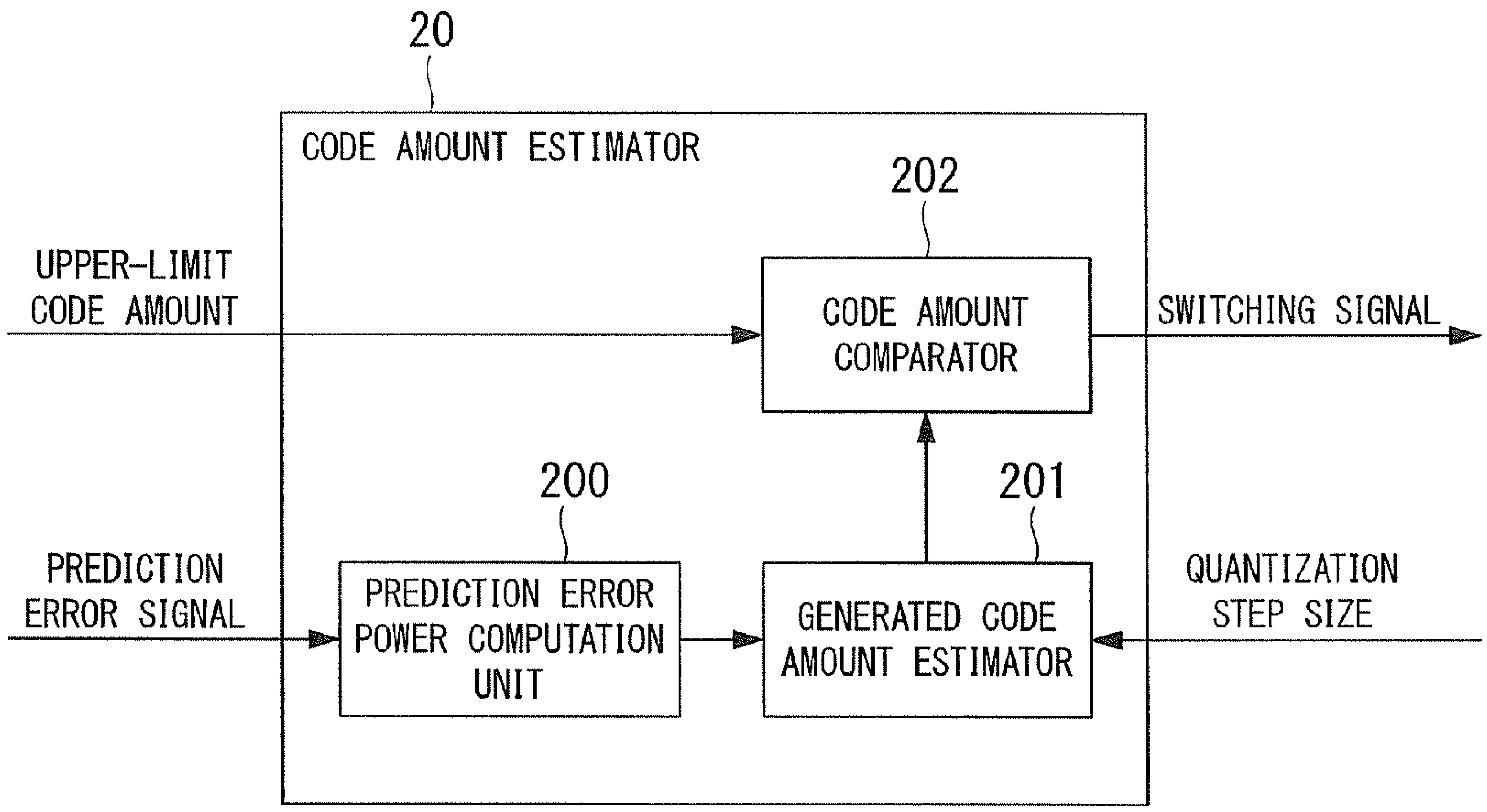

20
CODE AMOUNT ESTIMATOR
202
UPPER-LIMIT CODE AMOUNT
CODE AMOUNT COMPARATOR
SWITCHING SIGNAL
200
201
PREDICTION ERROR SIGNAL
PREDICTION ERROR POWER COMPUTATION UNIT
GENERATED CODE AMOUNT ESTIMATOR
QUANTIZATION STEP SIZE

FIG. 3

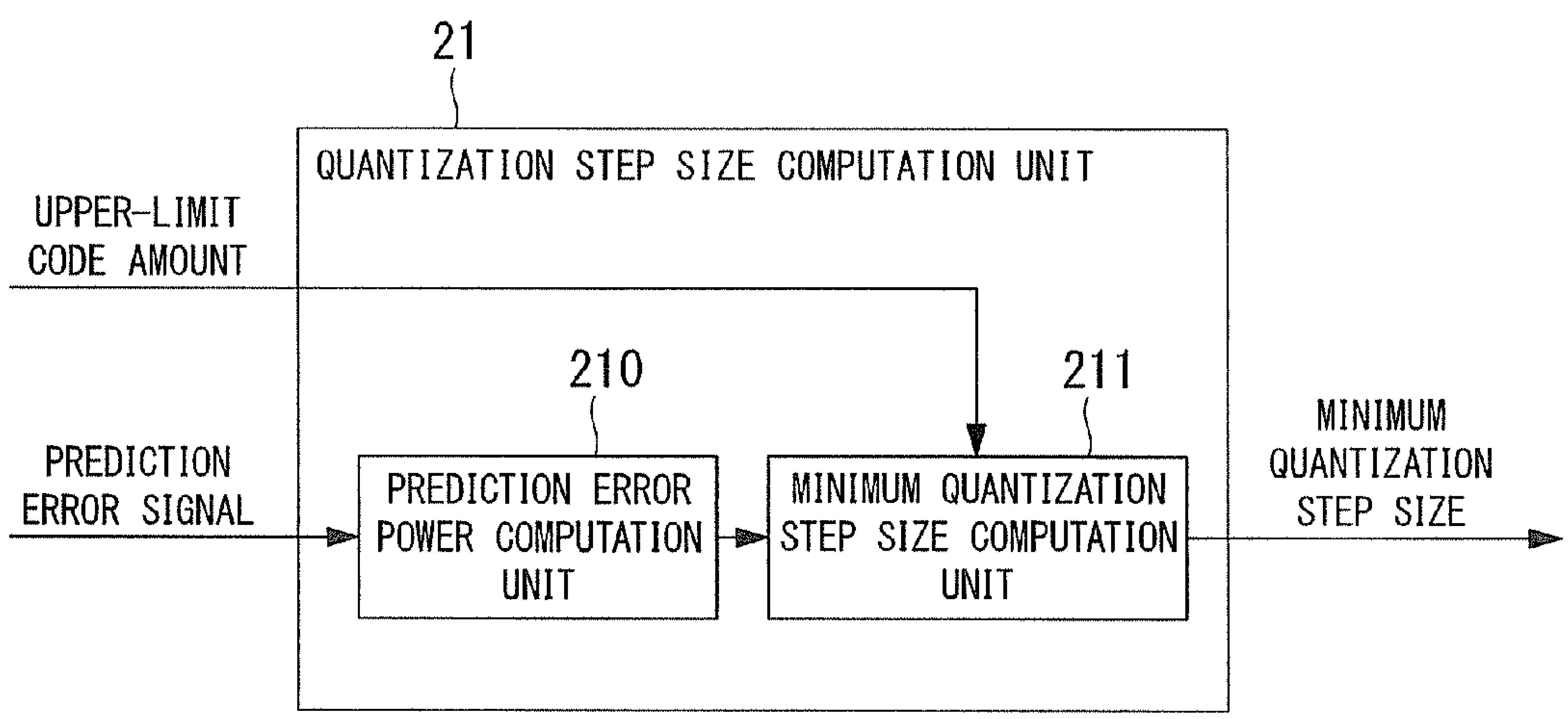

21
QUANTIZATION STEP SIZE COMPUTATION UNIT
UPPER-LIMIT CODE AMOUNT
210
211
PREDICTION ERROR SIGNAL
PREDICTION ERROR POWER COMPUTATION UNIT
MINIMUM QUANTIZATION STEP SIZE COMPUTATION UNIT
MINIMUM QUANTIZATION STEP SIZE

FIG. 4

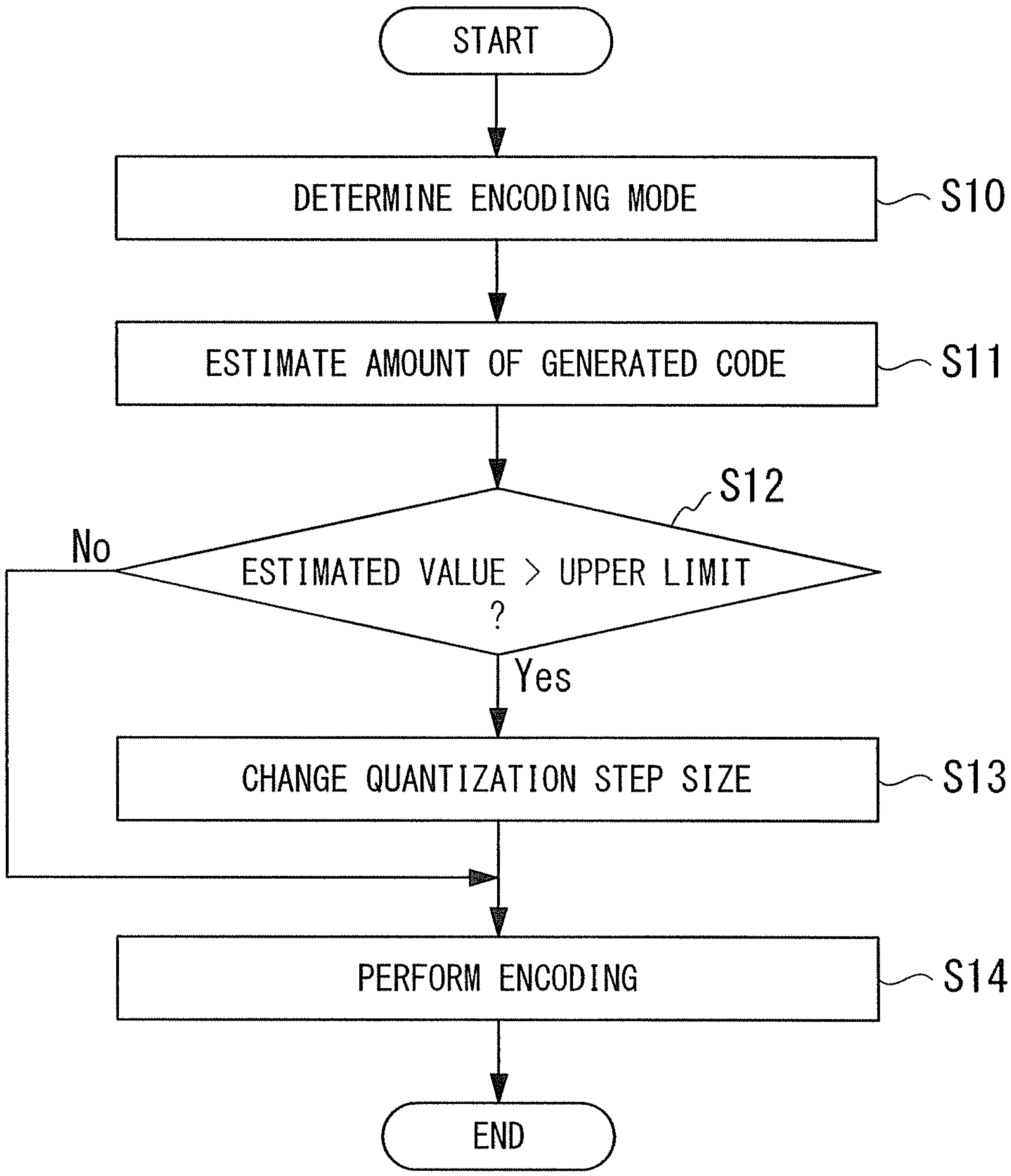

START
DETERMINE ENCODING MODE
S10
ESTIMATE AMOUNT OF GENERATED CODE
S11
S12
No
ESTIMATED VALUE > UPPER LIMIT
?
Yes
CHANGE QUANTIZATION STEP SIZE
S13
PERFORM ENCODING
S14
END

