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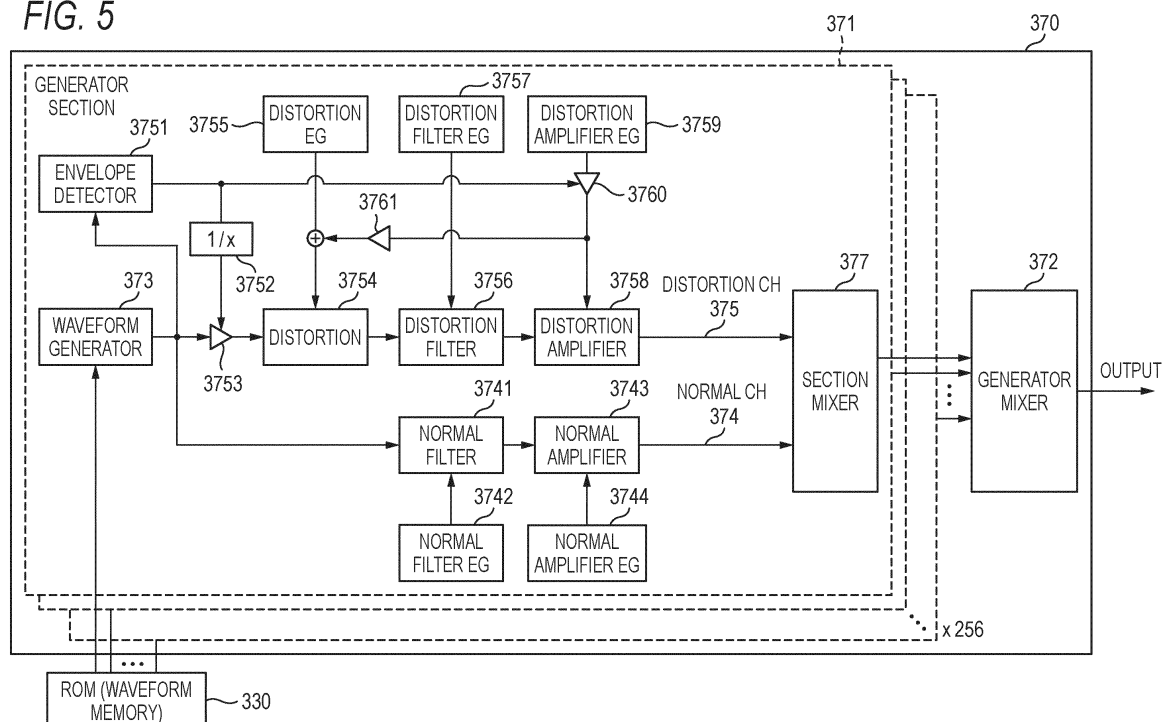
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(54) ELECTRONIC MUSICAL INSTRUMENT, METHOD AND PROGRAM

(57) An electronic musical instrument includes: means for determining, in accordance with a user operation on at least one operation element (360), first waveform data (a) from a plurality of pieces of waveform data, the first waveform data (a) including multiple first waveforms having different first amplitudes; means for generating (3753) normalized data (b) that includes multiple second waveforms having same second amplitude, based on the first waveform data (a); means for amplifying (3754A) the second amplitude of at least one of the

multiple second waveforms in the normalized data (b) to generate amplified data (c); means for clipping (3754B) at least one waveform included in the amplified data (c) at a certain clipping level to generate clipped data (d) that includes multiple third waveforms; and means for changing (3758) amplitudes of the multiple third waveforms in the clipped data (d) to the different first amplitudes to generate waveform data (e) that includes multiple fourth waveforms.

FIG. 5**EP 3 757 985 A1**

Description

TECHNICAL FIELD

[0001] The present disclosure relates to an electronic musical instrument, a method and a program.

BACKGROUND ART

[0002] In the related art, a variety of technologies for reproducing sounds of musical instruments with strings, including an acoustic piano, a guitar and the like, in an electronic musical instrument are developed. In the musical instruments with strings, a sound that is generated as a result of contact of the vibrating string with another object is also generated. Therefore, also in the electronic musical instruments, it is attempted to reproduce such contact sound.

[0003] For example, JP-A-2011-154394 discloses technology of reproducing a sound of a damper coming into contact with a vibrating string upon key release of an acoustic piano.

[0004] According to the technology disclosed in JP-A-2011-154394, only the same monotonous contact sound is always reproduced.

SUMMARY OF DISCLOSURE

[0005] An electronic musical instrument related to one aspect of the present disclosure includes: means for determining, in accordance with a user operation on at least one operation element, first waveform data from a plurality of pieces of waveform data, the first waveform data including multiple first waveforms having different first amplitudes; means for generating normalized data that includes multiple second waveforms having same second amplitude, based on the first waveform data; means for amplifying the second amplitude of at least one of the multiple second waveforms in the normalized data to generate amplified data; means for clipping at least one waveform included in the amplified data at a certain clipping level to generate clipped data that includes multiple third waveforms; and means for changing amplitudes of the multiple third waveforms in the clipped data to the different first amplitudes to generate waveform data that includes multiple fourth waveforms.

[0006] According to the present disclosure, it is possible to favorably reproduce a contact sound that is generated when playing the acoustic musical instrument.

BRIEF DESCRIPTION OF DRAWINGS

[0007]

FIG. 1A is a view for illustrating a contact sound that is generated in an acoustic piano;

FIG. 1B is a view for illustrating Comparative Example where a contact sound that is generated in the

acoustic piano is not reproduced, and an embodiment of the present disclosure where the contact sound is reproduced;

FIG. 2A is a view for illustrating a contact sound that is generated in a guitar;

FIG. 2B is a view for illustrating Comparative Example where a contact sound that is generated in the guitar is not reproduced, and an embodiment of the present disclosure where the contact sound is reproduced;

FIG. 3 depicts an example of an outer shape of an electronic musical instrument in accordance with an embodiment of the present disclosure;

FIG. 4 is a block diagram depicting a hardware configuration of the electronic musical instrument;

FIG. 5 is a block diagram depicting a schematic configuration of a sound source LSI;

FIG. 6 is a view for illustrating processing that is executed in a distortion channel;

FIG. 7 is a block diagram depicting a schematic configuration of a distortion in the sound source LSI;

FIG. 8A depicts an example of an envelope for generating a piano sound;

FIG. 8B depicts an example of the envelope for generating the piano sound;

FIG. 8C depicts an example of the envelope for generating the piano sound;

FIG. 9A depicts an example of an envelope for generating a guitar sound;

FIG. 9B depicts an example of the envelope for generating the guitar sound;

FIG. 9C depicts an example of the envelope for generating the guitar sound;

FIG. 10 is a flowchart depicting a sequence of processing that is executed by a CPU; and

FIG. 11 is a subroutine flowchart depicting a sequence of sound source LSI control processing of step S108 in FIG. 10.

DESCRIPTION OF EMBODIMENTS

[0008] Hereinbelow, after describing the principle of the present disclosure, embodiments based on the principle of the present disclosure will be described with reference to the accompanying drawings.

[0009] In the description of the drawings, the same elements are denoted with the same reference signs, and the overlapping descriptions are omitted. Also, for convenience of descriptions, the dimensional ratios in the drawings may be different from the actual ratios due to exaggerated illustrations.

<Principle of Present Disclosure>

[0010] First, in a musical instrument with strings, a cause of a contact sound that is generated as a result of contact of the vibrating string with another object, and an output image of a waveform including the contact sound

are described.

[0011] FIG. 1A is a view for illustrating a contact sound that is generated in an acoustic piano. FIG. 1B illustrates an output image diagram of a waveform that does not include a contact sound generated in the acoustic piano (Comparative Example), and an output image diagram of a waveform that includes the contact sound (first embodiment).

[0012] In an acoustic piano 100 as shown in FIG. 1A, when a key 110 is released, a damper 120 comes into contact with a string 130, so that vibration of the string 130 is attenuated. Even when felt used for the damper 120 is made of a soft material, the felt applies a larger resistance to the string 130, as compared to the air. Therefore, when the damper 120 comes into contact with the string 130, the vibration of the string 130 is irregularly attenuated, so that a contact sound is generated. While an amplitude of the string 130 is large, the damper 120 is bounced (jumped up) by the string 130 and cannot be thus in contact with the string 130 for a long time. However, as the amplitude of the string 130 becomes smaller over time, a time period for which the damper 120 is in contact with the string 130 becomes longer, and the contact sound is emphasized among sounds being produced.

[0013] In an electronic musical instrument configured to reproduce sounds of the acoustic piano 100, as shown in an upper drawing of FIG. 1B (Comparative Example), a level of sound, i.e., an amplitude of a waveform upon the key release is controlled so as to change over time, in accordance with an envelope that reproduces an envelope of amplitudes of the string 130 upon the key release. However, in the electronic musical instrument of the related art, the change in contact sound over time as described above is not reproduced. Therefore, in an electronic musical instrument of the present embodiment, as shown in a lower drawing of FIG. 1B (the first embodiment of the present disclosure), amplitudes of a waveform are restricted when the amplitudes exceed certain levels (levels of a broken line) indicating threshold values of generation of the contact sound, and a distortion sound corresponding to a waveform of which amplitudes are restricted is thus generated as a sound that simulates the contact sound. For example, amplitudes of a waveform corresponding to a sound upon the key release of the acoustic piano 100 are controlled so as to be largely restricted over time. Also, the distortion sound as the contact sound is controlled so as to be further emphasized as a time period k1, a time period k2, and a time period k3 progress, as shown in the lower drawing of FIG. 1B, for example (a difference value between the threshold value of the broken line and a solid line value of the solid line indicative of an amplitude envelope gradually increases as the time period k1, the time period k2, and the time period k3 progress, so that the amplitudes of the waveform are largely restricted over time and the contact sound that is the distortion sound is further emphasized over time). Therefore, it is possible to favorably repro-

duce the contact sound of the damper 120 and the string 130, which is generated upon the key release in the acoustic piano 100.

[0014] FIG. 2A is a view for illustrating a contact sound that is generated in a guitar. FIG. 2B is an output image diagram of a waveform that does not include a contact sound generated in the guitar (Comparative Example), and an output image diagram of a waveform that includes the contact sound (second embodiment).

[0015] Also in plucked string instruments such as a guitar 200 as shown in FIG. 2A, when a string release where a player's finger F releases from a string 210 is performed, a contact sound is generated. More specifically, while the finger F presses the string 210, the contact sound is not generated because the string 210 vibrates about a fret 220 as a support point. However, when the finger F starts to move away from the fret 220, the support point of the string 210 moves from the fret 220 to the finger F, so that the string 210 vibrates about the finger F as a support point. When the string 210 comes into contact with the fret 220 or the like, the contact sound is generated. For this reason, in the guitar 200, the contact sound starts to be heard immediately after the string releases, unlike the acoustic piano 100. Then, as the amplitude of the string 210 becomes smaller over time or the finger F moves away from the fret 220, the contact sound becomes difficult to be heard.

