United States Patent [19]

Okamoto

[11] **3,886,834**

[45] **June 3, 1975**

[54] **ELECTRONIC MUSICAL INSTRUMENT CAPABLE OF MODULATION CONTROLLING A SECOND KEYBOARD SECTION TONE SIGNAL IN ACCORDANCE WITH A FIRST KEYBOARD SECTION TONE SIGNAL**

[75] Inventor: **Eisaku Okamoto,** Hamakita, Japan

[73] Assignee: **Nippon Gakki Seizo Kabushiki Kaisha,** Hamamatsu-shi, Japan

[22] Filed: **May 8, 1974**

[21] Appl. No.: **467,892**

[30] **Foreign Application Priority Data**

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Sept. 8, 1973 Japan 48-105447
Sept. 8, 1973 Japan 48-105448

[52] **U.S. Cl.** **84/1.17;** 84/1.19; 84/1.22; 84/1.24

[51] **Int. Cl.** **G10h 1/04;** G10h 5/00

[58] **Field of Search** ..... 84/1.01, 1.17, 1.24, DIG. 2, 84/DIG. 8, DIG. 20, 109–1.11, 1.13, 1.19, 1.22, 1.25, 1.26, 1.27, DIG. 11

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Primary Examiner—Stephen J. Tomsky
Assistant Examiner—Stanley J. Witkowski
Attorney, Agent, or Firm—Flynn & Frishauf

[57] **ABSTRACT**

An electronic musical instrument is capable of modulation controlling at least one of the pitch frequency, tone color and volume envelope of a second keyboard section tone signal by a tone signal obtained by operating any key on the first keyboard section. To control the frequency, tone color and volume envelope of the second keyboard section tone signal, a voltage controlled oscillator, voltage controlled filter and voltage controlled amplifier can be used. The first keyboard section tone signal may be frequency divided and/or waveform converted so as to control the second keyboard section tone signal.