FIG. 5A

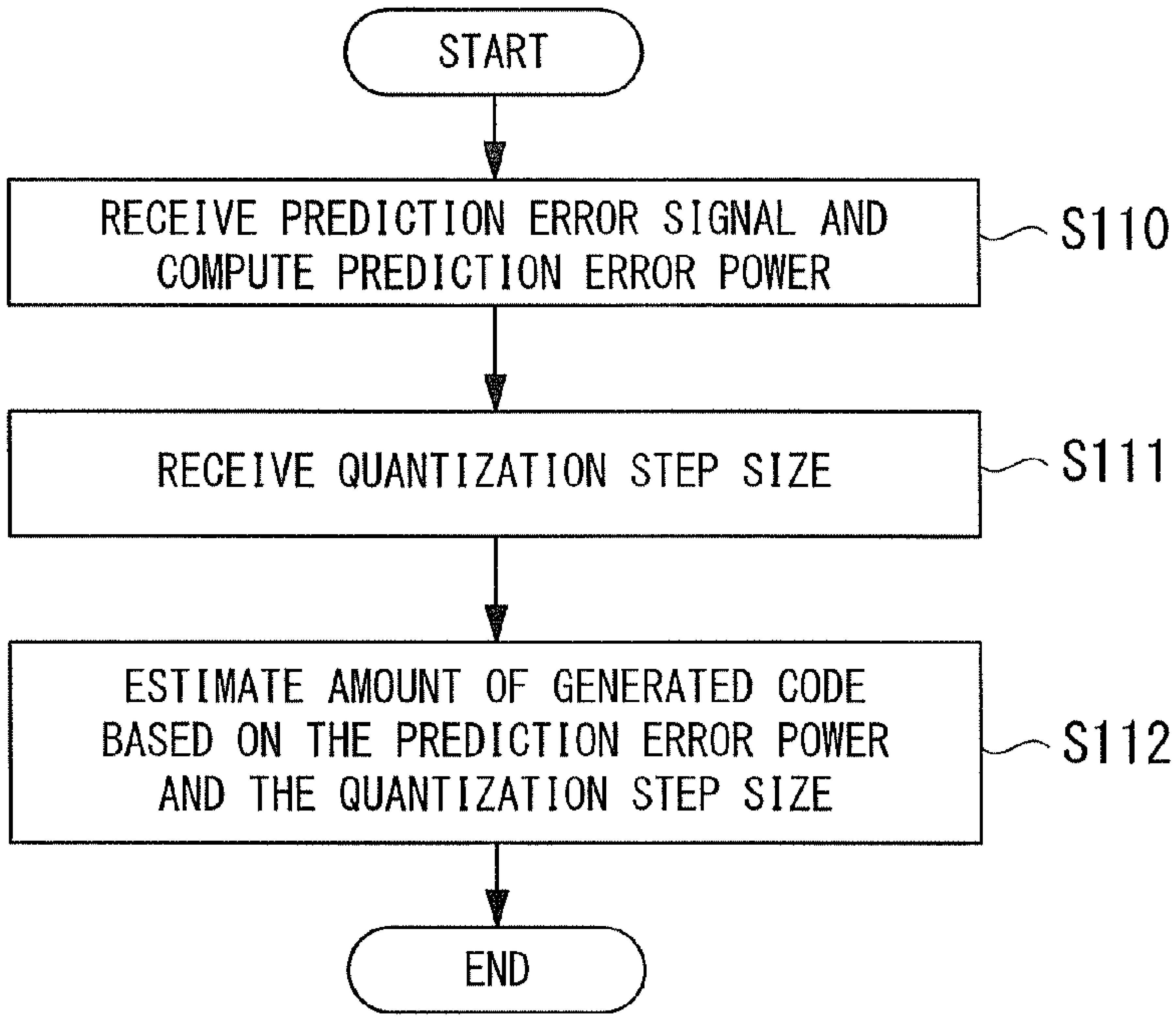

START
RECEIVE PREDICTION ERROR SIGNAL AND COMPUTE PREDICTION ERROR POWER
S110
RECEIVE QUANTIZATION STEP SIZE
S111
ESTIMATE AMOUNT OF GENERATED CODE BASED ON THE PREDICTION ERROR POWER AND THE QUANTIZATION STEP SIZE
S112
END

FIG. 5B

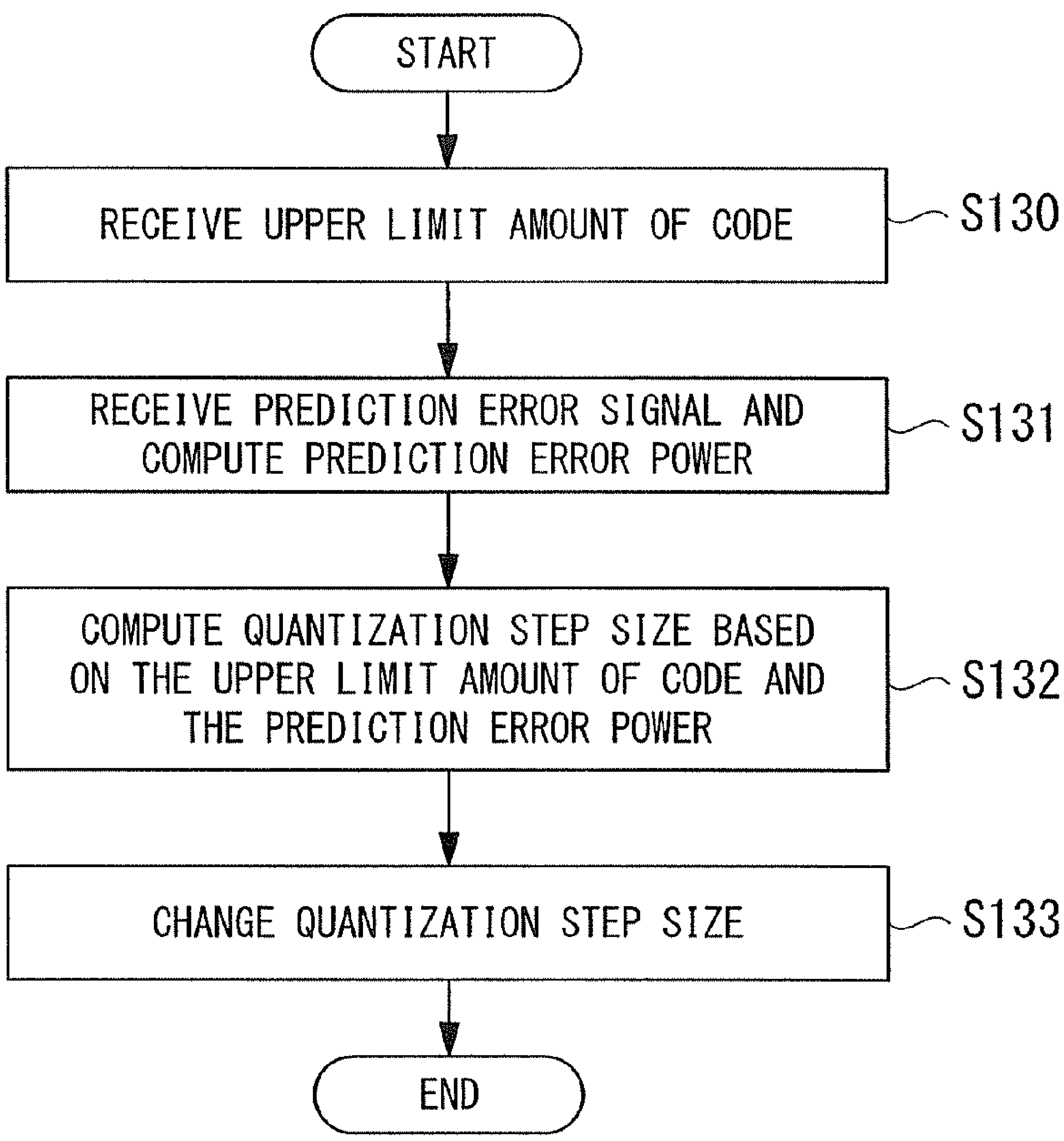

START
RECEIVE UPPER LIMIT AMOUNT OF CODE
S130
RECEIVE PREDICTION ERROR SIGNAL AND COMPUTE PREDICTION ERROR POWER
S131
COMPUTE QUANTIZATION STEP SIZE BASED ON THE UPPER LIMIT AMOUNT OF CODE AND THE PREDICTION ERROR POWER
S132
CHANGE QUANTIZATION STEP SIZE
S133
END

FIG. 6

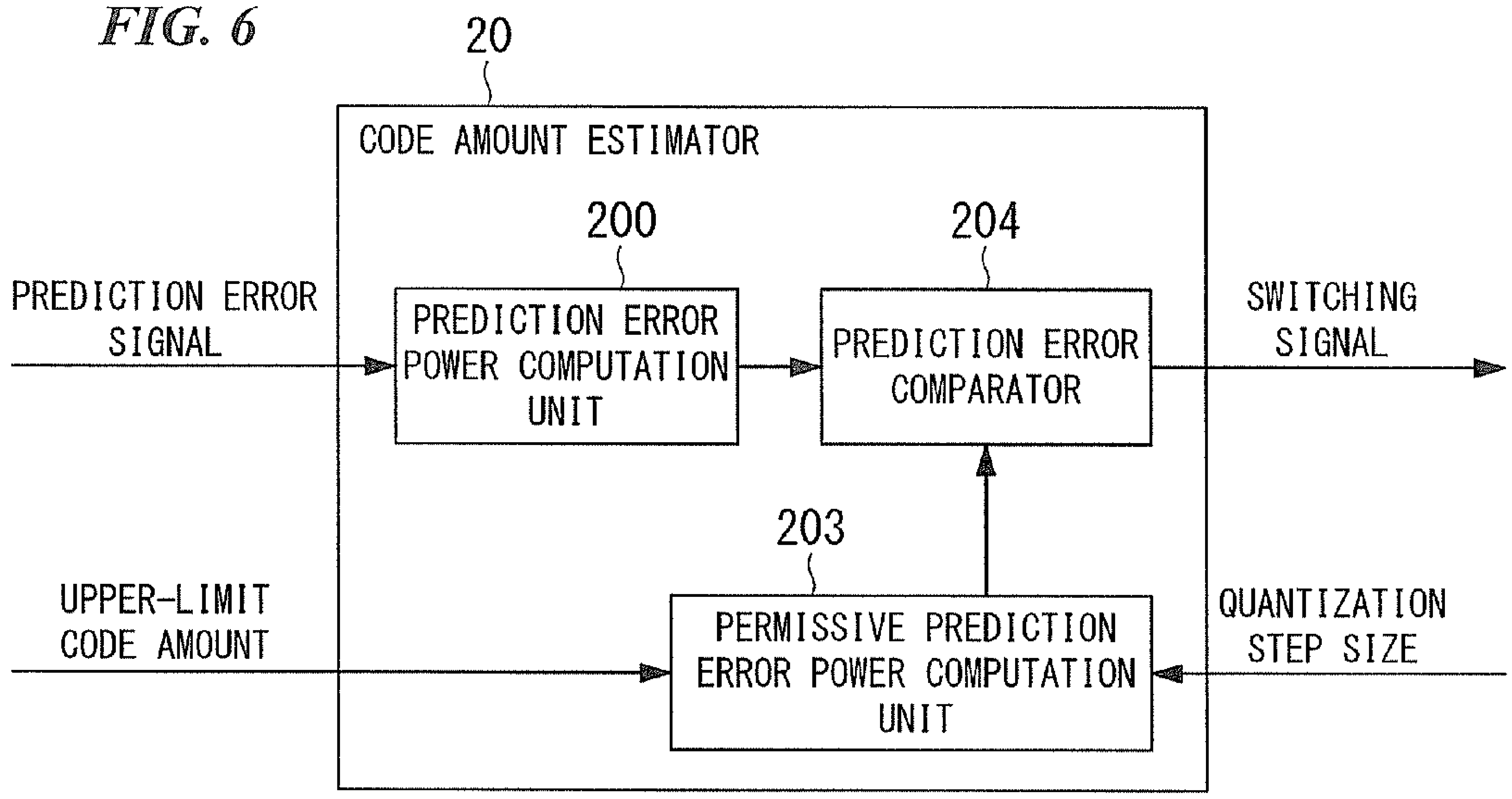

20
CODE AMOUNT ESTIMATOR
200
204
PREDICTION ERROR SIGNAL
PREDICTION ERROR POWER COMPUTATION UNIT
PREDICTION ERROR COMPARATOR
SWITCHING SIGNAL
203
UPPER-LIMIT CODE AMOUNT
PERMISSIVE PREDICTION ERROR POWER COMPUTATION UNIT
QUANTIZATION STEP SIZE

FIG. 7

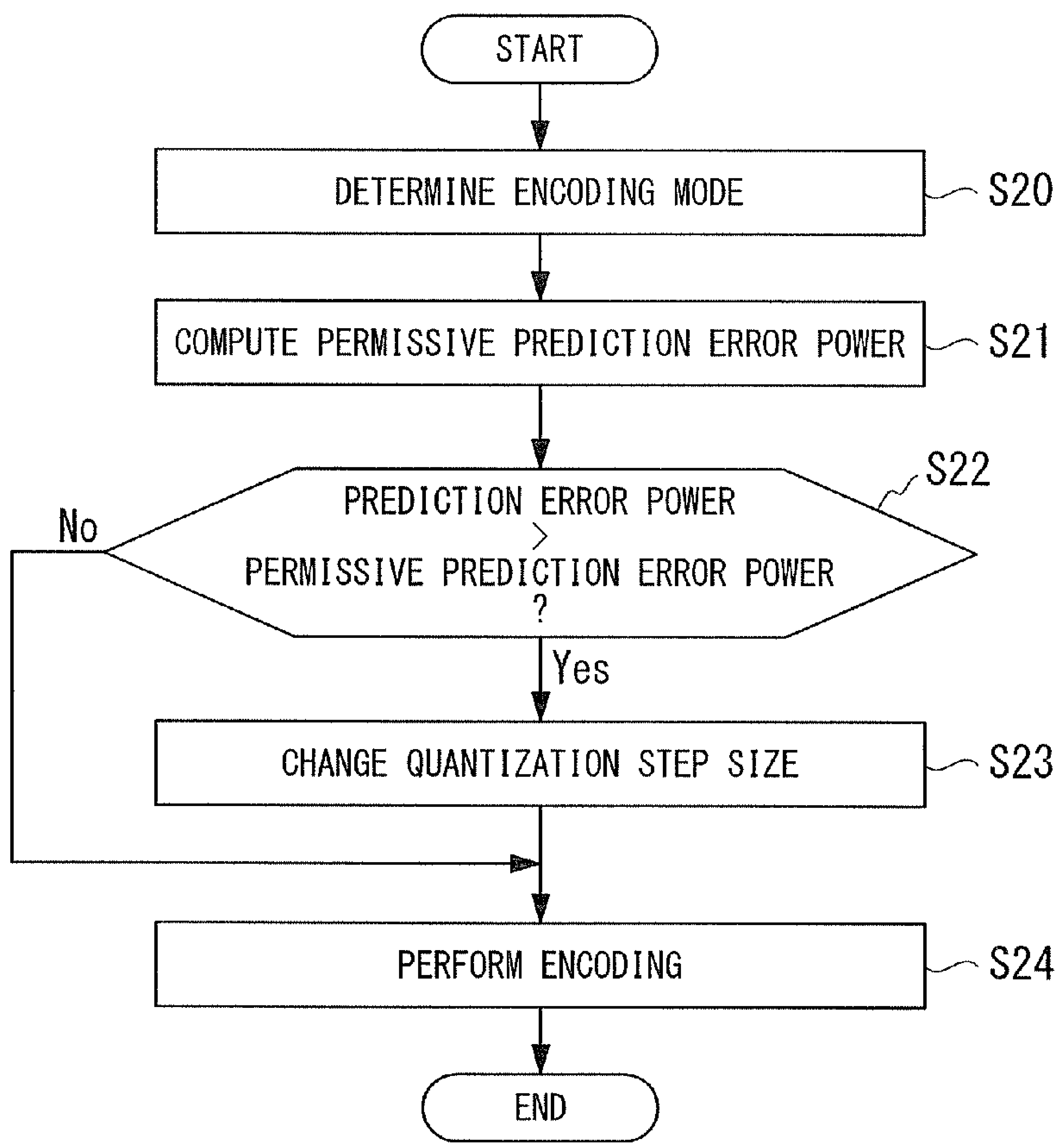

START
DETERMINE ENCODING MODE
S20
COMPUTE PERMISSIVE PREDICTION ERROR POWER
S21
S22
PREDICTION ERROR POWER > PERMISSIVE PREDICTION ERROR POWER ?
No
Yes
CHANGE QUANTIZATION STEP SIZE
S23
PERFORM ENCODING
S24
END

