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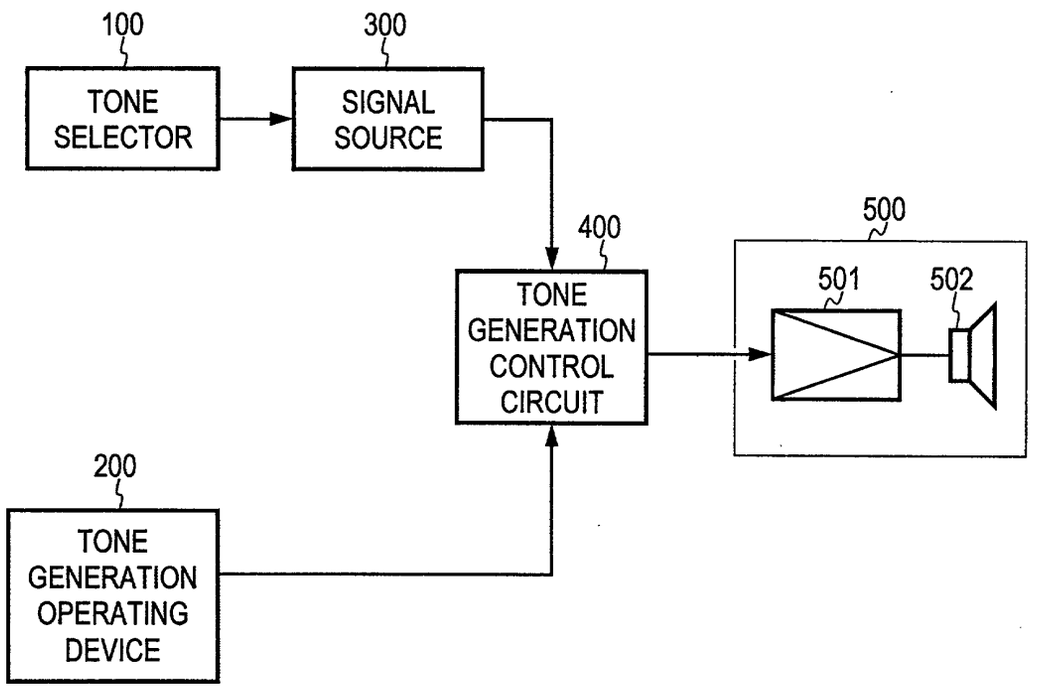
(54) Tone generation operating device and electronic musical instrument using the same

(57) A player selects a tone with his one hand (100) and performs a tone generating operation with the other hand (200). The player electrically detects all operations with the other hand without using any tools and uses the detected signals as tone generation information.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a tone generation operating device that is close to strings in the basic execution but enables a player to show every kind of musical expression with his bare hands without using a bow, a pick, a plectrum and so forth and an electronic musical instrument using the tone generation operating device.

[0002] Of conventional electronic musical instruments, an electronic keyboard musical instrument called a synthesizer is not without resemblance to the electronic musical instrument according to the present invention.

[0003] Fig. 17 depicts the general configuration of a conventional electronic keyboard instrument. The conventional keyboard instrument comprises: a keyboard 11; a tone source 12 that is driven by a signal from a switch indicating the tone selected on the keyboard 11 to generate an electrical signal of a frequency corresponding to the selected tone; and a loudspeaker system 15 composed of an amplifier 13 for amplifying the electric signal generated by the tone source 2 and a loudspeaker 14.

[0004] The tone source 12 has connected thereto various registers 12A and a sound effecter 12B. The registers 12A are those for setting, for example, the tone of one of musical instruments in which the electronic keyboard is desired to be played, for setting the attack speed of the tone, the loudness during attack and the decay speed, and for setting timbre. The sound effecter 12B has a facility of imparting a pitch bend to the tone being generated or a facility of repeatedly changing the tone volume.

[0005] In the conventional electronic keyboard instrument, for example, the attack speed of tone, the loudness during the attack time, the decay speed, and so forth are preset in the registers 12A as mentioned above--this makes it impossible for a player to freely select the attack speed, the tone amplitude during the attack time and the decay speed by changing the key depressing operations. That is, the conventional electronic keyboard instrument is defective in that the player cannot fully express his emotion, as is well-known in the art.

[0006] Heretofore, various solutions to the above problems have been proposed. One of such proposals is to detect the speed of depression of each key on the keyboard 11 and control the tone volume during attack in accordance with the detected speed. That is, there is proposed an electronic keyboard instrument of the type wherein the stronger (the more quickly) the key is depressed, the more the amplitude of the tone being generated increases, providing increased volume.

[0007] The addition of the above function enables the player to express his emotion to some extent by changing the key striking operation, but it is not fully satisfactory.

[0008] The conventional electronic keyboard instrument has such defects as listed below.

(a) Defective touch response function

Since the difference in operating time between two electrical contacts provided for each key is detected as a signal corresponding to the speed of depression of the key, it is theoretically impossible to play a quick passage in a pianissimo manner.

(b) Incapability of playing in legato and slur

Since an envelope generator responds to each key depression to repeat tone generation, it is impossible to play in legato or slur which can be easily achieved with actual stringed and wind instruments. All keyboard instruments, including electronic keyboard instruments, cannot be played in either legato or slur.

(c) Incapability of detache method

For the method of playing with a fast attack and a fast decay to articulate detached tones, the electronic keyboard instrument calls for an envelope generator for detache. For this reason, there is no difference in the basic performance among tenute, marcato and detache.

(d) Incapability of quick grace and quick trill

In all kinds of keyboard instruments including electronic keyboard instruments as well, semitone- or whole-tone spaced adjacent keys must be alternately depressed and released repeatedly with high accuracy. From the viewpoint of human engineering, it is difficult to play keys with 10 to 12 mm stroke. In the stringed and wind instruments two tones are generated alternately by each stroke operation, and hence the tone generation repeating speed is doubled.

(e) Incapability of quick staccato in pianissimo

In addition to the afore-mentioned defects related to the envelope generator and the touch response, no tone can be generated unless keys are depressed to the position of tone generation; hence, quick staccato is impossible to play.

(f) Incapability of tone silencing control during key-OFF period

As described above, not only electronic keyboard instruments but also acoustic instruments, for example, a piano, a violin, a flute, a trumpet and so forth are all not free from some defects to a certain degree. Even if a composer or player wishes to realize his ideal or desired musical expression, it is physically impossible, in many cases, due to the tone generating principles of the instruments to satisfy his wish. It is utterly impossible to require, for example, a piano to generate such a sustain tone as obtainable with a violin or the violin to generate such a chord as obtainable with the piano.

SUMMARY OF THE INVENTION

[0009] It is therefore an object of the present invention to provide an electronic musical instrument that permits various methods of playing acoustic instruments as well as conventional electronic keyboard instrument.

[0010] The electronic musical instrument according to the present invention comprises:

a body;
a tone selector provided on said body, for selecting a tone to be generated;
a signal source for generating a tone source signal containing a pitch frequency corresponding to the tone selected by said tone selector;
a tone generation operating device provided on said body, for generating a tone generation control signal for processing said tone source signal for tone generation; and
at least one tone generation control circuit for processing said tone source signal by said tone generation control signal for tone generation to generate a tone signal.

[0011] According to the present invention, the tone generation operating device comprises:

a min lever formed by a rectangular plate member, rotatably supported at one end by a base with its free end resiliently biased in one direction by the biasing force of a spring, and operable to turn over a predetermined angular range defined by a pair of stoppers;
a quick lever mounted on said main lever, rotatably supported at one end by said main lever near its supporting point, resiliently biased in the same direction as said main lever, and operable to turn over a predetermined angular range defined by a pair of stoppers, said quick lever being smaller than said main lever and operable at high speed;
a first sensor for outputting a voltage signal in proportion to the amount of depression of said main lever; and
a second sensor for outputting a voltage signal in proportion to the amount of depression of said quick lever.

[0012] The most striking feature of the electronic musical instrument according to the present invention resides in the construction in which the tone selector for selecting the tone desired to generate and the tone generation operating device for generating the tone selected by the tone selector are provided independently of each other. That is, the electronic musical instrument according to the present invention is designed so that a player performs the tone selecting operation with one hand and the tone generating operation with the other hand. With this arrangement, whether to generate the tone selected by the tone selector can be controlled by the tone generation operating device that is manipulated with the other hand. Accordingly, legato or slur performance can easily be done, for example, by changing the tone on the part of the tone selector while keeping the tone generation operating device in its tone-generating state.

[0013] Further, since the tone selector and the tone generation operating device are manipulated separately of each other, the tone generating operation can be performed independently of the tone selecting operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a block diagram for explaining features of the electronic musical instrument according to the present invention;
Fig. 2A is a front view for explaining an example of the external structure of the electronic musical instrument according to the present invention;
Fig. 2B is a front view for explaining another example of the external structure of the electronic musical instrument according to the present invention;
Fig. 3A is a front view for explaining a structural feature of the electronic musical instrument according to the present invention;
Fig. 3B is its side view;
Fig. 4 is a plan view for explaining a modified form of a tone selector for use in the electronic musical instrument according to the present invention;
Fig. 5 is an enlarged sectional view for explaining another modified form of the tone selector for use in the electronic musical instrument depicted in Fig. 3;
Fig. 6 is a perspective view, partly in section, for explaining an example of the tone generation operating device characteristic of the present invention;
Fig. 7 is its sectional view;
Fig. 8 is a perspective view for explaining the external structure of the tone generation operating device for use in the present invention;
Fig. 9 is a block diagram for explaining the electrical circuitry of the electronic musical instrument according to the present invention;
Fig. 10 is a block diagram for explaining an example of execution made possible by the electronic musical instrument according to the present invention;
Fig. 11 is a waveform diagram for explaining the operation for the execution in Fig. 10;
Fig. 12 is a block diagram for explaining another example of execution made possible by the electronic musical instrument according to the present invention;
Fig. 13 is a block diagram similar to Fig. 12;
Fig. 14 is a block diagram similar to Fig. 12;
Fig. 15 is a block diagram similar to Fig. 12;

Fig. 16 is a block diagram similar to Fig. 12; and
Fig. 17 is a block diagram for explaining the outlines of a conventional electronic keyboard instrument.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] A description will be given first, with reference to Fig. 1, of the configuration characteristic of the present invention. Reference numeral 100 denotes a tone selector that decides the tone desired to generate; 200 denotes a tone generation operating device that generates a tone generation control signal for controlling whether to generate the desired tone, the volume (amplitude) of the desired tone during the attack time, the sustain time of the tone, the decay speed of the tone, and so forth; 300 denotes a signal source that generates a tone source signal containing the pitch frequency corresponding to the tone selected by the tone selector 100; 400 denotes a tone generation control circuit that effects interrupting control and/or amplitude control of the tone source signal from the signal source 300 by the tone generation control signal from the tone generation operating device 200 to generate a tone signal; and 500 denotes a loudspeaker unit composed of an amplifier 501 and a loudspeaker 502.

[0016] The tone generation control circuit 400 can be formed by multiplying means that multiplies the tone source signal from the signal source 300 and the tone control signal from the tone generation operating device 200. Concretely, it can be formed using a variable gain controlled amplifier VCA.

[0017] The present invention features that the tone selector 100 and the tone generation operating device 200 are provided independently of each other as depicted in Fig. 1. This structural feature produces entirely new working-effects as will become apparent from the embodiments described below.

[0018] Figs. 2A and 2B show appearances of electronic instruments according to the present invention. Depicted in Fig. 2A is a relatively small, alto- or soprano-type electronic musical instrument. In this case, a player carries the instrument slung over his neck with a belt 5 so that he can play while walking.

[0019] Shown in Fig. 2B is a relatively large electronic musical instrument, whose weight is supported by a support rod 6. In this case, the player sits playing the instrument.

[0020] Fig. 3 illustrates the general construction of the electronic musical instrument according to the present invention. Reference numeral 17 denotes an instrument body, which is shown to be similar to that of an ordinary stringed instrument but need not always be so. Extended from the body 12 is a fingerboard 18, which may be of the same construction as that part of an ordinary stringed instrument which is called a neck. The tone selector 100 is mounted on the fingerboard 18. In the illustrated example, the tone selector 100 is made up of conductive strings 101 and conductive frets 102 arranged on the fingerboard 18.

[0021] Reference numeral 19 denotes a lever pivotally secured at one end to the body 17 about a pivot pin 19A. The lever 19 carries at the other end the tone generation operating device 200 shown in Fig. 1. About the pivot pin 19A there are provided variable resistors for volume control and for pitch bend use and for timbre control. These variable resistors are each actuated in accordance with the angle of rotation of the lever 19 as will be described later on.