[0016] In the electronic musical instrument configured to reproduce sounds of the guitar 200, as shown in an upper drawing of FIG. 2B, a level of sound, i.e., an amplitude of a waveform upon the key release is controlled so as to change over time, in accordance with an envelope that reproduces an envelope of amplitudes of the string 210 upon the key release. More specifically, the amplitude of the waveform is controlled so as to increase over time during a time period k4 immediately after the key release of the electronic musical instrument, i.e., immediately after the string release of the guitar 200, and to attenuate over time during time periods k5 and k6 thereafter, for example. Also, a clipping level is set as shown in a lower drawing of FIG. 2B, for example. The distortion sound as the contact sound is controlled so that it is emphasized over time during the time period k4 (because the difference value between the threshold value of the broken line and the solid line value of the solid line becomes gradually larger), is attenuated over time during the time period k5 (because the difference value between the threshold value of the broken line and the solid line value of the solid line becomes gradually smaller), and is not heard during the time period k6 (because the solid line value has not reached the threshold value). Thereby, it is possible to favorably reproduce the contact sound that is generated when the string 210 comes into contact with the fret or the like upon the key release in the guitar 200.

[0017] In the below, a configuration, processing and the like of the electronic musical instrument configured to reproduce the contact sounds as described above are

described with reference to the drawings.

<Embodiment of Disclosure>

(Configuration)

[0018] FIG. 3 depicts an example of an outer shape of an electronic musical instrument in accordance with an embodiment of the present disclosure. FIG. 4 is a block diagram depicting a hardware configuration of the electronic musical instrument.

[0019] As shown in FIGS. 3 and 4, an electronic musical instrument 300 includes a CPU (Central Processing Unit) 310, a RAM (Random Access Memory) 320, a ROM (Read Only Memory) 330, a switch panel 340, an LCD (liquid crystal monitor) 350, a keyboard 360, a sound source LSI (large-scale integration) 370, a D/A converter 380, an amplifier 385 and a timer counter 390. The CPU 310, the RAM 320, the ROM 330 and the sound source LSI 370 are each connected to a bus 395. Also, the switch panel 340, the LCD 350 and the keyboard 360 are each connected to the bus 395 via each of an I/O interface 345, an LCD controller 355 and a key scanner 365.

[0020] The CPU 310 as a processor is configured to control the respective constituent elements and to execute a variety of calculation processing, in accordance with programs. The RAM 320 is configured to temporarily store programs, data and the like, as a work area.

[0021] The ROM 330 as a memory has a program area and a data area, and stores a variety of programs, data and the like in advance. The ROM 330 is configured to store a plurality of pieces of waveform data corresponding to multiple musical instrument sounds, as a waveform memory, for example.

[0022] The switch panel 340 includes a plurality of switches 341, and is configured to receive a user operation of pressing each of the plurality of switches 341. For example, the switch panel 340 includes the plurality of switches 341 corresponding to multiple musical instrument sounds, and receives a user operation of selecting a certain musical instrument sound from the multiple musical instrument sounds. The I/O interface 345 is configured to monitor each of the plurality of switches 341 of the switch panel 340, and, when it is detected that each of the plurality of switches 341 is pressed, notifies the detection to the CPU 310.

[0023] The LCD 350 is configured to display a variety of information. The LCD controller 355 is an IC (integrated circuit) configured to control the LCD 350.

[0024] The keyboard 360 has a plurality of keys 361 as operation elements, and is configured to receive user operations of pressing and releasing the keys, as a user operation. Each of the plurality of keys 361 is configured to operate at one end of a leaf spring or the like, as a support point, and may include a plurality of switches (contact points) that is sequentially turned on or off by the key pressing or the key release.

[0025] The key scanner 365 is configured to monitor

each of the plurality of keys 361 of the keyboard 360, and to detect whether each of the plurality of keys 361 is pressed or released. When the key pressing is detected, the key scanner 365 detects and notifies, to the CPU 310, a key number (note number) of the pressed key 361, and a velocity upon the key pressing corresponding to a key pressing speed. Also, when the key release is detected, the key scanner 365 detects and notifies, to the CPU 310, a key number of the released key 361, and a velocity upon the key release corresponding to a key release speed. The key scanner 365 may detect the velocity upon the key pressing or upon the key release by measuring a difference between times at which at least two switches of each of the plurality of keys 361 are detected to be on or off.

[0026] The sound source LSI 370 as a processor adopts a well-known waveform memory reading method, and is configured to read out and process waveform data corresponding to a musical instrument sound selected by the user from the ROM 330, and to output the same to the D/A converter 380. The sound source LSI 370 will be described later in detail with reference to FIG. 5.

[0027] The D/A converter 380 is configured to convert digital waveform data output from the sound source LSI 370 into analog waveform signals, and to output the same to the amplifier 385. The amplifier 385 is configured to amplify the analog waveform signals output from the D/A converter 380, and to output the same to a speaker, an output terminal or the like (not shown).

[0028] The timer counter 390 includes a counter configured to increment a value every 1 μ sec, for example, and is configured to measure time.

[0029] In the meantime, the electronic musical instrument 300 may include a constituent element, in addition to the above-described constituent elements, and may not include some of the above-described constituent elements.

[0030] Subsequently, the sound source LSI 370 is described in detail. FIG. 5 is a block diagram depicting a schematic configuration of the sound source LSI. FIG. 6 is a view for illustrating processing that is executed in a distortion channel. FIG. 7 is a block diagram depicting a schematic configuration of a distortion in the sound source LSI. FIGS. 8A to 8C depict examples of an envelope that is generated in the sound source LSI.

[0031] As shown in FIG. 5, the sound source LSI 370 includes a plurality of generator sections 371 (for example, corresponding to 256 channels), and a generator mixer 372 configured to adjust and mix waveform data that is output from each of the generator sections 371. Each of the generator sections 371 includes a waveform generator 373, a normal channel (normal line) 374 and a distortion channel (distortion line) 375.

[0032] The waveform generator 373 is configured to determine and read out, from the plurality of pieces of waveform data stored in the ROM 330, waveform data corresponding to a musical instrument sound selected by the user at a reading speed corresponding to the key

number of the pressed key 361, and to generate and output waveform data corresponding to the key number. The waveform data output from the waveform generator 373 is divided and input to the normal channel 374 and the distortion channel 375.

[0033] The normal channel 374 includes a normal filter 3741, a normal filter envelope generator 3742, a normal amplifier 3743 and a normal amplifier envelope generator 3744. Meanwhile, in the below, as shown in FIG. 5, the envelope generator is also denoted as "EG". The normal filter 3741 is configured to control a quality of sound corresponding to the waveform data input to the normal channel 374, in accordance with a filter envelope generated by the normal filter EG 3742 and indicating a temporal change in a cutoff frequency of a filter (for example, a low-pass filter). The normal amplifier 3743 is configured to control a level of sound corresponding to the waveform data, i.e., an amplitude of the waveform indicated by the waveform data, in accordance with an amplifier envelope generated by the normal amplifier EG 3744 and indicating a temporal change in a volume of sound (level).

[0034] The distortion channel 375 includes an envelope detector 3751, an envelope calculator 3752, a normalization amplifier 3753, a distortion 3754, a distortion EG 3755, a distortion filter 3756, a distortion filter EG 3757, a distortion amplifier 3758, a distortion amplifier EG 3759, an inverse correction amplifier 3760 and a clipping control amplifier 3761.

[0035] The envelope detector 3751 includes an absolute value circuit (full wave rectification circuit), a low-pass filter and the like, and is configured to detect an amplitude envelope of a waveform indicated by the waveform data (first waveform data (a)) input to the distortion channel 375, as shown in FIG. 6A. The envelope calculator 3752 is configured to adjust (normalize) amplitudes of the waveform indicated by the waveform data input to the distortion channel 375 to a constant amplitude, i.e., to calculate an amplifier envelope of which amplitudes of the waveform are kept without changing, based on the first amplitude envelope detected by the envelope detector 3751. For example, when a value of the first amplitude envelope detected by the envelope detector 3751 is attenuated from a certain value by 50%, the envelope calculator 3752 calculates an amplifier envelope of which waveform is amplified by 200% by the normalization amplifier 3753. The normalization amplifier 3753 is configured to normalize the amplitudes of the waveform, as shown in FIG. 6B, by multiplying the amplifier envelope calculated by the envelope calculator 3752 by the waveform indicated by the waveform data input to the distortion channel 375. Meanwhile, in the below, processing executed by the normalization amplifier 3753, in which different first amplitudes of a first waveform indicated by the first waveform data as certain waveform data input to the distortion channel 375 are all changed to same second amplitude, is also referred to as normalize processing. Also, waveform data indicative of a second waveform as the waveform of which amplitudes have

been changed is also referred to as normalized data (b). The second amplitudes may be larger than the first amplitudes.

[0036] As shown in FIG. 7, the distortion 3754 includes a distortion gain amplifier 3754A and a clipper 3754B. The distortion gain amplifier 3754A is configured to amplify at least a part of the waveform (normalized data (b)) of which amplitudes have been normalized, as shown in FIGS. 6C and 7, in accordance with an amplifier envelope (hereinbelow, referred to as "distortion envelope") generated by the distortion EG 3755 and indicating a temporal change of gain. As shown in FIGS. 6D and 7, the clipper 3754B is configured to clip the amplified waveform (amplified data (c)), based on a setting value of a clipping level with respect to a positive region of the waveform, which is supplied from the CPU 310. More specifically, the clipper 3754B restricts amplitudes, which exceed a positive clipping level, of the amplitudes of the amplified waveform (amplified data (c)) to the positive clipping level. The clipping level is determined in accordance with the musical instrument sound selected by the user, and may be set for both a positive region and a negative region of a waveform. The clipping level may be set for at least one of the positive region and the negative region of the waveform. Meanwhile, in the below, waveform data indicative of a third waveform as the clipped waveform is also referred to as clipped data (d).

[0037] The distortion filter 3756 is configured to control a quality of sound corresponding to data of the clipped waveform, in accordance with a filter envelope generated by the distortion filter EG 3757. The distortion amplifier 3758 is configured to control a level of sound corresponding to the data of the clipped waveform, in accordance with an amplifier envelope generated by the distortion amplifier EG 3759 (hereinbelow, referred to as "distortion amplifier envelope"). As shown in FIG. 5, the distortion amplifier envelope is further adjusted by the inverse correction amplifier 3760 that will be described later.