FIG. 8A

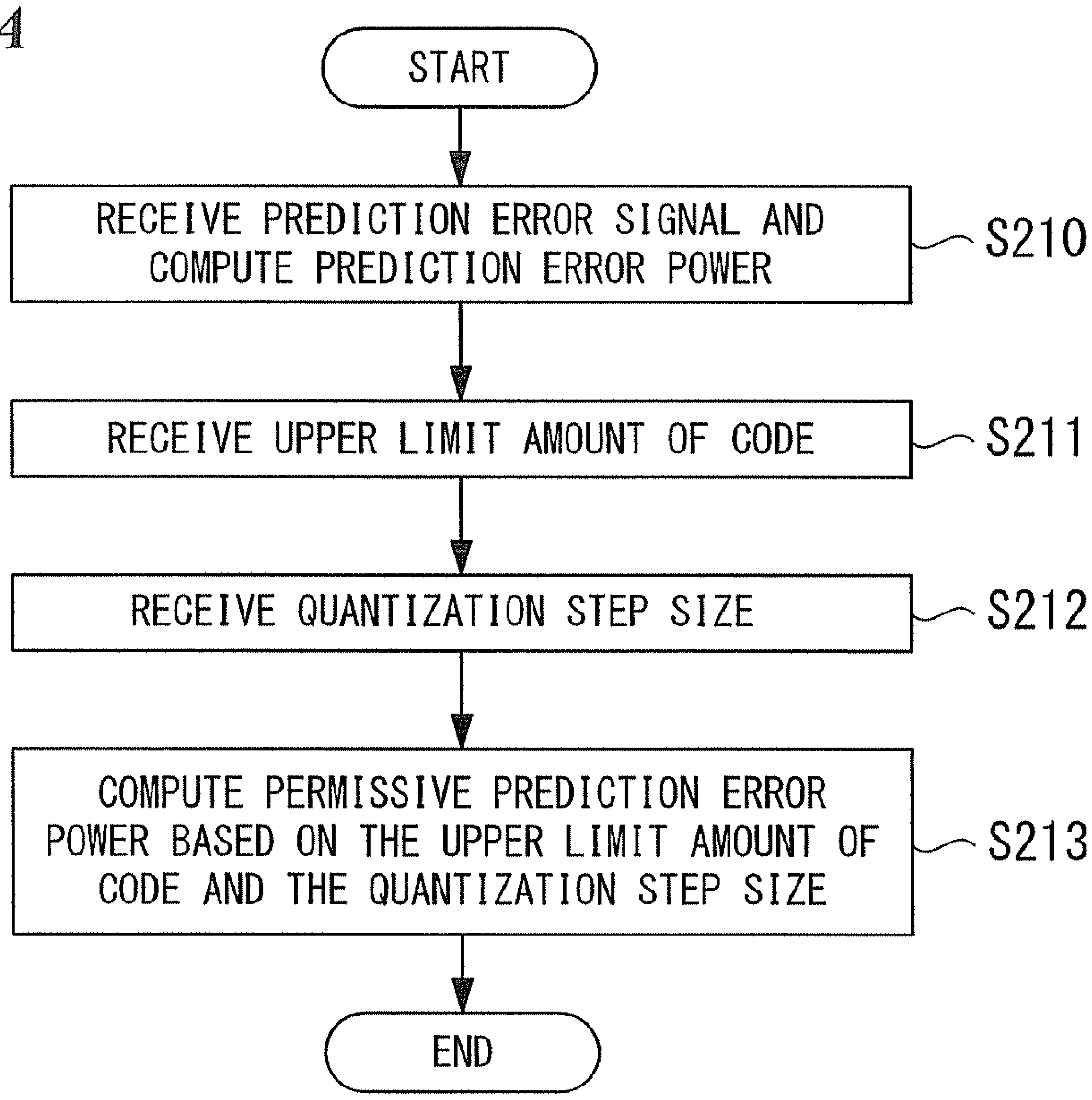

START
RECEIVE PREDICTION ERROR SIGNAL AND COMPUTE PREDICTION ERROR POWER
S210
RECEIVE UPPER LIMIT AMOUNT OF CODE
S211
RECEIVE QUANTIZATION STEP SIZE
S212
COMPUTE PERMISSIVE PREDICTION ERROR POWER BASED ON THE UPPER LIMIT AMOUNT OF CODE AND THE QUANTIZATION STEP SIZE
S213
END

FIG. 8B

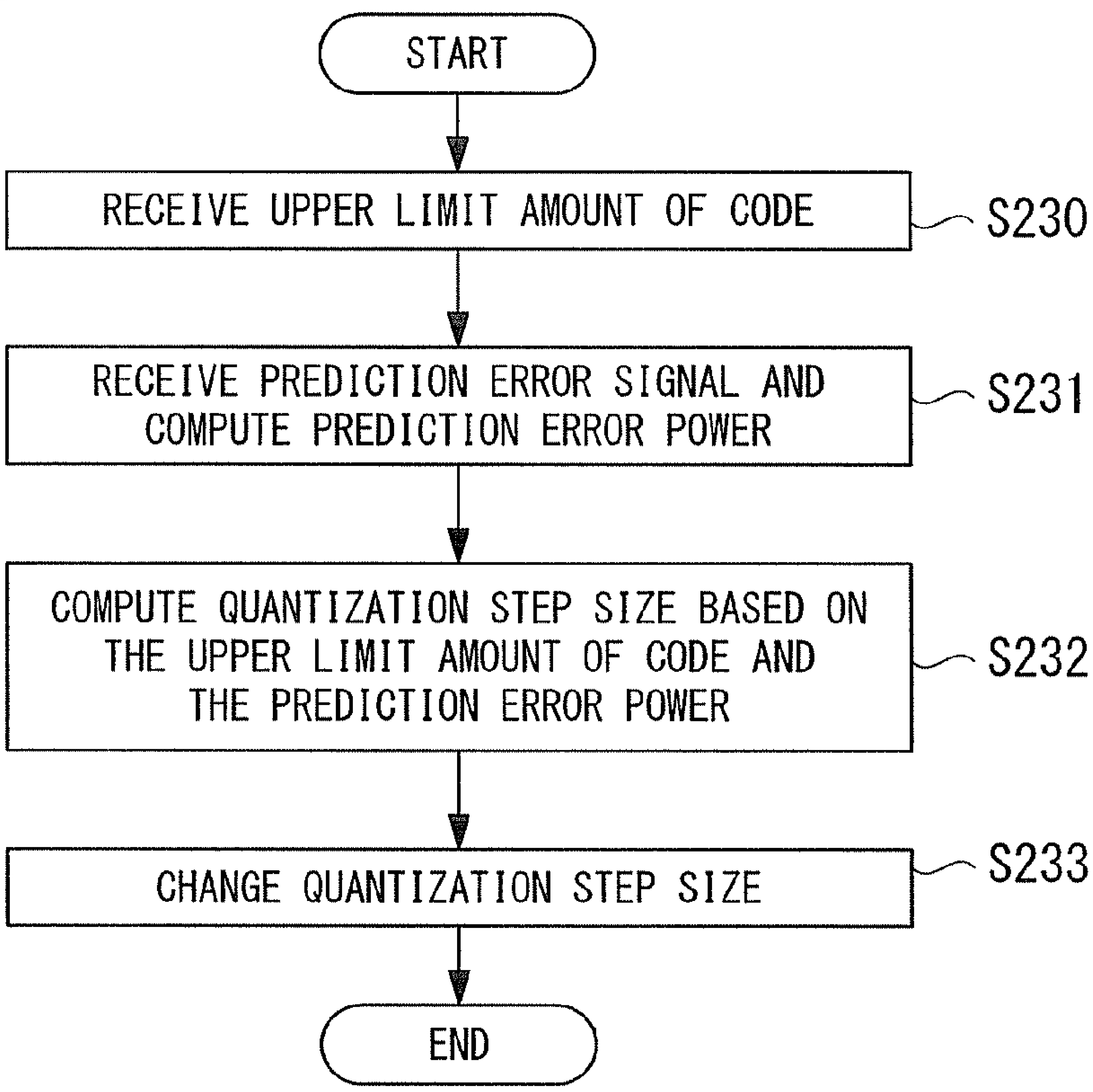

START
RECEIVE UPPER LIMIT AMOUNT OF CODE
S230
RECEIVE PREDICTION ERROR SIGNAL AND COMPUTE PREDICTION ERROR POWER
S231
COMPUTE QUANTIZATION STEP SIZE BASED ON THE UPPER LIMIT AMOUNT OF CODE AND THE PREDICTION ERROR POWER
S232
CHANGE QUANTIZATION STEP SIZE
S233
END

FIG. 9

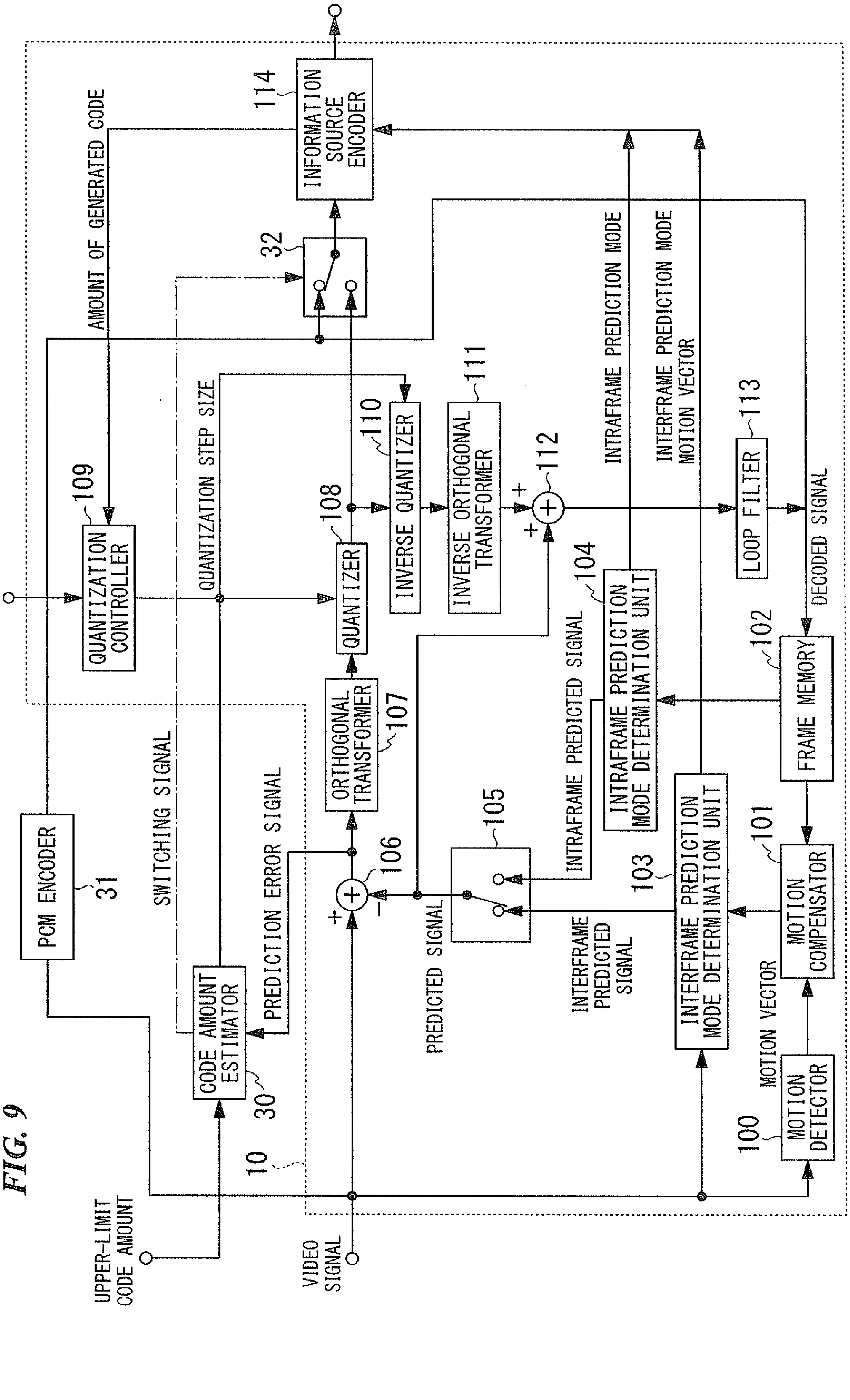

UPPER-LIMIT CODE AMOUNT
VIDEO SIGNAL
BIT RATE
PCM ENCODER
31
CODE AMOUNT ESTIMATOR
30
10
SWITCHING SIGNAL
PREDICTION ERROR SIGNAL
QUANTIZATION CONTROLLER
109
QUANTIZATION STEP SIZE
AMOUNT OF GENERATED CODE
106
+
−
PREDICTED SIGNAL
ORTHOGONAL TRANSFORMER
107
QUANTIZER
108
INVERSE QUANTIZER
110
INVERSE ORTHOGONAL TRANSFORMER
111
112
32
INFORMATION SOURCE ENCODER
114
105
INTRAFRAME PREDICTED SIGNAL
INTERFRAME PREDICTED SIGNAL
INTRAFRAME PREDICTION MODE DETERMINATION UNIT
104
INTERFRAME PREDICTION MODE DETERMINATION UNIT
103
INTRAFRAME PREDICTION MODE
INTERFRAME PREDICTION MODE MOTION VECTOR
LOOP FILTER
113
DECODED SIGNAL
FRAME MEMORY
102
MOTION COMPENSATOR
101
MOTION VECTOR
MOTION DETECTOR
100