[0022] The tone selector 100 is composed of the conductive strings 101 and the conductive frets 102 as referred to above. The number of conductive strings 101 is selected in the range of four to six according to the character of the musical instrument. That is, six, four strings are used for a musical instrument of the guitar family, four for the violin family, and three for a samisen or three-stringed Japanese banjo. Fig. 3 shows the case where the musical instrument of the violin family is assumed, with four strings.

[0023] The conductive strings 101 are selectively pressed against one of the conductive frets 102 to establish electric connections between them, and the tone is selected according to which of the strings 101 is pressed into contact with which of the frets 102. Accordingly, the conductive strings 101 need not be stretched with a tensile strength high enough to resonate at predetermined frequencies as in ordinary musical instruments.

[0024] Fig. 4 depicts another example of the tone selector 100, in which membrane switches 103 (switches formed by placing contacts between laminated sheets) are arranged in matrix form so that they are pressed to select a tone. Fig. 5 shows still another example of the tone selector 100, in which a resistance layer 104 is coated all over the front surface of the fingerboard 18, an insulating sheet 106 is disposed opposite the resistance layer 104 and thin, streak-like conductive layers 105 are formed on the back of the insulating sheet 106 in opposing relation to the respective strings 101. By pressing the insulating sheet 106 to bring the conductive layer 105 into contact with the resistance layer 104, a voltage signal corresponding to the position of contact therebetween is derived from the resistance layer 105 to select a tone.

[0025] At any rate, the tone is selected by a method similar to that used for ordinary stringed instruments--this enables the player to play the instrument without a sense of incongruity. While in the Fig. 3 embodiment the loudspeaker unit 500 (see Fig. 1) is built in the instrument body 17, it will easily be understood that the incorporation of the loudspeaker unit 500 in the body 17 is not essential to the present invention. The signal source 300 and the tone generation control circuit 400 shown in Fig. 1 may also be optionally built in the body 17 or provided separately thereof.

[0026] Turning next to Figs. 6 to 8, the configuration

of the tone generation operating device 200 will be described.

[0027] In Figs. 6 to 8, reference numeral 21 denotes a cover of the tone generation operating device 200; 22 denotes base for supporting respective elements of the tone generation operating device 200; 23 denotes a main lever that is a principal part of the tone generation operating device 200; and 24 denotes a quick lever characteristic of the present invention.

[0028] A description will be given first of the construction of the main lever 23. The main lever 23 is formed by a plate-like member substantially rectangular in plane configuration, which is coupled at one end to the base 22 through a plate spring 231 so that the other end portion of the main lever 23 is pretensioned upward by the biasing force of the plate spring 22. The upward tension is received by a pad 226 (Fig. 7) mounted on the underside of the base 22 and an end plate 232a of an inverted T-section lever stopper 232 secured to the underside of the main lever 23 and extended downward through a through hole 22H made in the base 22, by which the main lever is held in a predetermined position. Incidentally, the pad 226 is formed by a cushion material attached to a plate spring 225 that supports a strain sensor 227 or shock sensor 227' described later on--this is intended to prevent the lever stopper 232 from making direct contact with the plate spring 225. Further, a pad 226 of a cushion material is also interposed between the plate spring 225 and the base 22 to prevent the plate spring 225 from making direct contact with the base 22.

[0029] On the other hand, the end plate 232a of the lever stopper 232 is extended to the side opposite the pad 226 to form an actuator of a first sensor 223 mounted on the underside of the base 22. The first sensor 223 is formed by an optical distance measuring device (a photo interrupter) composed of a light emitting element and a light receiving element. The first sensor 223 measures the time from the instant the light emitted from the light emitting element is reflected by the end plate 232a of the lever stopper 232 to the instant the reflected light reaches the light receiving element, and generates a voltage signal of a value proportional to the amount of depression of the main lever 23. Reference numeral 221 denotes a cushion made of rubber which receives the main lever 23 when it is depressed.

[0030] Reference numeral 228 denotes a speed sensor for sensing the speed of depression of the main lever 23, which has a normally closed contact and a normally open contact. Upon depression of the main lever 23, the normally closed contact turns OFF (open) and then the normally open contact turns OFF (closed); the speed sensor 228 measures the time from the timing of generation of the OFF signal to the timing of generation of the ON signal and outputs a voltage corresponding to the time length thus measured.

[0031] On the operating surface of the main lever 23 there is provided a first touch sensor 234, which is an electrode formed by a conductive plate or plated layer of a conductive material. The instant a finger of the player touches the conductive layer, the touch sensor 234 senses a change in noise by the player or in the electrostatic capacity of the main lever 23, thereby detecting the contact of the player's finger with the main lever 23.

[0032] On the end face of the base 22 projecting outwardly of the free end portion of the main lever 23 there is mounted a second touch sensor 229. The second touch sensor 229 may also be an electrode formed by a conductive plate or plated layer of a conductive material. The second touch sensor 229 senses the contact therewith of the player's finger by, for example, an increase in noise or a change in the electrostatic capacity of the sensor 229 itself, and measures the time from the instant the player's finger moves off the first touch sensor 234 to the instant the finger touches the second touch sensor 229, generating a voltage signal of a value that is in inverse proportion to the time measured. That is, the value of the voltage signal increases with a decrease in the time during which the player's finger moves from the first touch sensor 234 to the second touch sensor 229. Since the speed sensor 228 and the first sensor 223 are well known, no further description will be given of their construction.

[0033] Next, a description will be given of the construction of the quick lever 24 characteristic of the present invention. While in the Fig. 6 embodiment two quick levers 24A and 24B are mounted on one main lever 23, the number of quick levers is not limited specifically to two but may be one or three as well. The following description will be made of the example that uses two quick levers 24A and 24B mounted on one main lever 23.

[0034] The quick levers 24A and 24B are each made smaller than the main lever 23 and lightweight so that they can respond to high-sped playing operations. The quick levers 24A and 24B have their rear end portions secured to one end portion of a plate spring 241, which has its other end portion is secured to the rear end portion of the main lever with a spacer 242 interposed therebetween so that the quick levers 24A and 24B are held above the top of the main lever 23 with their free end portions upwardly raised by the spring force of the plate spring 241. At the same time, an L-section lever stopper 243, which projects downwardly from the underside of the free end of each of the quick levers 24A and 24B and passes through a through hole 23H bored through the main lever 23, abuts against and hence is stopped by a stopper 245 mounted on the underside of the main lever 23 (Fig. 7), by which each of the quick levers 24A and 24B is positioned at a standstill. Reference numeral 244 denotes a pad formed by a cushion material on the top of the main lever 23, for receiving each of the quick levers 24A and 24B when it is pressed.

[0035] A second sensor 246 is mounted on the underside of the main lever 23 in opposing relation to the bend of the L-shaped lever stopper 243. As is the case with the afore-mentioned first sensor 223, the second sensor

246 can also be formed by an optical distance measuring device (a photo interrupter), which generates a voltage signal proportional to the amount of depression of each of the quick levers 24A and 24B.

[0036] Next, a description will be given of configurational or structural features of the main lever 23 and the quick levers 24A and 24B. The main lever 23 features a raised rib or ridge 233 provided on its operating surface (on which the first touch sensor 234 is provided) substantially centrally thereof in its widthwise direction. In the Fig. 6 example, the operating surface of the main lever 23 is gradually sloped or raised from its both longer marginal edges towards the center of the operating surface in its widthwise direction to form the ridge 233. Plural main levers 23 each having the ridge 233 are arranged side by side, by which plural sawtooth projections and depressions can be formed in the direction of arrangement of the main levers 23. By sliding player's fingers in the direction of arrangement of the projections and depressions, the player can press the man levers 23 in his desired order. This allows ease in playing arpeggio.

[0037] On the top of each of the quick levers 24A and 24B there are formed plural projections and depressions arranged lengthwise thereof. These projections and depressions may preferably be formed sawtooth--this enhances operability. By sliding the player's fingers in the direction of arrangement of the projections and depressions (indicated by the arrow B in Fig. 7), the quick levers 24A and 24B can be moved up and down at high speed. Accordingly, the same tone can easily be generated repeatedly. Further, by alternately actuating the two quick levers 24A and 24B with two fingers (through utilization of the projections and depressions), the same tone can be repeatedly generated at so high a speed as not to be achievable with conventional keyboard musical instruments.

[0038] Fig. 8 shows the external structure of an example of the tone generation operating device 200 provided with four sets of the main lever 23 and the quick levers 24A and 24B. With the provision of the four sets of the main lever 23 and the quick levers 24A and 24B, it is possible to generate four tones at the same time. These tones are completely synchronized with the movements of player's fingers; theoretically, the tones can be generated without delay.

[0039] Fig. 9 illustrates the electrical circuitry of the afore-mentioned four-channel type electronic musical instrument. Based on the tones selected by the tone selectors 100, for example, voltage-controlled oscillators, which form signal sources 310A, 310B, 310C and 310D, each generate a tone source signal containing a pitch frequency corresponding to the selected tone. In the channel with the string 101 not pressed against the fret 102, a signal of a tone corresponding to an open string is generated.

[0040] A control signal from the tone selector 100, for determining each tone, is applied to the signal source 300 and converted by, for example, a voltage-controlled oscillator VCO forming the signal source 300, into a tone source signal of a desired timbre containing the pitch frequency of the tone selected by the tone selector 100. The tone source signal generated by the signal source 300 is input to a signal input terminal of, for example, a variable gain controlled amplifier VCA forming the tone generation control circuit 400. A tone generation control signal from the tone generation operating device 200 is input to a gain control terminal of each variable gain controlled amplifier VCA, wherein the tone source signal is gain-controlled (multiplied) by the tone generation control signal to generate a tone or musical signal.

[0041] Accordingly, even if the tone source signal containing the pitch frequency of the selected tone is applied from the signal source 300 to the signal input terminal of each variable gain controlled amplifier VCA, the tone generation control circuit 400 does not output the tone source signal unless the tone generation control signal is input thereto from the tone generation operating device 200; namely, a tone is generated only when the main lever 23 or quick levers24A and 24B forming the tone generation operating device 200 are pressed. This tone generation control will hereinafter be referred to as first tone generation control.

[0042] As will be seen from Fig. 9, the string 101, which forms each tone selector 100, and the main lever 23, which forms each tone generation operating device 200, are operatively associated with one of the channels. By depressing the main lever 23 or quick levers 24A and 24B of the same channel as the string of the selected string, it is possible to generate the selected tone.

[0043] In Fig. 9, reference numeral 900 denotes an output control unit. The output control unit 900 mixes tone signals output from the variable gain controlled amplifiers VCA forming the tone generation control circuits 400, and provides the mixed signal to the loudspeaker unit 500. Variable resistors 601, 602 and 603 provided on the lever 10 at its pivotal mounting point 9A as referred to previously with reference to Fig. 3 are connected to the output control unit 100. By actuating these variable resistors 601, 602 and 603 in accordance with the angle of rotation of the lever 19, it is possible to produce effects such as control of the level of the signal to be sent to the loudspeaker unit 500, shifting its frequency to conduct pitch-bend performance and timbre control. In this instance, the variable resistors 601, 602 and 603 can each be actuated in distinction from the others as described below. When turning the lever 19 in parallel to the body 17 without applying any force to the lever 19 in the thickwise direction of the body 17, only the variable resistor 601 is driven to effect volume control. When the lever 19 is turned while being somewhat pressed forwardly of the player, only the variable resistor 602 for pitch bend use is driven. When the lever 19 is turned while being pressed more forward, only the variable resistor 603 for timbre control is driven. Such sound effect

control by the lever 19 will hereinafter be referred to as second tone generation control.

[0044] Incidentally, the sensors for sensing the amount of operation are not limited specifically to the variable resistors 601, 602 and 603 shown in Fig. 9 but may be sensors for sending the speed of rotation, angular velocity or acceleration of the lever 19. Output signals from these variable resistors are used to effect control for crescendo, descrescendo, sforzando, bright, mellow and the like, thereby achieving richly expressive performance.

[0045] The configuration of the electronic musical instrument according to the present invention will be understood from the above. Next, a description will be given of embodiments for realizing various methods of performance made possible by the present invention.

(A) Quick passage

[0046] According to the present invention, since the quick levers 24A and 24B, small-sized but operable at high speed, are mounted on the main lever 23, it is possible to play a quick passage with a low sound.

