

[54] BASS TONE PRODUCING DEVICE FOR AN ELECTRONIC MUSICAL INSTRUMENT

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[51] Int. Cl.G10h 1/06, G10h 5/12

[58] Field of Search.....84/1.01, 1.11-1.13, 84/1.17, 1.19-1.23, 1.26, DIG. 9

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[57] ABSTRACT

In a keyboard electronic musical instrument having pedal keys, a bass tone producing device comprises a fundamental bass tone signal source for generating 16' bass tone signals having predetermined pitches for the respective pedal keys, and two harmonic bass tone signal sources for respectively generating 8' and 4' bass tone signals. Output signals from the three bass tone signal sources are respectively supplied to three keyer circuits which are gang operated by a pedal key to be rendered conductive upon depression thereof. On the one hand, the three different bass tone signals obtained through the keyer circuits are mixed in a predetermined ratio and supplied to a tone coloring filter having a peak frequency of about 100 to 300 Hz to establish a first composite signal. On the other hand, the two harmonic bass tone signals are mixed in a predetermined ratio, passed through a phase inverter, and applied to another tone coloring filter having a peak frequency of about 1,000 Hz to establish a second composite signal.

Both of the composite signals are finally mixed to form desired bass tones having clear harmonic components.

11 Claims, 13 Drawing Figures

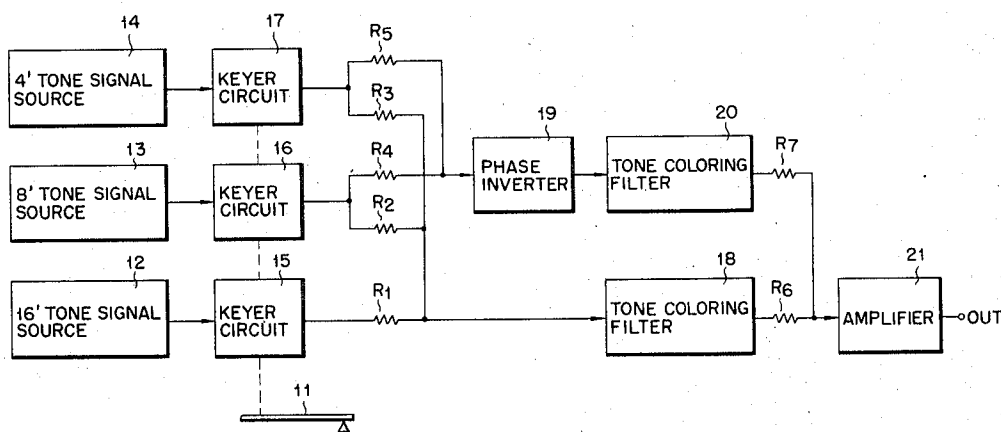


FIG. 1

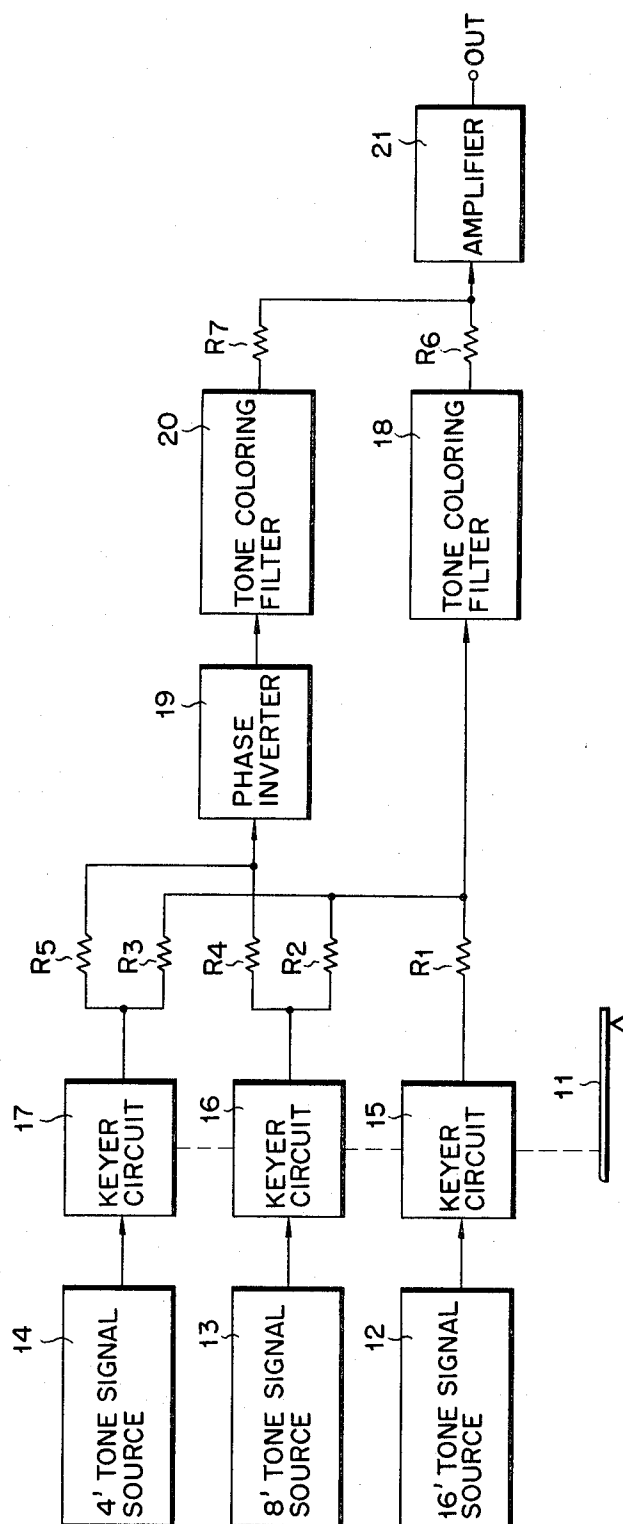


FIG. 2

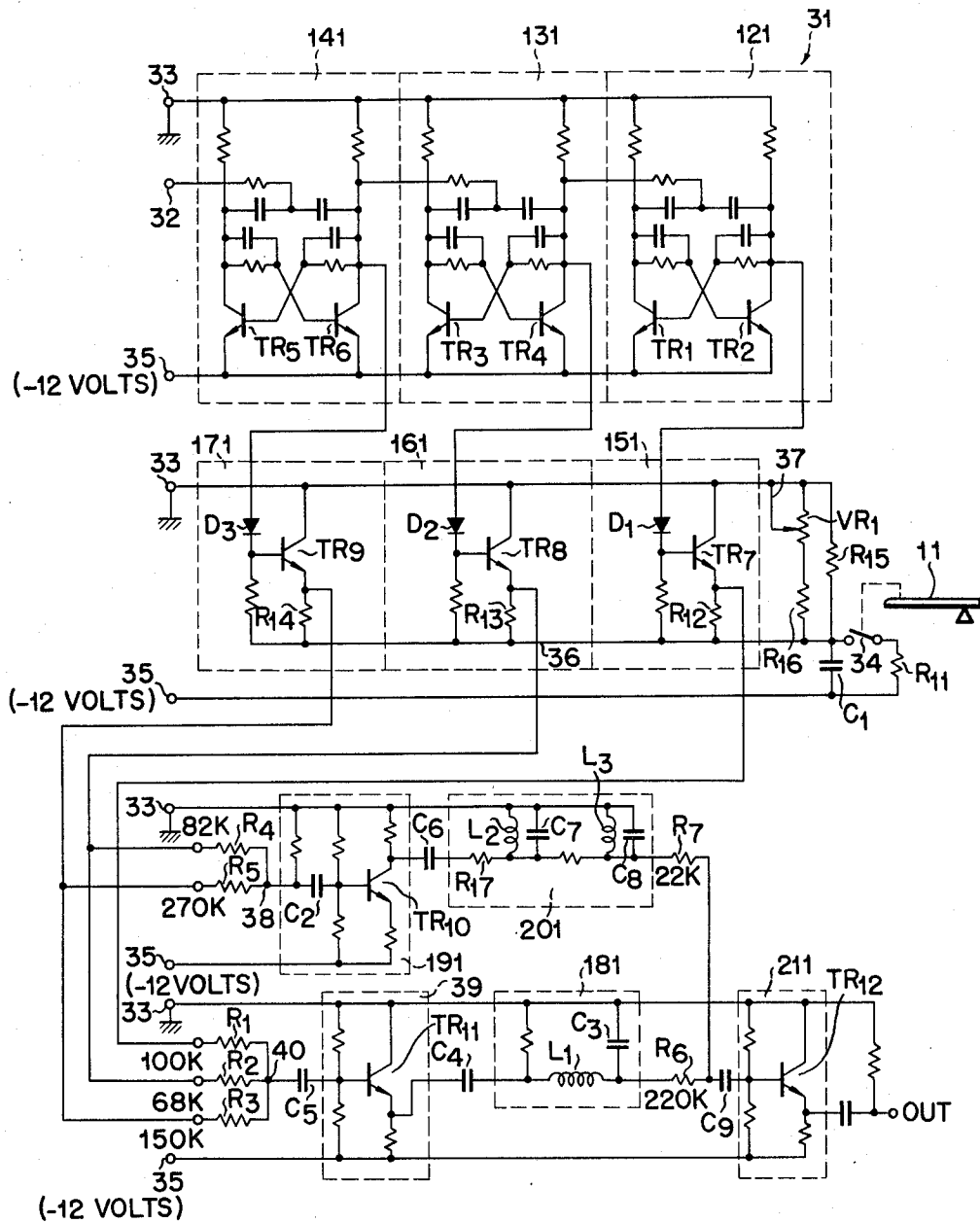


FIG. 3

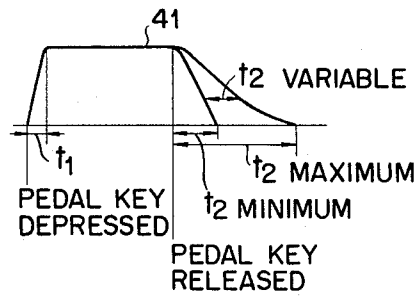


FIG. 4

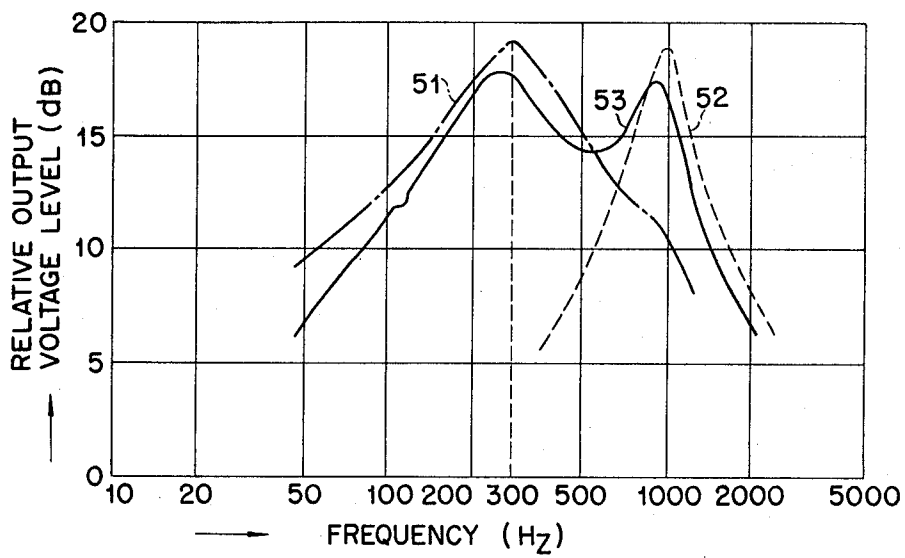


FIG. 5

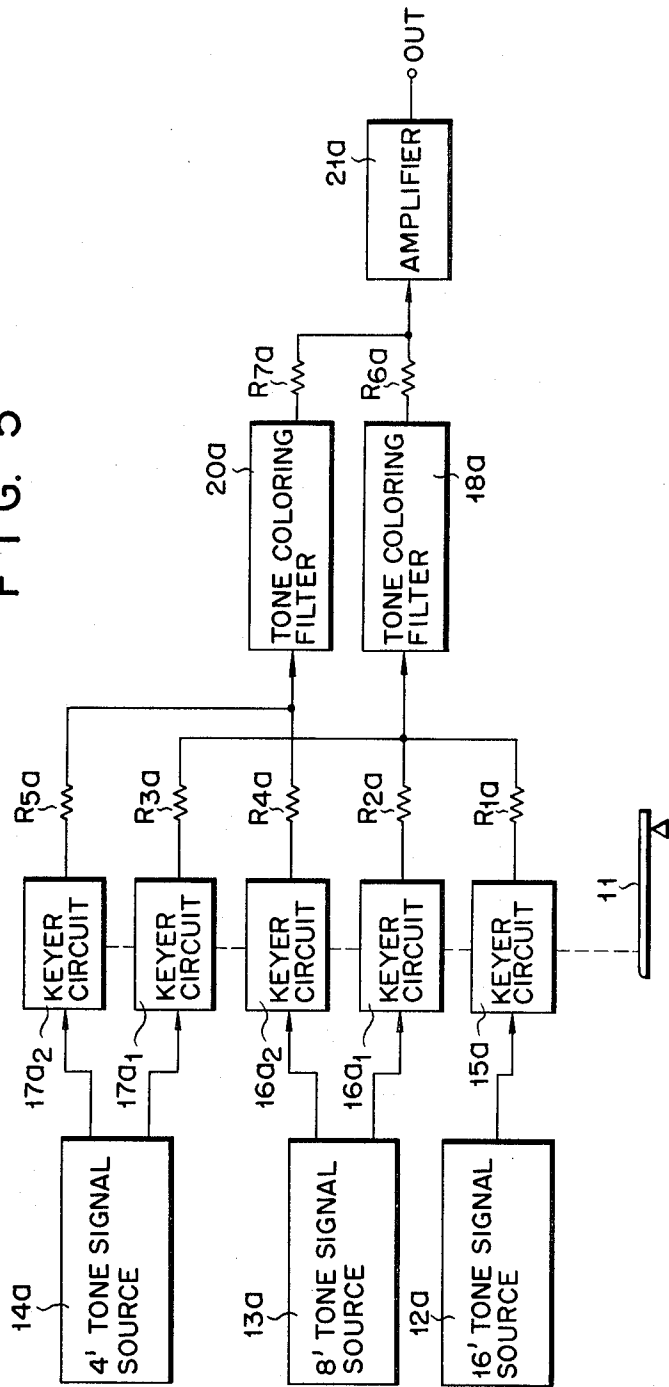


FIG. 6