FIG. 10

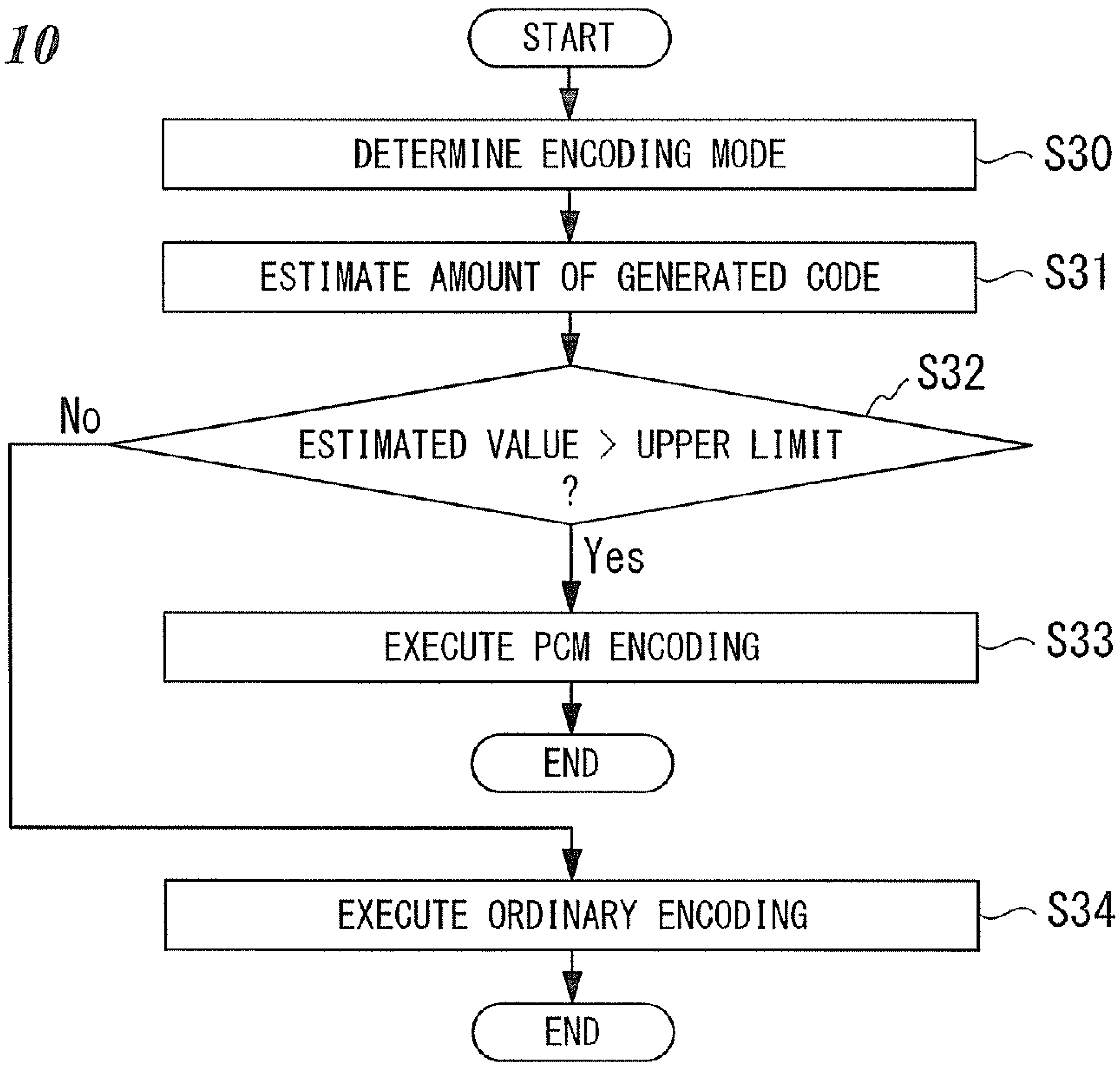

START
DETERMINE ENCODING MODE
S30
ESTIMATE AMOUNT OF GENERATED CODE
S31
S32
ESTIMATED VALUE > UPPER LIMIT ?
No
Yes
EXECUTE PCM ENCODING
S33
END
EXECUTE ORDINARY ENCODING
S34
END

FIG. 11

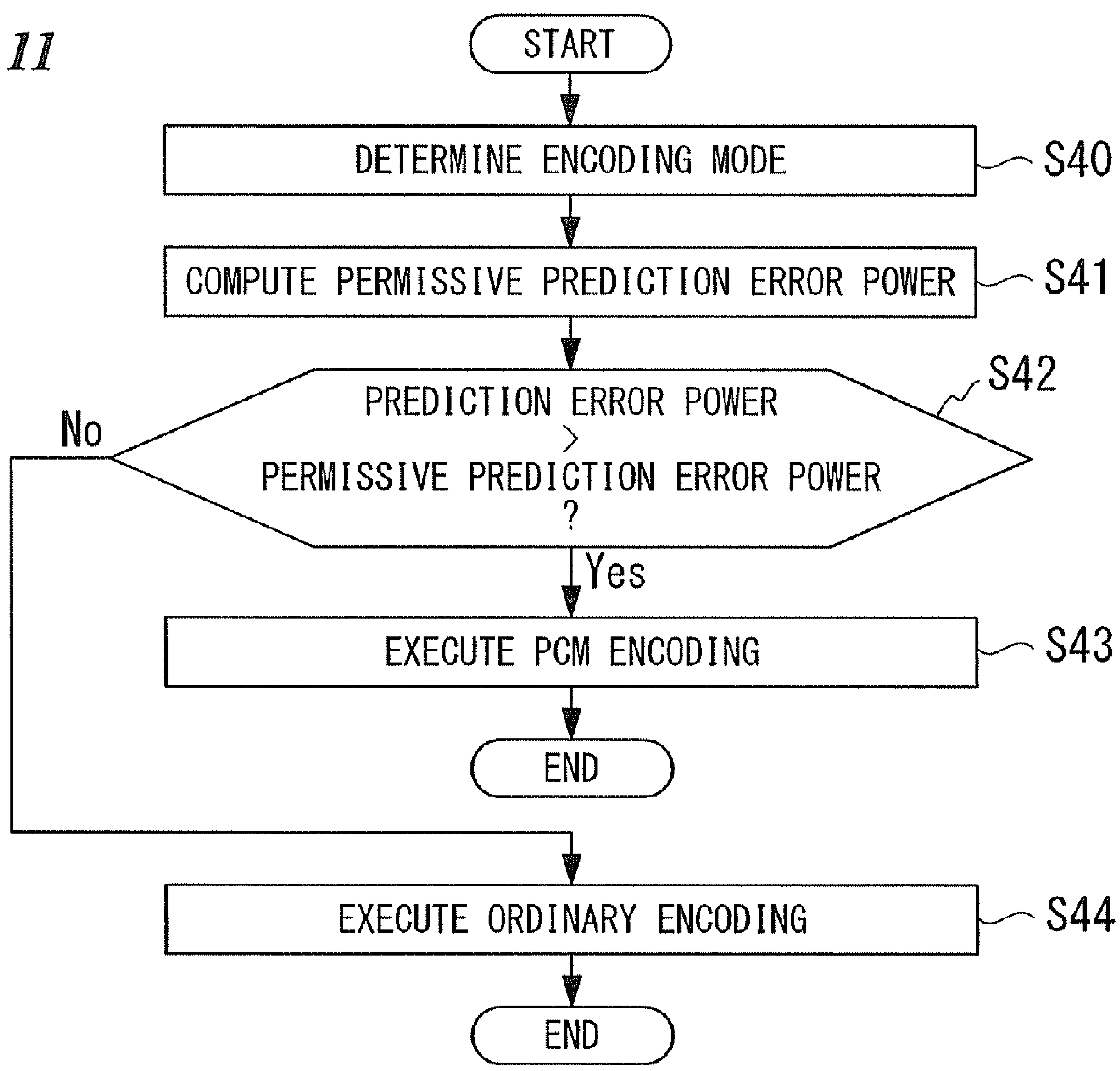

START
DETERMINE ENCODING MODE
S40
COMPUTE PERMISSIVE PREDICTION ERROR POWER
S41
S42
PREDICTION ERROR POWER > PERMISSIVE PREDICTION ERROR POWER ?
No
Yes
EXECUTE PCM ENCODING
S43
END
EXECUTE ORDINARY ENCODING
S44
END

FIG. 12

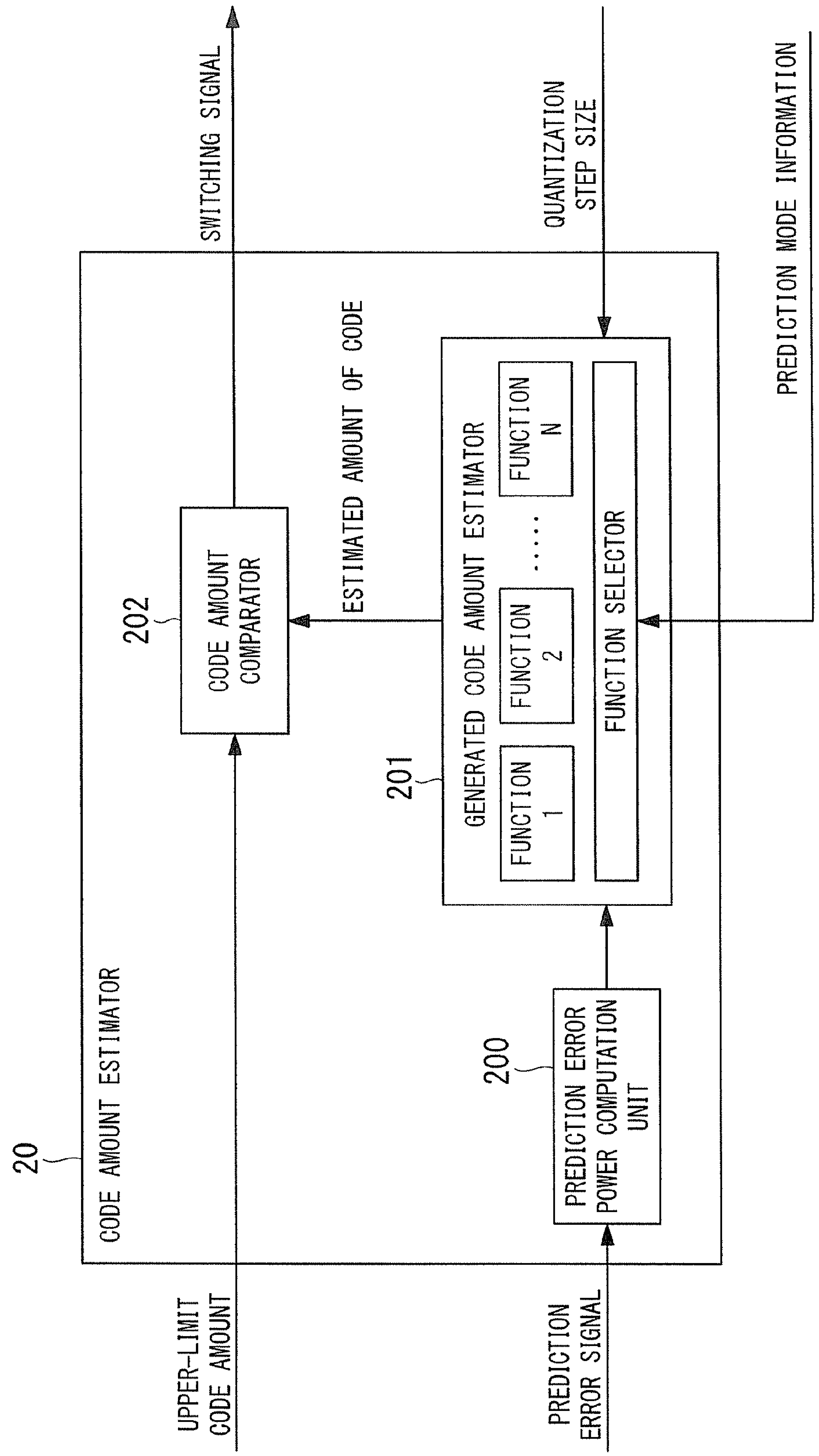

20
CODE AMOUNT ESTIMATOR
UPPER-LIMIT CODE AMOUNT
PREDICTION ERROR SIGNAL
200
PREDICTION ERROR POWER COMPUTATION UNIT
201
GENERATED CODE AMOUNT ESTIMATOR
FUNCTION 1
FUNCTION 2
FUNCTION N
FUNCTION SELECTOR
202
CODE AMOUNT COMPARATOR
ESTIMATED AMOUNT OF CODE
SWITCHING SIGNAL
QUANTIZATION STEP SIZE
PREDICTION MODE INFORMATION