[0047] Fig. 10 depicts a circuit configuration for achieving the performance. A tone source signal SA-1 (Fig. 11A) of a fixed amplitude, which contains the pitch frequency specified by the operation of the tone selector 200, is output from a voltage-controlled oscillator VCO operating as the signal source 300, and the tone source signal SA-1 of the fixed amplitude is applied, for example, to a signal input terminal of a variable gain controlled amplifier VCA acting as the tone generation control circuit 400.

[0048] The pitch frequency of the tone source signal of the fixed amplitude, which is output from the signal source 300, corresponds to the tone selected by the tone selector 100. To play a quick passage, the quick lever 24 is used. Even if one quick lever is repeatedly manipulated with the same finger (refer to the arrow A in Fig. 7), it quickly responds, permitting performance of a quick passage. The output signal from the tone generation operating device 200 is a multiplied output SD-1 (see Fig. 11D) from a multiplier 250 by which an output signal SB-1 (see Fig. 11B) from the second sensor 246 having detected the amount of depression of the quick lever 24 is multiplied by an output signal SC-1 (see Fig. 11C) from the first sensor 223 having detected the amount of depression of the main lever 23. Accordingly, the amplitude of the multiplied output signal SD-1 is in proportion as well to the force having depressed the main lever 23.

[0049] That is, by setting the spring force F1 of the plate spring 231 supporting the main lever 23 and the spring force F2 of the plate spring 241 supporting the quick lever 24 so that they bear the relationship F1>F2, the quick lever 24 can be manipulated at high speed with a small amount of force. In addition, since the quick lever 24 is pressed with a small amount of force, the amount of depression of the main lever 23 can be made very small. As a result, the amplitude of the multiplied output signal SD-1 from the amplifier 250 decreases accordingly. By applying the multiplied output signal DS-1 sa a tone generation control signal to the tone generation control circuit 400, the amplitude of its output tone source signal SE-1 (see Fig. 11E) also decreases. Accordingly, a quick passage can be played pianissimo.

[0050] Further, according to the illustrated configuration, as the quick lever 24 is pressed increasingly harder, the main lever 23 is also depressed increasingly deeper and the amplitude of the multiplied output signal SD-1 also gradually larger, permitting richly expressive performance.

(B) Slur and Legato

[0051] In the conventional electronic keyboard musical instrument, tone sources corresponding to respective tones are provided, and a signal from the selected tone signal source is given a tone-generation waveform envelope specific to the selected musical instrument. With such a configuration, an attack of the tone defined by the tone-generation waveform envelope occurs upon each key depression, making it difficult to play slur and legato in the same manner as the piano, for instance. Through utilization of the output signal from the first touch sensor 234 mounted on the main lever 23, the present invention allows ease in playing slur and legato which is difficult to achieve with the conventional electronic instrument.

[0052] Fig. 12 shows the circuit configuration for playing slur and legato. Assume that the selected tone be that corresponding to the channel of the tone selector 100. In the tone generation operating device 200, upon pressing the main lever 23 corresponding to the channel in which the tone is being selected by the tone selector 100, the first touch sensor 234 senses the contact therewith of the main lever 23 and the sensed signal SF-2 is provided to a multiplier 251. Simultaneously with this, a signal SC-2 proportional to the amount of depression of the main lever 23 is provided from the first touch sensor 234 to the multiplier 251, from which a multiplied signal SD-2 of the signals SC-2 and SF-2 is output as a tone generation control signal from the tone generation operating device 200.

[0053] Since the output signal SF-2 from the first touch sensor 234 is held at a fixed level, for example, at the "1" logic level while the player's finger is in contact with the main lever 23, the multiplied output signal SD-2 becomes a voltage signal proportional to the amount of depression of the main lever 23. Accordingly, the tone generation control circuit 400 outputs the signal fed from the tone source (VCO) with an amplitude corresponding to the amount of depression of the main lever 23. By changing the tone in the tone selector 100 in the same channel simultaneously with the above, the tone is changed continuously, and hence slur and legato can

be played.

(C) Detache

[0054] Fig. 13 shows the circuit configuration for playing detache. In this case, the output signal from the speed sensor 228, which senses the speed of depression of the main lever 23, is input to an envelope generator 252, from which is provided a tone generation waveform envelope signal of an attack amplitude proportional to the speed of the depression of the main lever 23. That is, the speed sensor 228 outputs a voltage signal of the amplitude proportional to the speed of depression of the main lever 23 or the corresponding digital value, and the envelope generator 252 outputs a tone generation waveform envelope signal that has an attack amplitude (amplitude during attack) proportional to the value of the input signal to the envelope generator 252. The tone generation waveform envelope is specific to each musical instrument and is generally expressed by attack, decay, sustain and release portions that continue on the time axis. After the attack the envelope varies in accordance with characteristics preset in the envelope generator 252.

[0055] On release of the main lever 23, the output signal from the first touch sensor 234 goes zero, and consequently, the output signal from the tone generation operating device 200 abruptly goes zero at that time even if the envelope generator 252 is outputting an envelope waveform. As a result, the output signal from the tone generation control circuit 400 turns OFF. That is, since the tone can be silenced by moving the player's finger off the first touch sensor 234 of the main lever 23, it is possible to play detache.

(D) Grace and trill

[0056] This performance can be achieved by the circuit configuration depicted in Fig. 10. That is, by depressing the quick lever 24, the main lever 23 is also depressed. The first sensor 223 provides a voltage signal proportional to the amount of the depression of the main lever 23. At the same time, since the quick lever 24 is also being depressed, the second sensor 246 also produces an output signal. Accordingly, the multiplier 250 multiples the both the output signals from the both sensors and provides the multiplied output signal SD-1, which is applied to the tone generation control circuit 400 to control it, outputting therefhrough the tone source signal from the VCO 300 corresponding to the tone selected by the tone selector 100.

[0057] By switching the tone selection on the corresponding string by the tone selector 100 in this state, it is possible to play grace and trill. The grace and trill that can be played in this case are the grace and trill of the same speed and of the same quality as those played by the actual wind and stringed instruments.

(E) Staccato in a pianissimo manner

[0058] This performance can be achieved by the same circuit configuration as that shown in Fig. 12. That is, the output signal from the first touch sensor 234 is a "0" or "1" logic signal, by which the multiplier 251 is ON-OFF controlled to permit or inhibit the passage therethrough of the signal from the first sensor 223 that has sensed the amount of depression of the main lever 23. This enable On-OFF control of the amplitude control signal to be applied to the tone generation control circuit 400; hence, by intermittently contacting the player's finger the first touch sensor 234, the signal that is generated by the signal source 300 in the tone selected by the tone selector 100 can be interrupted at high speed. In this instance, if the main lever 23 is not greatly depressed, it is possible to perform staccato in a pianissimo manner.

(F) Silence control during lever OFF state

[0059] Fig. 14 shows the circuit configuration for effecting control during the lever OFF duration. In this case, the envelope generator 227, the multiplier 253, an inverting amplifier 254, the strain sensor 227 and the speed sensor 228 are used. As shown in Fig. 7, when the main lever 23 is depressed to the position where the end plate 232a of the lever stopper 232 is farthest from the base 22, free end of the plate spring 225 fixed at one end to the base 22 is at a distance from the pad 224 on the base 22. On release of the main lever 223, the spring force of the spring 231 overcomes the spring force of the plate spring 225, allowing the plate spring 225 to be pressed against the pad 224 by the end plate 232a.

[0060] The plate-like strain sensor 227 is passed on a gently curved portion adjacent the fixed end portion of the plate spring 225. With the plate spring 225 pressed against the pad 224, the internal strain of the strain sensor 227 is at a maximum, and consequently, its output voltage is also at a maximum. When the main lever 23 is pressed and the plate spring 225 is released from the pressure toward the pad 224, the internal strain of the strain sensor 227 is at a minimum and its output voltage is also minimized.

[0061] When the main lever 23 is not depressed, the output voltage from the strain sensor 227 is at a maximum, and a difference voltage ΔS between the output voltage and a reference voltage E is detected by the inverting amplifier 255 and applied to the multiplier 253. The reference voltage E is preset so that the difference voltage ΔS becomes approximately zero. Upon depressing the main lever 23 in this state, the speed of depression is sensed by the speed sensor 228, from which is output a voltage signal proportional to the speed of depression, and the voltage signal is provided to the envelope generator 252. The envelope generator 252 generates an envelope having an attack approximately proportional to the speed of depression, and pro-

vides the envelope to the multiplier 253.

[0062] On the other hand, the output voltage from the strain sensor 227 is attenuated by the depression of the main lever 23, while at the same time the output voltage ΔS from the inverting amplifier 255 becomes maximized. The multiplier 253 calculates the product of the voltage ΔS and the envelope, and outputs the multiplied output. On release of the main lever 23 during the envelope output period, the plate spring 225 is pressed by the end plate 232a and the strain increases; as a result, the difference voltage ΔS attenuates down to its minimum value and the multiplier outputs also attenuates accordingly. That is, the tone silence operation is carried out. Since attenuation speed of the output voltage from the strain sensor 227 depends on the strain attenuation speed of the strain sensor 227, the tone silencing operation can be performed quickly or slowly by releasing the main lever 23 quickly or slowly.

[0063] The above description has been given of the embodiments of the present invention that realize the styles of performance possible with the actual musical instruments by impossible with the prior art electronic keyboard instruments. The following description will be given of entirely novel styles of rendition that can be realized by the present invention.

(G) Repeated generation of the same tone

[0064] Fig. 15 shows the circuit configuration for this purpose. In this instance, the outputs from two second sensors 246A and 246B, which sense the amounts of depression of the main lever 23 and the two quick levers 24A and 24B, are added together by an adder 245, and the added output is applied to the multiplier 253. To the other input terminal of the multiplier 253 is provided the output from the first sensor that senses the amount of depression of the main lever 23. By repeating alternate depression of the two quick levers 24A and 24B mounted above the same main lever 23, the same tone can be generated repeatedly at the speed twice higher than that of the piano at the lowest, in practice, at the speed twice to four times higher.

(H) Repeated generation of the same tone at ultra-high speed

[0065] This also uses the Fig. 15 circuitry and utilizes the projections and depressions formed in the surface of the quick lever 24. By sliding the player's finger on the quick lever 24 in the direction of arrangement of the projections and depressions, the quick lever 24 moves up and down as the finger slides on the projections and depressions. The speed of repeating the up and down movements of the quick lever 24 can be controlled by the finger sliding speed; high-speed ON-OFF signals can be generated by quickly sliding the finger. In particular, by sliding two fingers over the two quick levers 24A and 24B alternately with each other, the same tone can be generated repeatedly at ultra-high speed. This speed is quite impossible to realize in the prior art.

(I) Percussive

[0066] Fig. 16 shows the circuit configuration necessary for percussive performance. In this case, the first touch sensor 234, the impact sensor 224' and the second touch sensor 229 are used. The output signal from the first touch sensor 234 is polarity inverted by an inverter 255', from which the inverted signal is input to the one input terminal of the multiplier 253. The output signal from the impact sensor 227' is applied to the envelope generator 256, whose output is provided to the other input terminal of the multiplier 253.

[0067] The output signal from the second touch sensor 229 is provided via an inverter 257 to the one input terminal of a multiplier 258, which is supplied at its other input terminal with the output signal from the multiplier 253.

[0068] With such an arrangement, when the player's finger is in touch with the main lever 23, the multiplier 253 is held closed by the inverter 255, and when the finger is slipped away from the first touch sensor 234 at the free end of the main lever 23, an output is derived from the impact sensor 227' by the return motion of the main lever 23, and the envelope generator 256 responds to the output from the impact sensor 257' to generate the tone generation waveform envelope corresponding to the desired musical instrument, the envelope being provided to the multiplier 253. At this time, since the first touch sensor 234 is already released, the inverter 255' outputs a "1," which is applied to the multiplier 253 to hold it open. Accordingly, the signal from the envelope generator 256 passes intact through the multiplier 253 and is input to the multiplier 258.

[0069] On the other hand, the second touch sensor 229 is placed on the base 22 just at the position where it is hit by the player's finger slipped away from the main lever 23 in the direction of the arrow C in Figs. 6 and 7. Accordingly, until the finger comes into touch with the second touch sensor 229 after slipping away from the main lever 23, the second touch sensor 229 outputs a "0" signal and the multiplier 258 is held open by the output "1" from the inverter 257. Accordingly, the output signal from the envelope generator 256 is applied intact to the signal source (VC) 300 to generate a tone. However, since the output from the second touch sensor 229 goes to "1" at the instant the finger comes into contact with the second touch sensor 229, the output from the multiplier 258 is cut off in the course of attenuation by the output "0"from the inverter 257. That is, the tone is damped out during attenuation. Accordingly, it is possible to achieve various damping of the tone during attenuation by changing the way of controlling the second touch sensor 229.