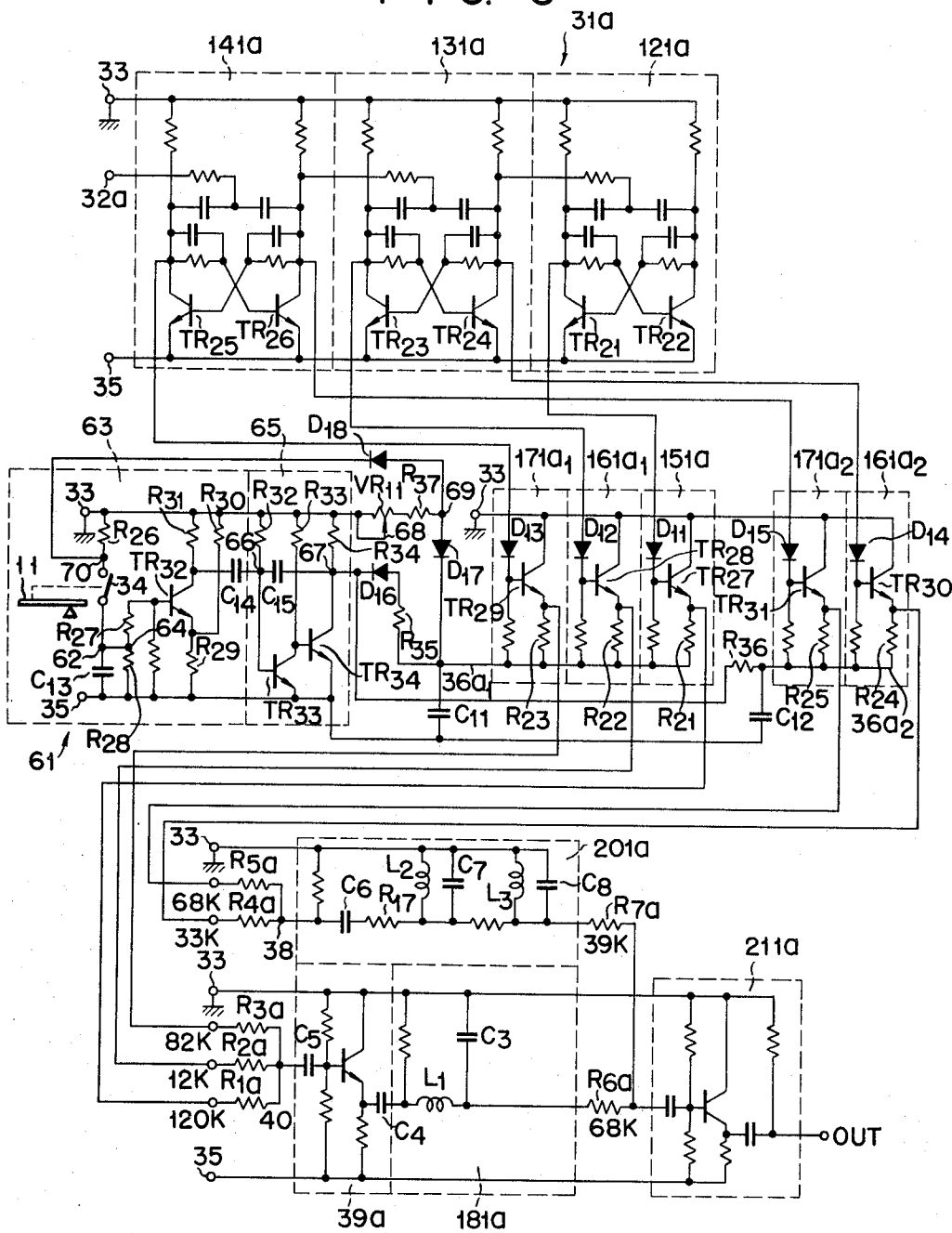


FIG. 7

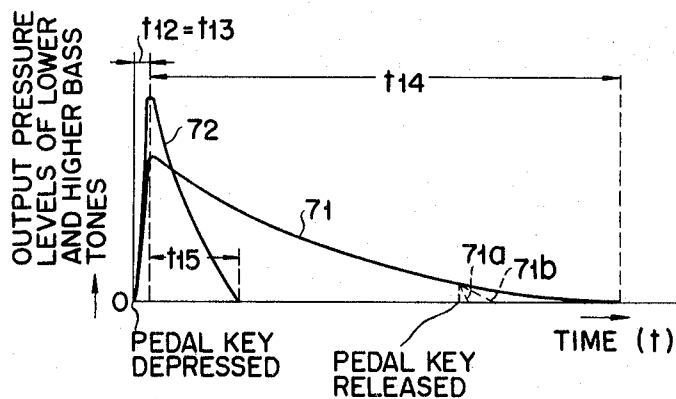


FIG. 8A

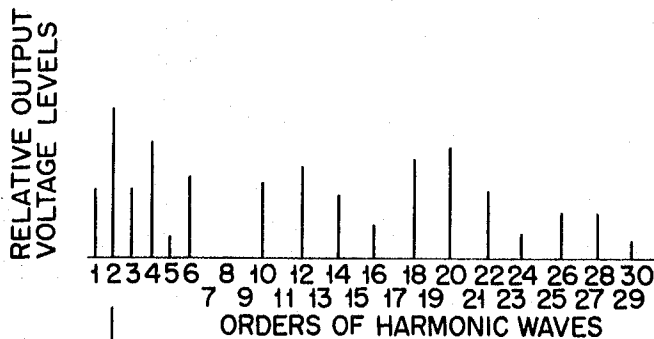


FIG. 8B

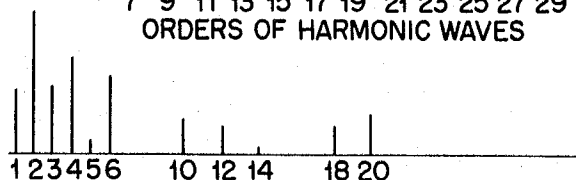


FIG. 8C

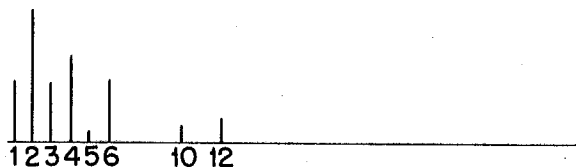


FIG. 8D

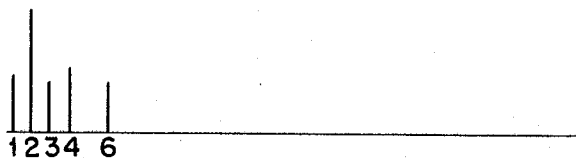


FIG. 8E

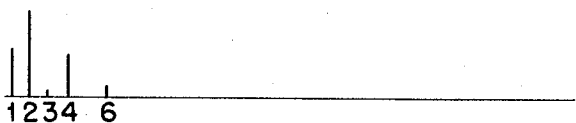
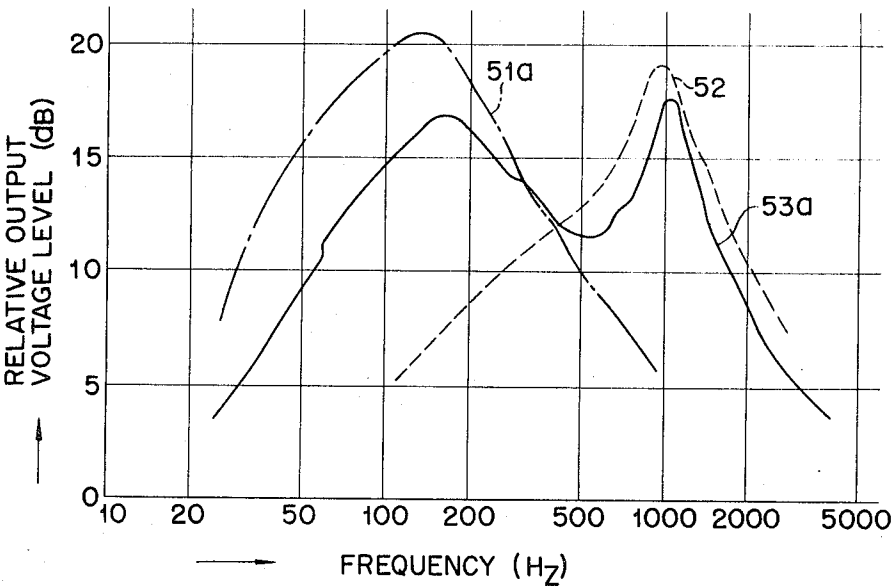


FIG. 9



BASS TONE PRODUCING DEVICE FOR AN ELECTRONIC MUSICAL INSTRUMENT

BACKGROUND OF THE INVENTION

This invention relates to a bass tone producing device for use in an electronic musical instrument and more particularly to a bass tone producing device in which a bass tone is composed of a fundamental signal and harmonic signal.

As is well known, the bass tones of a musical instrument are played by the pedal keys to beat the rhythm of the music and to support melody and chord tones which are played by manual keys. A keyboard electronic musical instrument such as an electronic organ is so designed as to produce desired base tones upon its pedal key depression. The bass tone consists of a fundamental tone and harmonic tones mixed in a proper ratio. Bass tones thus composed can have an excellent sound effect where the performance is given in a relatively limited room, but have a drawback where the performance is given in an appreciably spacious hall, the bass tones presenting a muffled sensation rich in lower components due to the acoustic character of the hall that the lower components have longer reverberating time.

It is accordingly the object of this invention to provide a bass tone producing device for an electronic musical instrument capable of producing bass tones having a tone color like that of a tuba, for example, sounding clear even in a relatively large spacious hall.