FIG. 13

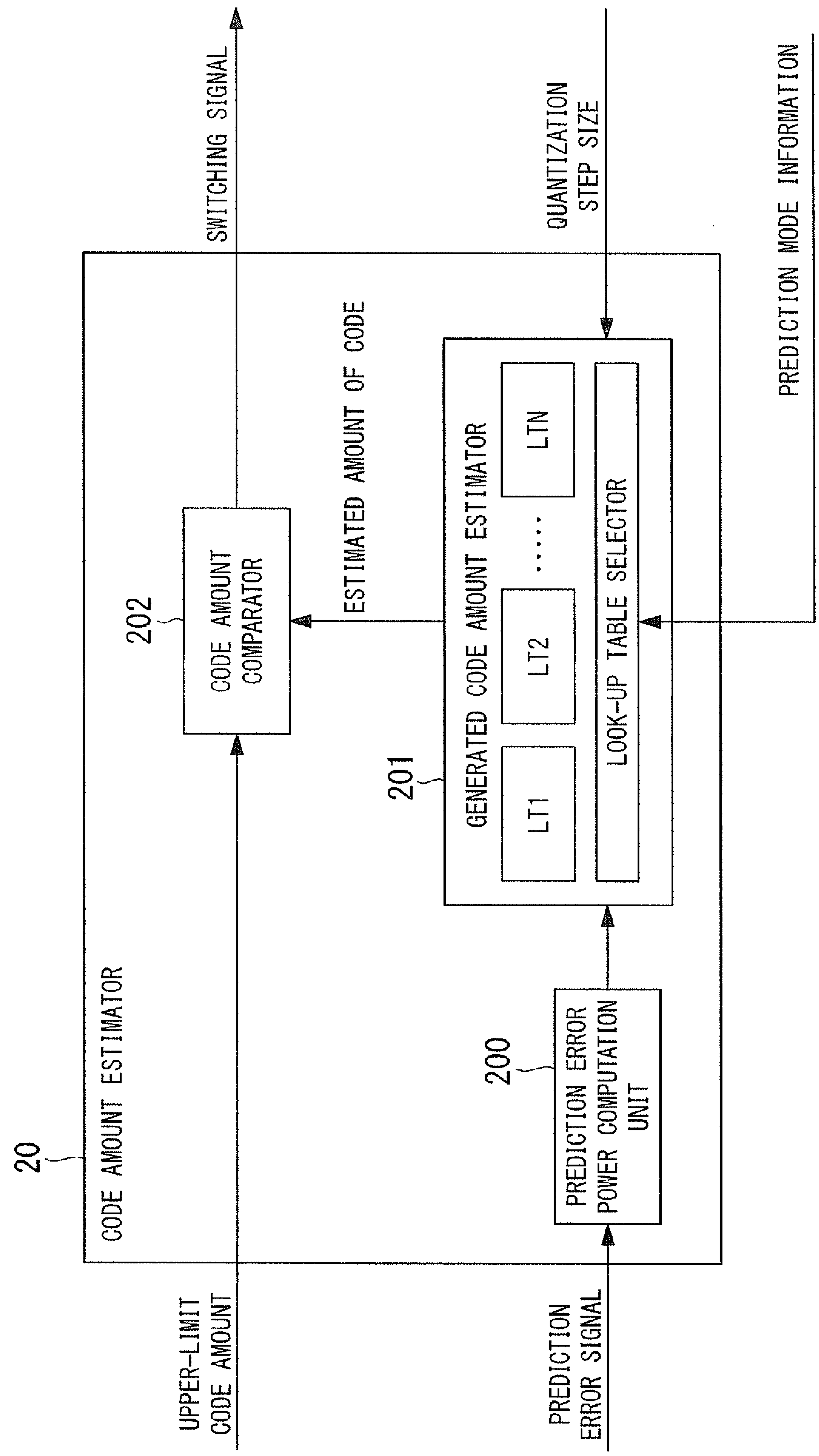

20
CODE AMOUNT ESTIMATOR
UPPER-LIMIT CODE AMOUNT
SWITCHING SIGNAL
202
CODE AMOUNT COMPARATOR
ESTIMATED AMOUNT OF CODE
201
GENERATED CODE AMOUNT ESTIMATOR
LT1
LT2
LTN
LOOK-UP TABLE SELECTOR
QUANTIZATION STEP SIZE
PREDICTION MODE INFORMATION
200
PREDICTION ERROR POWER COMPUTATION UNIT
PREDICTION ERROR SIGNAL

FIG. 14

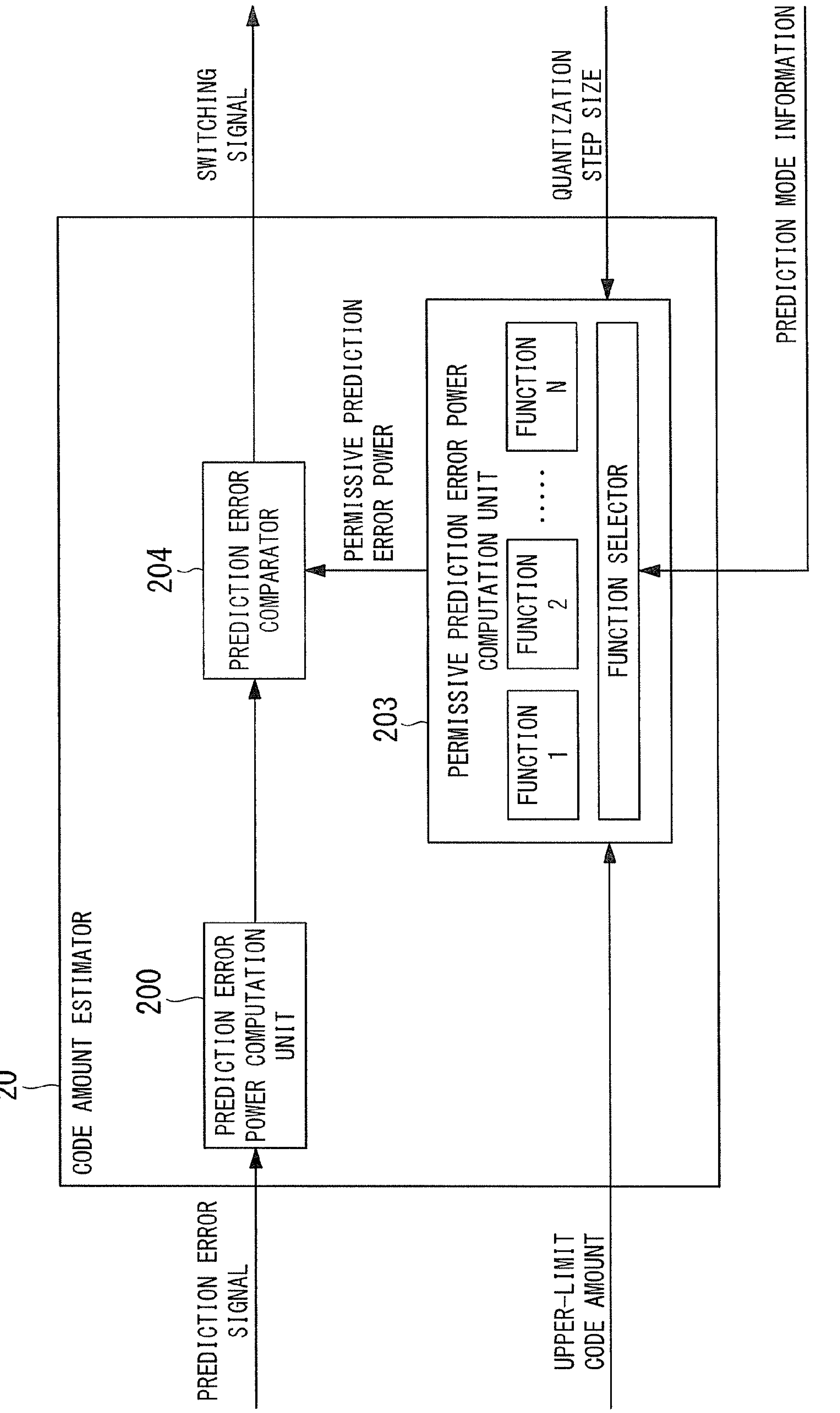

SWITCHING SIGNAL
QUANTIZATION STEP SIZE
PREDICTION MODE INFORMATION
20
CODE AMOUNT ESTIMATOR
200
PREDICTION ERROR POWER COMPUTATION UNIT
204
PREDICTION ERROR COMPARATOR
PERMISSIVE PREDICTION ERROR POWER
203
PERMISSIVE PREDICTION ERROR POWER COMPUTATION UNIT
FUNCTION 1
FUNCTION 2
FUNCTION N
FUNCTION SELECTOR
PREDICTION ERROR SIGNAL
UPPER-LIMIT CODE AMOUNT

FIG. 15

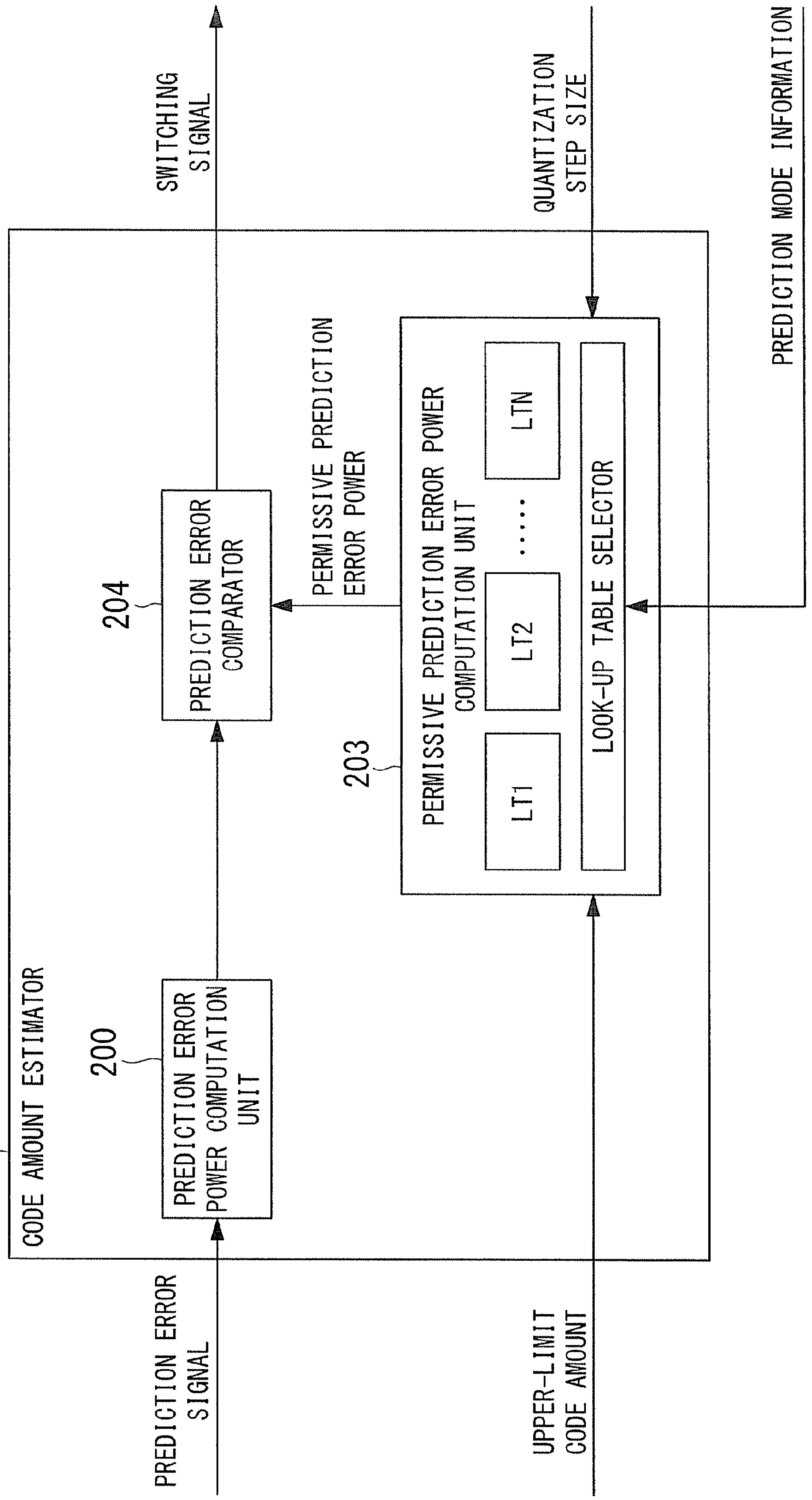

20
CODE AMOUNT ESTIMATOR
200
PREDICTION ERROR POWER COMPUTATION UNIT
204
PREDICTION ERROR COMPARATOR
203
PERMISSIVE PREDICTION ERROR POWER COMPUTATION UNIT
LT1
LT2
LTN
LOOK-UP TABLE SELECTOR
PERMISSIVE PREDICTION ERROR POWER
PREDICTION ERROR SIGNAL
UPPER-LIMIT CODE AMOUNT
SWITCHING SIGNAL
QUANTIZATION STEP SIZE
PREDICTION MODE INFORMATION

FIG. 16

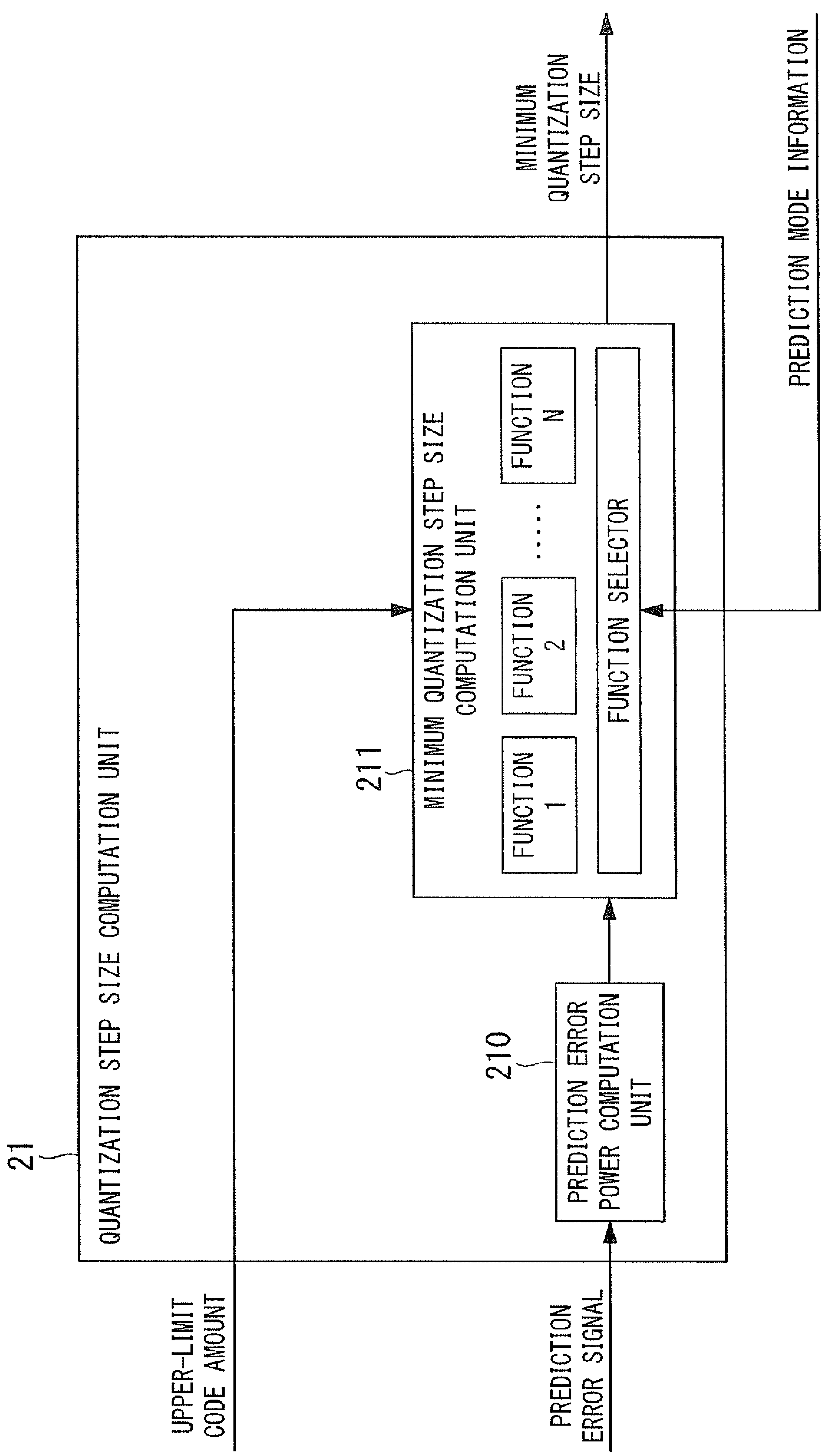

21
QUANTIZATION STEP SIZE COMPUTATION UNIT
210
PREDICTION ERROR POWER COMPUTATION UNIT
211
MINIMUM QUANTIZATION STEP SIZE COMPUTATION UNIT
FUNCTION 1
FUNCTION 2
FUNCTION N
FUNCTION SELECTOR
UPPER-LIMIT CODE AMOUNT
PREDICTION ERROR SIGNAL
MINIMUM QUANTIZATION STEP SIZE
PREDICTION MODE INFORMATION