[0070] The present invention is not limited specifically to the performances and effects described above but

may be applied as well to other basic performances and effects such as sostenute, marcato, crescendo and decrescendo. While in the above embodiments the signal source 300, the tone generation control circuit 400 and the loudspeaker unit 500 are all built in the body 17, they may be displaced outside the body 17. In this instance, the electronic musical instrument needs only to be equipped with the tone selector 100 and the tone generation operating device 200. With such an arrangement, it is possible to play the electronic musical instrument by use of the existing tone source unit for conventional electronic musical instruments.

[0071] Further, while in the above embodiments the small quick levers 24A and 24B are provided above one main lever 23, it is also possible to provide medium-sized lever above the main lever 23 and a small quick lever above the medium-sized lever.

EFFECT OF THE INVENTION

[0072] As described above, according to the present invention, since the tone selecting operation and the tone generating operation are carried out independently of each other, the tone generating operation can be controlled independently of the tone selecting operation. This furnishes additional freedom of performance, permitting richly expressive performance.

Claims

1. An electronic musical instrument comprising:

a body;
a tone selector provided on said body, for selecting a tone to be generated;
a signal source for generating a tone source signal containing a pitch frequency corresponding to the tone selected by said tone selector;
a tone generation operating device provided on said body, for generating a tone generation control signal for processing said tone source signal for tone generation; and
at least one tone generation control circuit for processing said tone source signal by said tone generation control signal for tone generation to generate a tone signal.

2. The electronic musical instrument of claim 1, wherein said tone selector comprises: a fingerboard supported to said body; and at least one tone selecting means disposed on said fingerboard, for outputting a select signal in response to that one of tones which is selected by a player's finger.

3. The electronic musical instrument of claim 2, wherein said tone selector is a device for effecting at least one or more of interruption control of said tone source signal, amplitude control of said tone source signal during its attack period, sustain time control of said tone source signal, amplitude control of said tone source signal in its sustain state, and its decay time control.

4. The electronic musical instrument of claim 2 or 3, wherein said tone selecting means, said signal source and said tone generation control circuit are provided for each of plural channels.

5. The electronic musical instrument of any one of claims 2, 3 and 4, further comprising: a lever pivotally secured at one end to said body and carrying at the other end said tone generation operating device; and sound effect control means for performing sound effect control for said tone signal in accordance with the rotational position of said lever/

6. The electronic musical instrument of claim 5, wherein said sound effect control means is means for performing at least one of volume control, pitch bend and timbre control.

7. The electronic musical instrument of any one of claims 2, 3, 4, 5 and 6, wherein said tone selector further comprises plural switches arranged in the form of lines on the surface of said fingerboard.

8. The electronic musical instrument of any one of claims 2, 3, 4, 5 and 6, wherein said tone selector further comprises a resistance layer disposed on the surface of said fingerboard and a conductive layer disposed opposite but closely spaced apart from said resistance layer.

9. The electronic musical instrument of any one of claims 2, 3, 4, 5 and 6, wherein said tone selector further comprises: plural conductive frets sequentially arranged on said fingerboard lengthwise thereof; and conductive strings stretched across said fingerboard in a direction at right angles to said conductive frets.

10. The electronic musical instrument of claim 2, wherein said tone generation operating device comprises:

a base attached to said body;
a rectangular, plate-like main lever secured at one end by a first spring to said base in manner to be rotatable with respect to the top of said base, the free end portion of said main lever being resiliently biased by the biasing force of said first spring;
first stopper means for limiting the rotational movement of said main lever to a predetermined angular range with respect to the top of

said base;
a quick lever rotatably supported by a second spring at one end above said main lever near its supported point, the free end portion of said quick lever being resiliently biased by the biasing force of said second spring in the same direction as said free end portion of said main lever;
second stopper means for limiting the rotational movement of said quick lever to a predetermined angular range with respect to said main lever, said quick lever being lightweight and small-sized as compared with said main lever;
a first sensor for outputting a voltage signal in proportion to the amount of depression of said main lever;
a second sensor for outputting a voltage signal in proportion to the amount of depression of said quick lever; and
tone generation control signal generating means for generating said tone generation control signal based on the output from either one of said first and second sensors.

11. The electronic musical instrument of claim 10, wherein said tone generation operating device is provided with plural sets of said quick lever and said first and second sensors.

12. The electronic musical instrument of claim 10 or 11, wherein said tone generation control signal generating means is a multiplier that multiplies the outputs from said first and second sensors and provides the multiplied output as said tone generation control signal.

13. The electronic musical instrument of any one of claims 10, 11 and 12, wherein: said tone generation operating device further comprises a touch sensor mounted on said main lever, for sensing contact with said main lever; and said tone generation control signal generating means is a multiplier that outputs the result of multiplication of outputs from said touch sensor and said first sensor as said tone generation control signal.

14. The electronic musical instrument of any one of claims 10, 11, 12 and 13, wherein: a plurality of said quick levers are rotatably secured by a plurality of second springs above said main lever; said tone generation operating device includes a plurality of said second sensors for generating voltage signals in proportion to the amounts of depression of said plurality of quick levers, respectively, and an adder for adding together said voltage signals from said plurality of second sensors; and said tone generation control generating means outputs the result of multiplication of the output from said first sensor and the output from said adder as said tone generation control signal.

15. The electronic musical instrument of claim 2, wherein said tone generation operating device comprises:

a base attached to said body;
a rectangular, plate-like main lever secured at one end by a first spring to said base in manner to be rotatable with respect to the top of said base, the free end portion of said main lever being resiliently biased by the biasing force of said first spring;
a touch sensor mounted on said main lever, for sensing contact with said main lever;
a speed sensor for sensing the speed of depression of said main lever;
first stopper means for limiting the rotational movement of said main lever to a predetermined angular range with respect to the top of said base;
a quick lever rotatably supported by a second spring at one end above said main lever near its supported point, the free end portion of said quick lever being resiliently biased by the biasing force of said second spring in the same direction as said free end portion of said main lever;
second stopper means for limiting the rotational movement of said quick lever to a predetermined angular range with respect to said main lever, said quick lever being lightweight and small-sized as compared with said main lever; and
tone generation control signal generating means for generating said tone generation control signal based on the outputs from said touch sensor and said speed sensor.

16. The electronic musical instrument of claim 2, wherein said tone generation operating device comprises:

a base attached to said body;
a rectangular, plate-like main lever secured at one end by a first spring to said base in manner to be rotatable with respect to the top of said base, the free end portion of said main lever being resiliently biased by the biasing force of said first spring;
a speed sensor for sensing the speed of depression of said main lever;
first stopper means for limiting the rotational movement of said main lever to a predetermined angular range with respect to the top of said base;
a quick lever rotatably supported by a second

spring at one end above said main lever near its supported point, the free end portion of said quick lever being resiliently biased by the biasing force of said second spring in the same direction as said free end portion of said main lever;

second stopper means for limiting the rotational movement of said quick lever to a predetermined angular range with respect to said main lever, said quick lever being lightweight and small-sized as compared with said main lever; and

a strain sensor for outputting a voltage signal in proportion to a strain produced In said strain sensor by being pressed by said first spring when said main lever returns to its initial position;

wherein said tone generation control signal generating means outputs the result of multiplication of the outputs from said speed sensor and said strain sensor as said tone generation control signal.

17. The electronic musical instrument of claim 2, wherein said tone generation operating device comprises:

a base attached to said body;

a rectangular, plate-like main lever secured at one end by a first spring to said base in manner to be rotatable with respect to the top of said base, the free end portion of said main lever being resiliently biased by the biasing force of said first spring;

first stopper means for limiting the rotational movement of said main lever to a predetermined angular range with respect to the top of said base;

a quick lever rotatably supported by a second spring at one end above said main lever near its supported point, the free end portion of said quick lever being resiliently biased by the biasing force of said second spring in the same direction as said free end portion of said main lever;

second stopper means for limiting the rotational movement of said quick lever to a predetermined angular range with respect to said main lever, said quick lever being lightweight and small-sized as compared with said main lever;

a touch sensor mounted on said quick lever, for measuring the time from the instant of removing a downward pressure applied to said main lever to the instant of applying a downward pressure to said base disposed under said main lever and for outputting a voltage signal in inverse proportion to said measured time; and

an impact sensor for outputting a voltage in proportion o an impact applied thereto by said first stopper when said main lever returns to its initial position;

wherein said tone generation control signal generating means outputs the result of multiplication of the outputs from said touch sensor and said impact sensor as said tone generation control signal.

18. The electronic musical instrument of any one of claims 10 to 17, wherein said quick lever has in its surface a plurality of projections and depressions in the lengthwise direction of said quick lever.

19. The electronic musical instrument of any one of claims 10 to 13 and 15 to 17, further comprising a plurality of said quick levers totatably disposed by a plurality of said second springs on said main lever.

20. The electronic musical instrument of any one of claims 10 to 19, wherein said main lever has a raised rib substantially at the center in the widthwise direction of said main lever.

21. A tone generation operating device for use in said electronic musical instrument of claim 1, comprising:

a rectangular, plate-like main lever secured at one end by a first spring to said base in manner to be rotatable with respect to the top of said base, the free end portion of said main lever being resiliently biased by the biasing force of said first spring, and said main lever being rotated over a predetermined angular range defined by a pair of stoppers;

a quick lever rotatably supported by a second spring at one end above said main lever near its supported point, the free end portion of said quick lever being resiliently biased by the biasing force of said second spring in the same direction as said free end portion of said main lever, and said quick lever being rotated over a predetermined angular range defined by a pair of stoppers and smaller in size than said main lever and operable at high speed;

a first sensor for outputting a voltage signal in proportion to the amount of depression of said main lever; and

a second sensor for outputting a voltage signal in proportion to the amount of depression of said quick lever.

22. The tone generation operating device of claim 21, wherein a plurality of sets of said main levers and said first and second sensors are provided.

23. The tone generation operating device of claim 21 or 22, wherein said quick lever has in its surface a plurality of projections and depressions in the lengthwise direction of said quick lever.

24. The tone generation operating device of any one of claims 21, 22 and 23, wherein a plurality of said quick levers are provided on said main lever.

25. The tone generation operating device of any one of claims 21, 22 23 and 24, wherein said main lever has a raised rib substantially at the center in the widthwise direction of said main lever.

26. The tone generation operating device of any one of claims 21, 22 23, 24 and 25, wherein the result of multiplication of outputs from said first and second sensors is used as an output signal from said tone generation operating device.

27. The tone generation operating device of any one of claims 21, 22 23, 24 and 25, further comprising a touch sensor mounted on the top of said main lever, and wherein the result of multiplication of output signals from said touch sensor and said first sensor is used as an output signal from said tone generation operating device.

28. The tone generation operating device of any one of claims 21, 22 23, 24 and 25, further comprising a speed sensor for sensing the speed of depression of said main lever and for generating a voltage signal of an amplitude proportional to said speed of depression, and a touch sensor mounted on the top of said main lever for sensing contact with said main lever, and wherein the result of multiplication of outputs from said speed sensor and said touch sensor is used as the output signal from said tone generation operating device.

29. The tone generation operating device of any one of claims 21, 22 23, 24 and 25, further comprising a speed sensor for sensing the speed of depression of said main lever and for generating a voltage signal of an amplitude proportional to said speed of depression, and a a strain sensor for outputting a voltage signal in proportion to a strain occurring in response to a return of said lain lever to its initial position, and wherein the result of multiplication of the outputs from said speed sensor and said strain sensor is used as the output signal from said tone generation operating device.

30. The tone generation operating device of any one of claims 23, 24 and 25, further comprising a plurality of second sensors mounted on said plurality of quick levers, respectively, for generating voltage signals in proportion to the amounts of depression of said plurality of said quick levers, and wherein the output result of multiplication of the result of addition of the voltage signals from said plurality of second sensors and the output from said first sensor is used as the output signal from said tone generation operating device.

31. The tone generation operating device of any one of claims 21, 22, 23, 24 and 25, further comprising: a first touch sensor mounted on the top of said main lever; an impact sensor for detecting an impact produced when said main lever returns to its initial position; and a second touch sensor for measuring the time from the instant of removing a downward pressure applied to said main lever to the instant of applying a downward pressure to said base disposed under said main lever and for outputting a voltage signal in inverse proportion to said measured time; and wherein the result of multiplication of the outputs from said first touch sensor, said second touch sensor and said impact sensor is used as the output signal from said tone generation operating device.

32. An electronic musical instrument comprising: a body; a fingerboard mounted on said body; a tone selector mounted on said fingerboard; and said tone generation operating device of claim 21.