SUMMARY OF THE INVENTION

The bass tone producing device of this invention delivers, upon depression of a pedal key of an electronic musical instrument, an ordinary bass tone signal consisting of a fundamental bass tone having a prescribed pitch and harmonic signals having pitches of a higher octave than that of the fundamental base tone mixed in a proper ratio as well as an additional bass tone signal consisting of the harmonics. The former bass tone signal is conducted through a first tone coloring filter having a relatively low peak frequency, while the latter bass tone signal is passed through a second tone coloring filter having a peak frequency higher than the first tone coloring filter. The filtered two bass tone signals are blended in a proper ratio with the phase of the latter reversed or suitably shifted so as to produce final desired bass tone signals, which are composed in good condition free from mutual complicated interference among the component signals. Tones reproduced by these composite bass tone signals have peak tone pressures (formants) in not only a relatively low frequency region but also a higher frequency region, so that where an electronic musical instrument is played in a spacious hall, the tones display an excellent rhythmical effect without presenting a muffled sensation rich in low pitch components as is often the case with the prior art bass tone producing device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block circuit diagram of a bass tone producing device for a keyboard electronic musical instrument according to an embodiment of this invention;

FIG. 2 is a concrete circuit arrangement of the bass tone producing device of FIG. 1;

FIG. 3 is a curve diagram showing the rising and decaying characteristics of output bass tones from the device of FIG. 2;