FIG. 17

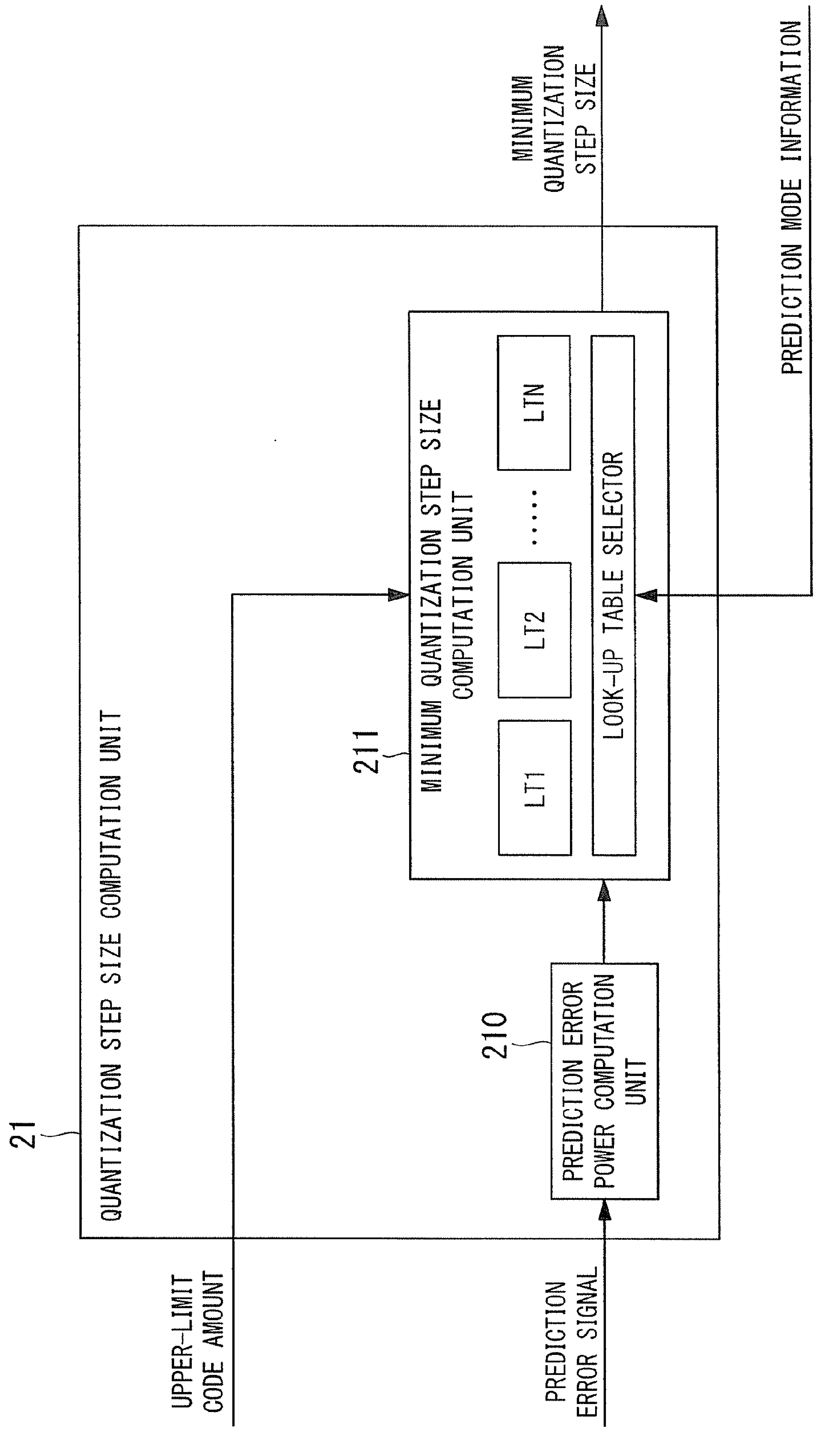
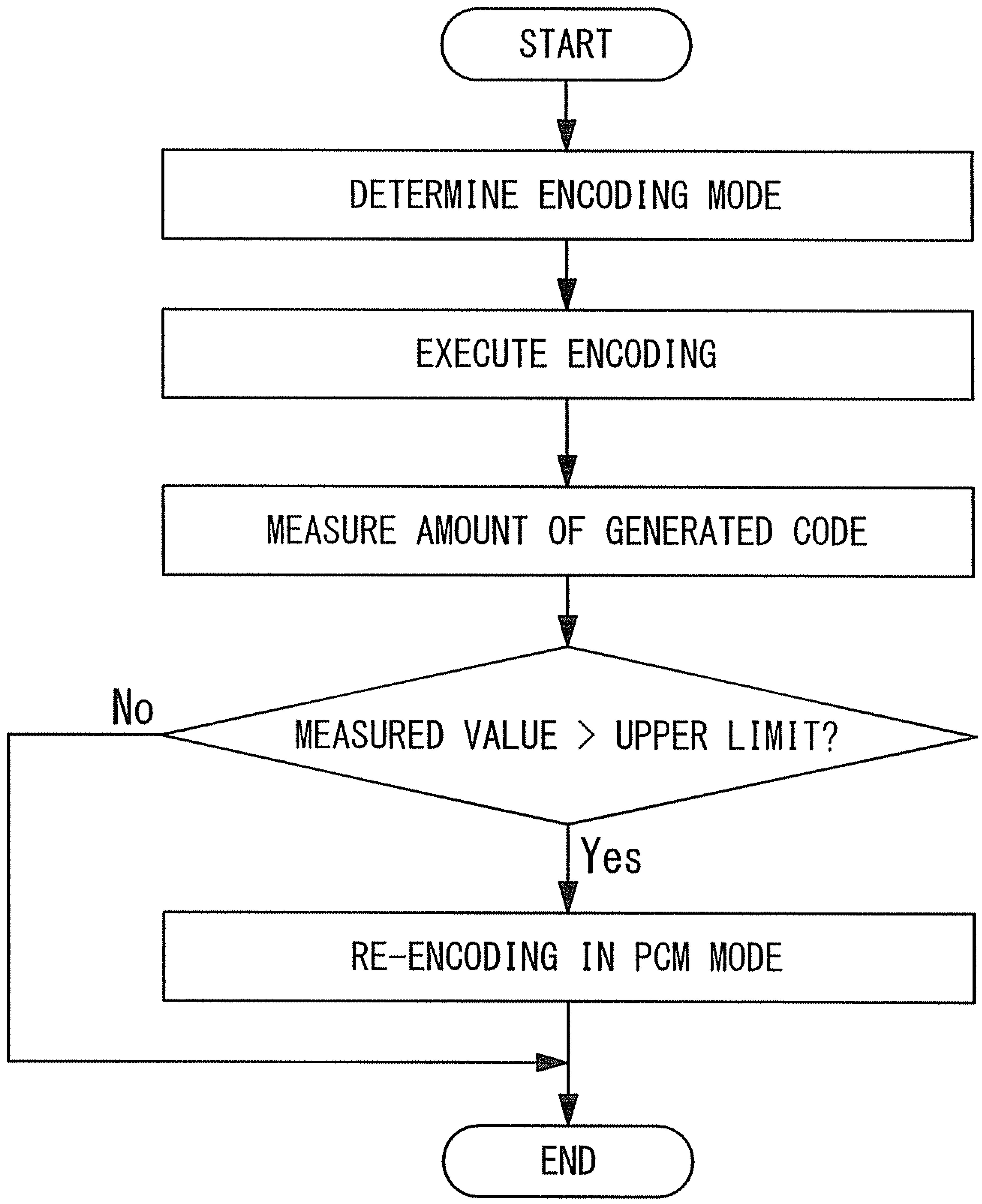

21
QUANTIZATION STEP SIZE COMPUTATION UNIT
211
MINIMUM QUANTIZATION STEP SIZE COMPUTATION UNIT
LT1
LT2
LTN
LOOK-UP TABLE SELECTOR
210
PREDICTION ERROR POWER COMPUTATION UNIT
UPPER-LIMIT CODE AMOUNT
PREDICTION ERROR SIGNAL
MINIMUM QUANTIZATION STEP SIZE
PREDICTION MODE INFORMATION

FIG. 18


START
DETERMINE ENCODING MODE
EXECUTE ENCODING
MEASURE AMOUNT OF GENERATED CODE
MEASURED VALUE > UPPER LIMIT?
No
Yes
RE-ENCODING IN PCM MODE
END

VIDEO ENCODING APPARATUS AND METHOD, VIDEO ENCODING PROGRAM, AND STORAGE MEDIUM WHICH STORES THE PROGRAM

TECHNICAL FIELD

The present invention relates to a video encoding apparatus and a corresponding method for applying orthogonal transformation to a prediction error signal between a video signal of an encoding target area and a predicted signal thereof, and quantizing an obtained orthogonal transformation coefficient by using a quantization step size so as to encode the coefficient, and also relates to a video encoding program used for implementing the video encoding apparatus and a storage medium which stores the program. In particular, the present invention relates to a video encoding apparatus and a corresponding method, which do not require re-encoding or encoding which handles two or more encoding modes and implement encoding which generates codes less than an upper limit amount of code, a video encoding program used for implementing the video encoding apparatus, and a storage medium which stores the program.

Priority is claimed on Japanese Patent Application No. 2007-185374, filed Jul. 17, 2007, the contents of which are incorporated herein by reference.

BACKGROUND ART

In H.264 as an international coding standard, the upper limit amount of code for one macroblock is determined (see, for example, Non-Patent Document 1).

Therefore, a video encoding apparatus based on H.264 should perform encoding in a manner such that the amount of generated code generated for one macroblock does not exceed the above upper limit amount.

In order to implement the above condition, the amount of generated code is measured after encoding, and if the measured amount exceeds the upper limit, encoding should be again performed with revised encoding conditions.

However, in such a method, the amount of computation or the processing time increases due to re-encoding with revised encoding conditions.

In a proposed method for solving the above problem, encoding processes (orthogonal transformation, quantization, information source encoding, and the like) corresponding to two or more encoding modes to which different encoding conditions are assigned are simultaneously executed, and one which produces an encoding result whose amount of generated code does not exceed the relevant upper limit is selected.

However, in such a method, encoding processes corresponding to two or more encoding modes having different encoding conditions should be simultaneously executed, and an encoding result whose amount of generated code does not exceed the upper limit is not always obtained.

Therefore, in order to reliably encode each macroblock of any input image with a number of bits less than an upper limit, H.264 employs a pulse code modulation (PCM) mode in which the pixel value is directly transmitted without compression (i.e., without quantization).

In a conventional technique using the above, as shown in FIG. **18**, encoding is executed after determining the encoding mode, and the amount of code generated in the encoding is measured. If the measured value exceeds an upper limit, re-encoding is performed in the PCM mode.

On the other hand, in comparison with a conventional encoding method using a coding table, an arithmetic coding method employed in H.264 has a feature such that the amount of code cannot be instantaneously measured.

Therefore, an excess over the upper limit number of bits may be detected after the processing of the next macroblock is started. In such a situation, a problem occurs in that there is a delay in a pipeline operation (i.e., parallel execution).

Accordingly, in a hardware device for performing a pipeline operation for macroblocks (as units), if an input image of a macroblock whose number of bits exceeds an upper limit is re-encoded in the above-described PCM mode, an additional memory is necessary for storing the input image until the encoding reaches the final stage.

Therefore, in a currently-proposed technique (see, for example, Non-Patent Document 2) relating to hardware devices for performing pipeline operation for macroblocks as units, when there is a macroblock whose number of bits exceeds an upper limit, not the input image of the macroblock but a local decoded image thereof in the relevant encoder is re-encoded in the PCM mode.

Non-Patent Document 1: ITU-T Rec.H.264, "Advanced video coding for generic audio visual services", pp. 249-256, 2003.

Non-Patent Document 2: Keiichi Chono, Yuzo Senda, Yoshihiro Miyamoto, "A PCM coding method using decoded images for obeying the upper limit on the number of bits of MB in H.264 encoding", pp. 119-120, PCSJ2006.

DISCLOSURE OF INVENTION

Problem to be Solved by the Invention

As described above, in a video encoding apparatus based on H.264, encoding should be performed in a manner such that the amount of code generated for one macroblock is within a specific upper limit. In order to implement this condition, the amount of generated code is measured after an encoding process, and if the amount of generated code exceeds a specific upper limit, re-encoding may be performed with revised encoding conditions.