13 Claims, 5 Drawing Figures

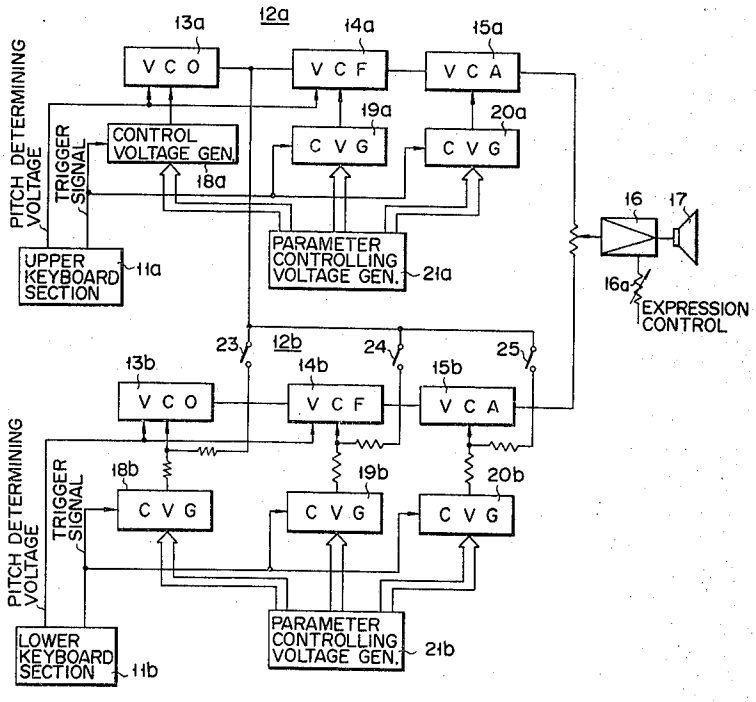


FIG. 1

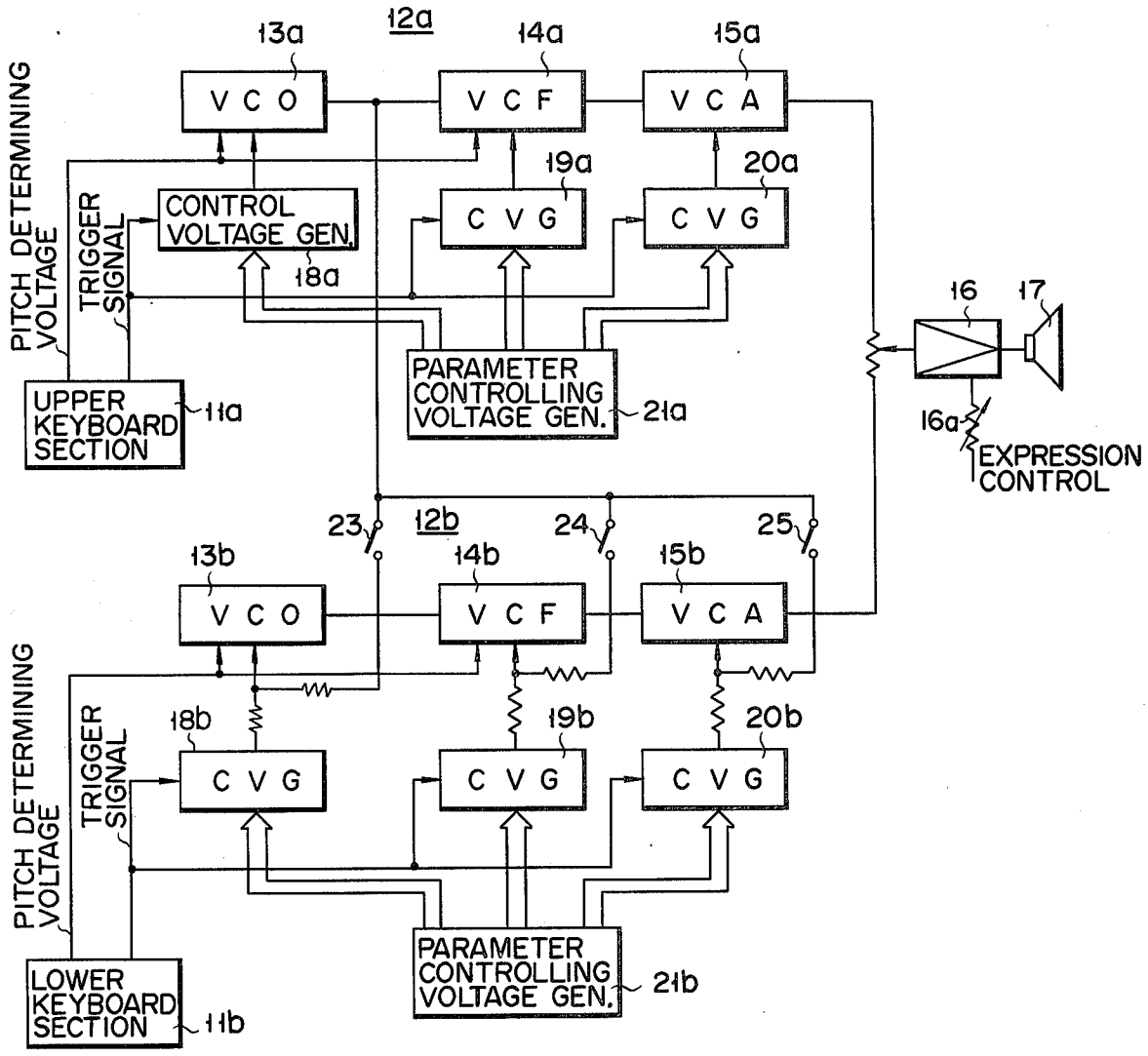

12a
13a
14a
15a
VCO
VCF
VCA
19a
20a
CVG
CVG
CONTROL VOLTAGE GEN.
18a
PITCH DETERMINING VOLTAGE
TRIGGER SIGNAL
UPPER KEYBOARD SECTION
11a
PARAMETER CONTROLLING VOLTAGE GEN.
21a
16
17
16a
EXPRESSION CONTROL
23
12b
24
25
13b
14b
15b
VCO
VCF
VCA
18b
19b
20b
CVG
CVG
CVG
PITCH DETERMINING VOLTAGE
TRIGGER SIGNAL
LOWER KEYBOARD SECTION
11b
PARAMETER CONTROLLING VOLTAGE GEN.
21b

FIG. 2

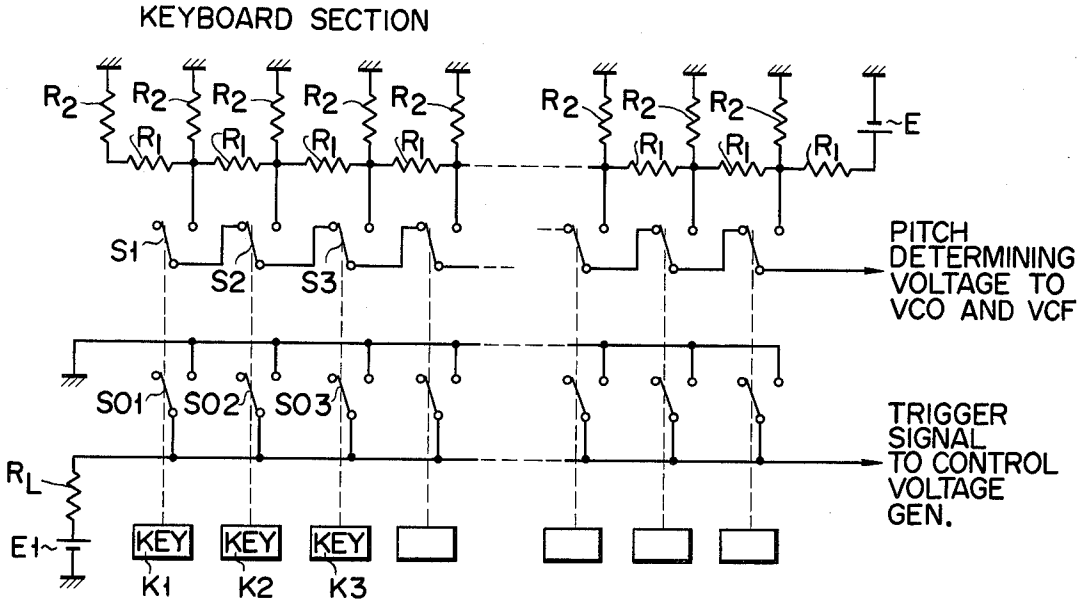

KEYBOARD SECTION
R2
R1
E
S1
S2
S3
PITCH DETERMINING VOLTAGE TO VCO AND VCF
SO1
SO2
SO3
TRIGGER SIGNAL TO CONTROL VOLTAGE GEN.
RL
E1
KEY
K1
K2
K3