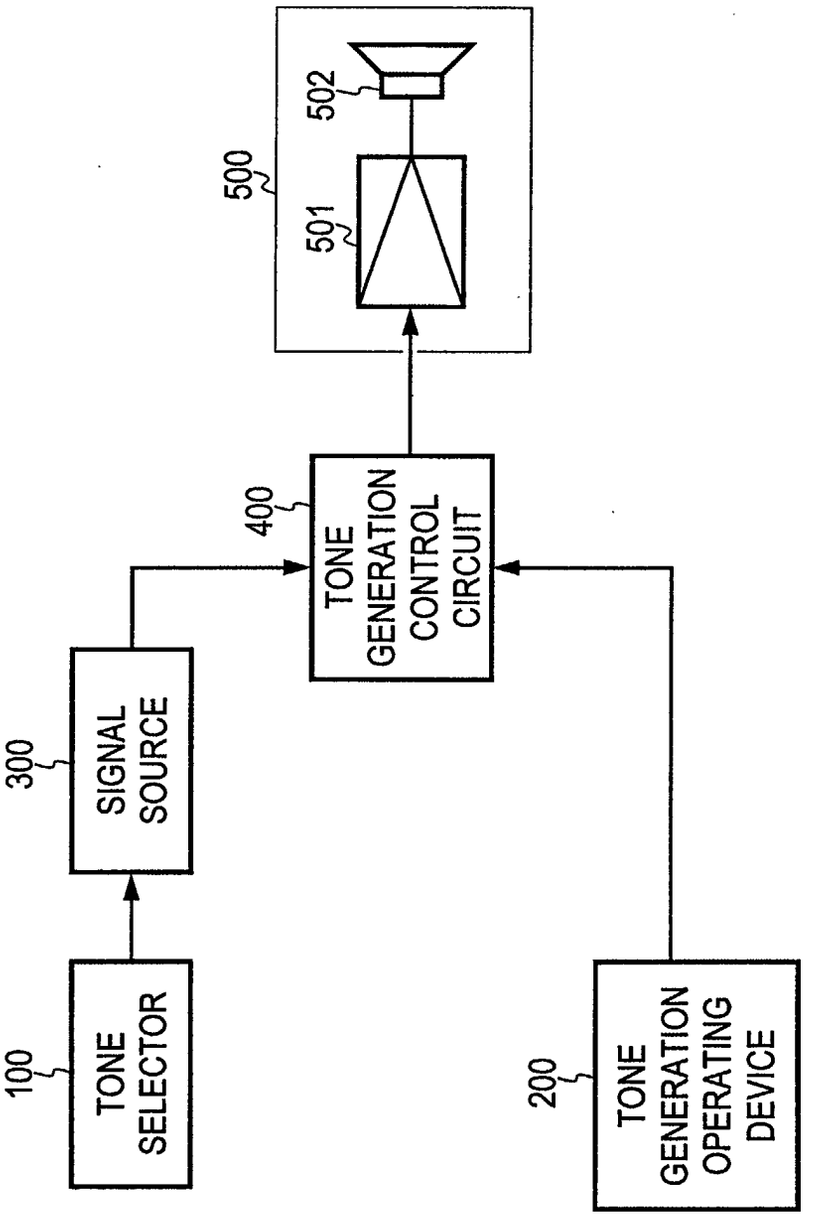

100
TONE SELECTOR
300
SIGNAL SOURCE
400
TONE GENERATION CONTROL CIRCUIT
200
TONE GENERATION OPERATING DEVICE
500
501
502

FIG. 1

FIG. 2B

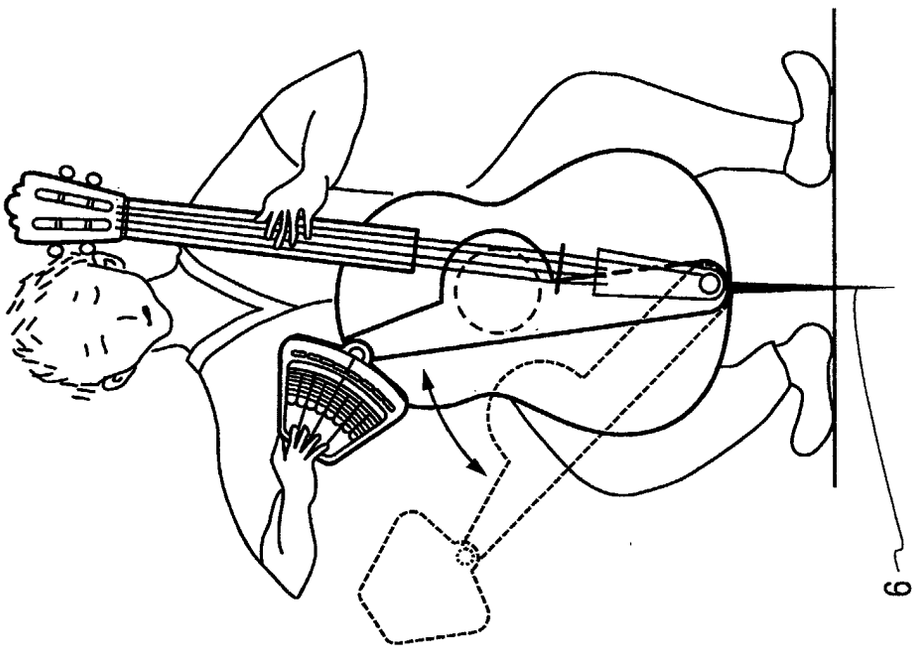


FIG. 2A

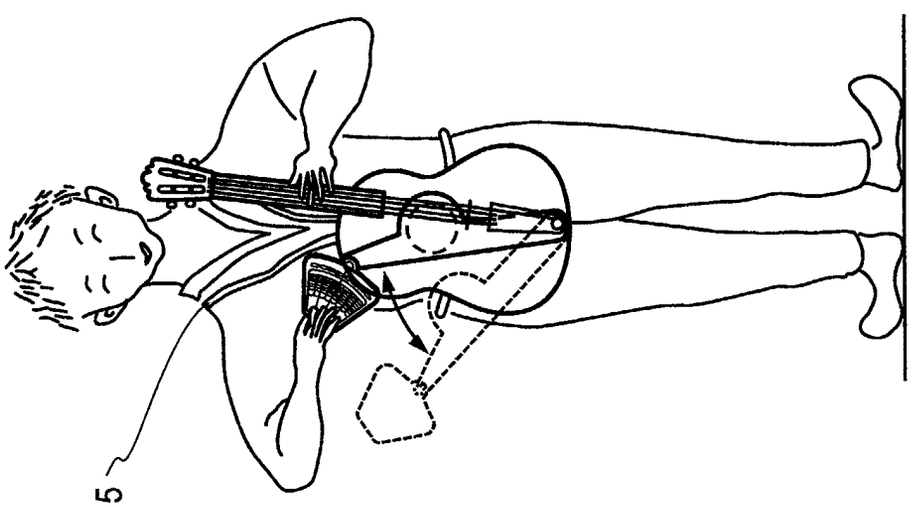


FIG. 3B

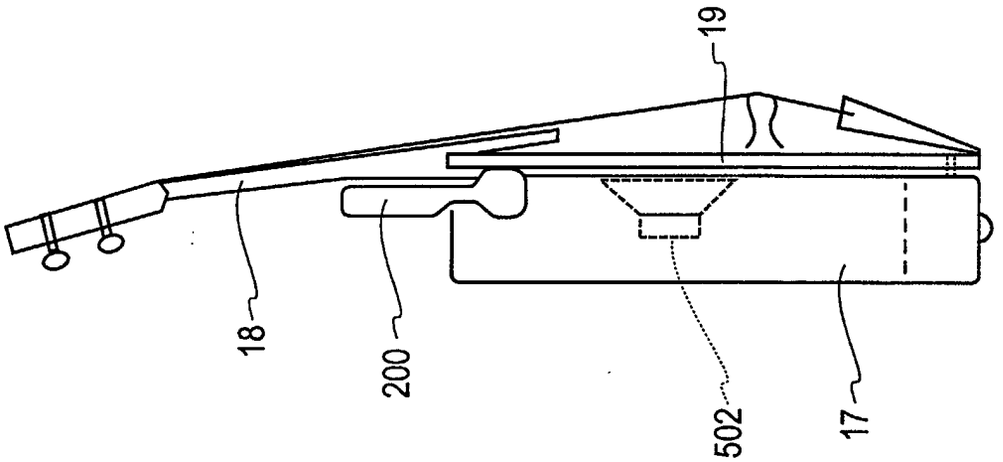


FIG. 3A

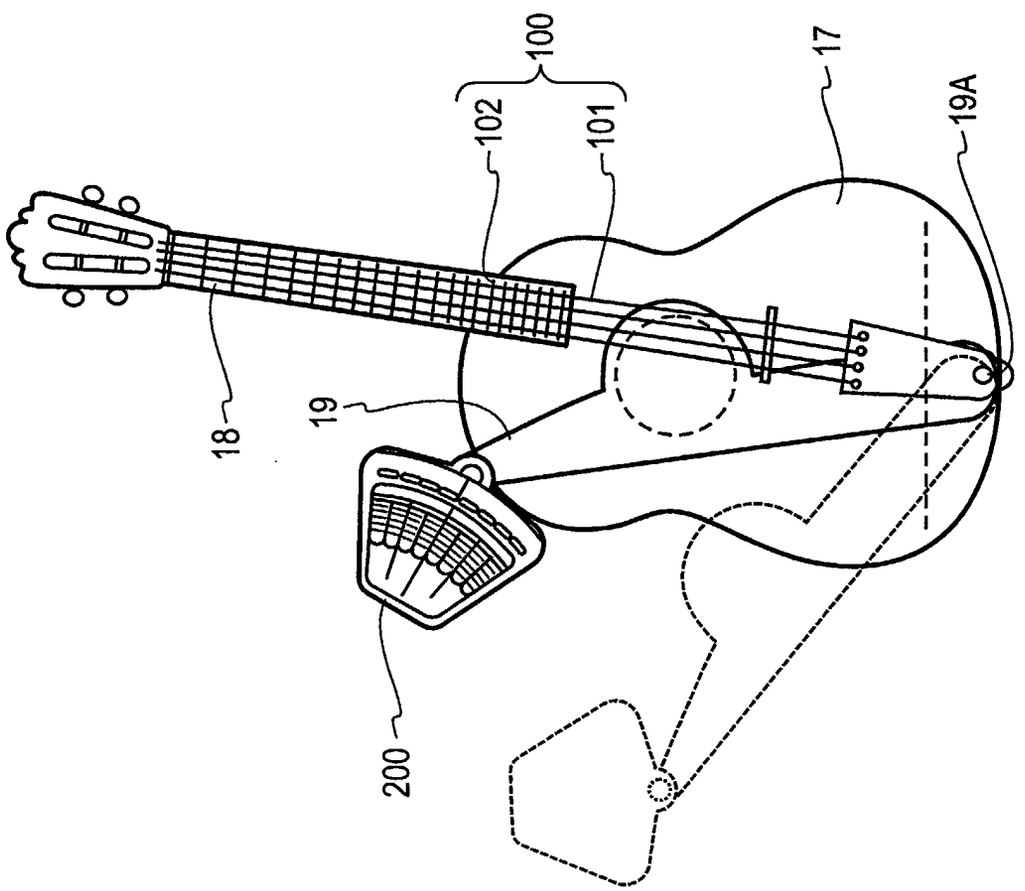


FIG. 4

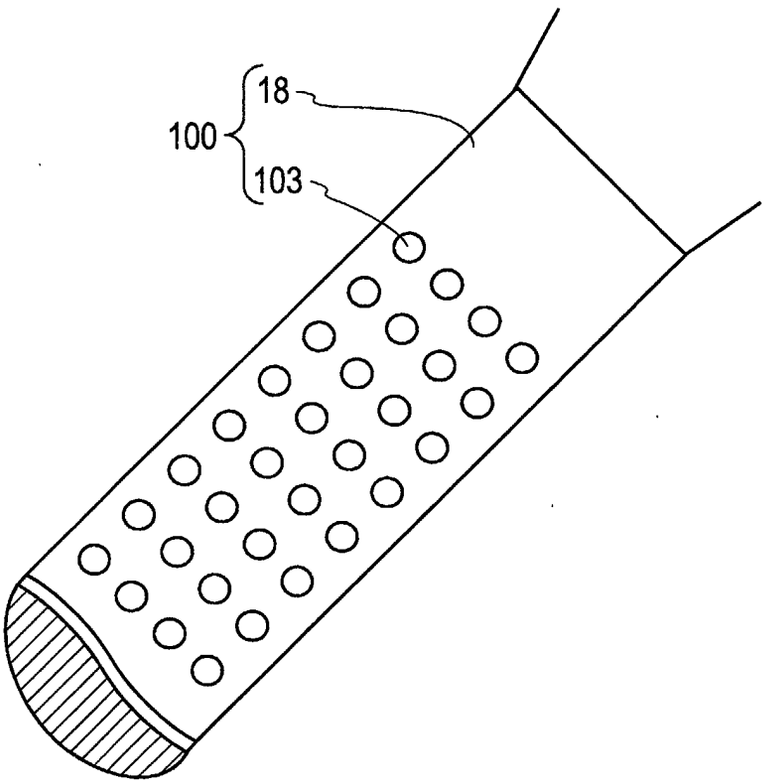


FIG. 5

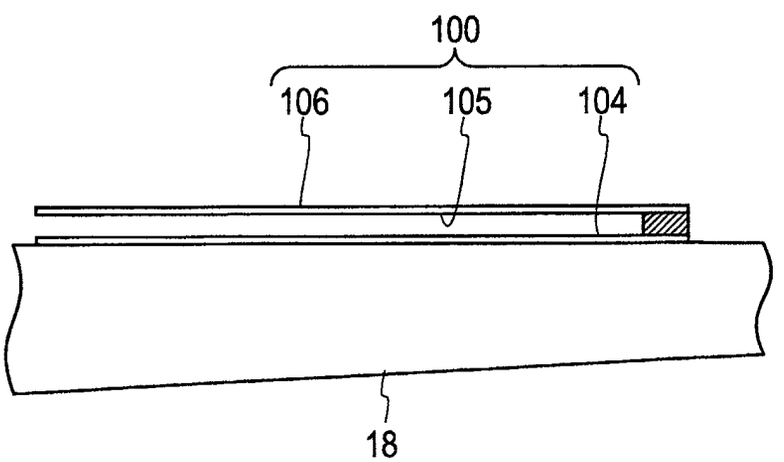