However, in such a method, the amount of computation or the processing time increases due to re-encoding with revised encoding conditions.

In a proposed method for solving the above problem, encoding processes corresponding to two or more encoding modes to which different encoding conditions are assigned are simultaneously executed, and the one which produces an encoding result whose amount of generated code does not exceed the relevant upper limit is selected.

However, in such a method, encoding processes corresponding to two or more encoding modes having different encoding conditions should be simultaneously executed, and an encoding result whose amount of generated code does not exceed the upper limit is not always obtained.

Therefore, in the conventional technique as shown in the above-referenced FIG. **18**, encoding is performed after determining the encoding mode, and the amount of code generated in the encoding is measured. If the measured value exceeds an upper limit, re-encoding is performed in the PCM mode.

However, in the above conventional technique, even when the amount of generated code can be reduced in comparison with the re-encoding in the PCM mode, such a possibility is disregarded.

Furthermore, the arithmetic coding method employed in H.264 has a feature such that the amount of code cannot be instantaneously measured, and thus a processing delay occurs in a hardware device which executes a pipeline operation.

In light of the above circumstances, an object of the present invention is to provide a novel image encoding technique which does not require re-encoding or encoding corresponding to two or more encoding modes, and implements an encoding whose amount of generated code does not exceed an upper limit without awaiting a measured result of the amount of generated code.

Means for Solving the Problem

In order to achieve the object, the present invention provides a video encoding apparatus for applying orthogonal transformation to a prediction error signal between a video signal of an encoding target area and a predicted signal for the video signal, and quantizing an obtained orthogonal transformation coefficient by using a preset quantization step size so as to encode the coefficient. The apparatus comprises:

(1) a computation device that computes a prediction error power which is a power of the prediction error signal;

(2) a determination device that receives the prediction error power computed by the computation device, the preset quantization step size to be used in the relevant encoding, and an upper limit of an amount of code generated for the encoding target area, and determines whether or not an amount of code generated when performing quantization using the quantization step size to be used in the encoding exceeds the upper limit; and

(3) a change device that changes an encoding process based on a result of the determination by the determination device,

wherein the determination device computes a permissive power for the prediction error power computed by the computation device, based on the upper limit of the amount of generated code and the quantization step size to be used in the encoding, and compares the permissive power with the prediction error power computed by the computation device so as to determine whether or not the amount of code generated when performing the quantization step size to be used in the encoding exceeds the upper limit.

The above-described processing devices can also be implemented by a computer program. Such a computer program may be provided by storing it in an appropriate computer-readable storage medium, or by means of a network, and can be installed and operate on a control device such as a CPU so as to implement the present invention.

Generally, amount G of generated code and quantization step size Q have the following relationship:

$$G=X/Q$$

where X is a value depending on the input signal.

In addition, for the same quantization step size Q, there is a correlation between the amount G of generated code and power D of the input signal. Therefore, in the selection of the prediction mode used in the encoding, a mode for minimizing the prediction error power is selected.

In accordance with the above relationships, an approximate amount of generated code can be estimated.

In consideration of the above, a prediction error power which is a power of the prediction error signal (as an encoding target) is computed. Based on the computed prediction error power and the quantization step size to be used in the encoding, an amount of code generated when performing the quantization using the quantization step size to be used in the encoding is estimated. The estimated value is compared with the relevant upper limit of the amount of generated code, so that it can be determined whether or not the amount of code generated when performing quantization using the quantization step size to be used in the encoding exceeds the upper limit.

In the above determination process, the amount of generated code is directly estimated. However, the determination process is equivalent to a process for determining whether or not the prediction error power is within a permissive power range defined based on the upper limit of the amount of generated code.

Therefore, in the video encoding apparatus of the present invention, a permissive power for the prediction error power is computed based on the upper limit of the amount of generated code and the quantization step size to be used in the encoding, and the permissive power is compared with the computed prediction error power so as to determine whether or not the amount of code generated when performing the quantization using the quantization step size to be used in the encoding exceeds the upper limit.

The estimated value for the amount of generated code or the permissive power for the prediction error power, which is used in the determination process, can be easily computed by means of a function or a table.

That is, it is possible to estimate the amount of generated code by setting variables of a function, which are the prediction error power and the quantization step size, to the values of the prediction error power and the quantization step size, where the value of the function is the relevant amount of generated code. It is also possible to estimate the amount of generated code by referring to a table in which a relationship between data values of the prediction error power, the quantization step size, and the relevant amount of generated code is defined.

It is also possible to compute the permissive power for the prediction error power by setting variables of a function, which are the upper limit of the amount of generated code and the quantization step size, to the values of the upper limit and the quantization step size, where the value of the function is the permissive power for the prediction error power. It is also possible to compute the permissive power for the prediction error power by referring to a table in which a relationship between data values of the upper limit of the amount of generated code, the quantization step size, and the permissive power for the prediction error power is defined.

Strictly speaking, different encoding modes (prediction modes) have different overhead amounts of code or the like, and such a function or look-up table depends on the encoding mode. Therefore, it is preferable that such a function or look-up table is provided for each encoding mode, and one suitable for the encoding mode of the encoding target area is selected and used.

If it is determined by the above determination process that the amount of code generated when performing quantization using the quantization step size to be used in the encoding exceeds the upper limit, then (i) in a first example, a quantized value of the orthogonal transformation coefficient may not be encoded, but the video signal may be encoded without quantizing the video signal; and (ii) in a second example, a quantization step size may be obtained, which is computed based on the prediction error power and the upper limit of the amount of generated code and implements generation of the amount of code which does not exceed the upper limit, and the quantization step size may be switched from the quantization step size to be used in the encoding to the obtained quantization step size.

The computation of the quantization step size used in the above switching operation is implemented using an inverse function of the function which is used for the above-described estimation of the amount of generated code. Therefore, also in this case, the relevant quantization step size can be easily computed using a function or a table.

That is, it is possible to compute the quantization step size which implements generation of the amount of code which does not exceed the upper limit, by setting variables of a function, which are the prediction error power and the upper limit of the amount of generated code, to the values of the prediction error power and the upper limit, where the value of the function is the quantization step size which implements the generation of the amount of code which does not exceed the upper limit.

It is also possible to compute the quantization step size which implements generation of the amount of code which does not exceed the upper limit of the amount of generated code, by referring to a table in which a relationship between data values of the prediction error power, the upper limit, and the quantization step size which implements the generation of the amount of code which does not exceed the upper limit is defined.

Strictly speaking, different encoding modes (prediction modes) have different overhead amounts of code or the like, and such a function or look-up table depends on the encoding mode. Therefore, it is preferable that such a function or look-up table is provided for each encoding mode, and one suitable for the encoding mode of the encoding target area is selected and used.

EFFECT OF THE INVENTION

As described above, the present invention can be applied to an apparatus for applying orthogonal transformation to a prediction error signal between a video signal of an encoding target area and a predicted signal for the video signal, and quantizing an obtained orthogonal transformation coefficient by using a quantization step size so as to encode the coefficient. The present invention can implement encoding which generates codes less than an upper limit amount of code, without measuring the amount of generated code. Therefore, the present invention does not require re-encoding or encoding which handles two or more encoding modes and can implement the encoding which generates codes less than the upper limit amount of code.

Additionally, As the present invention can implement an encoding whose amount of generated code does not exceed an upper limit without awaiting a measured result of the amount of generated code, no processing delay occurs in a hardware device which executes a pipeline operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram showing a video encoding apparatus as an embodiment of the present invention.

FIG. **2** is a diagram showing an example structure of the code amount estimator in the embodiment.

FIG. **3** is a diagram showing an example structure of the quantization step size computation unit in the embodiment.

FIG. **4** is a flowchart executed by the video encoding apparatus of the embodiment.

FIG. **5**A is also a flowchart executed by the video encoding apparatus.

FIG. **5**B is also a flowchart executed by the video encoding apparatus.

FIG. **6** is a diagram showing another example structure of the code amount estimator in the embodiment.

FIG. **7** is a flowchart executed by the video encoding apparatus employing the structure in FIG. **6**.

FIG. **8**A is also a flowchart executed by the video encoding apparatus.

FIG. **8**B is also a flowchart executed by the video encoding apparatus.

FIG. **9** is a diagram showing a video encoding apparatus as another embodiment of the present invention.

FIG. **10** is a flowchart executed by the video encoding apparatus of the embodiment.

FIG. **11** is another flowchart executed by the video encoding apparatus of the embodiment.

FIG. **12** is a diagram showing an example structure of the generated code amount estimator.

FIG. **13** is a diagram showing another example structure of the generated code amount estimator.

FIG. **14** is a diagram showing an example structure of the permissive prediction error power computation unit.

FIG. **15** is a diagram showing another example structure of the permissive prediction error power computation unit.

FIG. **16** is a diagram showing an example structure of the quantization step size computation unit.

FIG. **17** is a diagram showing another example structure of the quantization step size computation unit.

FIG. **18** is a flowchart explaining a conventional technique.

REFERENCE SYMBOLS

10 structural part as an H.264 video encoding apparatus based on H.264
20 code amount estimator
21 quantization step size computation unit
22 selector switch
200 prediction error power computation unit
201 generated code amount estimator
202 code amount comparator
210 prediction error power computation unit
211 minimum quantization step size computation unit

BEST MODE FOR CARRYING OUT THE INVENTION

Below, the present invention will be explained in detail in accordance with embodiments thereof.

FIG. **1** shows a video encoding apparatus as an embodiment of the present invention.

In FIG. **1**, reference numeral **10** indicates a structural part (surrounded by a dotted line) as an H.264 video encoding apparatus based on H.264, reference numeral **20** indicates a code amount estimator provided for implementing the present invention, reference numeral **21** indicates a quantization step size computation unit provided for implementing the present invention, and reference numeral **22** indicates a selector switch for implementing the present invention.

Similar to conventional video encoding apparatuses based on H.264, the part **10** as the H.264 video encoding apparatus includes a motion detector **100**, a motion compensator **101**, a frame memory **102**, an interframe prediction mode determination unit **103**, an intraframe prediction mode determination unit **104**, a selector switch **105**, a subtractor **106**, an orthogonal transformer **107**, a quantizer **108**, a quantization controller **109**, an inverse quantizer **110**, an inverse orthogonal transformer **111**, an adder **112**, a loop filter **113**, and an information source encoder **114**. After the subtracter **106** generates a prediction error signal between a video signal of an encoding target macroblock and a predicted signal thereof, the orthogonal transformer **107** subjects the generated prediction error signal to orthogonal transformation. In accordance with the quantization step size set by the quantization controller **109**, the quantizer **108** quantizes orthogonal transformation coefficients obtained by the orthogonal transformation. The information source encoder **114** subjects the quantized values to entropy encoding so as to encode the video signal.

FIG. **2** shows an example structure of the code amount estimator **20**.

The code amount estimator **20** receives an upper limit value of the amount of code generated for the relevant macroblock (i.e., an upper limit amount of code), the prediction error signal generated by the subtractor **106**, and the quantization step size set by the quantization controller **109**, and includes a prediction error (electric) power computation unit **200**, a generated code amount estimator **201**, and a code amount comparator **202**.

The prediction error power computation unit **200** computes a prediction error power, which is a power of the prediction error signal generated by the subtractor **106**.

Based on the prediction error power computed by the prediction error power computation unit **200** and the quantization step size set by the quantization controller **109**, the generated code amount estimator **201** estimates an amount of code generated when quantizing the encoding target macroblock by the relevant quantization step size.

The code amount comparator **202** compares the estimated amount of generated code obtained by the generated code amount estimator **201** with the upper limit (defined in H.264) for the amount of code generated for the macroblock. If the estimated amount of generated code obtained by the generated code amount estimator **201** is greater than the upper limit for the amount of code generated for the macroblock, the code amount comparator **202** directs the selector switch **22** to switch the quantization step size supplied to the quantizer **108** from the quantization step size set by the quantization controller **109** to a quantization step size computed by the quantization step size computation unit **21**. In contrast, if the estimated amount of generated code obtained by the generated code amount estimator **201** is smaller than or equal to the upper limit for the amount of code generated for the macroblock, the code amount comparator **202** directs the selector switch **22** to directly use the quantization step size set by the quantization controller **109** as the quantization step size supplied to the quantizer **108**.

FIG. **3** shows an example structure of the quantization step size computation unit **21**.

The quantization step size computation unit **21** receives the upper limit value of the amount of code generated for the relevant macroblock (i.e., the upper limit amount of code) and the prediction error signal generated by the subtractor **106**, and includes a prediction error (electric) power computation unit **210** and a minimum quantization step size computation unit **211**.

The prediction error power computation unit **210** computes a prediction error power, which is a power of the prediction error signal generated by the subtractor **106**.

Based on the prediction error power computed by the prediction error power computation unit **210** and the upper limit of the amount of code generated for the macroblock, the minimum quantization step size computation unit **211** computes a quantization step size for implementing code amount generation which does not exceed the upper limit (i.e., a minimum quantization step size).

FIGS. **4** to **5**B show flowcharts executed by the video encoding apparatus of the present embodiment.

Based on the flowcharts, the operation of the video encoding apparatus in the present embodiment will be explained in detail.

As shown in the flowchart of FIG. **4**, in the video encoding apparatus of the present embodiment, the encoding mode is determined in the first step S**10**. In the next step S**11**, the amount of code generated when performing the encoding by using the currently-set quantization step size is estimated.

In the next step S**12**, it is determined whether or not the estimated amount of code generated for the relevant macroblock is greater than the upper limit defined therefor. If it is determined that the estimated amount is greater than the upper limit, the operation proceeds to step S**13**, where the quantization step size is changed. In the next step S**14**, encoding is performed using the newly-set quantization step size.

If it is determined in the determination of step S**12** that the estimated amount is smaller than or equal to the upper limit, the operation directly proceeds to step S**14** by skipping step S**13**, and encoding is performed using the currently-set quantization step size.

FIG. **5**A is a flowchart of the process of estimating the amount of generated code in step S**11**, and FIG. **5**B is a flowchart of the process of changing the quantization step size in step S**13**.