FIG. 3

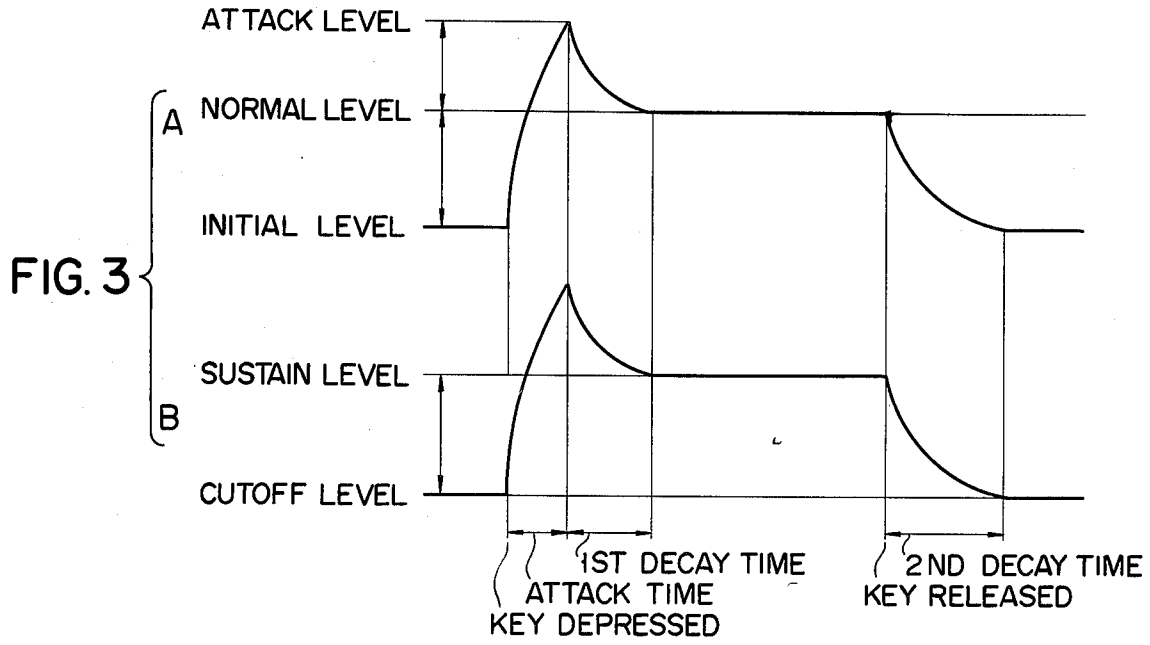

ATTACK LEVEL
A
NORMAL LEVEL
INITIAL LEVEL
SUSTAIN LEVEL
B
CUTOFF LEVEL
1ST DECAY TIME
ATTACK TIME
KEY DEPRESSED
2ND DECAY TIME
KEY RELEASED