FIG. 4 is a chart showing curves of the frequency characteristics of the respective filters included in the device of FIG. 2 and a curve of the actually measured frequency characteristics of composed bass tone signals;

FIG. 5 is a schematic block circuit diagram of a bass tone producing device according to another embodiment of the invention;

FIG. 6 is a concrete circuit arrangement of the device of FIG. 5;

FIG. 7 is a curve diagram showing the rising and decaying characteristics of two types of bass tone signals delivered from the different groups of keyer circuits of FIG. 6;

FIGS. 8A to 8E show actually measured frequency spectra of final output signals produced from the circuitry of FIG. 6 at different times in its decay; and

FIG. 9 indicates curves of the frequency characteristics of the filters and the mixed output in FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A bass tone producing device according to the preferred embodiments of this invention will now be described by reference to the appended drawings.

FIG. 1 is a schematic block circuit diagram of a bass tone producing device according to an embodiment of the invention. There are provided, for each one of the keys (actually 13 or 25 or 32 keys are arranged in the order of musical notes, though only one of them is indicated), a 16' tone signal source 12 as a fundamental bass tone signal source, 8' and 4' tone signal sources 13 and 14 as harmonic bass tone signal sources. The source 12 is generally so designed as to generate a tone signal whose pitch is one octave lower than the notation notes in a musical staff, and is known as a 16-foot tone signal. Likewise, the harmonic bass tone signal sources generate an 8-foot tone signal and a 4-foot tone signal, respectively.