As shown in the flowchart of FIG. **5**A, in step S**11**, the prediction error signal is received so as to compute the prediction error power (see first step S**110**), and in the next step S**111**, the currently-set quantization step size is received. In the next step S**112**, based on the computed prediction error power and the received quantization step size, the amount of code generated when performing the encoding by using the currently-set quantization step size is estimated.

In the above-explained step S**13**, as shown in the flowchart of FIG. **5**B, the upper limit value of the amount of code generated for the relevant macroblock (i.e., the upper limit amount of code) is received in the first step S**130**, and in the next step S**131**, the prediction error signal is received so as to compute the prediction error power. In the next step S**132**, based on the received upper limit of the amount of generated code and the computed prediction error power, a quantization step size for implementing the code amount generation which does not exceed the upper limit is computed. In the next step S**133**, in accordance with the computed quantization step size, the quantization step size used in the relevant encoding is changed.

Accordingly, the video encoding apparatus shown in FIG. **1** estimates the amount of code generated when performing the encoding using the currently-set quantization step size, based on a relationship between the amount of generated code and the quantization step size. If the estimated value is greater than the upper limit for the amount of code generated for the relevant macroblock, a quantization step size for implementing the code amount generation which does not exceed the upper limit is computed, and the quantization step size used in the encoding is changed to the computed value.

Therefore, in accordance with the video encoding apparatus of the present embodiment, re-encoding or encoding corresponding to two or more encoding modes is unnecessary, and an encoding whose amount of generated code does not exceed an upper limit can be implemented without awaiting a measured result of the amount of generated code.

FIG. **6** shows another example structure of the code amount estimator **20**.

When employing the shown structure, the code amount estimator **20** receives an upper limit value of the amount of code generated for the relevant macroblock (i.e., an upper limit amount of code), the prediction error signal generated by the subtractor **106**, and the quantization step size set by the quantization controller **109**, and includes a prediction error power computation unit **200**, a permissive prediction error power computation unit **203**, and a prediction error comparator **204**.

The prediction error power computation unit **200** computes a prediction error power, which is a power of the prediction error signal generated by the subtractor **106**.

The permissive prediction error power computation unit **203** computes a permissive power of the prediction error power (i.e., permissive prediction error power) based on the upper limit of the amount of code generated for the macroblock and the quantization step size set by the quantization controller **109**.

The prediction error comparator **204** compares the prediction error power computed by the prediction error power computation unit **200** with the permissive prediction error power computed by the permissive prediction error power computation unit **203**. If the prediction error power computed by the prediction error power computation unit **200** is larger than the permissive prediction error power computed by the permissive prediction error power computation unit **203**, the prediction error comparator **204** directs the selector switch **22** to switch the quantization step size supplied to the quantizer **108** from the quantization step size set by the quantization controller **109** to a quantization step size computed by the quantization step size computation unit **21**. In contrast, if the prediction error power computed by the prediction error power computation unit **200** is smaller than or equal to the permissive prediction error power computed by the permissive prediction error power computation unit **203**, the prediction error comparator **204** directs the selector switch **22** to directly use the quantization step size set by the quantization controller **109** as the quantization step size supplied to the quantizer **108**.

FIGS. **7** to **8**B show flowcharts executed by the video encoding apparatus of the present embodiment when the code amount estimator **20** has the structure as shown in FIG. **6**.

Based on the flowcharts, the operation of the video encoding apparatus in this case will be explained in detail.

As shown in the flowchart of FIG. **7**, when the code amount estimator **20** has the structure as shown in FIG. **6**, the video encoding apparatus of the present embodiment determines the encoding mode in the first step S**20**. In the next step S**21**, the permissive prediction error power as a permissive power of the prediction error power is computed.

In the next step S**22**, it is determined whether or not the prediction error power is larger than the permissive prediction error power. If it is determined that the prediction error power is larger than the permissive power, the operation proceeds to step S**23**, where the quantization step size is changed. In the next step S**24**, encoding is performed using the newly-set quantization step size.

Although it is not shown in the flowchart of FIG. **7**, when computing the permissive prediction error power in step S**21**, the prediction error power used in step S**22** is also computed.

If it is determined in the determination of step S**22** that the prediction error power is smaller than or equal to the permissive prediction error power, the operation directly proceeds to step S**24** by skipping step S**23**, and encoding is performed using the currently-set quantization step size.

FIG. **8**A is a flowchart of the process of computing the permissive prediction error power in step S**21**, and FIG. **8**B is a flowchart of the process of changing the quantization step size in step S**23**.

As shown in the flowchart of FIG. **8**A, in step S**21**, the prediction error signal is received so as to compute the prediction error power (see first step S**210**), and in the next step S**211**, the upper limit of the amount of code generated for the macroblock (i.e., the upper limit amount of code) is received. In the next step S**212**, the currently-set quantization step size is received, and in the next step S**213**, the permissive prediction error power is computed based on the received upper limit of the amount of generated code and the received quantization step size.

In the above-explained step S**23**, as shown in the flowchart of FIG. **8**B, the upper limit value of the amount of code generated for the macroblock (i.e., the upper limit amount of code) is received in the first step S**230**, and in the next step S**231**, the prediction error signal is received so as to compute the prediction error power. In the next step S**232**, based on the received upper limit of the amount of generated code and the computed prediction error power, a quantization step size for implementing the code amount generation which does not exceed the upper limit is computed. In the next step S**233**, in accordance with the computed quantization step size, the quantization step size used in the relevant encoding is changed.

Accordingly, when the code amount estimator **20** has the structure shown in FIG. **6**, the video encoding apparatus shown in FIG. **1** determines based on the permissive power of the prediction error power, which is derived by the upper limit of the amount of generated code and the quantization step size, whether or not the amount of code generated when performing the encoding by using the currently-set quantization step size exceeds the upper limit. If the relevant amount of generated code is greater than the upper limit, a quantization step size for implementing the code amount generation which does not exceed the upper limit is computed, and the quantization step size used in the encoding is changed to the computed value.

Therefore, in accordance with the video encoding apparatus of the present embodiment, re-encoding or encoding corresponding to two or more encoding modes is unnecessary, and an encoding whose amount of generated code does not exceed an upper limit can be implemented without awaiting a measured result of the amount of generated code.

FIG. **9** shows another embodiment of the video encoding apparatus in accordance with the present invention. In FIG. **9**, parts identical to those explained in FIG. **1** are given identical reference numerals.

In FIG. **9**, reference numeral **10** indicates a structural part (surrounded by a dotted line) as an H.264 video encoding apparatus based on H.264, reference numeral **30** indicates a code amount estimator provided for implementing the present invention, reference numeral **31** indicates a PCM encoder provided for implementing the present invention, and reference numeral **32** indicates a selector switch for implementing the present invention.

The PCM encoder **31** subjects the relevant video signal as an encoding target to PCM encoding, without performing quantization, and outputs the encoded data via the selector switch **32** to the information source encoder **114**.

The code amount estimator **30** has a basic structure identical to that of the code amount estimator **20** in the embodiment shown in FIG. **1**, and may have a structure shown in FIG. **2**. When having the structure shown in FIG. **2**, if the estimated value of the amount of generated code is greater than the upper limit of the amount of generated code, the code amount estimator **30** directs the selector switch **32** to supply the signal output from the PCM encoder **31** to the information source encoder **114**. In contrast, if the estimated value of the amount of generated code is smaller than or equal to the upper limit thereof, the code amount estimator **30** directs the selector switch **32** to supply the signal output from the quantizer **108** to the information source encoder **114**.

That is, as shown in a flowchart of FIG. **10**, when the code amount estimator **30** has the structure shown in FIG. **2**, the video encoding apparatus of the present embodiment first determines the encoding mode (see the first step S**30**). In the next step S**31**, the amount of code generated when performing the encoding using the currently set quantization step size is estimated. In the next step S**32**, it is determined whether or not the estimated amount of generated code is greater than the upper limit for the relevant amount of generated code. If it is determined that the estimated amount is greater than the upper limit, the operation proceeds to step S**33**, where the PCM encoding is executed. If it is determined that the estimated amount is smaller than or equal to the upper limit, the operation proceeds to step S**34**, where the ordinary encoding is executed.

The code amount estimator **30** may have the structure shown in FIG. **6**. In such a case, if the prediction error power is higher than a permissive prediction error power, the code amount estimator **30** directs the selector switch **32** to supply a signal output from the PCM encoder **31** to the information source encoder **114**. On the contrary, if the prediction error power is lower than or equal to the permissive prediction error power, the code amount estimator **30** directs the selector switch **32** to supply a signal output from the quantizer **108** to the information source encoder **114**.

That is, as shown in a flowchart of FIG. **11**, when the code amount estimator **30** has the structure shown in FIG. **6**, the video encoding apparatus of the present embodiment first determines the encoding mode (see the first step S**40**). In the next step S**41**, a permissive prediction error power, as the permissive power for the prediction error power, is computed. In the next step S**42**, it is determined whether or not the prediction error power is higher than the permissive prediction error power. If it is deter mined that the prediction error power is higher than the permissive power, the operation proceeds to step S**43**, where the PCM encoding is executed. If it is determined that the prediction error power is lower than or equal to the permissive power, the operation proceeds to step S**44**, where the ordinary encoding is executed.

As described above, the video encoding apparatus of the present embodiment (see FIG. **9**) determines whether or not the amount of code generated when encoding is executed using the currently set quantization step size exceeds an upper limit defined therefore. If the amount of generated code exceeds the upper limit, PCM encoding is executed without performing quantization.

Specifically, the code amount estimator **201** shown in FIG. **2**, the permissive prediction error power computation unit **203** shown in FIG. **6**, and the minimum quantization step size computation unit **211** shown in FIG. **3** each can be implemented using a function or a look-up table.

Strictly speaking, different prediction modes (encoding modes) have different overhead amounts of code or the like, and such a function or look-up table depends on the prediction mode. Therefore, it is preferable that such a function or look-up table is provided for each prediction mode, and one suitable for the prediction mode of the encoding target macroblock is selected and used.

That is, in a preferable example shown in FIG. **12**, the generated code amount estimator **201** in FIG. **2** has a plurality of functions (function **1** to function N) corresponding to a plurality of prediction modes, and one of the functions which is suitable for the prediction mode of the encoding target macroblock is selected and used.

In another preferable example shown in FIG. **13**, the generated code amount estimator **201** in FIG. **2** has a plurality of look-up tables (LT**1** to LTN) corresponding to a plurality of prediction modes, and one of the look-up tables which is suitable for the prediction mode of the encoding target macroblock is selected and used.

In another preferable example shown in FIG. **14**, the permissive prediction error power computation unit **203** in FIG. **6** has a plurality of functions (function **1** to function N) corresponding to a plurality of prediction modes, and one of the functions which is suitable for the prediction mode of the encoding target macroblock is selected and used.

In another preferable example shown in FIG. **15**, the permissive prediction error power computation unit **203** in FIG. **6** has a plurality of look-up tables (LT**1** to LTN) corresponding to a plurality of prediction modes, and one of the look-up tables which is suitable for the prediction mode of the encoding target macroblock is selected and used.

In another preferable example shown in FIG. **16**, the minimum quantization step size computation unit **211** shown in FIG. **3** has a plurality of functions (function **1** to function N) corresponding to a plurality of prediction modes, and one of the functions which is suitable for the prediction mode of the encoding target macroblock is selected and used.

In another preferable example shown in FIG. **17**, the minimum quantization step size computation unit **211** shown in FIG. **3** has a plurality of look-up tables (LT**1** to LTN) corresponding to a plurality of prediction modes, and one of the look-up tables which is suitable for the prediction mode of the encoding target macroblock is selected and used.

INDUSTRIAL APPLICABILITY

The present invention can be applied to a video encoding apparatus for applying orthogonal transformation to a prediction error signal between a video signal of an encoding target area and a predicted signal for the video signal, and quantizing an obtained orthogonal transformation coefficient by using a quantization step size so as to encode the coefficient. The present invention does not require re-encoding or encoding which handles two or more encoding modes and can implement encoding which generates codes less than an upper limit amount of code, without awaiting a measured result of the amount of generated code.

The invention claimed is:

1. A video encoding apparatus for applying orthogonal transformation to a prediction error signal between a video signal of an encoding target area and a predicted signal for the video signal, and quantizing an obtained orthogonal transformation coefficient by using a preset quantization step size so as to encode the coefficient, the apparatus comprising:

a determination circuit that receives information indicative of a prediction error power, the preset quantization step size, and an upper limit of an amount of code generated for the encoding target area, and determines whether or not an amount of code generated when performing quantization using the preset quantization step size exceeds the upper limit; and

a change circuit that changes an encoding process based on a result of the determination by the determination circuit,

wherein the determination circuit applies a permissive power for the prediction error power based on the upper limit and the preset quantization step size, and compares the permissive power with the prediction error power so as to determine whether or not the amount of code generated when performing the quantization using the preset quantization step size exceeds the upper limit.

2. The video encoding apparatus in accordance with claim **1**, wherein:

the determination circuit applies the permissive power for the prediction error power by setting variables of a function, which are the upper limit and the quantization step size, to the values of the upper limit and the quantization step size, where the value of the function is the permissive power.

3. The video encoding apparatus in accordance with claim **1**, wherein:

the determination circuit applies the permissive power for the prediction error power by referring to a table in which a relationship between data values of the upper limit, the quantization step size, and the permissive power is defined.

4. A non-transitory computer-readable storage medium which stores a video encoding program by which a computer executes an operation for implementing the video encoding apparatus in accordance with claim **1**.

5. A video encoding method for applying orthogonal transformation to a prediction error signal between a video signal of an encoding target area and a predicted signal for the video signal, and quantizing an obtained orthogonal transformation coefficient by using a preset quantization step size so as to encode the coefficient, the method comprising:

a determination step that receives information indicative of a prediction error power, the preset quantization step size, and an upper limit of an amount of code generated for the encoding target area, and determines whether or not an amount of code generated when performing quantization using the preset quantization step size exceeds the upper limit; and

a change step that changes an encoding process based on a result of the determination,

wherein the determination step applies a permissive power for the prediction error power based on the upper limit and the preset quantization step size, and compares the permissive power with the prediction error power so as to determine whether or not the amount of code generated when performing the quantization using the preset quantization step size exceeds the upper limit.

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