FIG. 4

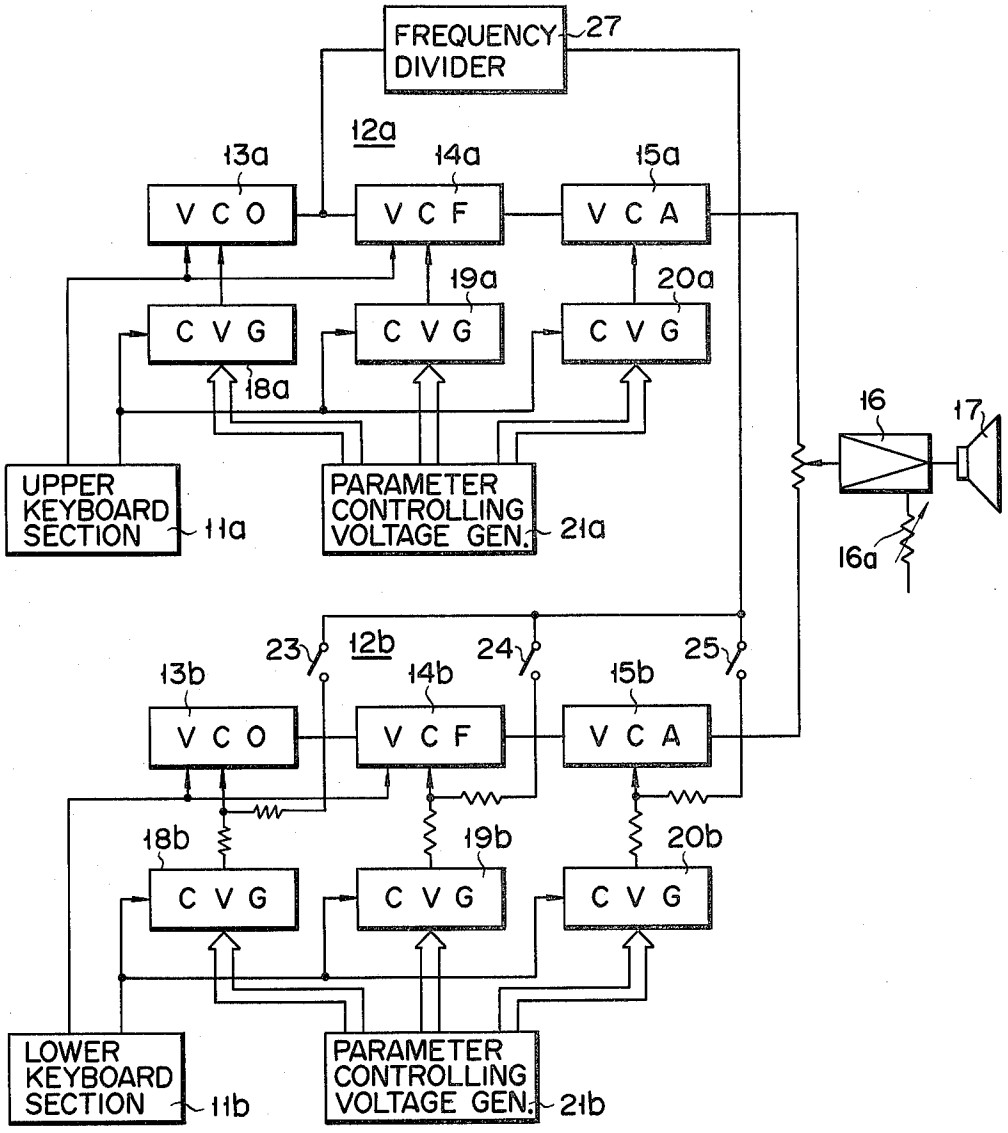
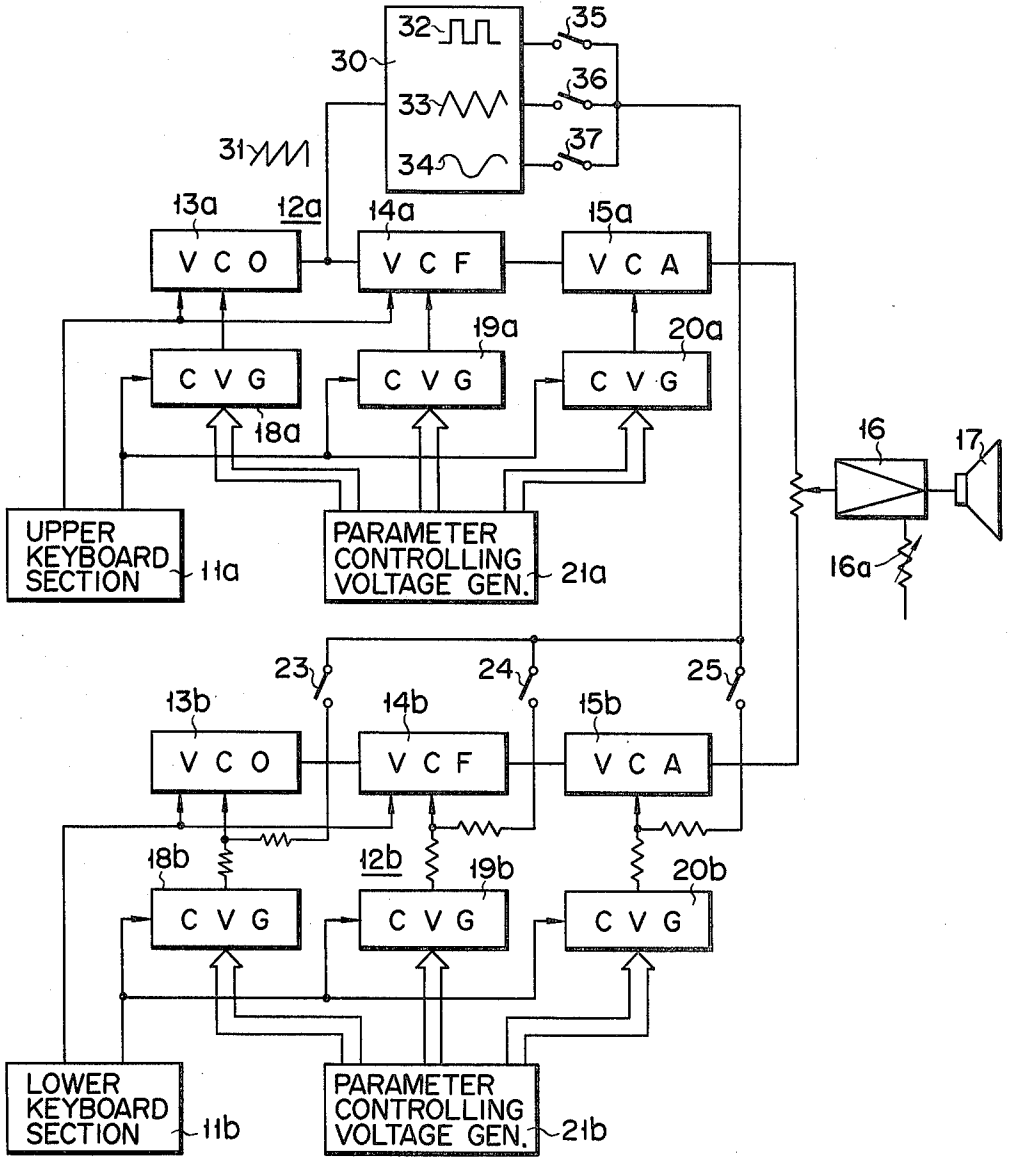