[0038] Each of the EGs 3742, 3744, 3755, 3757 and 3759 as described above is configured to generate each envelope as shown in FIGS. 8A to 8C, based on parameters relating to each envelope and supplied from the CPU 310, upon the key pressing and upon the key release. For example, the distortion EG 3755 generates a distortion envelope as shown in FIG. 8A.

[0039] The parameters relating to each envelope include a parameter relating to target levels L0 to L4, a parameter relating to rates R1 to R4 for reaching the target levels, and the like. When the value of the amplifier envelope supplied to the normal amplifier 3743 and the distortion amplifier 3758 becomes zero and operations of the normal amplifier 3743 and the distortion amplifier 3758 are thus stopped, an operation of the waveform generator 373 is also stopped. In the meantime, each of the EGs 3742, 3744, 3755, 3757 and 3759 may be supplied with a parameter corresponding to a velocity from the CPU 310 or may generate each envelope corresponding to the velocity. For example, each of the EGs

3742, 3744, 3755, 3757 and 3759 may be supplied, from the CPU 310, with parameters including a release rate R4 of which gradient is set gentler as a value of the velocity is smaller, i.e., a key release speed is lower.

[0040] The inverse correction (correction) amplifier 3760 is configured to adjust the distortion amplifier envelope so as to cancel an influence of the amplitude normalization by the normalization amplifier 3753, based on the amplitude envelope detected by the envelope detector 3751. For example, when a value of the amplitude envelope detected by the envelope detector 3751 is attenuated from a certain value by 50% and the waveform is amplified by 200% by the normalization amplifier 3753, the inverse correction amplifier 3760 attenuates the value of the distortion amplifier envelope by 50%. The amplitude envelope detected by the envelope detector 3751 is multiplied by the distortion amplifier envelope by the inverse correction amplifier 3760. A result thereof is also multiplied by the clipped waveform, as shown in FIG. 6E. Thereby, amplitudes of the clipped waveform are corrected to the amplitudes of the waveform before the normalization. That is, the amplitudes of the third waveform indicated by the clipped data are changed in conformity to the first amplitudes of the first waveform as the waveform before the normalization, so that waveform data (e) indicative of a fourth waveform (corresponding to "distortion waveform" that will be described later) of which amplitudes have been changed is generated and output.

[0041] The clipping control amplifier 3761 is configured to further adjust the distortion amplifier envelope adjusted by the inverse correction amplifier 3760, based on a setting value of gain supplied from the CPU 310. More specifically, the clipping control amplifier 3761 adjusts a gain of the distortion amplifier envelope, thereby adjusting an addition ratio of the distortion amplifier envelope to the distortion envelope. Thereby, the clipping control amplifier 3761 controls a degree of amplification by the distortion gain amplifier 3754A in the distortion 3754, and also controls indirectly a degree of clipping by the clipper 3754B. Therefore, the distortion 3754 can execute a feedback control of largely restricting the amplitudes as the values of the distortion amplifier envelope are larger, i.e., the amplitudes of the waveform are larger.

[0042] The generator section 371 further includes a section mixer 377. The section mixer 377 is configured to adjust and mix the waveform data output from the normal amplifier 3743 (hereinbelow, referred to as "normal waveform data") and the waveform data output from the distortion amplifier 3758 (hereinbelow, referred to as "distortion waveform data") (so that a waveform shape of sound output from the electronic musical instrument 300 is to be the waveform shape exemplified in the first embodiment of FIG. 1B or the second embodiment of FIG. 2B, for example). Specifically, for example, the section mixer 377 may adjust (attenuate) each of the input normal waveform data and distortion waveform data to 50% and then may add the same. Alternatively, the section mixer 377 may adjust (attenuate) waveform data obtained by

adding each of the normal waveform data and the distortion waveform data to 50%. Alternatively, the section mixer 377 may add first output waveform data in which the normal waveform data output from the normal amplifier 3743 has been changed in conformity to the envelope coinciding with the clipping level in the first embodiment of FIG. 1B or the second embodiment of FIG. 2B, for example, as the envelope generated by the normal amplifier EG, and second output waveform data output by the distortion amplifier 3758. The section mixer 377 is configured to output data of a waveform (added waveform) obtained by adding the normal waveform indicated by the normal waveform data and the distortion waveform indicated by the distortion waveform data. Thereby, the section mixer 377 can output the data of the added waveform corresponding to the distortion sound as a sound that simulates the contact sound.

[0043] The section mixer 377 may be supplied, from the CPU 310, a setting value of the addition ratio corresponding to the musical instrument sound selected by the user, or may adjust the addition ratio of the normal waveform and the distortion waveform to a setting value of the addition ratio corresponding to the musical instrument sound. For example, a setting value of the addition ratio corresponding to the acoustic piano 100 may be set to a small value, and data of an added waveform of which a degree of distortion is small may be output. The added waveform may be a waveform corresponding to a modest contact sound such as a sound that is generated when the soft damper 120 comes into contact with the string 130 in the acoustic piano 100 as shown in FIG. 1A. Also, a setting value of the addition ratio corresponding to the guitar 200 may be set to a large value, and data of an added waveform of which a degree of distortion is large may be output. The added waveform may be a waveform corresponding to a contact sound in which higher harmonics are emphasized, such as a sound that is generated when the string 210 comes into contact with the rigid metal fret 220 in the guitar 200 as shown in FIG. 2A.

[0044] Also, in the section mixer 377, a rough addition ratio of the normal waveform and the distortion waveform may be set as a fixed ratio, and a slight variation in the addition ratio over time may be reproduced by each of the EGs 3744 and 3759 and the like. Also, the section mixer 377 may be supplied, from the CPU 310, with a setting value of the addition ratio corresponding to a velocity, and may adjust the addition ratio of the normal waveform and the distortion waveform to the setting value of the addition ratio corresponding to a velocity.

[0045] In the meantime, the sound source LSI 370 may be configured to implement functions, in addition to the above-described functions, and may also be configured not to implement some of the above-described functions. For example, the waveform generator 373 may be configured to execute loop processing of repeatedly reading out the waveform data from the ROM 330, thereby generating waveform data corresponding to a sustained sound. Also, the waveform generator 373 may be con-

figured to read out data of a waveform of which amplitudes have been already normalized from the ROM 330. In this case, the envelope detector 3751, the envelope calculator 3752, the normalization amplifier 3753, the inverse correction amplifier 3760 and the like may be omitted. Also, the generator mixer 372 may be supplied, from the CPU 310, with a setting value of a level corresponding to a velocity or may adjust a value of a level of sound corresponding to each waveform data output from each generator section 371 to the setting value of a level corresponding to a velocity.

(Examples of Envelope)

[0046] Subsequently, examples of the envelope that is generated by each of the EGs 3742, 3744, 3755, 3757 and 3759 are described. FIGS. 8A to 8C depict examples of an envelope that is generated for an acoustic piano sound. FIGS. 9A to 9C depict examples of an envelope that is generated for a guitar sound.

[0047] As described above, in the acoustic piano 100 as shown in FIG. 1A, when the key release is performed on the key 110, a sound of the damper 120 coming into contact with the string 130 is generated, and a ratio of the contact sound in the sound being produced increases over time. In order to favorably reproduce the phenomenon, for example, the distortion EG 3755 generates a distortion envelope as shown in FIG. 8A, the normal filter EG 3742 and the distortion filter EG 3757 generate a filter envelope as shown in FIG. 8B, and the normal amplifier EG 3744 and the distortion amplifier EG 3759 generate an amplifier envelope as shown in FIG. 8C. In a case where an absolute value of the clipping level is set to 1.0, in the example of FIG. 8A, a value of the threshold value envelope upon the key pressing is set to zero that is the minimum value, so that the contact sound is not generated upon the key pressing. Also, a value of the distortion envelope upon the key release is set to approximate 1.0 along the rates R3 and R4 over time.

[0048] Also, in the guitar 200 as shown in FIG. 2A, when the release is performed on the string 210, a sound of the string 210 coming into contact with the fret 220 or the like is generated, and the contact sound is difficult to be heard over time. In order to favorably reproduce the phenomenon, the distortion EG 3755 generates a distortion envelope as shown in FIG. 9A, the normal filter EG 3742 and the distortion filter EG 3757 generate a filter envelope as shown in FIG. 9B, and the normal amplifier EG 3744 and the distortion amplifier EG 3759 generate an amplifier envelope as shown in FIG. 9C. In a case where an absolute value of the clipping level is set to 1.0, when a value of the distortion envelope upon the key pressing is set to be less than 1.0, as shown in FIG. 9C, the contact sound upon the key pressing is difficult to be generated. Also, a value of the distortion envelope upon the key release is set to 1.0 or greater immediately after the key release, and is then set to be less than 1.0, so that the contact sound heard immediately after the key

release is difficult to be heard over time. In the meantime, the addition ratio of the distortion envelope and distortion amplifier envelope corresponding to the sound of the guitar 200 may be set to about 1:0.6, for example.

(Processing)

[0049] Subsequently, processing that is executed by the CPU 310 is described in detail. FIG. 10 is a flowchart depicting a sequence of processing that is executed by the CPU. FIG. 11 is a subroutine flowchart depicting a sequence of sound source LSI control processing of step S108 in FIG. 10. Algorithms shown in each flowchart are stored as programs in the ROM 330 or the like, and are executed by the CPU 310.

[0050] As shown in FIG. 10, when a power supply becomes on, the CPU 310 first executes initialization processing on each constituent element of the electronic musical instrument 300 (step S101). Then, the CPU 310 executes user interface processing (UI processing) of displaying a variety of information on the LCD 350 or receiving a user operation via the switch panel 340 (step S102). For example, the CPU 310 receives a user operation of selecting a certain musical instrument sound from the multiple musical instrument sounds, via the switch panel 340.

[0051] Subsequently, the CPU 310 determines whether the user has performed the key pressing (step S103). When it is determined that the key pressing has been performed (step S103: YES), the CPU 310 executes key pressing processing (also referred to as "sound producing processing" or "note-on processing") (step S104). The key pressing processing includes processing of acquiring a key number and a velocity of the key 361 on which the key pressing has been performed, processing of assigning the generator section 371, and the like, for example. Also, the key pressing processing includes control processing for causing the sound source LSI 370 to execute initialization and operation start of the waveform generator 373 in the assigned generator section 371, readout of the waveform data in the waveform generator 373 of which operation has started, initialization of each of the EGs 3742, 3744, 3755, 3757 and 3759, and the like. In the meantime, the operation of each of the EGs 3742, 3744, 3755, 3757 and 3759 is automatically started in EG steady processing of step S107, which will be described later. On the other hand, when it is determined that the key pressing has not been performed (step S103: NO), the CPU 310 proceeds to processing of step S105.