Output signals from the 16' tone signal source 12 and the 8' and 4' tone signal sources 13 and 14 are conducted via respective keyer circuits 15, 16 and 17 gang-actuated with the depression of the corresponding pedal key 11, and individual resistors R_1 , R_2 and R_3 connected to the output terminals of the keyer circuits 15 to 17 to be mixed in a predetermined ratio. The bass tone signals thus mixed are supplied to a tone coloring filter 18 having a relatively low peak frequency to form a first composite signal. On the other hand, output signals from the 8' and 4' tone signal sources 13 and 14 are passed through the corresponding keyer circuits 16 and 17 and separate resistors R_4 and R_5 connected to the output terminals of the keyer circuits 16 and 17 to be mixed in a predetermined ratio and, after the phase is reversed by a phase inverter 19, are supplied to another tone coloring filter 20 having a higher peak frequency than the tone coloring filter 18 to form a second composite signal. The above-mentioned two composite signals delivered from both tone coloring filters 18 and 20 are introduced via individual resistors 6 and 7 to be blended finally in a predetermined ratio. The bass tone signal thus blended is properly amplified by an amplifier 21 to be fed to the next stage (not shown) in the instrument.

FIG. 2 is a concrete circuit arrangement of the bass tone producing device of FIG. 1. The fundamental bass tone signal source 12, and the harmonic bass tone signal sources 13 and 14 are constituted by a frequency divider chain 31 consisting of three cascade connected bistable multivibrators 121, 131 and 141 respectively including two transistors as TR_1 - TR_2 , TR_3 - TR_4 and TR_5 - TR_6 .

It will be noted that the tone signal sources (generally provided in a number of 85 or 97 corresponding to musical notes of C_1 to C_8 or C_1 to C_9) are formed of 12 master oscillators representing one octave of the highest musical scale and a plurality of frequency dividers cascade connected to the respective oscillators in turn. Accordingly, the first stage bistable multivibrator 141 constituting the 4' tone signal source 14 included in the frequency divider chain 31 has its input terminal 32 impressed with an output signal from a preceding frequency divider stage (not shown).

The keyer circuits 15 to 17 are constructed of emitter follower keyer circuits 151, 161 and 171 including transistors TR_7 , TR_8 and TR_9 respectively whose bases are connected via forwardly directed diodes D_1 , D_2 and D_3 to the collectors of the corresponding transistors of the bistable multivibrators 121, 131 and 141, for example, the right side transistors TR_2 , TR_4 and TR_6 respectively. The aforesaid transistors TR_7 , TR_8 and TR_9 have their collectors directly connected to a grounded positive source line 33, and their emitters connected via resistors R_{12} , R_{13} and R_{14} to a line 36 which is connected to a negative source line 35 via a resistor R_{11} and a normally open key switch 34 closed upon depression of the pedal keys 11. Between the line 36 and the negative source line 35 is connected a capacitor C_1 . Between the line 36 and the positive source line 33 is connected in parallel a resistor R_{15} and a series circuit consisting of a resistor R_{16} and a variable resistor VR_1 having a movable contact 37 connected to the positive source line 33.

The emitters of the transistors TR_7 , TR_8 and TR_9 are respectively connected via the resistors R_1 , R_2 and R_3 of the indicated values and a capacitor C_5 to the base of a transistor TR_{11} included in an emitter follower amplifier 39 provided if required.

The tone coloring filter 18 is comprised of a low pass filter 181 including an inductor L_1 and a capacitor C_3 connected between one end of the inductor L_1 and the positive source line 33. The inductor L_1 has the other end connected via a coupling capacitor C_4 to the emitter of the transistor TR_{11} .

The emitters of the transistors TR_8 and TR_9 are also connected to the base of a transistor TR_{10} included in a grounded-emitter amplifier 191 constituting the inverter 19 via the resistors R_4 and R_5 of the indicated values as well as via a coupling capacitor C_2 connected to the common connection 38 of the resistors R_4 and R_5 .

The tone coloring filter 20 is formed of a band pass filter 201 including a group of an inductor L_2 and a capacitor C_7 and another group of an inductor L_3 and a capacitor C_8 , the two groups being connected in parallel between the positive source line 33 and the collector of the transistor TR_{10} via a coupling capacitor C_6 and a resistor R_{17} . The amplifier 21 is formed of an emitter follower amplifier 211 including a transistor TR_{12} having its base applied through a coupling capacitor C_9

with the aforesaid two mixtures of bass tone signals delivered from the low pass filter 181 and the band pass filter 201 after the mixtures are further blended together through the resistors R_6 and R_7 of the indicated values.

The operation of a bass tone producing device according to this invention will now be described by reference to FIG. 2. While any of the pedal keys 11 is not depressed, the corresponding key switch 34 remains open, the capacitor C_1 is charged with source voltage through a parallel circuit consisting of the resistor R_{15} and the series circuit of variable resistor VR_1 and resistor R_{16} . Accordingly, the line 36 has substantially the same voltage as the positive source line 33 to keep the transistors TR_{12} , TR_{13} and TR_{14} of the switching circuits 151, 161 and 171 nonconducting, deriving no bass tones.

Where, under this condition, a pedal key 11 is depressed by a player's foot, the corresponding key switch 34 is closed to cause the voltage stored in the capacitor C_1 to be discharged through the resistor 11. In the later described length of transient time t_1 after key depression, the line 36 has its voltage brought to substantially the same level as that of the negative source line 35. At this time, the transistors TR_7 , TR_8 and TR_9 of the keyer circuits 151, 161 and 171 are triggered to be changed from a nonconducting to a conducting state, bringing the entire circuitry of FIG. 2 to a stationary operating condition. Thus the fundamental bass tone signal having a predetermined pitch and the harmonic bass tone signals thereof derived from the collectors of the respective right side transistors TR_2 , TR_4 and TR_6 included in the bistable multivibrators are mixed through the corresponding diodes D_1 to D_3 , the now triggered keyer circuits 151, 161 and 171 and the corresponding resistors R_1 to R_3 . The mixed bass tone signals are properly amplified by the amplifier 39 and conducted to the low pass filter 181 to form a first composite signal. On the other hand, the harmonic bass tone signals from the corresponding triggered keyer circuits 161 and 171 are mixed through the corresponding resistors R_4 and R_5 and, after reversed in phase and properly amplified by the common emitter amplifier 191, conducted to the band pass filter 201 to form a second composite signal. The two composite signals obtained from both the filters 181 and 201 are further mixed together through the resistors R_6 and R_7 and properly amplified by the amplifier 211.

Where, under this condition, the depressed pedal key 11 is released, the corresponding key switch 34 is opened to have the capacitor C_1 charged again with source voltage in the later described sustain time t_2 after the release. Accordingly, the entire circuitry of FIG. 2 is rendered inoperative until the pedal key 11 is depressed next time.