FREQUENCY DIVIDER
27
12a
13a
14a
15a
V C O
V C F
V C A
19a
20a
C V G
C V G
C V G
18a
16
17
16a
UPPER KEYBOARD SECTION
11a
PARAMETER CONTROLLING VOLTAGE GEN.
21a
23
12b
24
25
13b
14b
15b
V C O
V C F
V C A
18b
19b
20b
C V G
C V G
C V G
LOWER KEYBOARD SECTION
11b
PARAMETER CONTROLLING VOLTAGE GEN.
21b

FIG. 5


32
35
30
36
33
37
31
34
13a
12a
14a
15a
V C O
V C F
V C A
19a
20a
C V G
C V G
C V G
18a
16
17
16a
UPPER KEYBOARD SECTION
11a
PARAMETER CONTROLLING VOLTAGE GEN.
21a
23
24
25
13b
14b
15b
V C O
V C F
V C A
18b
12b
19b
20b
C V G
C V G
C V G
LOWER KEYBOARD SECTION
11b
PARAMETER CONTROLLING VOLTAGE GEN.
21b

ELECTRONIC MUSICAL INSTRUMENT CAPABLE OF MODULATION CONTROLLING A SECOND KEYBOARD SECTION TONE SIGNAL IN ACCORDANCE WITH A FIRST KEYBOARD SECTION TONE SIGNAL

BACKGROUND OF THE INVENTION

This invention relates to an electronic musical instrument and more particularly to an electronic musical instrument capable of modulation controlling a second keyborad section tone signal by a first keyboard section tone signal.

With a conventional electronic musical instrument, for example, a melody performance, chord performance and bass performance are effected by an upper keyboard, lower keyboard and pedal keyboard, respectively. Tone signals obtained in response to key operation in each keyborad are independently subject to treatment such as a tone color formation, envelope formation etc.

SUMMARY OF THE INVENTION

It is the object of this invention to provide an electronic musical instrument capable of modulation controlling a second tone signal obtained in response to a key operation on a second keyboard section by a first tone signal obtained in response to key operation on a first keyboard section, whereby a diversified performance effect can be attained.

According to this invention a second tone signal has any one or at least one of its pitch frequency, tone color and volume envelope modulated by a first tone signal.

The first and second tone signals may be ones derived, in response to key operation, from conventional tone generators including master oscillators and frequency dividers.

According to a preferred embodiment of this invention, the above-mentioned second tone signal is formed by a voltage controlled oscillator in response to that pitch determining voltage of a magnitude corresponding to the note of any operated key which is derived from a pitch determining voltage source in response to the key operation. To the second tone signal a tone color and volume envelope are imparted by a voltage controlled filter and voltage controlled amplifier, respectively. The above-mentioned first tone signal is coupled as a control voltage to any one or at least one of a voltage controlled oscillator, voltage controlled filter and voltage controlled amplifier so as to control at least one of the pitch frequency, tone color and volume envelope of the second tone signal. In this case, the first tone signal may be selectively coupled through switches to one of voltage controlled oscillator, voltage controlled filter and voltage controlled amplifier.

The first tone signal, like the second tone signal, may be formed by a voltage controlled oscillator in response to a pitch determining voltage which is obtained from a pitch determining voltage source in response to key operation. The output of the voltage controlled oscillator, like the second tone signal, may be coupled to the voltage controlled filter and voltage controlled amplifier.

The voltage controlled oscillator, voltage controlled filter and voltage controlled amplifier associated with the first tone signal and the voltage controlled oscillator, voltage controlled filter and voltage controlled amplifier associated with the second tone signal are controlled by those control voltages from control voltage generators which are varied with time during the key depression time and during the key release time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an electronic musical instrument according to one embodiment of this invention;

FIG. **2** is a circuit arrangement of a keyboard section of FIG. **1**;

FIG. **3** shows the waveforms of control voltages formed by control voltage generators of FIG. **1**; and

FIGS. **4** and **5** are block diagrams showing the other embodiments of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1** showing one emodiment of this invention, the reference numerals **11***a* and **11***b* denote upper and lower keyboard sections where a pitch determining voltage having a magnitude corresponding to the note of any operated key and a trigger signal indicating a key operation are generated. To the upper and lower keyboard sections **11***a* and **11***b* musical tone signal producing circuits **12***a* and **12***b* are respectively coupled. The musical tone signal producing circuit **12***a* includes a voltage controlled oscillator (hereinafter referred to as VCO) **13***a* for generating in response to a pitch determining voltage from the upper keyboard section **11***a* a tone signal having a frequency corresponding to the note of operated key; voltage controlled filter (hereinafter referred to as VCF) **14***a* for imparting a tone color to the tone signal from VCO; and voltage controlled amplifier (hereinafter referred to as VCA) **15***a* for imparting a volume envelope to an output signal of VCF. To VCF **14***a* is also coupled the pitch determining voltage from the keyboard section **11***a*. Likewise, the musical tone signal producing circuit **12***b* includes a VCO **13***b*, VCF **14***b* and VCA **15***b*.

The outputs of the musical tone signal producing circuits **12***a* and **12***b* are coupled to sound reproducing means including an amplifier **16** expression control **162** and loudspeaker **17**.