[0052] Subsequently, the CPU 310 determines whether the user has performed the key release (step S105). When it is determined that the key release has been performed (step S105: YES), the CPU 310 executes key release processing (also referred to as "silencing processing", "sound muffling processing" or "note-off processing") (step S106). The key release processing includes processing of acquiring a key number and a velocity of the key 361 on which the key release has been

performed, control processing of each of the EGs 3742, 3744, 3755, 3757 and 3759, and the like, for example. That is, the CPU 310 executes, as the key release processing, processing of shifting each of the EGs 3742, 3744, 3755, 3757 and 3759 to a release state, for example. On the other hand, when it is determined that the key release has not been performed (step S105: NO), the CPU 310 proceeds to processing of step S107.

[0053] Subsequently, the CPU 310 executes EG steady processing (step S107). More specifically, the CPU 310 supplies parameters corresponding to the selected musical instrument sound and the current state to each of the EGs 3742, 3744, 3755, 3757 and 3759, thereby executing processing of generating envelopes. Then, the CPU 310 executes sound source LSI control processing (step S108). The sound source LSI control processing will be described later in detail with reference to FIG. 11.

[0054] Subsequently, the CPU 310 determines whether a value counted by the timer counter 390 is equal to or greater than 1000 μ sec, i.e., 1ms (step S109). When it is determined that the counted value is not equal to or greater than 1000 μ sec, i.e., is less than 1000 μ sec (step S109: NO), the CPU 310 stands by until the counted value becomes equal to or greater than 1000 μ sec. On the other hand, when it is determined that the counted value is equal to or greater than 1000 μ sec (step S109: YES), the CPU 310 subtracts 1000 μ sec from the value counted by the timer counter 390 (step S110), and returns to the processing of step S102. That is, the CPU 310 executes the processing of step S109 and S110 so as to execute the processing from step S102 to S108 every 1000 μ sec on average.

[0055] Subsequently, the sound source LSI control processing of step S108 is described in detail. The CPU 310 controls the sound source LSI 370 to execute processing from step S201 to S206 shown in FIG. 11.

[0056] More specifically, as shown in FIG. 11, in the sound source LSI 370, an envelope obtained by adding the distortion amplifier envelope and distortion envelope adjusted by the inverse correction amplifier 3760 and the clipping control amplifier 3761 is set to a gain of the distortion gain amplifier 3754A (step S201). In the meantime, a gain of the inverse correction amplifier 3760 corresponds to the amplitude envelope detected by the envelope detector 3751, as described above.

[0057] Also, the filter envelope generated by the distortion filter EG 3757 is set in the distortion filter 3756 (step S202). Also, the distortion amplifier envelope adjusted by the inverse correction amplifier 3760 is set in the distortion amplifier 3758 (step S203). Also, the filter envelope generated by the normal filter EG 3742 is set in the normal filter 3741 (step S204), and the amplifier envelope generated by the normal amplifier EG 3744 is set in the normal amplifier 3743 (step S205).

[0058] Then, it is determined whether all the values of the amplifier envelope supplied to the normal amplifier 3743 and the distortion amplifier 3758 have reached zero and the operations of both the normal amplifier 3743 and

the distortion amplifier 3758 have stopped (step S206).

[0059] When it is determined that the operations of both the amplifiers 3743 and 3758 have stopped (step S206: YES), the operation of the waveform generator 373 is also stopped (step S207), and the sound source LSI control processing is over. On the other hand, when it is determined that the operation of any one of both the amplifiers 3743 and 3758 has not stopped (step S206: NO), the sound source LSI control processing is over.

[0060] The present embodiment achieves following effects.

[0061] The electronic musical instrument 300 generates the normalized data indicative of the second waveform by the normalize processing of changing the different first amplitudes of the first waveform indicated by the first waveform data as certain waveform data input to the distortion channel 375 to the same second amplitude. Then, the electronic musical instrument 300 amplifies at least a part of the second waveform indicated by the normalized data, and clips the amplified waveform by a certain clipping level to generate the clipped data indicative of the third waveform. Also, the electronic musical instrument 300 changes the amplitudes of the third waveform indicated by the clipped data in conformity to the first amplitudes of the first waveform, thereby generating and outputting the waveform data indicative of the fourth waveform. The waveform data indicative of the output fourth waveform is mixed with the waveform data output from the normal amplifier 3743 in the normal channel 374 by the section mixer 377. Thereby, the electronic musical instrument 300 can generate the distortion sound corresponding to the waveform of which amplitudes are restricted, as a sound that simulates the contact sound, and can reproduce the contact sound of the string that is generated in the musical instrument with strings and changes over time and in accordance with a playing method and the like.

[0062] Also, the electronic musical instrument 300 detects the amplitude envelope of the first waveform before the normalize processing, and multiplies the value calculated based on the detected amplitude envelope by the first waveform, thereby changing the first amplitudes of the first waveform to the second amplitudes. Thereby, the electronic musical instrument 300 can normalize the amplitudes of the original waveform simply by executing the multiplication processing that is relatively simple signal processing.

[0063] Also, the electronic musical instrument 300 multiplies the value calculated based on the detected amplitude envelope by the third waveform indicated by the clipped data, thereby changing the amplitudes of the third waveform in conformity to the first amplitudes. Thereby, the electronic musical instrument 300 can correct the amplitudes of the clipped waveform to the amplitudes of the waveform before the normalization simply by executing the multiplication processing that is relatively simple signal processing.

[0064] Also, the second amplitudes are larger than the

first amplitudes. Thereby, the electronic musical instrument 300 can change the different first amplitudes of the first waveform to the second amplitudes larger than the first amplitudes.

[0065] Also, the clipping level is set, in accordance with the musical instrument sound, which is selected by the user, from the multiple musical instrument sounds. Thereby, the electronic musical instrument 300 can favorably reproduce the contact sound that is different for each musical instrument.

[0066] Also, the electronic musical instrument 300 adds (mixes) the normal waveform and the distortion waveform with the set addition ratio. Thereby, the electronic musical instrument 300 can output the data of the waveforms added with the diverse addition ratios. Therefore, the electronic musical instrument 300 can favorably reproduce the contact sound of the soft damper 120 coming into contact with the string 130 in the acoustic piano 100 and the contact sound of the string 210 coming into contact with the rigid metal fret 220 in the guitar 200, for example.

[0067] In the meantime, the present disclosure is not limited to the above-described embodiment, and can be diversely changed and improved within the claims.

[0068] For example, in the above-described embodiment, the parameter, the setting value and the like corresponding to the velocity are supplied from the CPU 310 to the sound source LSI 370. However, a parameter, a setting value and the like corresponding to an element other than the velocity may be supplied to the sound source LSI 370. As the element other than the velocity, after-touch that can be detected by a pressure sensor or the like may be exemplified.

[0069] Also, in the above-described embodiment, the processing shown in FIG. 11 is executed by the CPU 310. However, at least some of the processing shown in FIG. 11 may be executed by the sound source LSI 370.

[0070] Also, in the above-described embodiment, the contact sounds that are generated in the acoustic piano 100 and the guitar 200 are reproduced in the electronic musical instrument 300. However, contact sounds that are generated in other musical instruments with strings may also be reproduced. As the other musical instruments, folk musical instruments such as sitar having a contact plate (bridge), a fretless bass, and the like may be exemplified. In the folk musical instruments such as sitar, even when vibration of the string is small to some extent, a long and stable contact sound is generated. In order to reproduce such contact sound, the electronic musical instrument 300 may control the value of the clipping level to a small value for a long time period, for example.

[0071] Also, in the above-described embodiment, the contact sounds that are generated in the musical instruments with strings are reproduced in the electronic musical instrument 300. However, the contact sounds may be reproduced in other instruments. As the other instruments, a PC and the like that are used for music produc-

tion may be exemplified.

[0072] In addition, the present disclosure is not limited to the above-described embodiment, and can be diversely modified without departing from the gist thereof, in the implementation phase. Also, the functions that are executed in the above-described embodiment may be implemented with being combined appropriately as much as possible. The above-described embodiment includes inventions of diverse stages, and various inventions can be extracted by combining appropriately a plurality of constituent elements disclosed in the embodiment. For example, even if some constituent elements are omitted from all the constituent elements disclosed in the embodiment, the resultant configuration can be extracted as an invention, inasmuch as the effects can be achieved.

Reference Signs List

[0073]

300: electronic musical instrument
310: CPU
320: RAM
330: ROM
340: switch panel
350: LCD
360: keyboard
370: sound source LSI
371: generator section
372: generator mixer
373: waveform generator
374: normal channel
375: distortion channel
3751: envelope detector
3752: envelope calculator
3753: normalization amplifier
3754: distortion
3754A: distortion gain amplifier
3754B: clipper (clipper)
3756: distortion filter
3758: distortion amplifier
3760: inverse correction amplifier
3761: clipping control amplifier
377: section mixer
380: D/A converter
385: amplifier
390: timer counter

Claims

1. An electronic musical instrument comprising:

means for determining, in accordance with a user operation on at least one operation element (360), first waveform data (a) from a plurality of pieces of waveform data, the first waveform data (a) including multiple first waveforms having dif-

- ferent first amplitudes;
 means for generating (3753) normalized data (b) that includes multiple second waveforms having same second amplitude, based on the first waveform data (a);
 means for amplifying (3754A) the second amplitude of at least one of the multiple second waveforms in the normalized data (b) to generate amplified data (c);
 means for clipping (3754B) at least one waveform included in the amplified data (c) at a certain clipping level to generate clipped data (d) that includes multiple third waveforms; and
 means for changing (3758) amplitudes of the multiple third waveforms in the clipped data (d) to the different first amplitudes to generate waveform data (e) that includes multiple fourth waveforms.
2. The electronic musical instrument according to Claim 1, further comprising:
- means for detecting (3751) an envelope of the multiple first waveforms indicated by the first waveform data (a); and
 means for multiplying (3753) a value calculated based on the envelope of the first waveforms by the first waveform data (a) so that an envelope of the multiple second waveforms is kept at a constant level of the same second amplitude.
3. The electronic musical instrument according to Claim 2, further comprising:
 means for multiplying a value calculated based on the envelope of the first waveforms by the clipped data (d) to generate the waveform data (e) indicative of the multiple fourth waveforms.
4. The electronic musical instrument according to one of Claims 1 to 3, wherein the second amplitude are larger than the first amplitudes.
5. The electronic musical instrument according to one of Claims 1 to 4, further comprising:
- means for generating the waveform data (e) indicative of the multiple fourth waveforms in a distortion line (3754, 3756, 3758) that includes a distortion amplifier (3758);
 means for generating the normal waveform data in a normal line (3741, 3743) that includes a normal amplifier (3743); and
 means for mixing the waveform data (e) indicative of the multiple fourth waveforms and the normal waveform data with a set ratio.
6. The electronic musical instrument according to one of Claims 1 to 5, wherein the certain clipping level is determined, in accordance with a musical instrument, which is selected based on a user operation, from a plurality of musical instruments.
7. A method comprising:
- determining, in accordance with a user operation on at least one operation element (360), first waveform data (a) from a plurality of pieces of waveform data, the first waveform data (a) including multiple first waveforms having different first amplitudes;
 generating normalized data (b) that includes multiple second waveforms having same second amplitude, based on the first waveform data (a);
 amplifying the second amplitude of at least one of the multiple second waveforms in the normalized data (b) to generate amplified data (c);
 clipping at least one waveform included in the amplified data (c) at a certain clipping level to generate clipped data (d) that includes multiple third waveforms; and
 changing amplitudes of the multiple third waveforms in the clipped data (d) to the different first amplitudes to generate waveform data (e) that includes multiple fourth waveforms.
8. The method according to Claim 7, further comprising:
- detecting an envelope of the multiple first waveforms indicated by the first waveform data (a); and
 multiplying a value calculated based on the envelope of the first waveforms by the first waveform data (a) so that an envelope of the multiple second waveforms is kept at a constant level of the same second amplitude.
9. The method according to Claim 8, further comprising:
 multiplying a value calculated based on the envelope of the first waveforms by the clipped data (d) to generate the waveform data (e) indicative of the multiple fourth waveforms.
10. The method according to one of Claims 7 to 9, wherein the second amplitude are larger than the first amplitudes.
11. The method according to one of Claims 7 to 10 further comprising:
- generating the waveform data (e) indicative of the multiple fourth waveforms in a distortion line (3754, 3756, 3758) that includes a distortion amplifier (3758);