FIG. 6

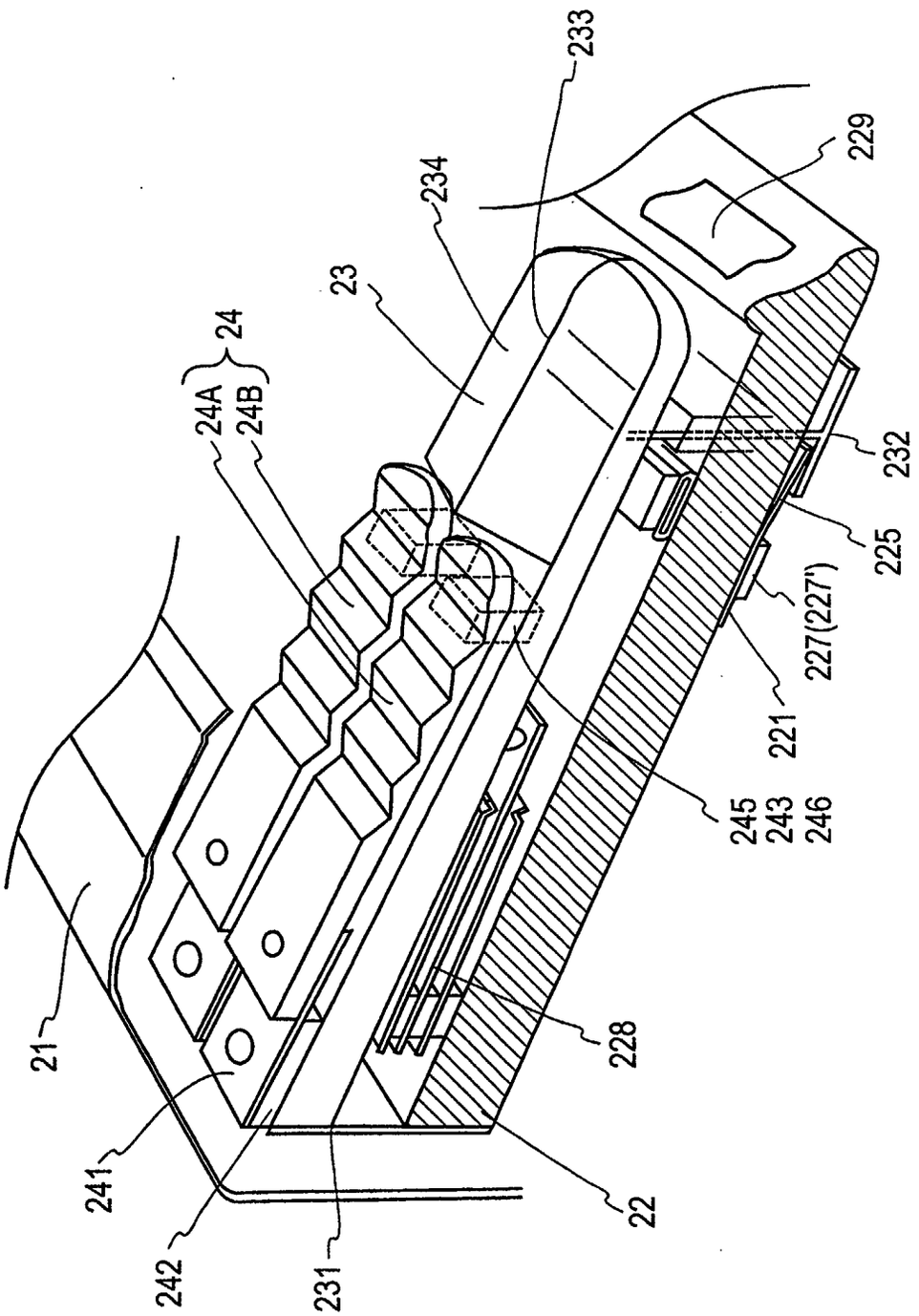

233
229
234
23
24
24A
24B
232
225
227(227')
221
245
243
246
21
228
241
242
231
22

FIG. 7

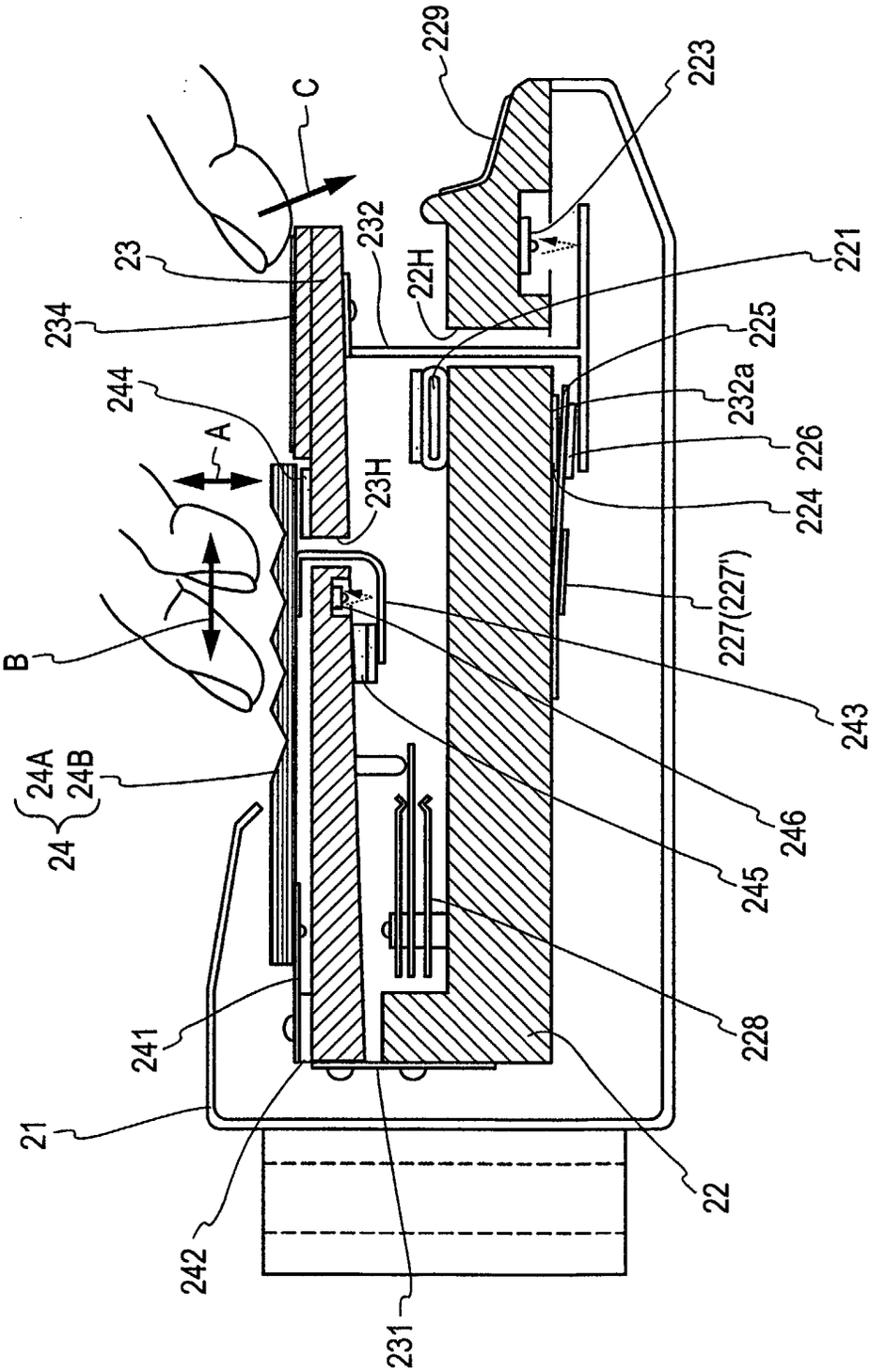

C
229
223
23
232
22H
221
234
225
244
232a
A
226
23H
224
B
227(227')
243
24A
24B
24
246
245
241
228
21
22
242
231

FIG. 8

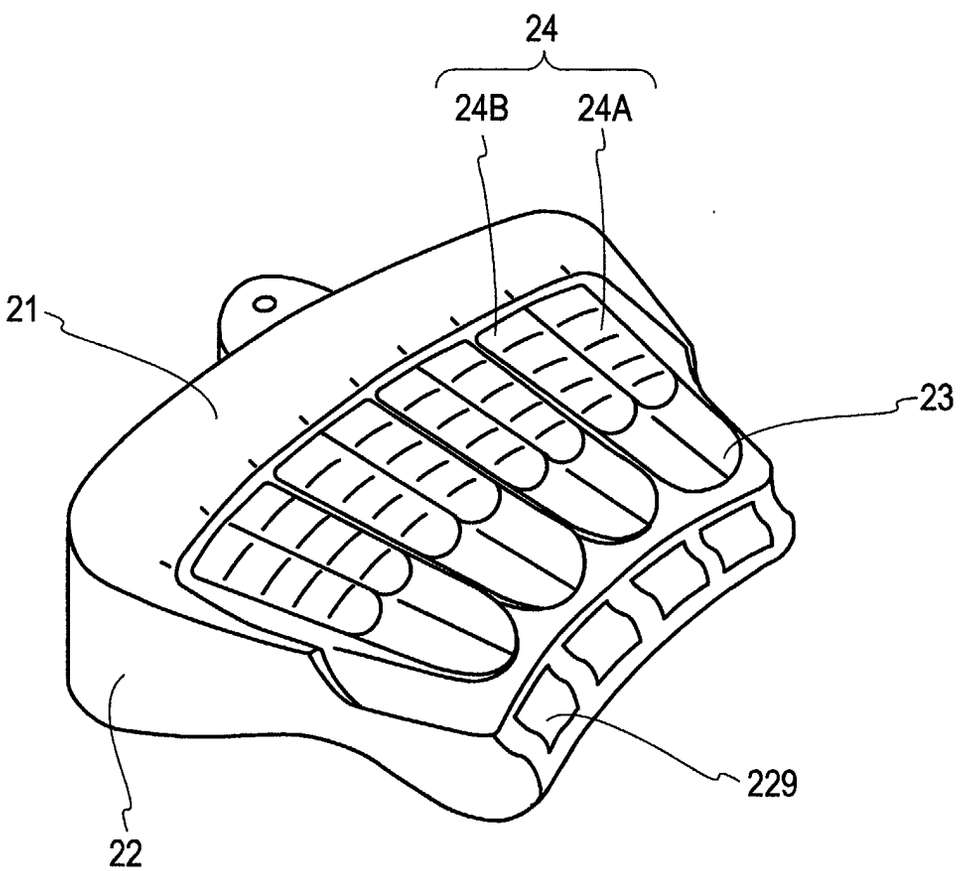


FIG. 9

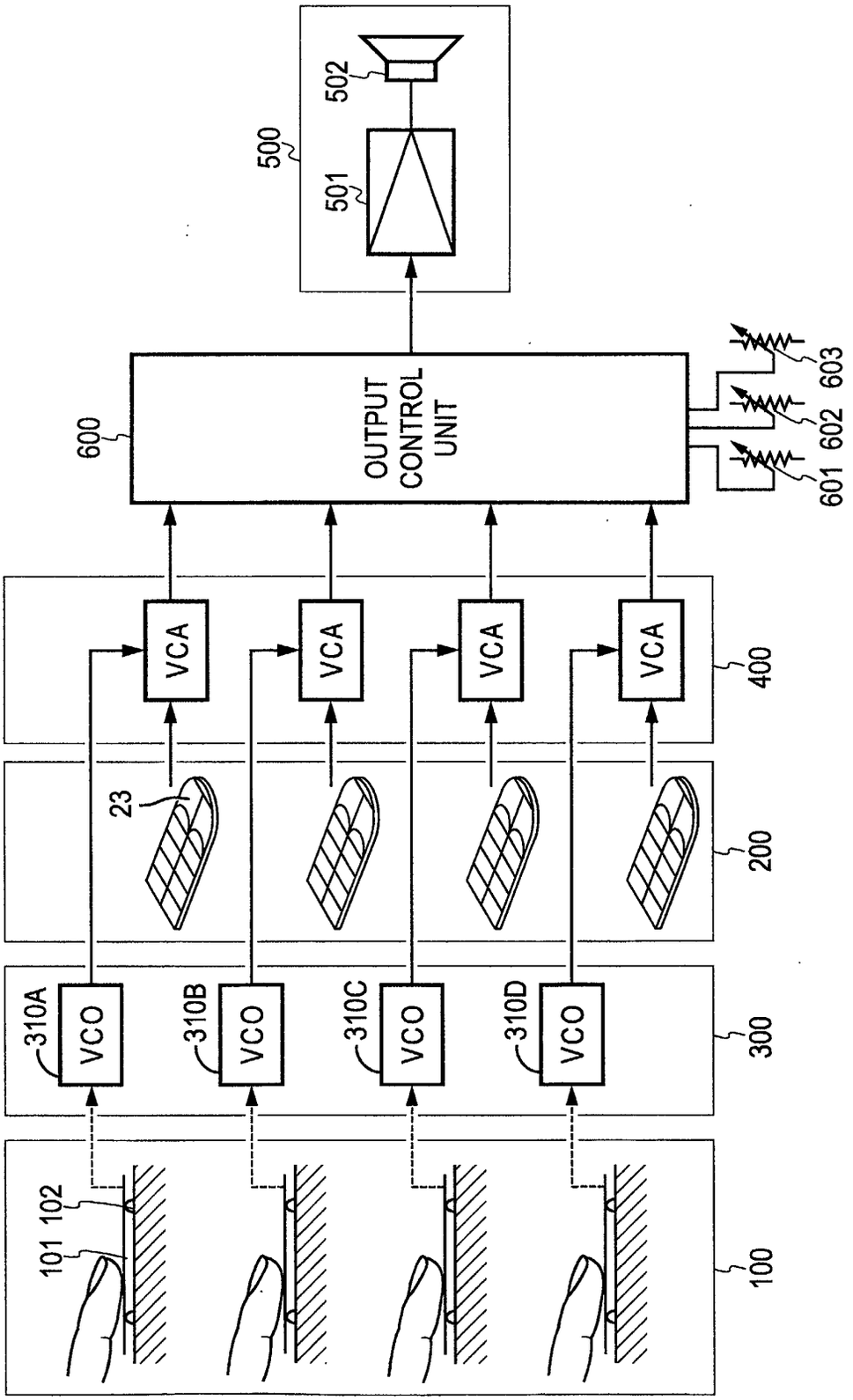

100
101
102
300
310A
VCO
310B
VCO
310C
VCO
310D
VCO
200
23
400
VCA
VCA
VCA
VCA
600
OUTPUT CONTROL UNIT
601
602
603
500
501
502

FIG. 10

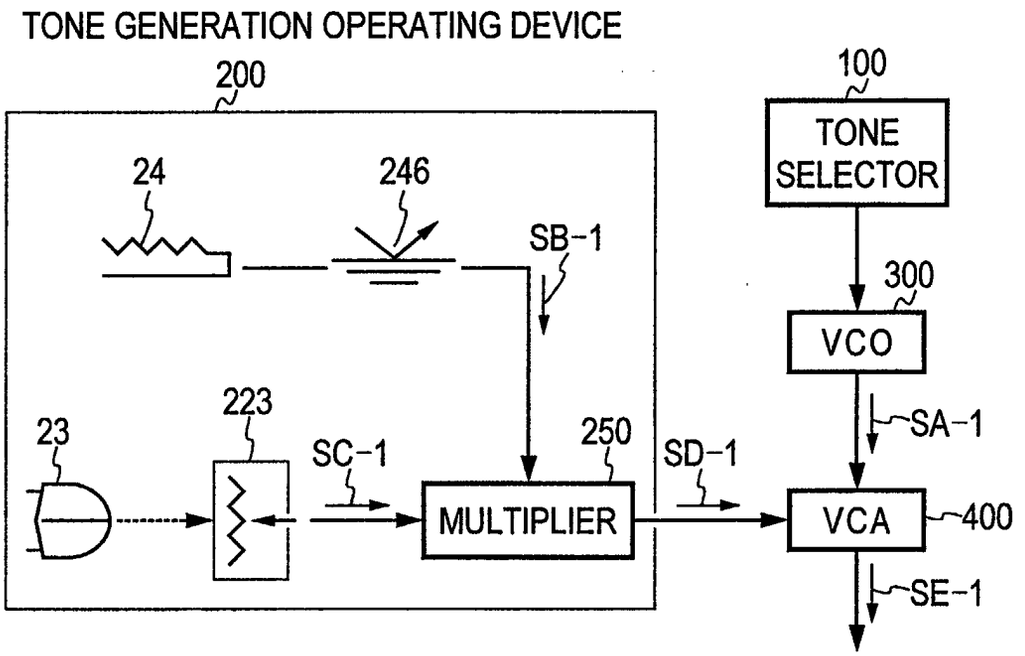

TONE GENERATION OPERATING DEVICE
200
100
TONE SELECTOR
24
246
SB-1
300
VCO
223
23
SC-1
250
SD-1
SA-1
MULTIPLIER
VCA
400
SE-1

FIG. 11

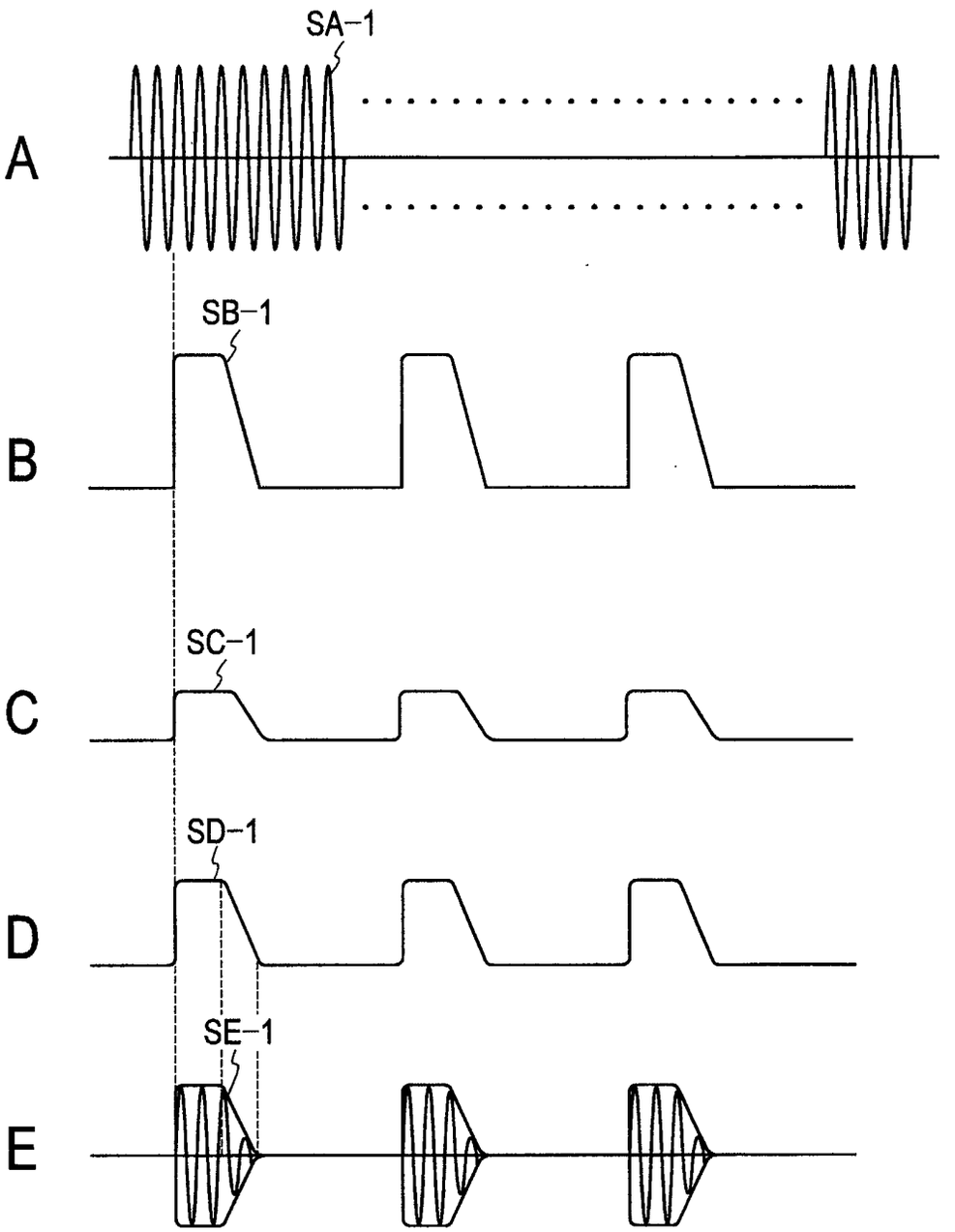


FIG. 12

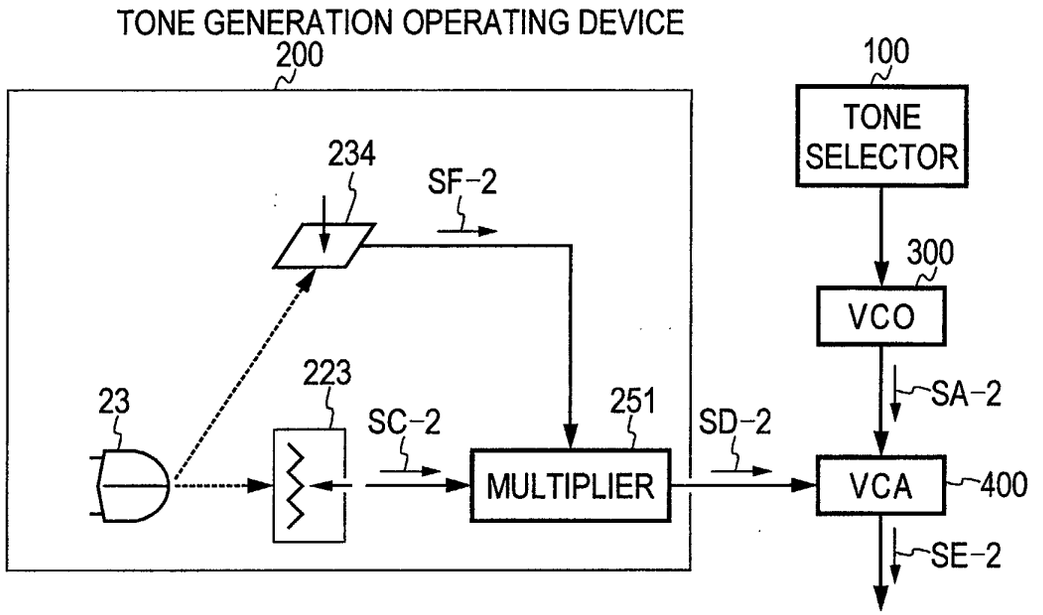

TONE GENERATION OPERATING DEVICE
200
100
TONE SELECTOR
234
SF-2
300
VCO
223
23
SC-2
251
SD-2
SA-2
MULTIPLIER
VCA
400
SE-2

FIG. 13

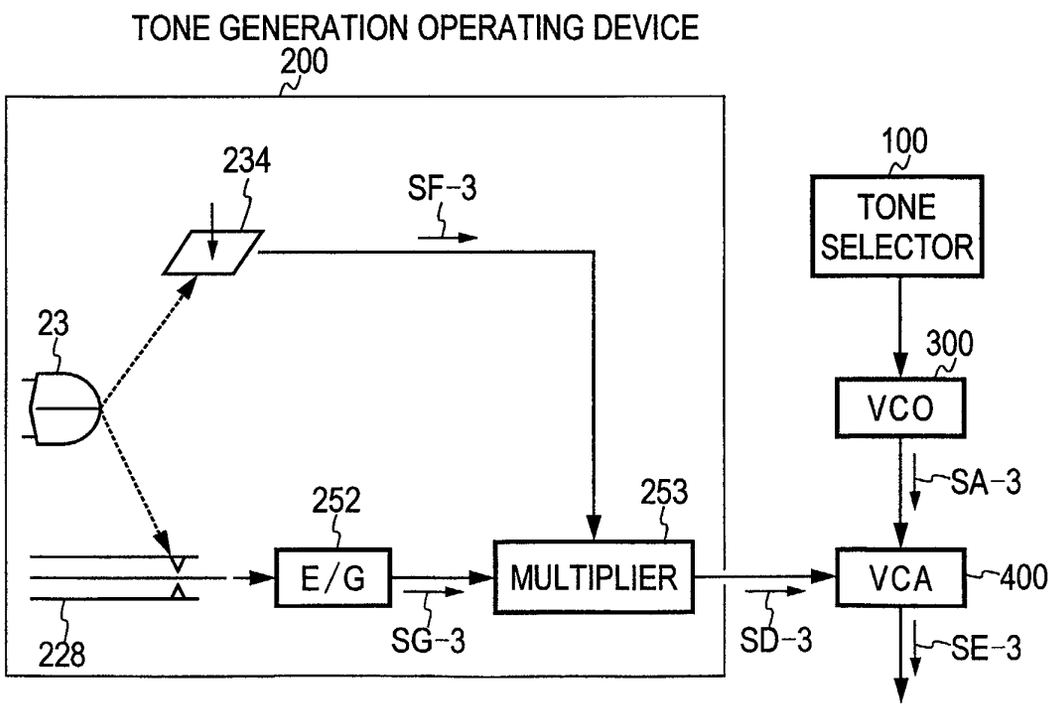

TONE GENERATION OPERATING DEVICE
200
100
TONE SELECTOR
234
SF-3
300
VCO
23
252
253
SA-3
E/G
MULTIPLIER
VCA
400
228
SG-3
SD-3
SE-3

FIG. 14

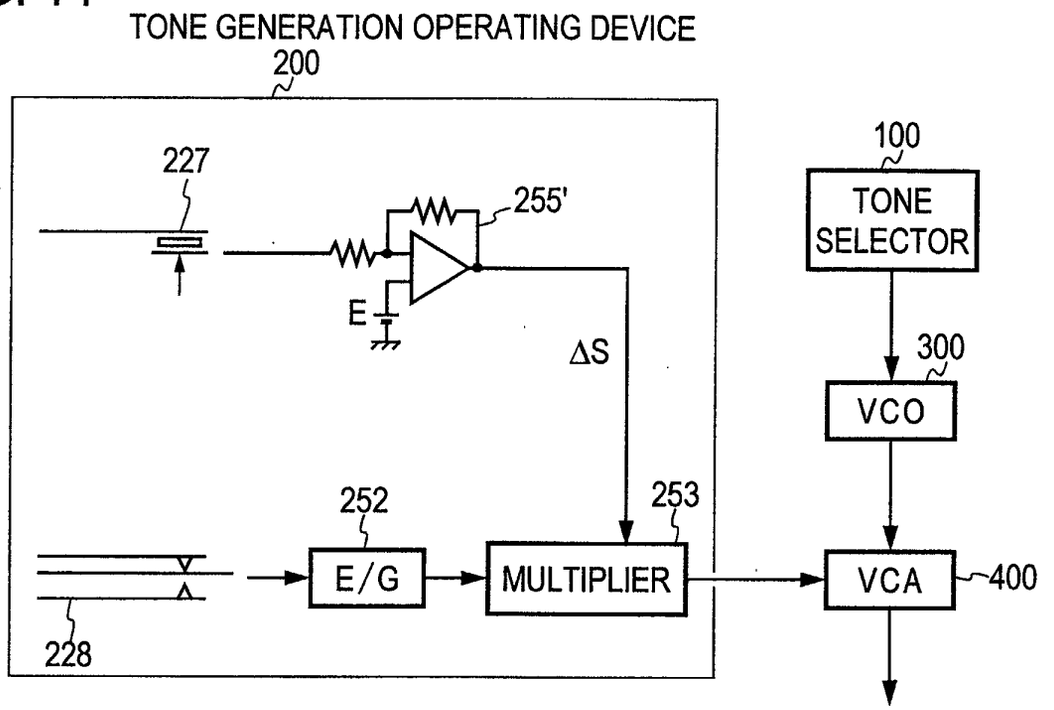

TONE GENERATION OPERATING DEVICE
200
227
255'
E
ΔS
100
TONE SELECTOR
300
VCO
252
253
E/G
MULTIPLIER
VCA
400
228

FIG. 15

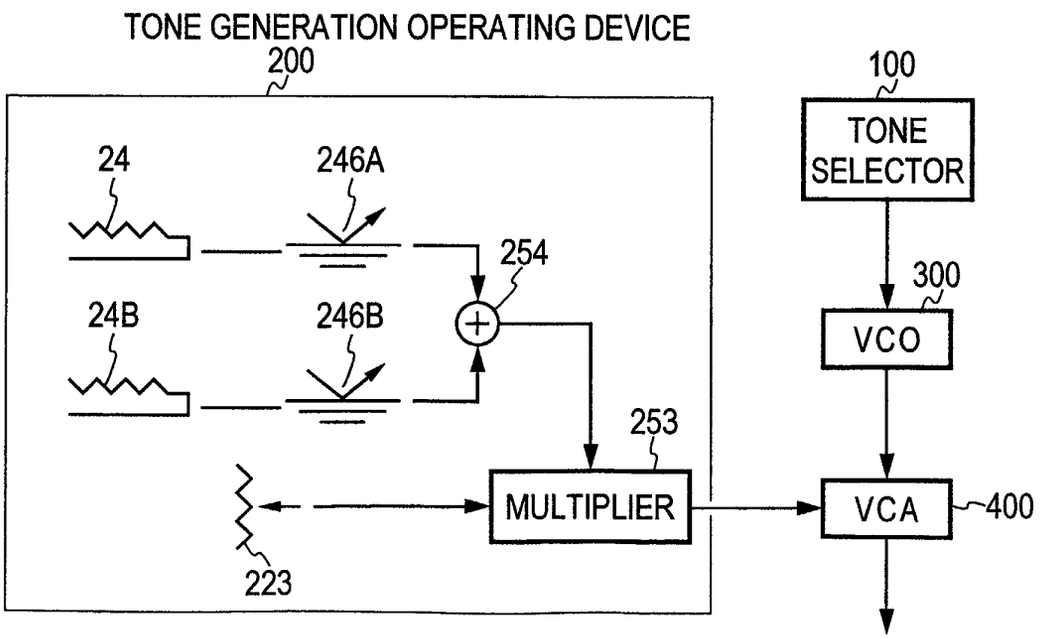

TONE GENERATION OPERATING DEVICE
200
24
246A
254
24B
246B
253
MULTIPLIER
223
100
TONE SELECTOR
300
VCO
VCA
400

FIG. 16

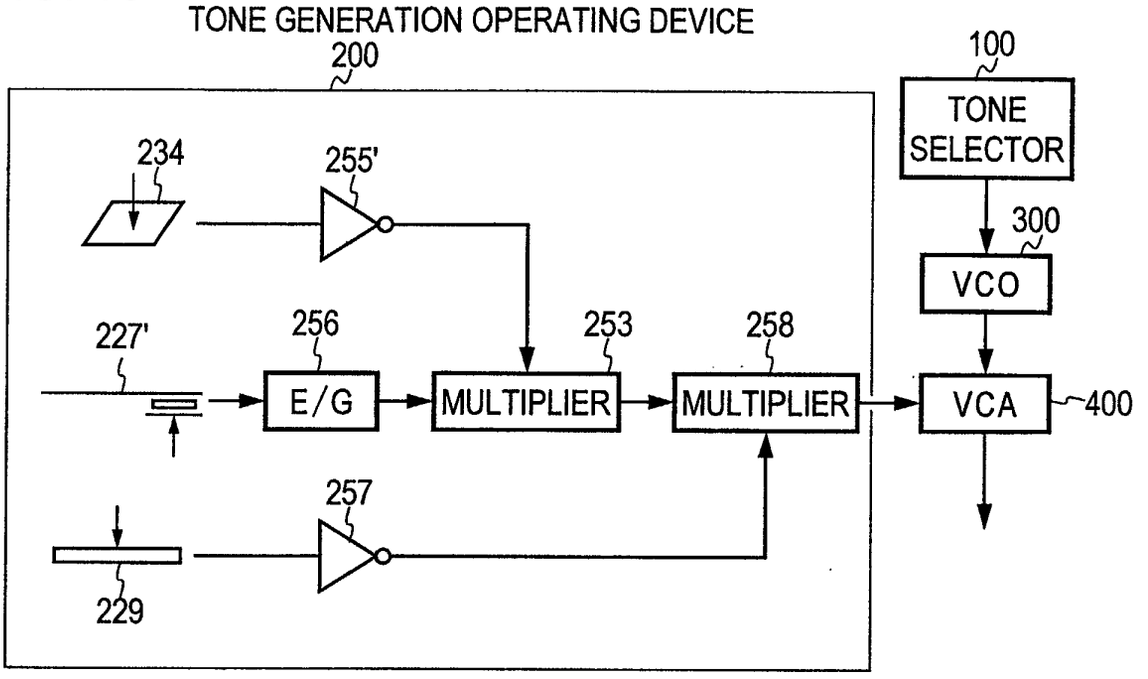
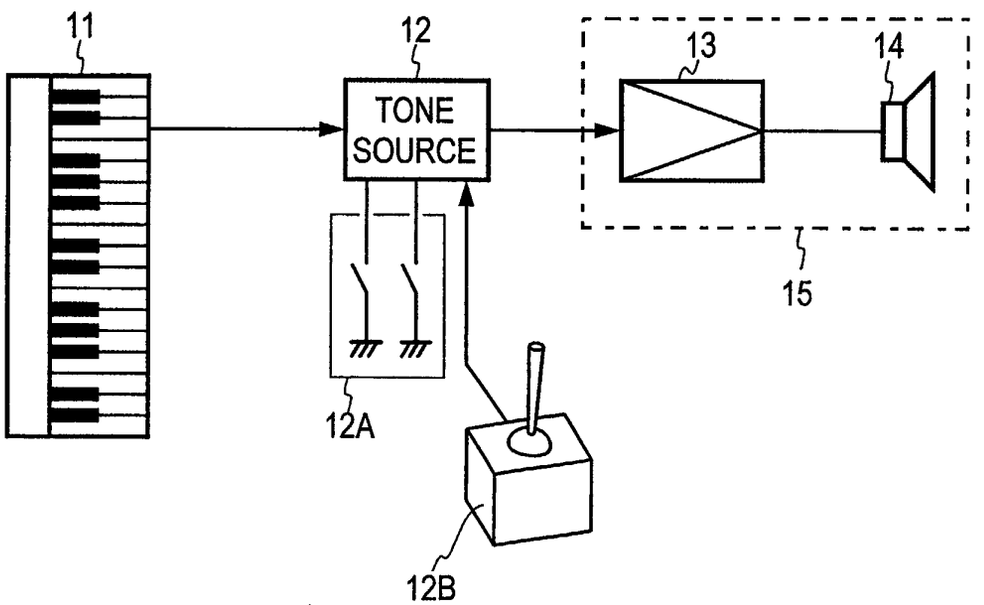

TONE GENERATION OPERATING DEVICE
200
100
TONE SELECTOR
300
VCO
234
255'
227'
256
253
258
E/G
MULTIPLIER
MULTIPLIER
VCA
400
257
229

FIG. 17


11
12
TONE SOURCE
13
14
15
12A
12B