The musical tone signal producing circuit **12***a* further includes control voltage generators **18***a*, **19***a* and **20***a* provided correspondingly to VCO **13***a*, VCF **14***a* and VCA **15***a* so as to control the tone pitch, tone color and volume envelope of the tone signal. The control voltage generators **18***a*, **19***a* and **20***a* are adapted to generate in response to a trigger signal from the keyboard section **11***a* voltage signals having various parameters set at a parameter controlling voltage generator **21***a* to thereby control VCO **13***a*, VCF **14***a* and VCA **15***a*. Likewise, the musical tone signal producing circuit **12***b* includes control voltage generators **18***b*, **19***b* and **20***b* for generating control voltages in response to a trigger signal from the keyboard section **11***b* so as to control VCO **13***b*, VCF **14***b* and VCA **15***b*, and a parameter controlling voltage generator **22***b* for supplying parameter controlling voltages to these control voltage generators the unlabeled resistors in FIG. **1** which are connected to VCO **13***b*, VCF **14***b* and VCA **15***b* are conventional mixing resistors.

Fig. **3** shows, by way of example, control voltage waveforms obtained from the control voltage generators **18***a* to **20***a* and **18***b* to **20***b*. In the control voltage waveforms shown, A shows the control voltage wave-

form as applied to VCO's 13*a* and 13*b* and VCF's 14*a* and 14*b*, while B shows the control voltage waveform as applied to VCA's 15*a* and 15*b*. Waveforms A and B are similar, but their nominal voltage levels are different. When the key is depressed, the voltage waveform A rises from an initial level to an attack level during an attack time and decays from the attack level to a normal level during a first decay time. The normal level continues until the key is released. Upon release of the key, the voltage waveform decays from the normal level to the initial level during a second decay time.

When the voltage waveform A is supplied to VCO's 13*a* and 13*b*, the tone signal is so controlled during the key depression time that its frequency is abruptly varied from an initial level frequency somewhat lower than a normal level frequency to an attack level frequency somewhat higher than the normal level frequency which is determined by the pitch determining voltage from the keyboard section. Thereafter, the tone signal frequency approaches to the normal level frequency during the first decay time and becomes equal to the normal level frequency after lapse of the first decay time. After the key is released, the tone signal frequency is lowered from the normal level frequency to the initial level frequency during the second decay time. Namely, the tone signal frequencies from VCO's 13*a* and 13*b* are modified in accordance with the waveform of voltages varied with time.

When the voltage waveform A is supplied to VCF's 14*a* and 14*b*, the cutoff frequencies of the filter are controlled in accordance with the voltage waveform. Consequently, the tone color of the tone signal is modified.

When the key is depressed, the voltage waveform B rises from a cutoff level to a peak level and, after lapse of an attack time, is returned to a sustain level during a first decay time. The sustain level is maintained until the key is released. After release of the key, the waveform decays from the sustain level to the cutoff level during a second decay time. Upon supply of the voltage waveform B to VCA's 15*a* and 15*b* an envelope as shown in the waveform B is imparted to the tone signal. It will be understood that, if the waveform B is not applied to VCA's 15*a* and 15*b*, the VCA's each act as a tone keyer, since they are in the cutoff state.

The parameter controlling voltage generators 21*a* and 21*b*, described in copending applications Ser. Nos. 457,656 and 462,398, both assigned to the same Assignee, as the present application, each have a power source and a plurality of potentiometers and are adapted to apply to the respective control voltage generators voltage for controlling various controlled parameters of control voltages from the respective control voltage generators. The control voltages applied to VCO and VCF have such controlled parameters as, for example, a normal level, attack level, initial level, attack time, first decay time and second decay time, while, on the other hand, the control voltage applied to VCA has such controlled parameters as a sustain level, attack time, first decay time and second decay time. In FIG. 1 and throughout the drawings, the thick arrows coupling blocks together represent a plurality of signal lines.

FIG. 2 shows the arrangement of the keyboard section for supplying a pitck determining voltage to VCO. The voltage of a power source E is divided by a voltage dividing circuit network including resistors R1 and R2. To the respective voltage dividing points are connected the normally open fixed contacts of key switches S1, S2 . . . S3 actuated by keys K1, K2, K3 . . . The movable contacts of the respective key switches are connected to the normally open fixed contacts of adjacent key switches. In the key switch arrangement shown, when a plurality of keys are depressed at a time a voltage on a voltage dividing point connected to the key switch actuated by a single key is delivered to VCO. The key switches S1, S2, S3 . . . are ganged with key switches S01, S02, S03 . . . and at the time of key operation a trigger signal based on a power source E1 is supplied to the control voltage generators via a load resistor RL. The control voltage generators initiate the formation of control voltages upon receipt of the trigger signal.

With the electronic musical instrument so constructed, the tone pitch, tone color and volume envelope of tone signals obtained by actuating any keys on the upper and lower keyboard sections are modulated by control voltages whose values are varied with time during the key depression and during the key release. As a result, diversified musical sounds very pleasing to the human ears are obtained.

According to this invention a tone signal obtained from VCO 13*a* is coupled, through switches 23, 24 and 25, as an additional control voltage to VCO 13*b*, VCF 14*b* and VCA 15*b* in the second musical tone signal producing circuit 12*b*. The additional control voltage is added to a respective control voltage from control voltage generators 18*b*, 19*b* and 20*b*.