generating the normal waveform data in a normal line (3741, 3743) that includes a normal amplifier (3743); and
mixing the waveform data (e) indicative of the multiple fourth waveforms and the normal waveform data with a set ratio. 5

12. The method according to one of Claims 7 to 11, wherein the certain clipping level is determined, in accordance with a musical instrument, which is selected based on a user operation, from a plurality of musical instruments. 10

13. A program for causing a computer to execute a process, the process comprising: 15

determining, in accordance with a user operation on at least one operation element (360), first waveform data (a) from a plurality of pieces of waveform data, the first waveform data (a) including multiple first waveforms having different first amplitudes; 20
generating normalized data (b) that includes multiple second waveforms having same second amplitude, based on the first waveform data (a); 25
amplifying the second amplitude of at least one of the multiple second waveforms in the normalized data (b) to generate amplified data (c); 30
clipping at least one waveform included in the amplified data (c) at a certain clipping level to generate clipped data (d) that includes multiple third waveforms; and
changing amplitudes of the multiple third waveforms in the clipped data (d) to the different first amplitudes to generate waveform data (e) that includes multiple fourth waveforms. 35

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FIG. 1A

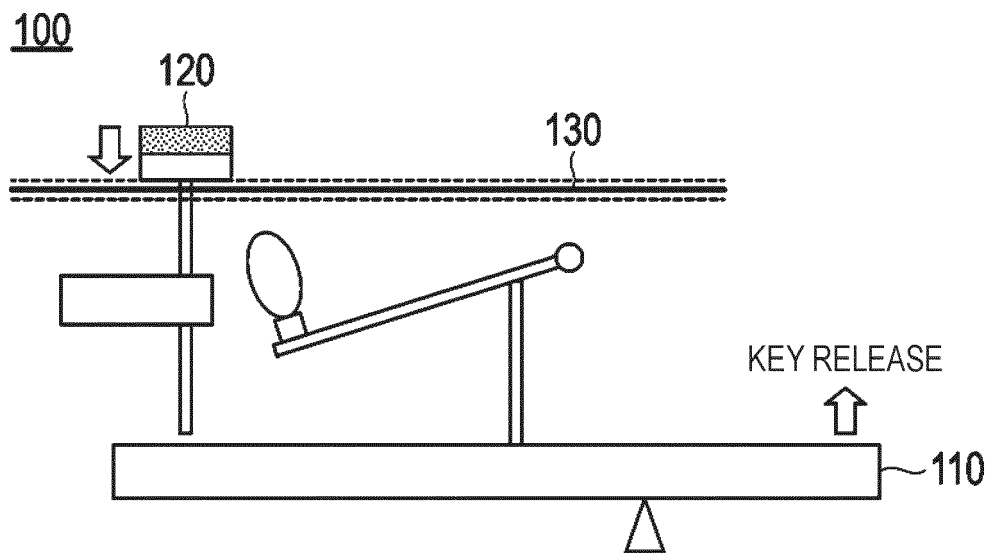


FIG. 1B

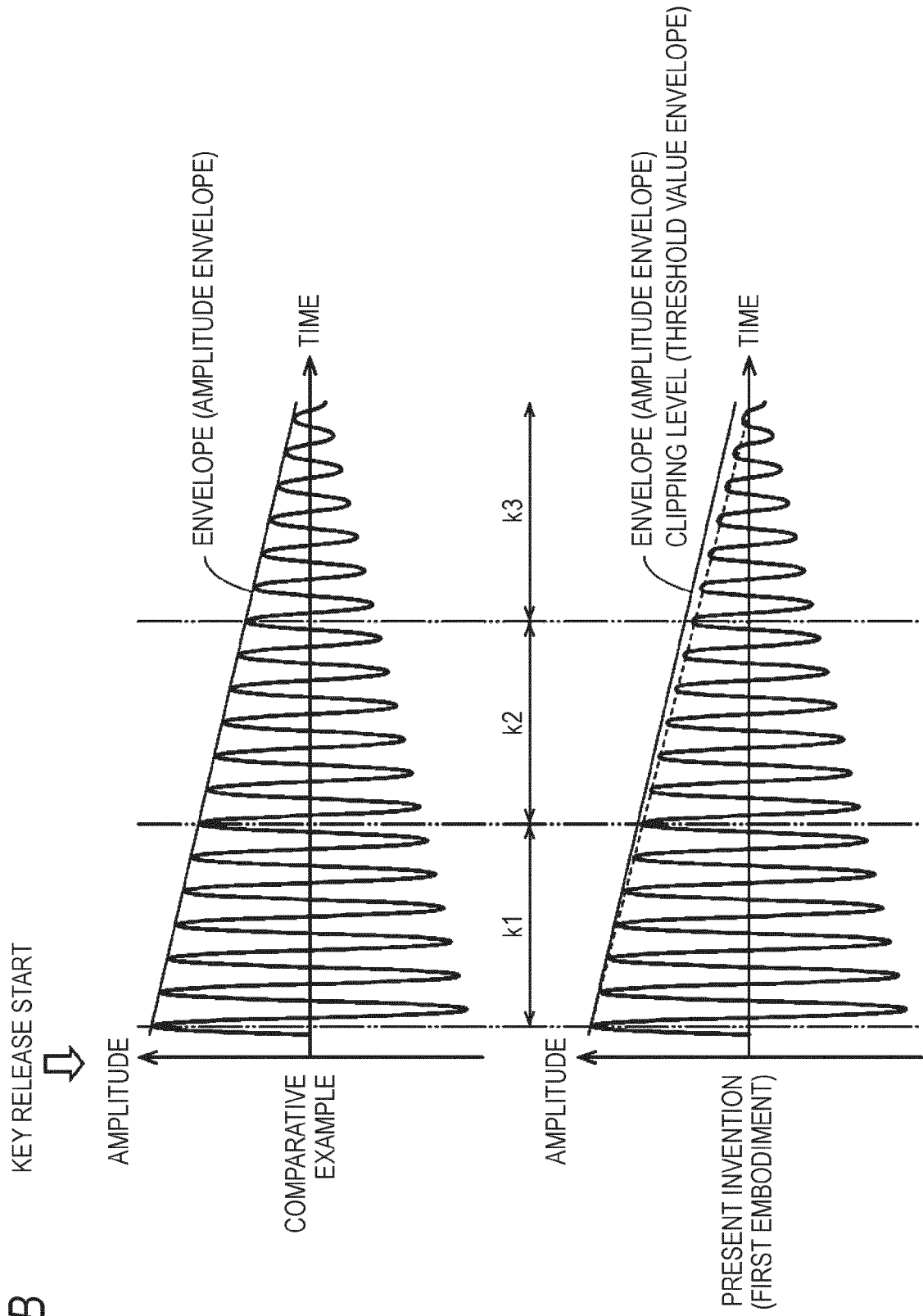


FIG. 2A