The curve 41 of FIG. 3 shows the operating condition of the circuitry of FIG. 2 resulting from depression of a pedal key 11. The circuitry is brought to a stationary operating condition in the prescribed length of transient time t_1 after key depression which is defined by a time constant representing the product of the capacitance of the capacitor C_1 and the resistance of the resistor R_{11} . This operating condition is sustained until the release of the depressed pedal key 11. Upon the release, the circuitry of FIG. 2 is again rendered in-

operable in the prescribed sustain time t_2 determined by a time constant representing the product of the capacitance of the capacitor C_1 and the composite resistance of the parallel circuit consisting of the resistor R_{15} and the series circuit of variable resistor VR_1 and resistor R_{16} . The sustain time t_2 can be freely varied within the range of t_2 maximum and t_2 minimum by the adjusted sliding of the movable contact 37 of the variable resistor VR_1 . According to the circuitry of FIG. 2, the aforesaid prescribed length of transient time t_1 and the maximum and minimum sustain times t_2 maximum and t_2 minimum are chosen to be $t_1 = 10$ to 20 milliseconds, t_2 maximum = 1.5 seconds and t_2 minimum = 0.2 second respectively.

FIG. 4 shows curves 51 and 52 showing the actually measured frequency characteristics of the low pass filter 181 (together with the CR coupling network) and the band pass filter 201 of FIG. 2 according to a preferred design and a curve 53 indicating the actually measured frequency characteristics of mixed bass tone signals delivered from the last output. As apparent from FIG. 4, the low pass filter 181 (together with the CR coupling network) has the frequency characteristics that it has a peak frequency around 300 Hz and causes signals passing therethrough to attenuate 3 dB around 150 Hz and 600 Hz. In contrast, the band pass filter 201 has the frequency characteristics that it has a peak frequency around 1,000 Hz and causes signals passing therethrough to attenuate 3 dB around 800 Hz and 1,300 Hz. Since the two composite signals obtained from filters 181 and 201 are satisfactorily blended together, as previously described, in reverse phase, so that the mixtures are prevented from mutual complicated interference.

The bass tone produced by the mixture of the two composite signals has a peak tone pressure level around a relatively low frequency portion (around 300 Hz according to this embodiment) and also around a higher frequency portion (around 1,000 Hz according to this embodiment). The present inventor has experimentally found, therefore, that even where an electronic musical instrument is played in a spacious hall, the resultant bass tones obtained by the device of this invention do not present a muffled sensation rich in the aforesaid low frequency component as is often the case with the prior art bass tone producing device but bear a tone color like that of a tuba, providing a clear and distinctive tone effect.

FIG. 5 is a schematic block circuit diagram of a bass tone producing device according to another embodiment of this invention.

The point at which the embodiment of FIG. 5 differs from the preceding one is that the two composite signals have different amplitudes and different decaying envelopes, and that the harmonic bass tone signals are derived in both of the opposite phases for dispensing with a phase inverter. To this end, the circuitry of FIG. 5 causes a pair of 8' bass tone signals and a pair of 4' bass tone signals to be generated in the reverse phase from the 8' tone signal source 13a and the 4' tone signal source 14a respectively. The opposite-phase paired 8' tone signals from the 8' tone signal source 13a are respectively conducted to separate keyer circuits 16a₁ and 16a₂. Similarly, the opposite-phase paired 4' tone signals from the 4' tone

signal source 14a are respectively supplied to separate keyer circuits 17a₁ and 17a₂. The circuitry of FIG. 5 causes the 8' and 4' tone signal sources 13a and 14a concurrently to act as the inverter 19 of FIG. 1, eliminating the necessity of providing a separate inverter. The other parts of the circuitry of FIG. 5 have substantially the same arrangement as the corresponding parts of FIG. 1 and are denoted by the corresponding numerals, description thereof being omitted.

FIG. 6 is a concrete circuit arrangement of FIG. 5. As in FIG. 2, the 16' tone signal source 12a and the 8' and 4' tone signal sources 13a and 14a jointly constitute a frequency divider chain 31a consisting of three cascade connected bistable multivibrators 121a, 131a and 141a, each including two transistors as TR₂₁-TR₂₂, TR₂₃-TR₂₄ and TR₂₅-TR₂₆. Keyer circuits 15a, 16a₁ and 17a₁ are constituted of emitter follower circuits 151a, 161a₁ and 171a₁ including transistors TR₂₇, TR₂₈ and TR₂₉ respectively which have their bases connected via forwardly directed diodes D₁₁, D₁₂ and D₁₃ to the collectors of respective left or right side transistors included in the bistable multivibrators 121a, 131a and 141a, for example, the left side transistors TR₂₁, TR₂₃ and TR₂₅ of each of the aforementioned three groups. The transistors TR₂₇ to TR₂₉ have the collectors directly connected to the grounded positive source line 33 and the emitters connected via resistors R₂₁, R₂₂ and R₂₃ respectively, to a line 36a₁ which is connected to the negative power source line 35 via a capacitor C₁₁. Output signals delivered in the later described manner from the emitters of the transistors TR₂₇ to TR₂₉ are supplied to a low pass filter 181a through corresponding resistors R_{1a} to R_{3a}, the coupling capacitor C₅, an emitter follower circuit 39a and the coupling capacitor C₄ in turn. On the other hand, the aforesaid keyer circuits 16a₂ and 17a₂ are comprised of emitter follower keyer circuits 161a₂ and 171a₂ including transistors TR₃₀ and TR₃₁ which have their bases connected via forwardly connected diodes D₁₄ and D₁₅ to the collectors of the right side transistors TR₂₄ and TR₂₆ of the respective groups of transistors included in the 8' and 4' tone signal sources 131a and 141a which correspond to the keyer circuits 16a₂ and 17a₂. The transistors TR₃₀ and TR₃₁ have their collectors directly connected to the positive power source line 33 and their emitters connected via resistors R₂₄ and R₂₅ to a line 36a₂ which is connected via a capacitor C₁₂ to the negative power source line 35. Output signals delivered in the later described manner from the emitters of the transistors TR₃₀ and TR₃₁ are supplied, as in the case of FIG. 2, to a band pass filter 201a through corresponding resistors R_{4a} and R_{5a} and the coupling capacitor C₆.

There is further provided a trigger circuit 61 of the undermentioned arrangement so as to trigger the aforementioned keyer circuits 15a, 16a₁, 17a₁, 16a₂ and 17a₂ upon depression of a pedal key 11. The trigger circuit 61 includes a series circuit of a resistor R₂₆, the normally open key switch 34 and a capacitor C₁₃ connected across the positive and negative source lines 33 and 35. A common connection 62 to the key switch 34 and the capacitor C₁₃ is connected to a common connection 64 to two resistors R₂₇ and R₂₈ connected in series between the base of a transistor TR₃₂ included in a common emitter trigger circuit 63 and the negative source line 35. The transistor TR₃₂ has its emitter con-

nected via a resistor R_{29} to the negative source line 35 and also via a resistor R_{30} to the positive source line 33. Further, the transistor TR_{32} has its collector connected via a resistor 31 to the positive source line 33 and also via a coupling capacitor C_{14} to the input terminal 66 of a one-shot multivibrator 65 which includes two transistors TR_{33} and TR_{34} , and further a feedback capacitor C_{15} connected between the collector of the rear side transistor TR_{34} used as the output terminal 67 of the one-shot multivibrator 65 and the base of the front side transistor TR_{33} used as the input terminal of the one-shot multivibrator 65. The transistor TR_{33} has its base connected via a resistor 32 to the positive source line 33. Both transistors TR_{33} and TR_{34} have their collectors connected via resistors R_{33} and R_{34} to the positive power source line 33 and also their emitters jointly connected to the negative source line 35.

The collector 67 of the transistor TR_{34} constituting the output terminal of the one-shot multivibrator 65 is connected to the line $36a_1$ via a diode D_{16} of the indicated polarity and a resistor R_{35} and also to the line $36a_2$ via a resistor R_{36} . Between the line $36a_1$ and the positive power source line 33 is connected a series circuit consisting of a diode D_{17} of the indicated polarity, a resistor R_{37} and a variable resistor VR_{11} . The variable resistor VR_{11} has its movable contact 68 connected to the positive power source line 33. There is further provided a diode D_{18} of the indicated polarity between a common connection 69 to the diode D_{17} and the resistor R_{37} and a common connection 70 to the resistor R_{28} and the key switch 34.

The operation of a bass tone producing device arranged as described above according to the second embodiment will now be described by reference to FIG. 6.

While the pedal key 11 is not depressed, the corresponding key switch 34 remains open and the one-shot multivibrator 65 has its front side transistor TR_{33} rendered conductive and its rear transistor TR_{34} rendered nonconductive. Accordingly, the collector 67 of the transistor TR_{34} has substantially the same voltage as that of the positive source line 33, so that the capacitor C_{11} is charged with source voltage through the series circuit of the variable resistor VR_{11} , resistor R_{37} and forwardly biased diode D_{17} , and the capacitor C_{12} is charged with source voltage through the series circuit of the resistors R_{34} and R_{36} . In this case, the diode D_{16} is reversely biased electrically to insulate the lines $36a_1$ and $36a_2$ from each other. Accordingly, the lines $36a_1$ and $36a_2$ have substantially the same voltage as the positive power source line 33, keeping nonconducting all the transistors TR_{27} to TR_{31} included in the keyer circuits 15a, 16a₁, 17a₁, 16a₂ and 17a₂. As the result, there is not delivered any bass tone.

Where, under this condition, a given pedal key 11 is depressed, the corresponding key switch 34 is closed to cause the capacitor C_{13} to be charged with source voltage through the resistor R_{28} and also the transistor TR_{32} of the trigger circuit 63 to have its base supplied with the now stepped-up voltage. Since the transistor TR_{32} is brought from a nonconducting to a conducting state, its output signal triggers the one-shot multivibrator 65 to reverse the condition of the transistors TR_{33} and TR_{34} included in the multivibrator 65, that is, to render the former nonconductive and the latter conductive. But after the predetermined short time (e.g. 10 ms), the

one-shot multivibrator comes back to the original state. Accordingly, the collector 67 of the transistor TR_{34} has the voltage momentarily brought up to substantially the same level as that of the negative power source line 35 decaying subsequently. As the result, the capacitor C_{11} has its stored energy discharged through the resistor R_{35} , the forwardly biased diode 16 and the energized transistor TR_{34} included in the multivibrator 65 in turn. Similarly the capacitor C_{12} has its charged voltage released through the resistor R_{36} and the now energized transistor TR_{34} .

The lines $36a_1$ and $36a_2$ have their voltages changed from that of the positive power source line 33 to a level substantially equal to that of the negative power source line 35 in the later described lengths of transient time t_{12} and t_{13} after depression of a pedal key 11, thus bringing the entire circuitry of FIG. 6 including the keyer circuits 151a to 171a₂ to a momentarily operating condition. Accordingly, all the transistors TR_{27} to TR_{31} included in the keyer circuits 151a to 171a₂ are triggered to a conducting and then back to a non-conducting state. Thus the fundamental bass tone signal having the predetermined pitch and the harmonic bass tone signals thereof which are delivered from the collectors of the respective left side transistors TR_{21} , TR_{23} and TR_{25} included in the bistable multivibrators 121a, 131a and 141a are mixed through the separate keyer circuits 151a, 161a₁ and 171a₁ and resistors R_{1a} to R_{3a} and, after properly amplified by the amplifier 39a, supplied to the low pass filter 181a to form a first composite signal having a percussive envelope. On the other hand, the harmonic bass tone signals which are delivered from the collectors of the respective right side transistors TR_{24} and TR_{26} included in the bistable multivibrators 131a₂ and 141a₂ in reverse phase to those obtained from the collectors of the left side transistors TR_{23} and TR_{25} are mixed through the corresponding keyer circuits 161a₂ and 171a₂ and resistors R_{4a} and R_{5a} and conducted to the band pass filter 201a to form a second composite signal having a percussive envelope. The two composite signals delivered from both the filters 181a and 201a are further blended together through the respective resistors R_{6a} and R_{7a} and amplified by the amplifier 211a.

The curves 71 and 72 in FIG. 7 illustrate the rising and decaying characteristics of output level of the respective composite signals upon depression of the pedal key 11. As apparent from FIG. 7, the transistor TR_{32} of the trigger circuit 63 is brought from a nonconducting to a conducting state and as the result, the transistors TR_{33} and TR_{34} of the one-shot multivibrator 65 have their conditions reversed, that is, the front side transistor TR_{33} is momentarily rendered nonconductive and the rear side transistor TR_{34} conductive but subsequently both of the transistors come back to original states. Thus the collector 67 of the transistor TR_{34} has the voltage abruptly changed from that of the positive power source line 33 to a level substantially equal to that of the negative power source line 35 and gradually back to the former. According to the aforesaid discharge of the capacitor C_{11} , the line $36a_1$ has its voltage brought from that of the positive power source line 33 to a level substantially equal to that of the negative power source line 35 in the prescribed length of transient time t_{12} which is defined by a time constant

representing the product of the capacitance of the capacitor C_{11} and the series composite resistance of the resistor R_{35} , the forwardly biased diode D_{16} and the energized transistor TR_{34} . Similarly according to the aforesaid discharge of the capacitor C_{12} , the line $36a_2$ has its voltage brought from that of the positive power source line 33 to a level substantially equal to that of the negative power source line 35 in the prescribed length of transient time t_{13} (in the circuitry of FIG. 6 t_{12} is chosen to be equal to t_{13}) which is defined by a time constant representing the product of the capacitance of the capacitor C_{12} and the series composite resistance of the resistor R_{36} and the energized transistor TR_{34} . Accordingly, the entire circuitry of FIG. 6 is brought to a full operating condition quickly and then is subjected to gradual change to non-operating state. As the collector 67 of the transistor TR_{34} has the voltage again changed from that of the negative power source line 35 to a level substantially equal to that of the positive power source line 33, the line $36a_1$ has its voltage changed again due to the aforesaid change of the capacitor C_{11} from that of the negative power source 35 to a level substantially equal to that of the positive power source line 33 after the sustain time t_{14} for the first composite bass tone signals composed of a 16' bass tone and an 8' and a 4' bass tone, the sustain time t_{14} being represented by the product of the capacitance of the capacitor C_{11} and the internal resistances of the working transistors TR_{27} , TR_{28} and TR_{29} and the resistors R_{21} , R_{22} and R_{23} , as the point 69 is made negative through the diode D_{16} . Similarly, the line $36a_2$ has its voltage changed from that of the negative power source line 35 to a level substantially equal to that of the positive power source line 33 after the sustain time t_{15} for the second composite bass tone signals free from the 16' bass tones and only consisting of the 8' and the 4' bass tones, the sustain time t_{15} being represented by the product of the capacitance of the capacitor C_{12} and the internal resistances of the working transistors TR_{30} and TR_{31} and the resistors R_{24} and R_{25} . At this time, the entire circuitry of FIG. 6 is brought to a fully inoperable state. Upon release of a pedal key 11, the transistor TR_{32} of the trigger circuit 63 is brought from a conducting to a non-conducting state but the transistors TR_{33} and TR_{34} of the one-shot multivibrator 63 are not affected at all. If the pedal key is released amidst the decaying period, the point 69 is released from the negative potential, and then the capacitor C_{11} is also charged through the diode D_{17} , the resistor R_{37} and the variable resistor VR_{11} expediting the charging operation. Thus the decaying envelope would be changed to 71a or 71b, the slope being controlled by the variable resistor VR_{11} .

FIGS. 8A to 8E are the frequency spectra of the finally produced bass tone as measured at certain time intervals. FIG. 8A shows the spectrum of the bass tone when the entire circuitry of FIG. 6 is in a full operating condition, and FIGS. 8B to 8E indicate the spectra measured about 100, 200, 300 and 400 milliseconds after the condition of FIG. 8A.

Referring to the circuitry of FIG. 6, the low pass filter 201a is chosen to have such frequency characteristics that as shown by the curve 51a of FIG. 9, the filter has a peak frequency of about 150 Hz and causes signals passing therethrough to attenuate 3 dB at about 80 Hz

and 200 Hz. This arrangement enables bass tones of lower frequency than those possible with the preceding embodiment to be reproduced. Obviously, the frequency characteristics of the low pass filter 201a and band pass filter 181a may be suitably designed to meet the object and applications of an electronic musical instrument intended.

While the resistors R_{1a} to R_{7a} may also be chosen to have such resistance as conforms with the object and applications of the electronic musical instrument, the circuitry of FIG. 6 uses resistors having the values of resistance indicated therein.

What is claimed is:

1. In a keyboard electronic musical instrument having pedal keys, a bass tone producing device comprising:

a fundamental bass tone signal source for generating a fundamental bass tone signal having predetermined pitches;

at least one harmonic bass tone signal source for generating signals of harmonic bass tones having pitches at least one octave higher than that of the fundamental bass tone represented by the signal generated by said fundamental bass tone signal source;

normally nonconductive keyer circuits rendered conductive upon the depression of an associated one of said pedal keys to derive therethrough the respective bass tone signals from both said bass tone signal sources;

signal composing means for mixing in a preset ratio both the bass tone signals obtained through said individual keyer circuits;

a first tone coloring filter supplied with output mixed signals from said signal composing means having a relatively low peak frequency to form a first composite signal;

a second tone coloring filter supplied with the harmonic bass tone signal obtained through the corresponding one of said keyer circuits and having a peak frequency higher than that of said first tone coloring filter to form a second composite signal;

means for reversing the phase of said harmonic bass tone signal in said second composite signal relative to the phase of said harmonic bass tone signal in said first composite signal; and

a final signal composing means for mixing the first and second composite signals in a predetermined ratio.

2. A bass tone producing device according to claim 1 wherein said harmonic bass tone signal source comprises two units for generating different harmonic bass tone signals, and there is further provided another signal composing means for mixing in a preset ratio two output signals from both said harmonic bass tone signal source units.

3. A bass tone producing device according to claim 1 wherein said fundamental and harmonic bass tone signal sources comprise a frequency divider chain comprised of a plurality of cascade-connected bistable multivibrators each including two transistors, and said keyer circuits comprise emitter follower circuits each including a transistor which has its base connected via a diode to the collector of one of the two transistors included in the corresponding one of said bistable mul-

tivibrators and its emitter connected via a resistor to a line which is connected to one of a pair of positive and negative power sources via a resistor and a normally open switch closed upon depression of a corresponding key on said pedal keyboard, said transistor having its collector connected to the other power source with a resistor network connected between the collector and emitter of said transistor.

4. A bass tone producing device according to claim 1 further including a trigger circuit wherein said fundamental and harmonic bass tone signal sources comprise a frequency divider chain comprised of a plurality of cascade-connected bistable multivibrators each including two transistors, and said keyer circuits comprise a first group of emitter follower circuits each including a transistor which has its base connected via a diode to the collector of one of the two transistors included in the corresponding one of said bistable multivibrators and its emitter connected via a resistor to a line which is connected via a capacitor to one of a pair of positive and negative power sources, said transistor having its collector connected to the other power source and said line being connected via a resistor and a diode to the output terminal of said trigger circuit rendered conductive upon depression of one of said pedal keys and also connected via a series circuit of a diode and a resistor network to the other power source; and a second group of emitter follower circuits each including a transistor which has its base connected via a diode to the collector of the other transistor included in the corresponding one of said bistable multivibrators and its emitter connected via a resistor to another line which is connected via a capacitor to said one power source, said transistor having its collector connected to the other power source line and said line being connected via a resistor to the output terminal of said trigger circuit and also connected via a resistor network to the other

power source.

5. A bass tone producing device according to claim 1 wherein said first tone coloring filter is a low pass filter.

6. A bass tone producing device according to claim 1 wherein said second tone coloring filter is a band pass filter.

7. A bass tone producing device according to claim 1 wherein said first signal composing means comprises a plurality of resistors connected at one end to the corresponding output terminals of said keyer circuits, said resistors being jointly connected at the other ends thereof.

8. A bass tone producing device according to claim 1 wherein said final signal composing means comprises two resistors connected at one end to the corresponding tone coloring filters, said resistors being jointly connected at the other ends thereof.

9. A bass tone producing device according to claim 4 wherein said trigger circuit includes a one-shot multivibrator.

10. A bass tone producing device according to claim 1 wherein said means for reversing the phase of said harmonic bass tone signal in said second composite signal comprises a phase inverter coupling the harmonic bass tone signal from said keyer circuits to said second tone coloring filter.

11. A bass tone producing device according to claim 1 wherein said means for reversing the phase of said harmonic bass tone signal in said second composite signal comprises means in said harmonic bass tone signal source for generating pairs of opposite phase harmonic bass tone signals, one of said bass tone signals being coupled to said first tone coloring filter, and the other of said bass tone signals, which is out of phase with respect to said one of said bass tone signals, being coupled to said second tone coloring filter.

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