Upon closure of the switch 23, a tone signal from VCO 13*a* is applied, together with a control voltage formed at the control voltage generator 18*b*, to VCO 13*b*. For this reason, the tone signal of VCO 13*b* is roughly frequency modulated in accordance with the waveform of control voltage from the control voltage generator 18*b* and finely frequency modulated by the additional control voltage.

When the switch 24 is closed, VCF 14*b* has its cutoff frequency roughly varied by a control voltage from the control voltage generator 19*b* and finely varied by the additional control voltage.

Upon closure of the switch 25, VCA 15*b* has its gain mainly varied by a control voltage from the control voltage generator 20*b* and additionally varied by the additional control voltage from VCO 13*a*. Consequently, a rough envelope formed in accordance with the control voltage waveform of the control voltage generator 20*b* is imparted to the output tone signal of VCA 15*b*, and the output tone signal of VCA 15*b* has its envelope finely varied by the additional control voltage.

Though with the embodiment of FIG. 1 the output of VCO 13*a* is utilized as an additional control voltage, the output of VCF 14*a* or VCA 15*a* may be used as the additional control voltage. Though the additional control voltage is coupled through switches 23, 24 and 25 to VCO 13*b*, VCF 14*b* and VCA 15*b*, it may be coupled to any one of VCO 13*b*, VCF 14*b* and VCA 15*b*.

FIGS. 4 and 5 show the other embodiments of this invention. In these Figures, same reference numerals are employed to designate parts or elements corresponding to those shown in FIG. 1 and any further explanation is, therefore, omitted. Unlabelled resistors in FIGS. 4 and 5 are conventional mixing resistors.

With the embodiment of FIG. 1 a second tone signal associated with the lower keyboard section 11*b* is mod-

ulated by a first tone signal associated with the upper keyboard section **11***a* having a higher compass than the lower keyboard section **11***b*. Where, however, the frequency of the modulation signal is higher than the frequency of a signal to be modulated, unclearness is liable to occur due to modulation. To obviate such unclearness it is desirable to couple the first tone signal associated with the upper keyboard section **11***a* to the second musical tone signal producing circuit **12***b*, as shown in FIG. **4**, through a frequency divider **27**.

With the embodiment of FIG. **5** a first tone signal associated with an upper keyboard section **11***a* is coupled through a waveform converter **30** to a second musical tone signal producing circuit **12***b*. In this case, a sawtooth wave **31** for example, of the second tone signal formed at VCO **13***a* may be converted by the waveform **30** into a plurality of different waveforms, for example, a rectangular waveform **32**, triangular waveform **33**, or sinusoidal waveform **34**. These waveforms are selectively coupled through switches **35**, **36** and **37** to the second musical tone signal producing circuit **12***b*. The use of the waveform converter **30** can provide more deversified performance effect. The waveform converter **30** may be used in combination with the frequency divider **27** shown in FIG. **4**.

Though with the above-mentioned embodiments multi-stage keyboard type electronic musical instrument having the upper and lower keyboards has been explained, this invention can also be applied to a single keyboard type electronic musical instrument. In this case, the single keyboard is divided into right and left half sections and a second tone signal obtained by actuating any key on the left half keyboard section is controlled by a first tone signal obtained by actuating any key on the right half keyboard section. This invention can also be applied to a modulation control between a manual keyboard section and a pedal keyboard section.

What is claimed is:

1. An electronic musical instrument comprising:

a first keyboard section including a plurality of keys and means for generating a pitch determining voltage having a magnitude which is a function of the note of an operated key;

a second keyboard section including a plurality of keys and means for generating a pitch determining voltage having a magnitude which is a function of the note of an operated key;

a first musical tone signal producing means connected to said first keyboard section and including a first voltage controlled oscillator means for generating in response to the pitch determining voltage a tone signal having a frequency which is a function of the note of the operated key on said first section;

a second musical tone signal producing means connected to said second keyboard section and including a second voltage controlled oscillator means for generating in response to the pitch determining voltage a tone signal having a frequency which is a function of the note of the operated key on said second keyboard section;

sound reproducing means connected to said first and second musical tone signal producing means; and

means for coupling a tone signal from said first musical tone signal producing means to said second voltage controlled oscillator means to thereby modulate the frequency of a tone signal produced by said second oscillator means.

2. An electronic musical instrument according to claim **1** wherein said last-mentioned means comprises means for dividing the frequency of the tone signal from said first musical tone signal producing means.

3. An electronic musical instrument according to claim **1** wherein said last-mentioned means comprises waveform converting means for converting the waveform of the tone signal from said first musical tone signal producing means.

4. An electronic musical instrument according to claim **3** wherein said waveform converting means includes means to convert the waveform of the tone signal from said first musical tone signal producing means into a plurality of kinds of waveforms and includes switching means for selecting one of the waveforms.

5. An electronic musical instrument according to claim **1** wherein said coupling means includes means for coupling the output of said first voltage controlled oscillator means to said voltage controlled oscillator means.

6. An electronic musical instrument according to claim **1** wherein said second musical tone signal producing means further comprises a voltage controlled filter means connected to said voltage controlled oscillator means for imparting a tone color to the tone signal from said oscillator means, said voltage controlled filter means being operative to vary in response to a control voltage the frequency characteristic thereof; and further comprising means for coupling the tone signal from said first musical tone signal producing means to said voltage controlled filter means as the control voltage.