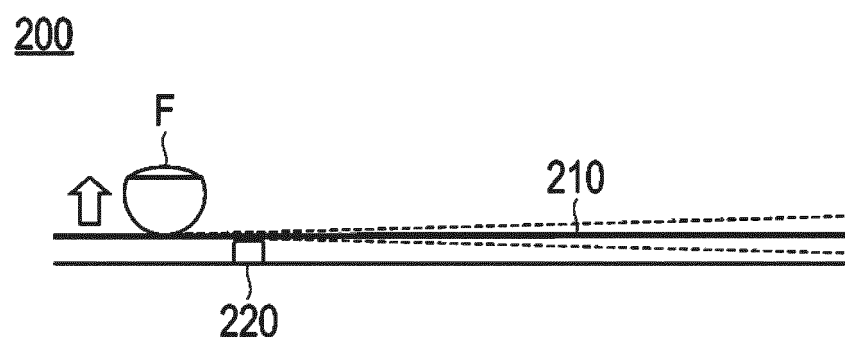


FIG. 2B

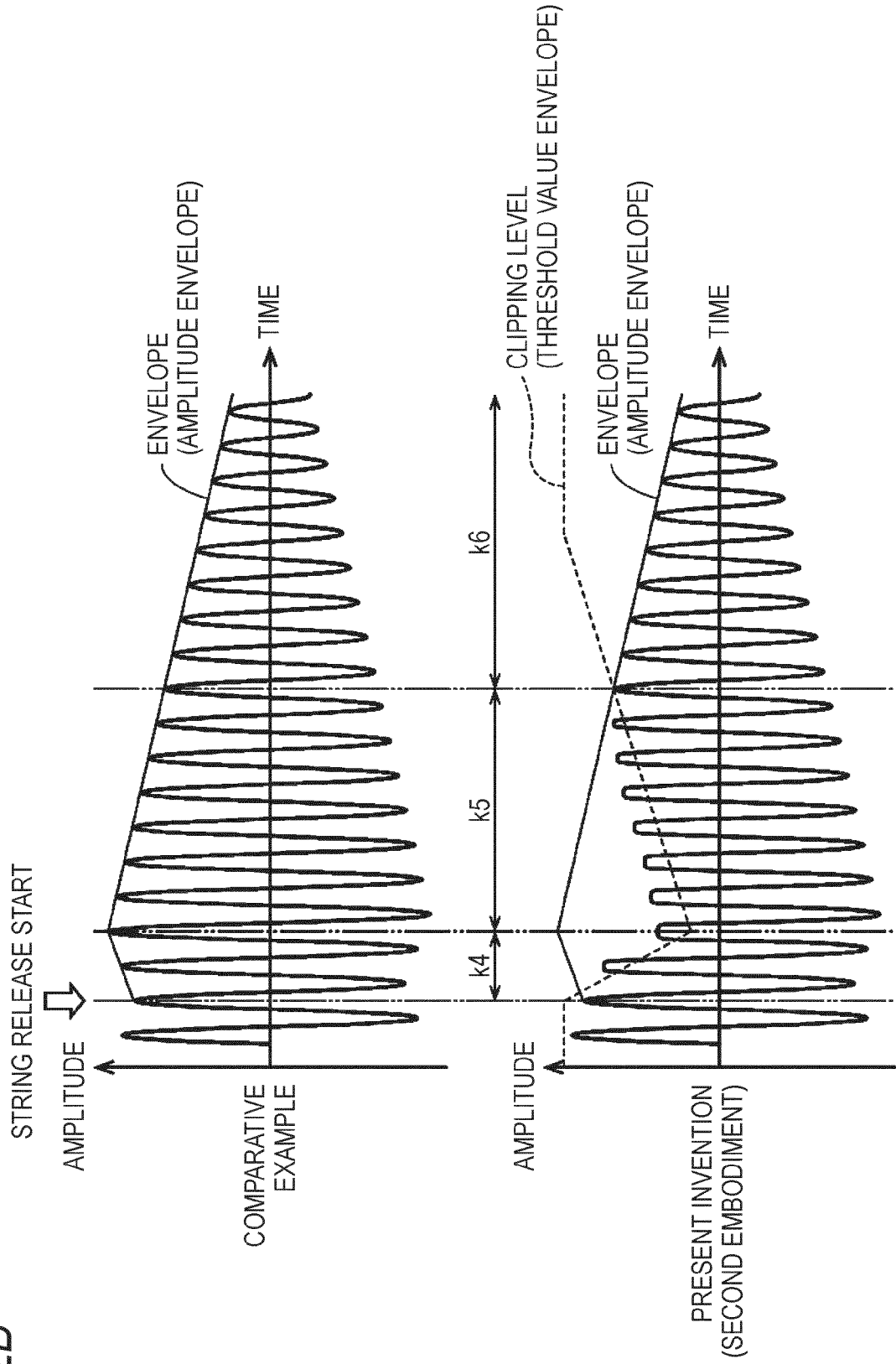


FIG. 3

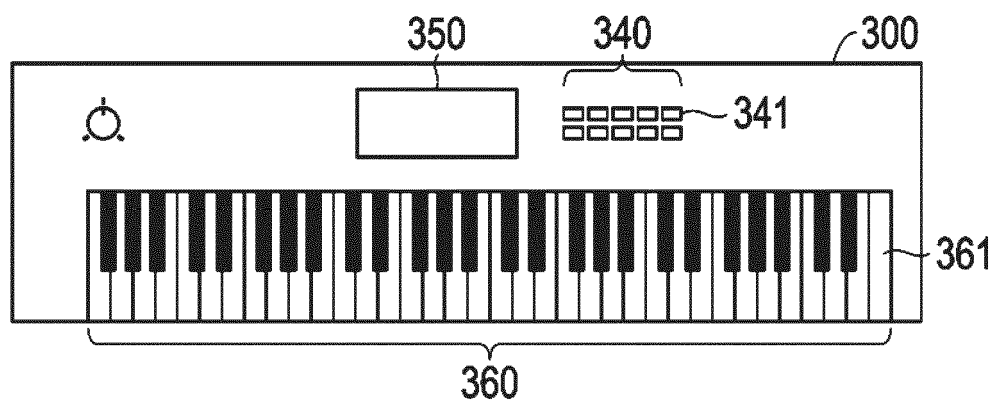


FIG. 4

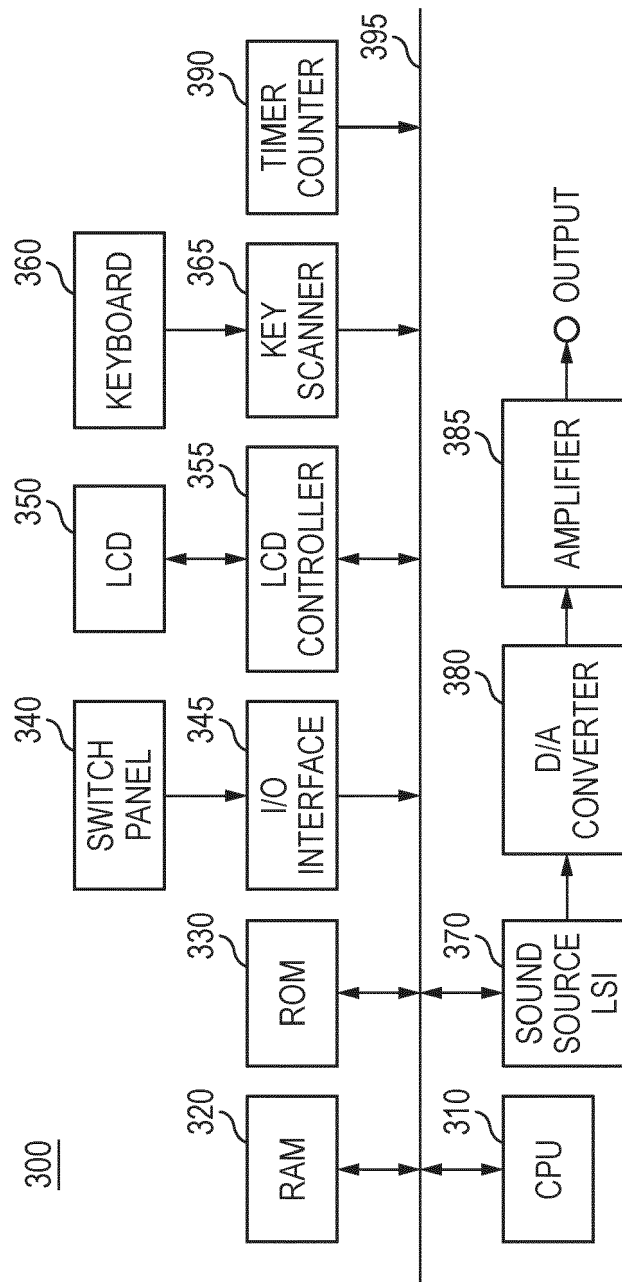


FIG. 5

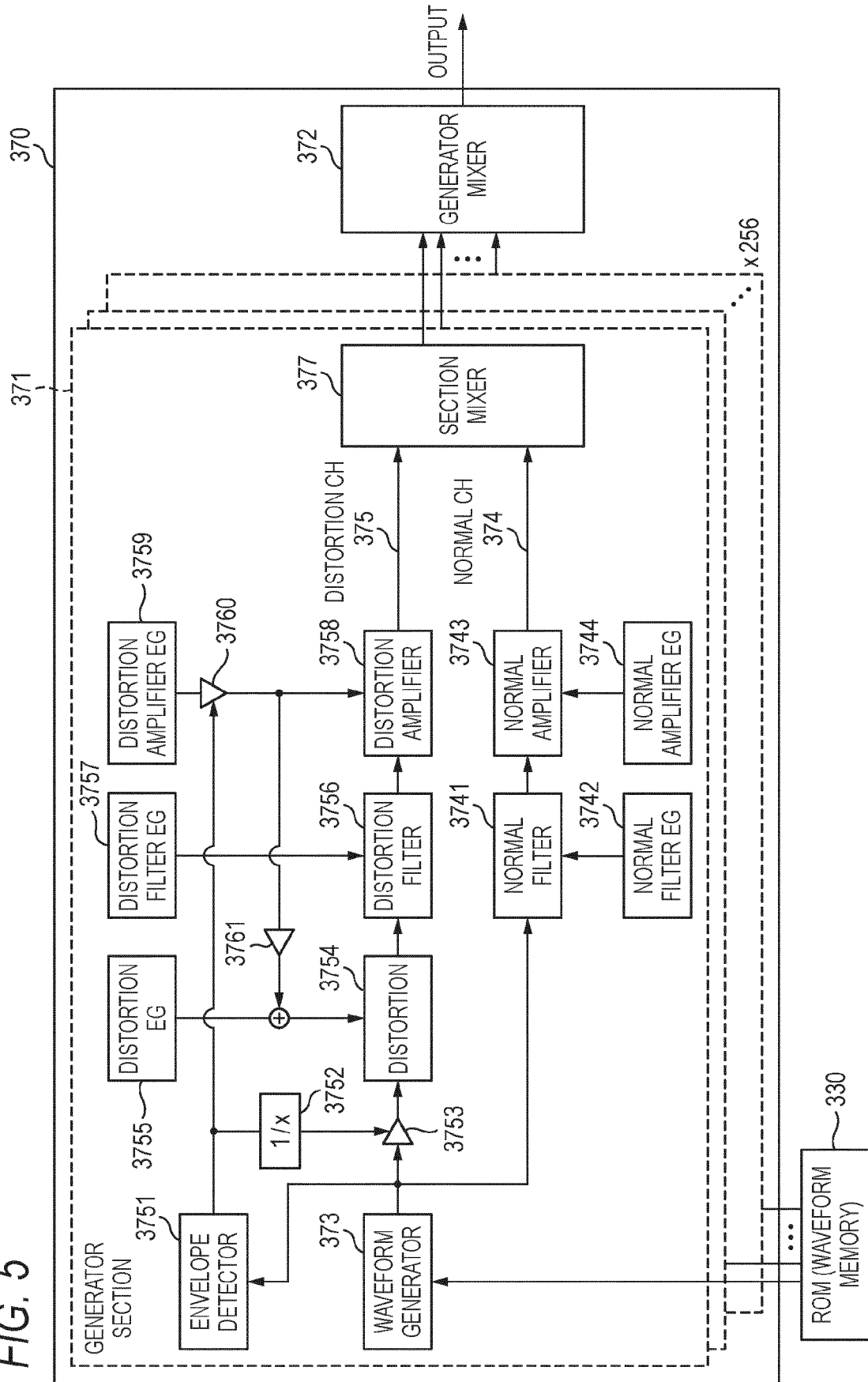


FIG. 6

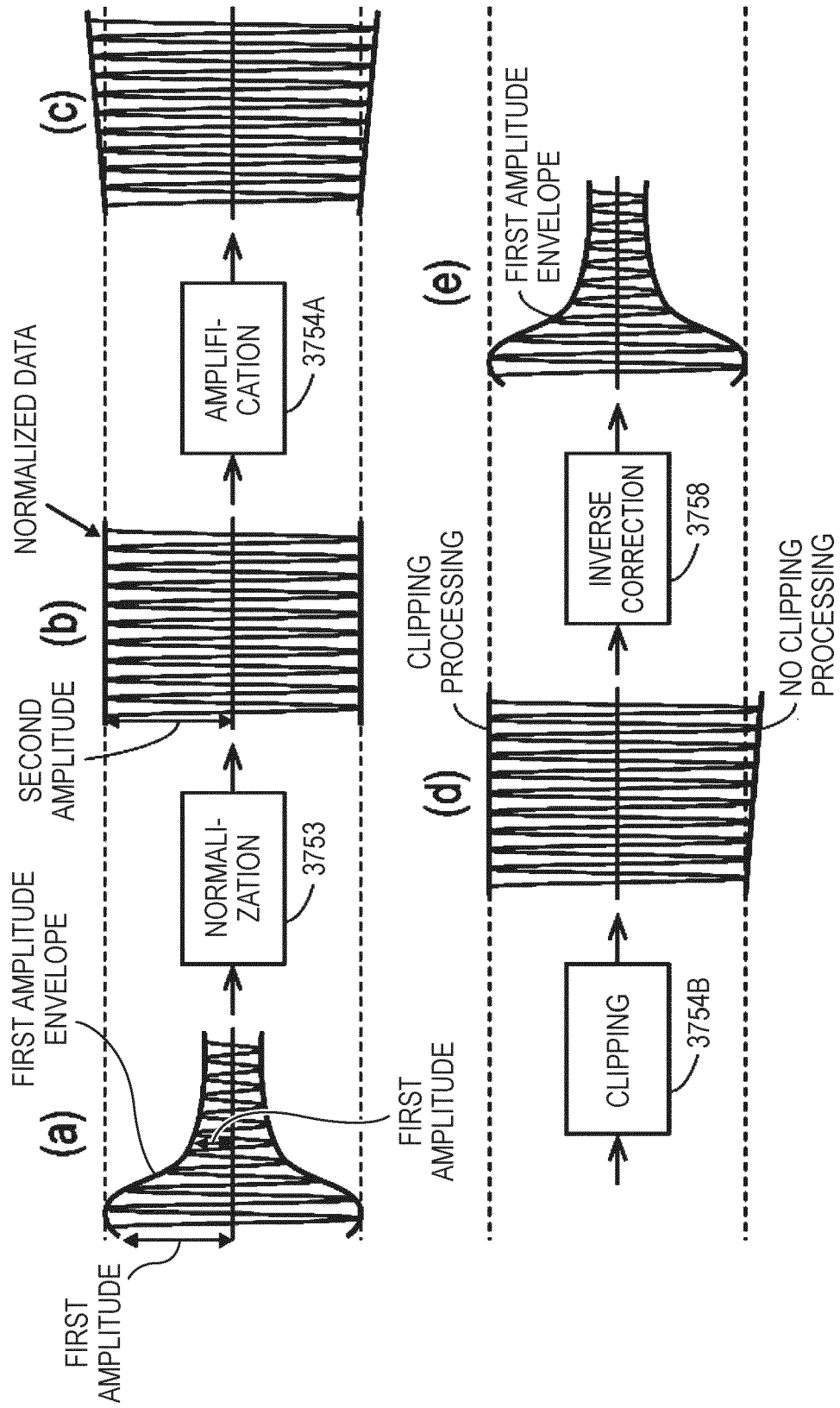


FIG. 7

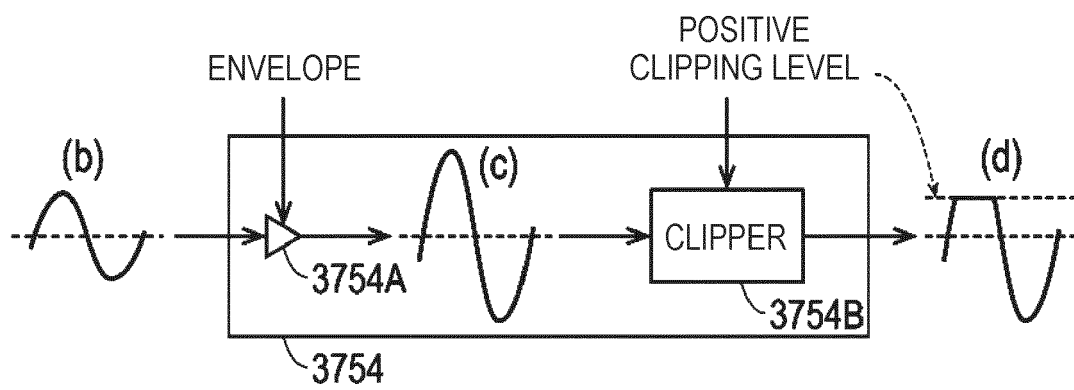


FIG. 8A

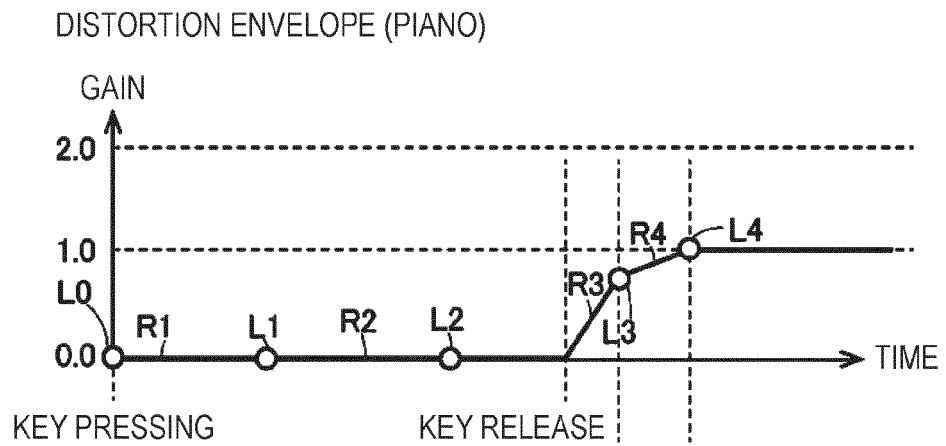


FIG. 8B

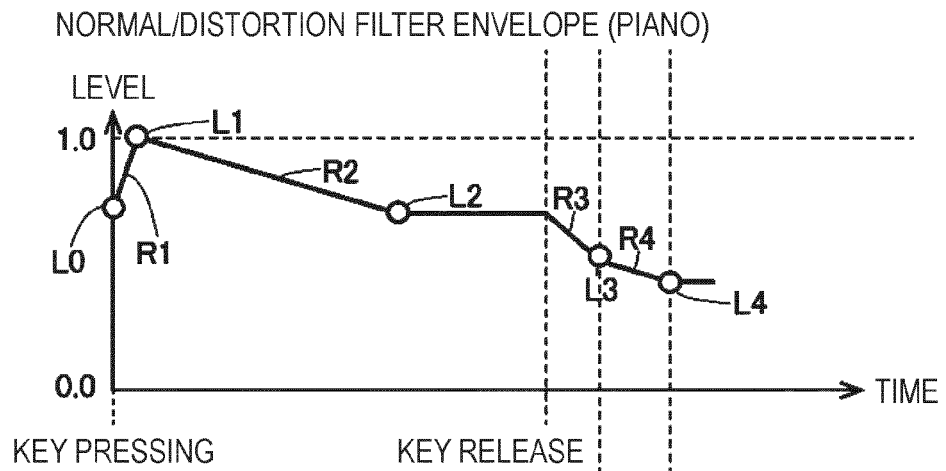


FIG. 8C

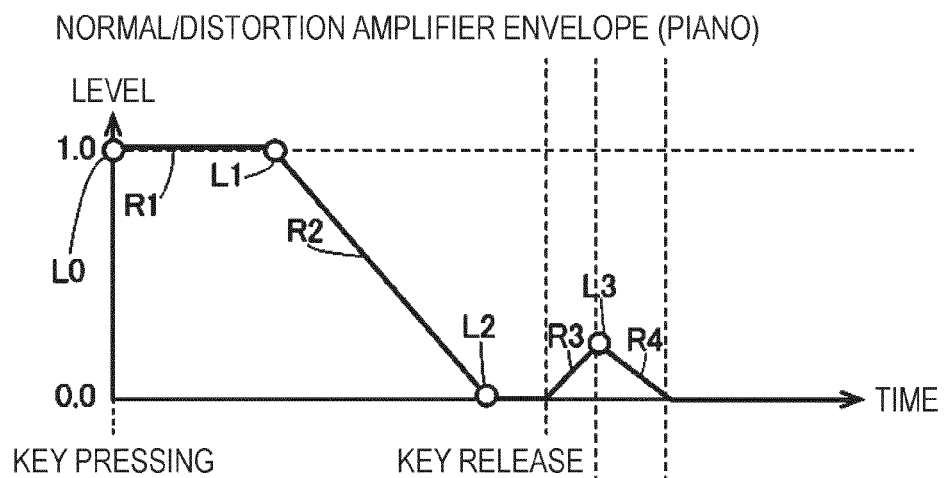


FIG. 9A

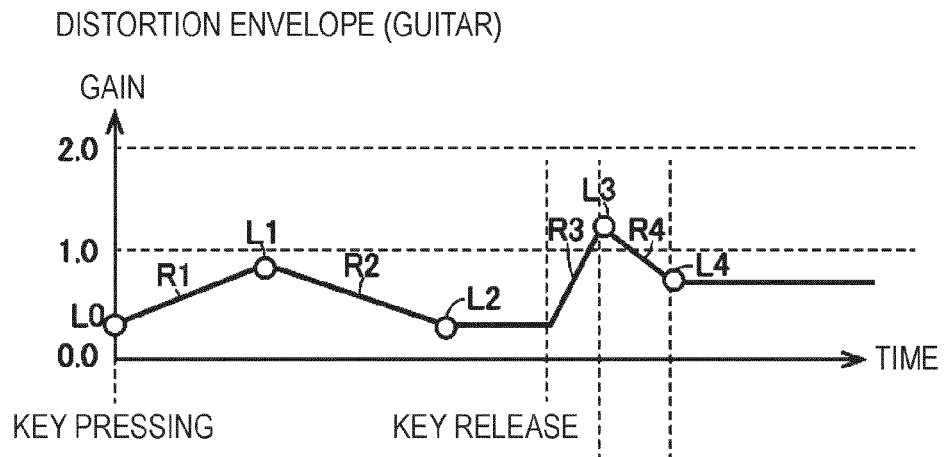


FIG. 9B

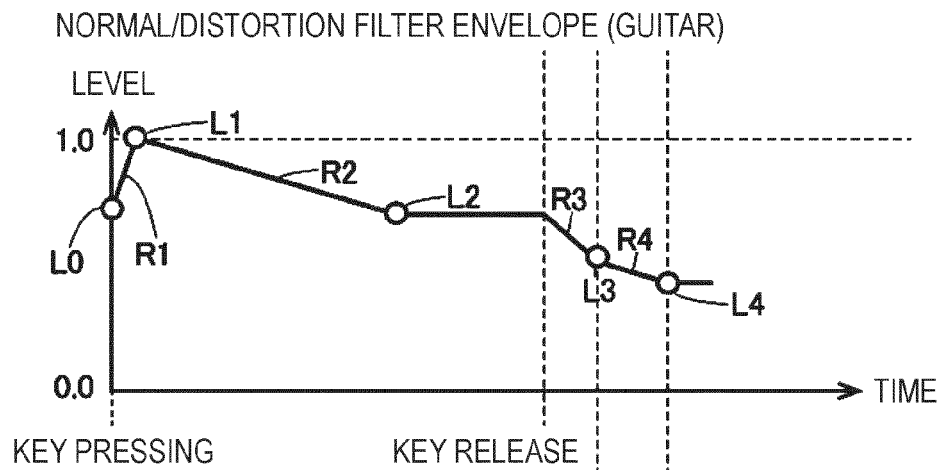


FIG. 9C

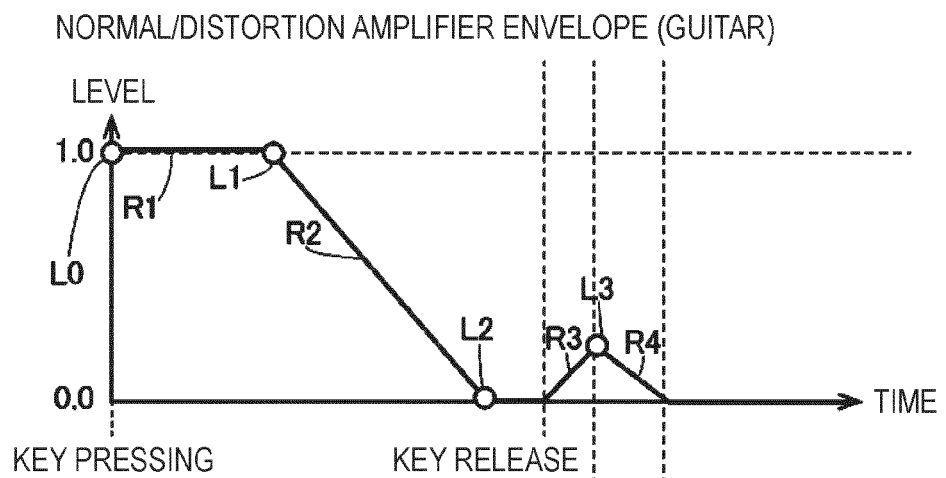


FIG. 10

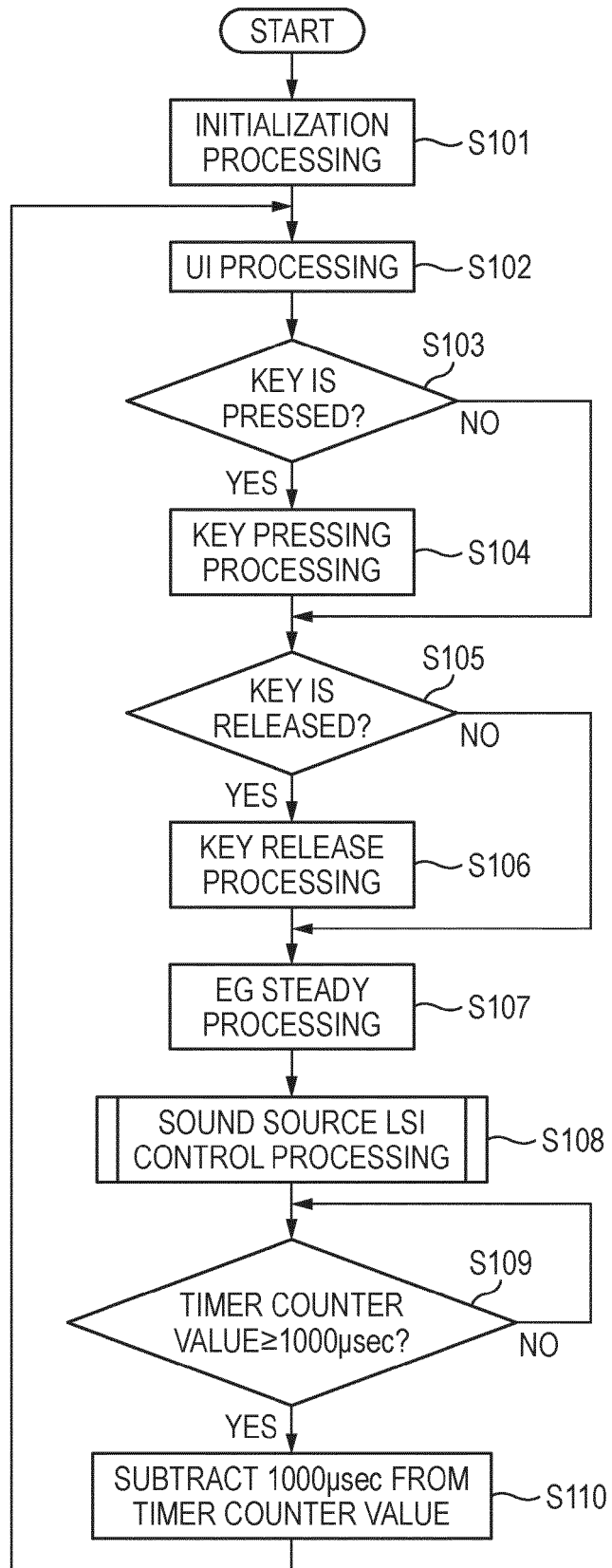
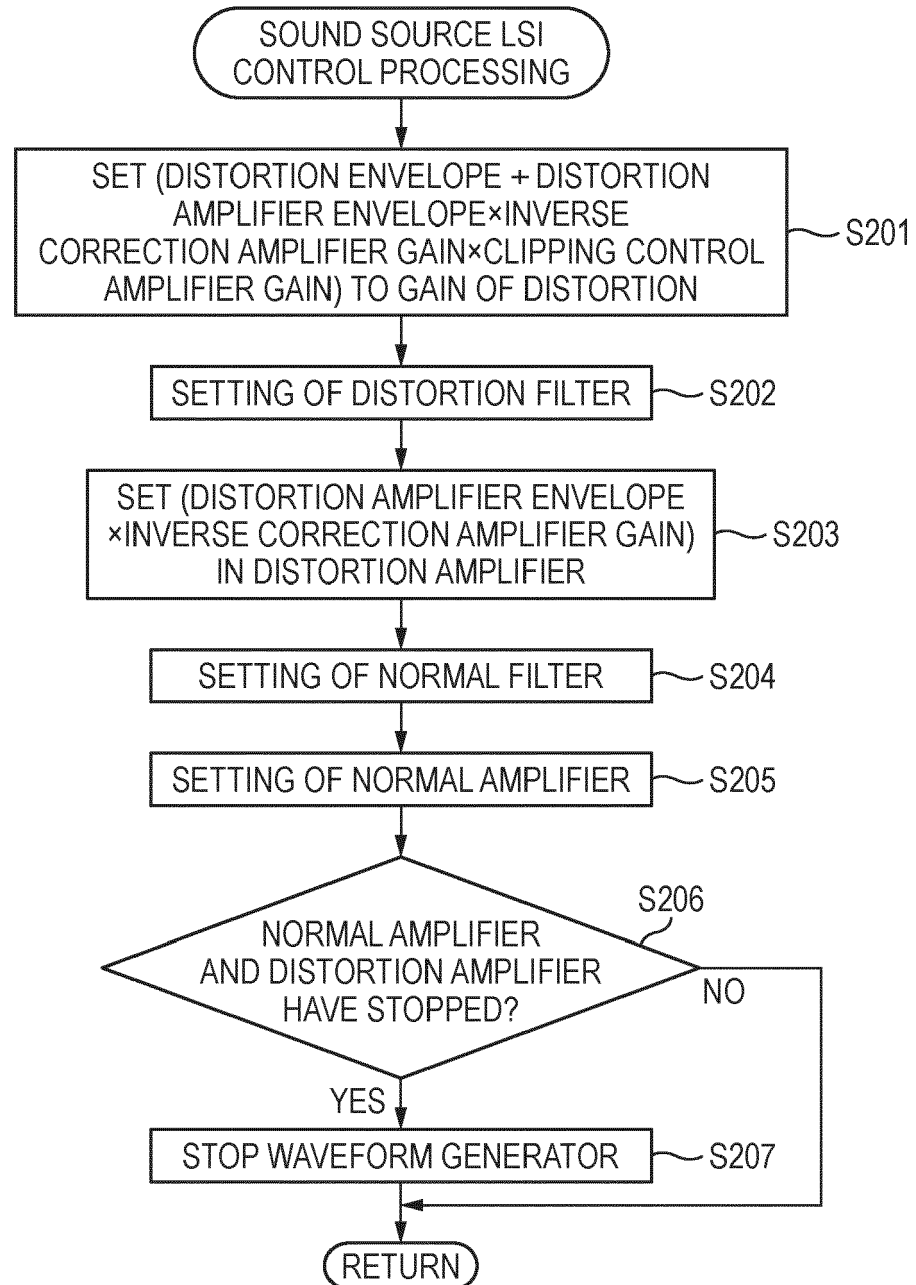


FIG. 11





EUROPEAN SEARCH REPORT

Application Number
EP 20 18 0039

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A	* columns 1, 6, 9; figures 1-5 * -----	2,3,8,9	G10H1/053 G10H1/14
Y	US 6 504 935 B1 (JACKSON DOUGLAS L [US]) 7 January 2003 (2003-01-07)	1,4-7, 10-13	G10H1/16 G10H7/02
A	* column 14, lines 35-37; figures 1,2,3 * * columns 20, 25, line 40 - line 60; claim 8; figures 4,9 * -----	2,3,8,9	ADD. G10H1/057 G10H1/18
Y	JP H05 134671 A (YAMAHA CORP) 28 May 1993 (1993-05-28)	1,4-7, 10-13	
A	* paragraphs [0001] - [0005], [0017] - [0019], [0044], [0060] - [0069]; figures 1, 7, 17, 18, 19, 21 * -----	2,3,8,9	
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			G10H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 1 September 2020	Examiner Glasser, Jean-Marc
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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