7. An electronic musical instrument according to claim **1** wherein said second musical tone signal producing means further comprises a voltage controlled amplifier means coupled to said second oscillator means, said amplifier means being operative to vary in response to a control voltage the gain thereof; and further comprising means for coupling the tone signal from said first musical tone signal producing means to said voltage controlled amplifier means as the control voltage.

8. An electronic musical instrument according to claim **1** wherein said first and second keyboard sections comprise means for generating in response to key operation first and second trigger signals indicating the key operation respectively; said first musical tone signal producing means comprises a first voltage controlled filter means coupled to said first oscillator means, a first voltage controlled amplifier means coupled to said voltage controlled filter means and first control voltage generating means responsive to the first trigger signal to generate control voltages which vary as a function of time and which are coupled to said first voltage controlled oscillator means, first voltage controlled filter means and first voltage controlled amplifier means; and wherein said second musical tone signal producing means comprises a second voltage controlled filter means coupled to said second oscillator means, a second voltage controlled amplifier means coupled to said second filter means, and second control voltage generating means responsive to the second trigger signal to generate control voltages which vary as a function of time and which are coupled to said voltage controlled oscillator means, second voltage controlled filter means and second voltage controlled amplifier means.

9. An electronic musical instrument comprising:

first and second keyboard sections each having a plurality of keys;

first and second musical tone signal producing means respectively coupled to said first and second keyboard sections for producing respective musical tone signals having pitch frequencies which are functions of the notes of keys operated on said respective first and second keyboard sections, at least said second musical tone signal producing means comprising a voltage controlled means for controlling at least one of the pitch frequency, tone color, and volume envelope of a musical tone signal generated by said electronic musical instrument;

sound reproducing means coupled to said first and second musical tone signal producing means for generating a musical sound; and

means for coupling said voltage controlled means a tone signal obtained from said first musical tone signal producing means in response to key operation on said first keyboard section for controlling said voltage controlled means.

10. An electronic musical instrument comprising:

a first keyboard section for generating a first pitch determining voltage having a magnitude which is a function of the note of an operated key and a first trigger signal indicating the key operation on said first keyboard section;

a second keyboard section for generating a second pitch determining voltage having a magnitude which is a function of the note of an operated key and a second trigger signal indicating the key operation on said second keyboard section;

a first musical tone signal producing means coupled to said first keyboard section and including a first voltage controlled oscillator means for generating in response to the pitch determining voltage from said first keyboard section a tone signal having a pitch frequency which is a function of the note of the operated key, a first voltage controlled filter means coupled to said first voltage controlled oscillator means, a first voltage controlled amplifier means coupled to said first voltage controlled filter means, and first control voltage generating means responsive to the first trigger signal to generate control voltages which vary as a function of time and which are coupled to said first voltage controlled oscillator means, voltage controlled filter means and voltage controlled amplifier means, said first voltage controlled oscillator means, voltage controlled filter means and voltage controlled amplifier means being operative to vary in response to the control voltages, the oscillator frequency of said first voltage controlled oscillator means, the frequency characteristic of said first voltage controlled filter means and the gain of said first voltage controlled amplifier means;

a second musical tone signal producing means coupled to said second keyboard section and including a second voltage controlled oscillator means for generating in response to the pitch determining voltage from said second keyboard section a tone signal having a pitch frequency which is a function of the note of the operated key, a second voltage controlled filter means coupled to said second voltage controlled oscillator means, a second voltage controlled amplifier means coupled to said second voltage controlled filter means, and a second control voltage generating means responsive to the second trigger signal to generate control voltages which vary as a function of time and which are coupled to said second voltage controlled oscillator means, voltage controlled filter means and voltage controlled amplifier means, said second voltage controlled oscillator means voltage controlled filter means and voltage controlled amplifier means being operative to vary in response to the control voltages the oscillation frequency of said second voltage controlled oscillator means, the frequency characteristic of said second voltage controlled filter means and the gain of said second voltage controlled amplifier means;

second reproducing means coupled to said first and second musical tone signal producing means; and

means for coupling as an additional control voltage an output signal from said first voltage controlled oscillator means in said first musical tone signal producing means to at least one of said second voltage controlled oscillator means, second voltage controlled filter means and second voltage controlled amplifier means in said second musical tone signal producing means.

11. An electronic musical instrument according to claim **10** wherein said last-mentioned means comprises switching means for selectively coupling the output signal from said first voltage controlled oscillator means to one of said second voltage controlled oscillator means, second voltage controlled filter means and second voltage controlled amplifier means.

12. An electronic musical instrument according to claim **10** wherein said last-mentioned means comprises means for dividing the frequency of the output signal from said first voltage controlled osicllator means, means.

13. An electronic musical imstrument according to claim **10** wherein said last-mentioned means comprises means for changing the waveform of the output signal from said first voltage controlled oscillator means, first.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,886,834
DATED : June 3, 1975
INVENTOR(S) : Eisaku OKAMOTO

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 19, before "voltage controlled" insert --second--;

Column 8, line 48, change "osicllator" to --oscillator--; after "means" delete "," and insert --.--;

line 49, delete "means.";

line 53, after "means" delete ", first"..

Signed and Sealed this

second Day of December 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE

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line 49, delete "means.";

line 53, after "means" delete ", first"..

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second Day of December 1975

[SEAL]

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Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks