United States Patent

[11] 3,617,604

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[21] Appl. No. 21,079
[22] Filed Mar. 19, 1970
[45] Patented Nov. 2, 1971
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[32] Priority Mar. 22, 1969
[33] Japan
[31] 44/21426

[54] **ELECTRONIC MUSICAL INSTRUMENT CAPABLE OF GENERATING MUSICAL TONE SIGNALS SIMULATING THE SOUNDS OF A WIND INSTRUMENT**
16 Claims, 13 Drawing Figs.

[52] U.S. Cl. 84/1.22, 84/1.1, 84/1.17, 84/1.19, 84/1.26
[51] Int. Cl. G10h 1/02
[50] Field of Search 84/1.09–1.11, 1.15, 1.19, 1.22, 1.23, 1.27, 1.17 1.26

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ABSTRACT: An electronic musical instrument produces musical tones simulating a natural flute voice closely. The instrument comprises a fundamental tone-pitched signal generator, a keyer associated with a key and keying the signal from the generator with an amplitude responsive to a depressing force of the key, a filter giving a tone color, as a formant component, of the flute voice to the keyed signal from the keyer, a tone pitched noise generator with a percussive envelope having a peak amplitude which is less responsive to the key-depressing force than the amplitude of the fundamental tone pitched signal, or not responsive to the key-depressing force. The tone signal having the flute formant and the noise signal having the pitch sense are mixed and radiated from a loudspeaker.

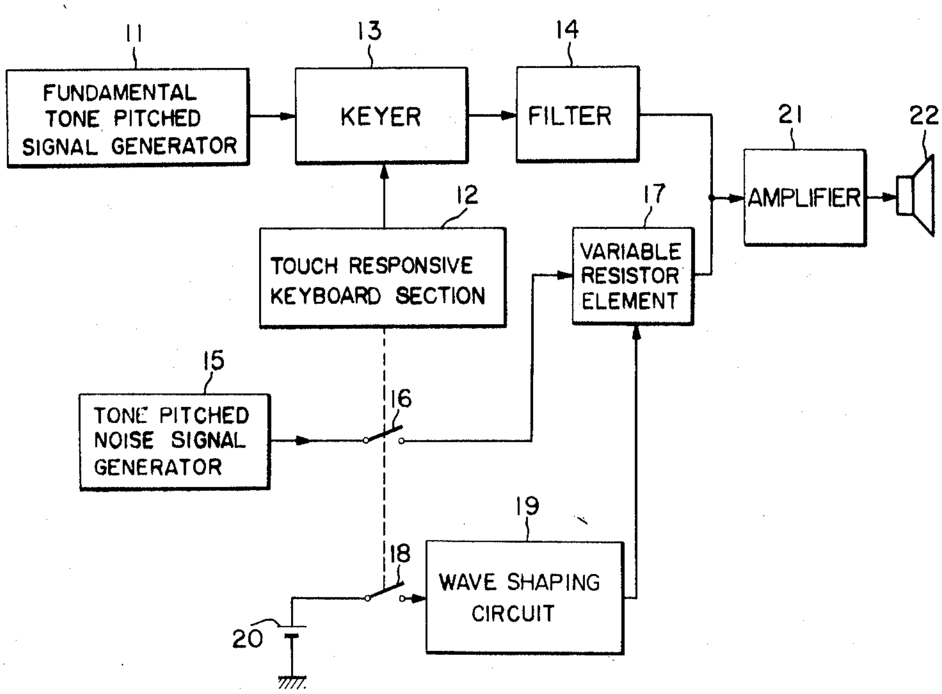

FIG. 1

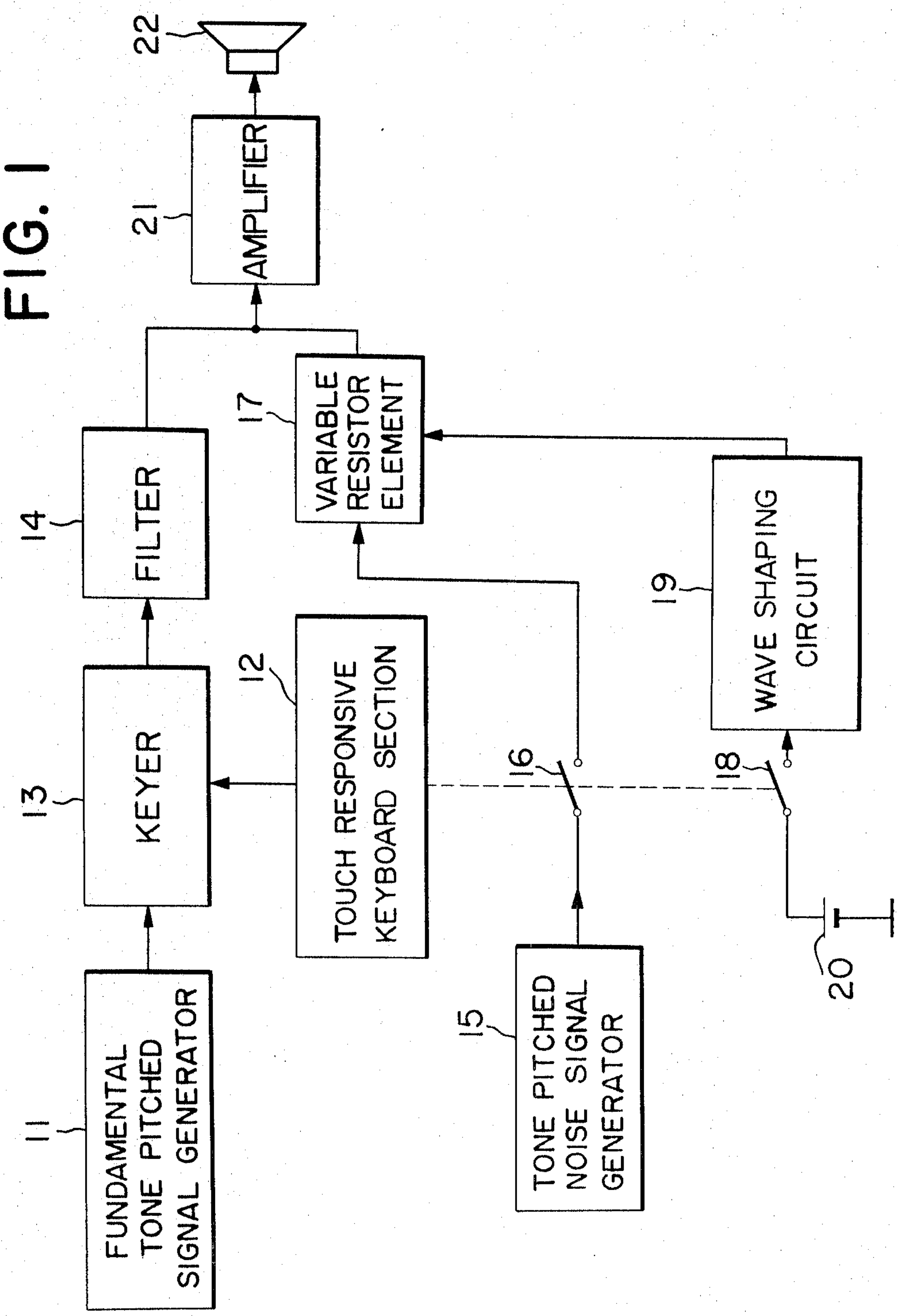

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FIG. 2A

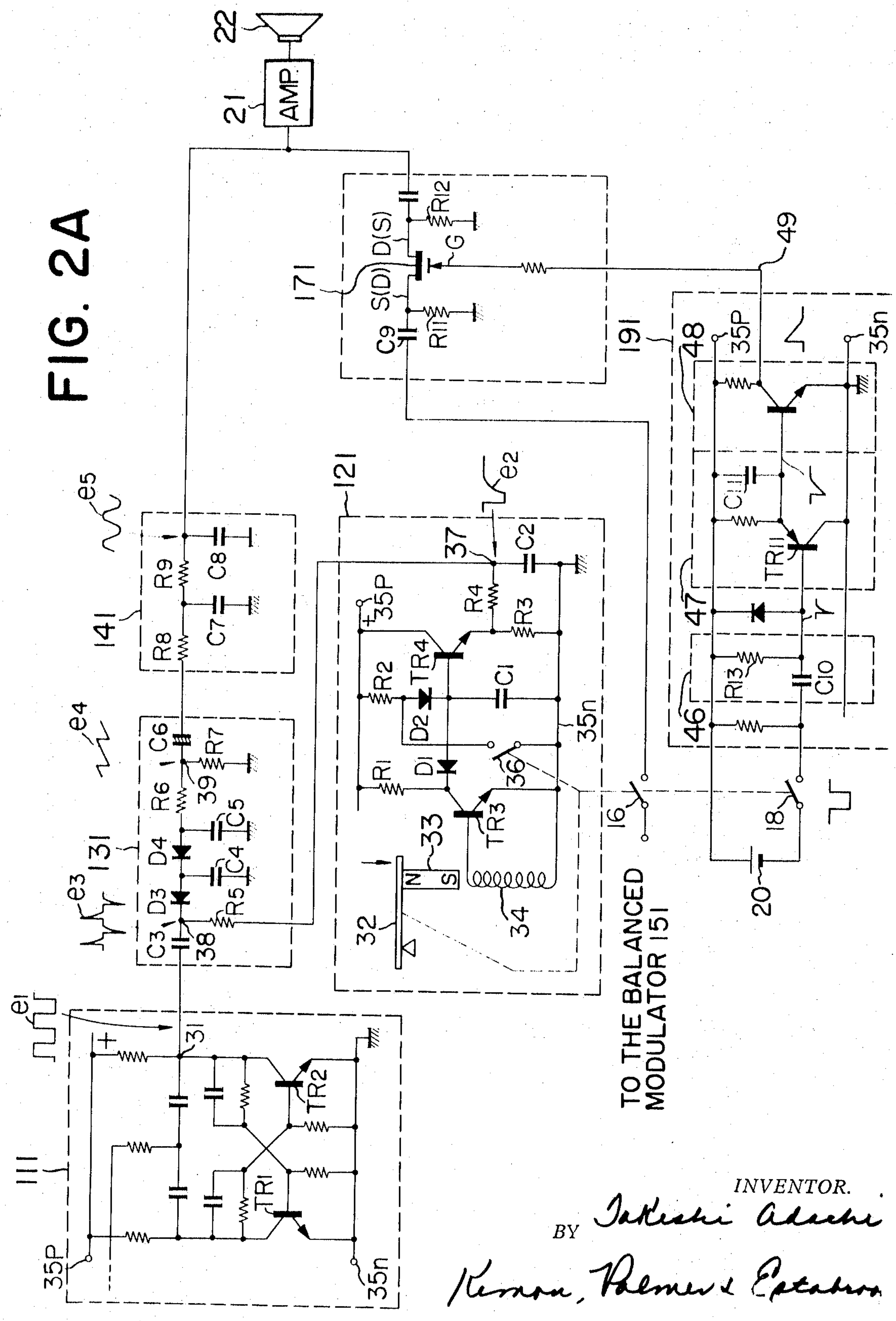

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FIG. 2B

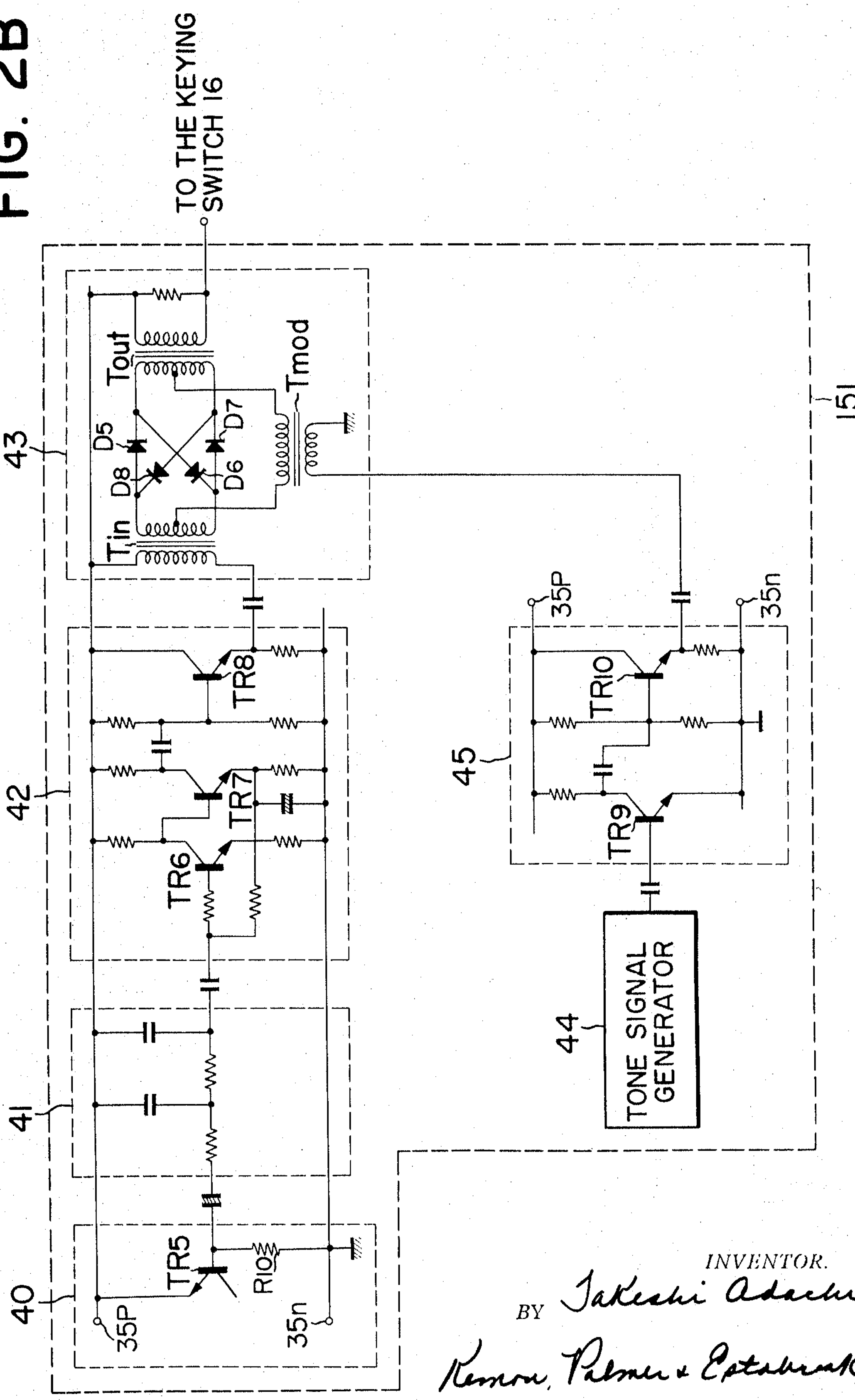

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FIG. 3A

FIG. 3B

FIG. 3C

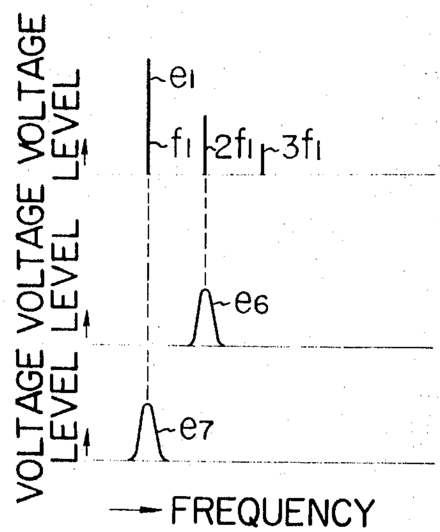

FIG. 4A

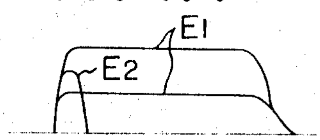

FIG. 4B

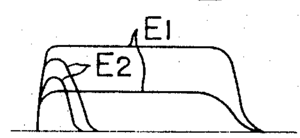

FIG. 4C

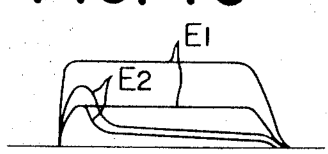

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FIG. 5

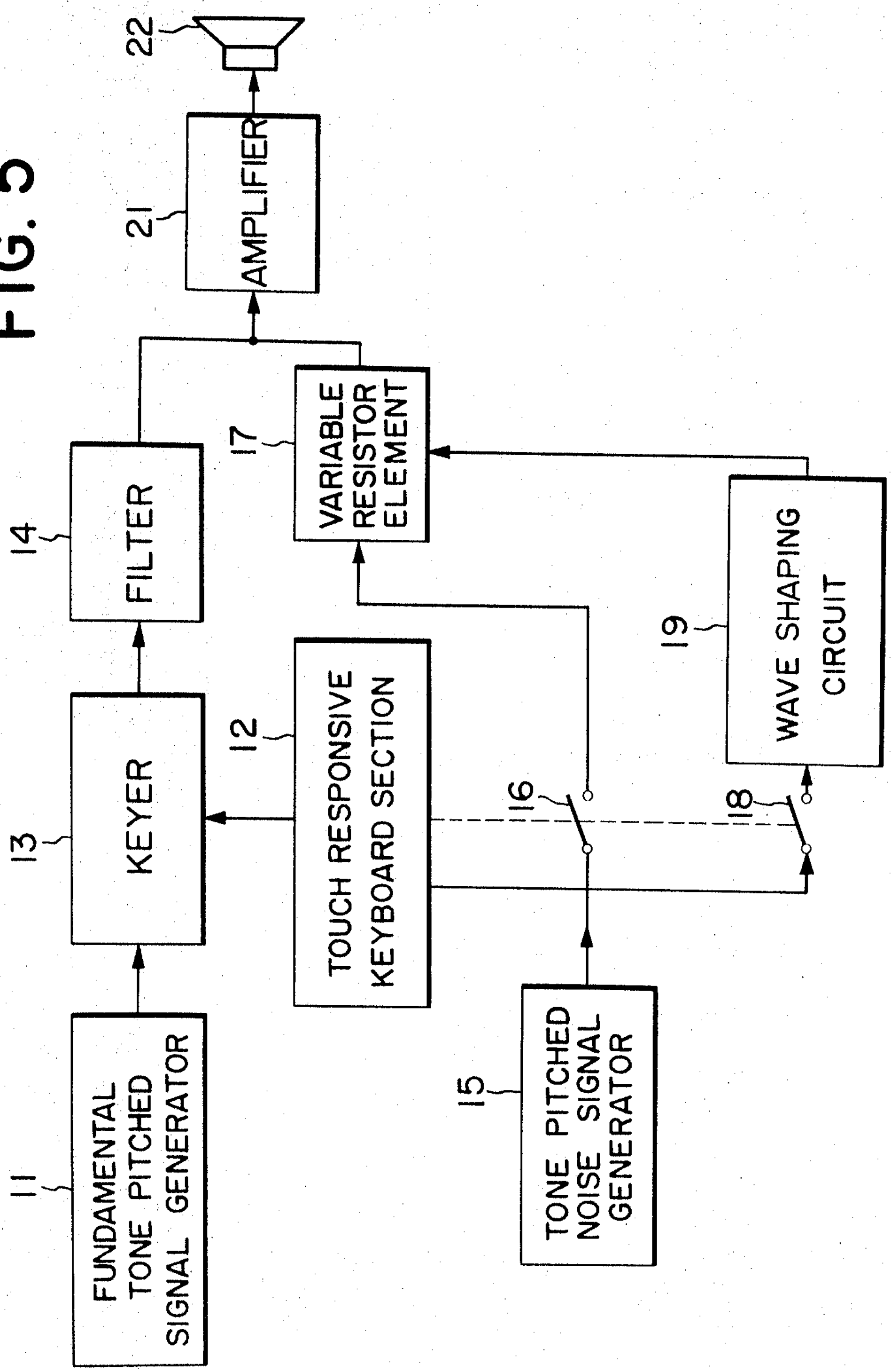

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FIG. 6

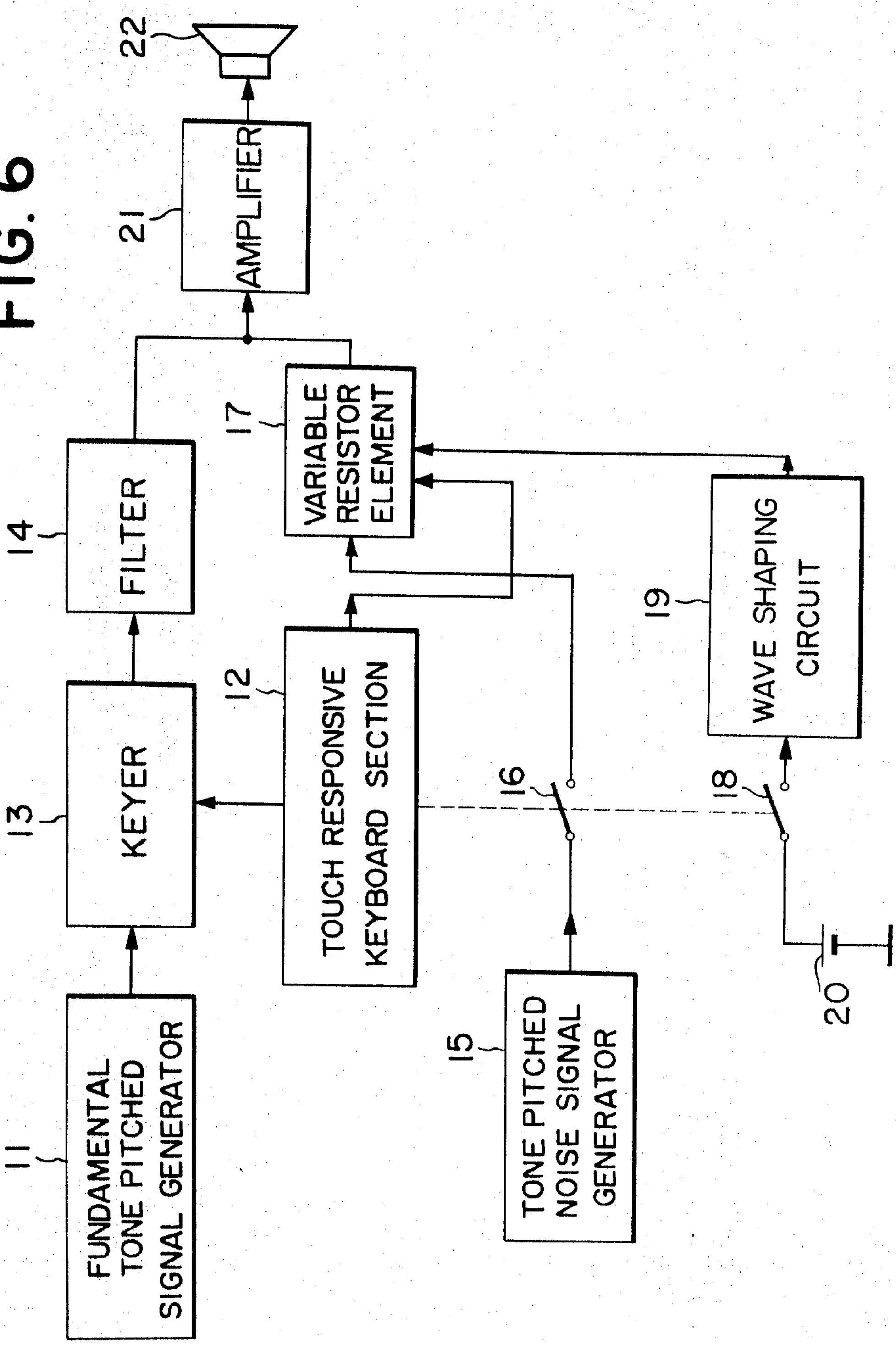

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FIG. 7

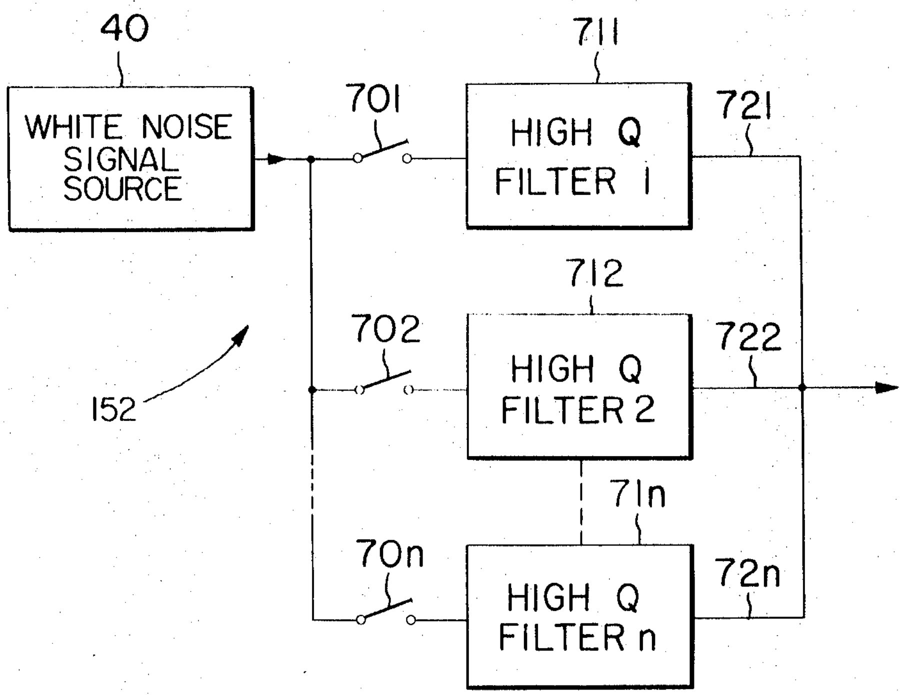
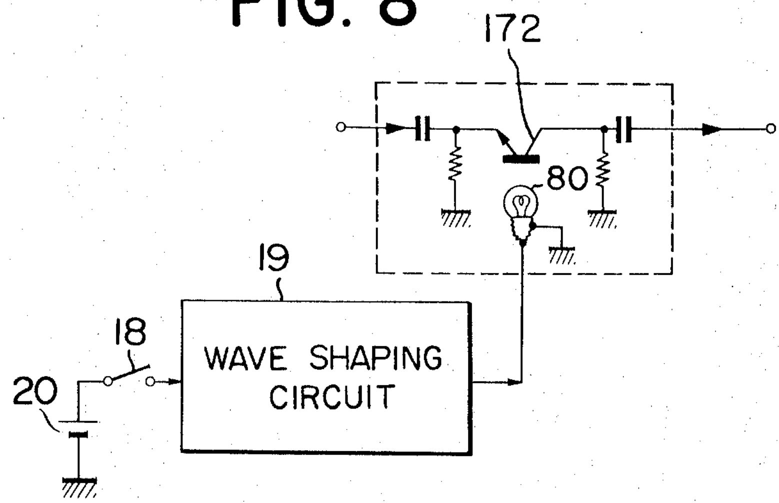


FIG. 8



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ELECTRONIC MUSICAL INSTRUMENT CAPABLE OF GENERATING MUSICAL TONE SIGNALS SIMULATING THE SOUNDS OF A WIND INSTRUMENT

BACKGROUND OF THE INVENTION

The present invention relates to an electronic keyboard musical instrument and more particularly to a novel type of said musical instrument which is so improved as to generate musical tone signals closely resembling the sounds of a desired wind instrument.

With a wind musical instrument, for example, a flute, there is generally generated at the start not only a sound component bearing the tone color of formant forming components which is sustained for a relatively long period, but also another sound component bearing the tone color of noise components which is sustained for a relatively short period. Such wind instrument is further characterized in that when it is blown soft, the formant component becomes soft and the noise-type sound component appears rather prominent, though only at the initial stage, whereas when it is blown forcefully, the formant component sounds loud and the noise component is not much noticed.

However, the prior art electronic musical instrument of the kind is primarily designed to form musical tone signals bearing a tone color which only approximates that of a formant component included in the sounds generally produced by a natural wind instrument. Accordingly, although, while being continuously played, the conventional electronic musical instrument appears to produce sounds which relatively resemble those of a natural wind instrument, it generates in fact musical tones which widely depart from natural ones.

SUMMARY OF THE INVENTION

The present invention has been accomplished to resolve the drawbacks encountered with the conventional electronic musical instrument and provide a novel type of said musical instrument wherein there is formed at the start not only a fundamental tone-pitched signal component bearing a tone color closely resembling that of formant component included in the sounds of a desired natural wind instrument and sustaining itself for a relatively long period, but also a tone-pitched noise signal component having a tone color closely resembling that of noise component included in the sounds of said natural wind instrument, whereby there can be played musical tones more resembling the sounds of a natural wind instrument than has been possible with the prior art.

BRIEF EXPLANATION OF THE DRAWINGS

FIG. 1 is a schematic block diagram of an electronic musical instrument according to an embodiment of the present invention;

FIGS. 2A and 2B show the concrete circuit arrangements of the various sections of the circuitry of FIG. 1;

FIGS. 3A to 3C illustrate the manner in which there is defined the tone pitch of output signals from the fundamental tone-pitched signal generator shown in FIG. 1 relative to that of output signals from the tone-pitched noise signal generator shown therein;

FIGS. 4A to 4C represent the different envelope forms of musical tone signals generated by the electronic musical instrument of the invention;

FIGS. 5 and 6 indicate different modifications of the circuitry of FIG. 1;

FIG. 7 is a modified schematic block diagram of the tone-pitched noise signal generator of FIG. 2B, and

FIG. 8 represents a modified circuit of the section of a variable resistance element included in FIG. 2A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

There will now be described by reference to the appended drawings an electronic musical instrument according to the embodiment and modifications of the present invention. FIG. 1 is a schematic block diagram of an embodiment of the invention. When there is depressed a given key included in the keyboard of an electronic keyboard musical instrument (not shown) comprising a plurality of juxtaposed keys, there is generated from a fundamental tone-pitched signal generator **11** a fundamental tone-pitched signal having a tone pitch (frequency) corresponding to the depressed key. There is also provided a touch-responsive keyboard section **12** which generates a DC voltage whose level varies, as later described, with the magnitude of a force with which there is depressed a key during performance. Output signals from the section **12** are supplied to a keyer **13** having the later described circuitry as keying signals corresponding to fundamental tone-pitched signals from the generator **11**. With this arrangement, there are generated from the keyer **13** output signals which are obtained by controlling the voltage level of fundamental tone-pitched signals from the generator **11** by that of keying signals from the section **12**. Output signals from the keyer **13** are impressed on a filter **14** to form a fundamental tone-pitched signal component bearing a tone color well resembling that of a formant component included in the sounds of a desired wind instrument, for example, a flute.

Further there is provided a tone-pitched noise signal generator **15** which generates a tone-pitched noise signal component having a tone color well resembling that of the noise component of the sounds of said flute in correspondence to the depressed key as in the case of fundamental tone pitched signal generator **11**. Tone-pitched noise signals from the noise signal generator **15** are conducted through a first normally open keying switch **16** which is only closed at the depression of its corresponding key to a variable resistance element **17** consisting of the later described field effect transistor (hereinafter referred to as FET) or a photoelectiric converting means. This element **17** serves as a percussion keyer. The control terminal of the variable resistance element **17** is supplied with a signal which is obtained by conducting, for example, a DC voltage from an indicated DC source **20** through the later described wave shaping circuit **19** via a second normally open keying switch **18** which is closed in interlocking relationship with the first keying switch **16**. With such arrangement, there is obtained from the variable resistance element **17** the aforesaid tone-pitched noise signal component from the noise signal generator **15** only while said element **17** is in an operative state, namely, while its control electrode is supplied with a signal from the wave-shaping circuit **19**. Output signals from the filter **14** and from the resistance element **17** are composed and these composite signals are supplied to a loudspeaker **22** through an amplifier **21**, thereby reproducing through the loudspeaker **22** musical tones closely resembling the sounds of a natural flute. FIGS. **2A** and **2B** represent the concrete circuit arrangements of the various sections of the circuitry of FIG. **1**. The fundamental tone-pitched signal generator **11** preferably consists of a bistable multivibrator **111** comprising, for example, two NPN-type transistors TR_1 and TR_2 shown in FIG. **2A**, and being triggered synchronously by an upper stage. From the output terminal **31** of the multivibrator **111** are obtained fundamental tone-pitched pitched signals e_1 having a tone pitch corresponding to the depressed key whose frequency is designated as f_1 and also assuming a waveform of a rectangular one having a frequency spectrum as shown in FIG. **3A**. The touch-responsive keyboard section **12** has a permanent magnetic piece **33** fitted to the underside of the depressed end of each of a plurality of keys **32** juxtaposed on keyboard. There is provided a coil **34** at a position where there is cut a magnetic flux from the magnetic piece **33** depressed together with a given key. The coil **34** is connected between the base and emitter terminals of an NPN-type emitter-grounded transistor TR_3 to supply input signals thereto. The collector terminal of the transistor TR_3 whose collector resistor R_1 is connected to the terminal **35*p*** of a +B source is connected through a diode D_1 of the indicated polarity to the base terminal of an NPN-type emitter-follower transistor TR_4. The base terminal of the transistor TR_4 is further connected to the contact of a diode D_2 of the indicated polarity and a capacitor C_1 included in a series circuit consisting of a resistor R_2, the diode D_2 and capacitor C_1 which are connected in series between the +B source terminal 35*p* and a grounded −B source terminal 35*n*. There is interposed between the contact of the resistor R_2 and diode D_2 and the −B source terminal 35*n* a third keying switch **36** operated in interlocking relationship with the first and second keying switches **16** and **18**. There is connected in parallel a series circuit consisting of a resistor R_4 and capacitor C_2 between both terminals of an emitter resistor R_3 interposed between the emitter terminal of the transistor TR_4 and −B source terminal 35*n*. The contact 37 of the resistor R_4 and capacitor C_2 constitutes the output terminal of the touch-responsive keyboard section **121** and the transistor TR_4 is supplied in advance with a base bias voltage by suitably setting the value of the resistor R_2 so as to allow saturated current to be introduced while the corresponding key is not depressed.

Since the touch-responsive keyboard section **121** of the aforementioned arrangement allows saturated current to flow through the transistor TR_4 while the corresponding key is not depressed, the potential of the output terminal **37** is maintained at substantially the same level as that of the +B source. When the corresponding key is depressed, there is induced in the coil **34** an AC voltage whose level varies with the magnitude of a force with which the key is depressed. After being amplified during passage through the transistor, the AC voltage is further rectified while travelling through the diode D_1 into a DC voltage of the negative polarity whose level varies with the magnitude of a force with which the key is depressed. The DC voltage obtained from the diode D_1 is supplied to the transistor TR_4 as an inverse-base-bias voltage, and said third keying switch **36** is closed in interlocking relationship with the depression of the key, so that the transistor TR_4 acts as a sort of C-class amplifying circuit which is only controlled by a base-bias voltage supplied through the diode D_l. Accordingly, when the key is depressed, there is obtained from the output terminal **37** of the touch-responsive keyboard section **121** the so-called touch-responsive negative DC voltage e_2 in the pulse form whose level varies with the magnitude of a force depressing the key and whose time width extends from the depression to the release of the key. It will be apparent that the rising and decaying properties of said pulsative DC voltage e_2 from said output terminal **37** are determined by the time constant of a charging and discharging circuit substantially consisting of the two resistors R_3 and R_4 and the capacitor C_2. The input terminal **38** of the keyer **131** is supplied with output signals e_1 from the multivibrator **111** through a coupling capacitor C_3 and also with output signals e_2 from the touch-responsive keyboard section **121** through a resistor R_5. To the input terminal **38** are connected the cathode terminals of two serially connected diodes D_3 and D_4, and between the contact of the two diodes D_3 and D_4 and the grounding point is connected a bypass capacitor C_4. Between the anode terminal of the diode D_4 and the grounding point is connected another bypass capacitor C_5. same anode terminal is connected to the later described filter **141** through a resistor R_6 and coupling capacitor C_6. Between the contact of said resistor R_6 and coupling capacitor C_6 and the grounding point is connected a resistor R_7.

The keyer **131** thus arranged allows its input terminal **38** to which there is connected the cathode terminal of the diode D_3 to be supplied with a substantially +B source voltage through the output terminal **37** of the touch-responsive keyboard section **121** while the corresponding key is not depressed, so that the keyer **131** is kept at an OFF state when the corresponding key is not depressed, and when the key is depressed the input terminal **38** of the keyer **131** is supplied through the output terminal **37** of the touch-responsive keyboard section **121** a more negative DC voltage e_2 substantially in the pulse from whose peak level is determined in accordance with the magnitude of a force with which the key is depressed, bringing the keyer **131** to an ON state. Thus output signals from the touch-responsive keyboard section **121** are supplied to the keyer **131** as a sort of keying (triggering) signal. From an output terminal **39** of the keyer **131** are obtained output signals corresponding to tone signals from the tone signal generator **111** only while the corresponding key is depressed. The level of the output signals is determined in accordance with the magnitude of a force depressing the key.

Since, in this case, the capacitor C_3 and resistor R_5 form a sort of differentiating circuit, signals e_3 appearing at the input terminal of the keyer **131** assume a differentiated waveform. And the two diodes D_3 and D_4 and two capacitors C_4 and C_5 jointly constitute an integrating circuit, so that signals e_4 appearing at the output terminal **39** of the keyer **131** bear an integrated waveform. The signals e_4 having an integrated waveform which are obtained from the output terminal **39** of the keyer **131** are supplied to the filter **141** consisting of two vertically inverted L-shaped circuits respectively comprising a group of a resistor R_8 and capacitor C_7 and a group of a resistor R_9 and capacitor C_8 in order to form a tone-pitched signal component e_5 bearing a tone color resembling that of a formant component included in the sounds of a desired wind instrument, for example, a flute.

The tone-pitched noise signal generator **151** includes a white noise source **40** including, for example, an NPN-type transistor TR_5 Shown in FIG. 2B. The emitter terminal of the transistor TR_5 is connected to the +B source terminal 35*p*. White noise signals generated from the white noise source **40** formed by grounding the base terminal of the transistor TR_5 through a resistor R_{10} are introduced through a high-cut filter **41** provided, if necessary, and arranged similarly to the aforementioned filter **141** so as to have their high-frequency component cut, and thereafter through an amplifier **42** comprising, for example, three indicated cascade connected NPN-type transistors TR_6, TR_7 and TR_8 to be amplified. A balanced modulator **43** included in the electronic musical instrument of the present invention is arranged in the following manner. Terminals constituting one of the two pairs of balanced terminals included in a full-wave-recitfying diode switch consisting of four diodes D_5, D_6, D_7 and D_8 are respectively used as input and output terminals of signals. To the input and output terminals are connected an input transformer Tin and output transformer Tout each consisting of a primary and secondary coil. Between the neutral points of the input and output transformers is interposed a modulation transformer Tmod similarly comprising a primary and secondary coil. The aforesaid noise signals amplified by the amplifier **42** are supplied to the input transformer Tin of the balanced modulator **43**. The modulation transformer Tmod of the balanced modulator **43** is supplied with output signals from a second tone signal generator **44** having substantially the same circuit arrangement as the first tone signal generator **111** further provided with associated key switches and keyers and, when there is depressed a given key, generating tone signals of a sine or rectangular waveform having a tone pitch twice or equal to that of signals e_1 from said first tone signal generator **111** after said output signals are amplified by an amplifier **45** formed by connecting, as illustrated, two NPN-type transistors TR_9 and TR_{10} in cascade relationship. With such arrangement, from the output transformer Tout of the balanced modulator **43** are obtained modulated signals which are formed by balanced modulating noise signals supplied from the input transformer Tin using signals supplied from the modulation transformer Tmod. The signal taken out from the output transformer Tout is essentially a noise signal but has a somewhat pitch sensation, the signal being e_6 or e_7 having a frequency spectrum as shown in FIG. 3B or 3C, as the signal contains a narrow band of frequencies close to the intended pitch frequency and approving in a random manner thereabout.

The variable-resistance element **17** includes FET **171** formed by grounding, for example, its source terminal S and drain terminal D through resistors R_{11} and R_{12} respectively as shown in FIG. 2A. When there is depressed a given key, the modulated signal corresponding thereto is supplied to the source terminal S or drain terminal D of FET **171** through the first keying switch **16** and a coupling capacitor C_9.

The shaping circuitry **191** should preferably be composed, for example, by connecting in cascade relationship a differentiating circuit **46** consisting of a capacitor C_{10} and resistor R_{13}, an integrating circuit **47** consisting of a PNP-type emitter follower transistor TR_{11} and a capacitor C_{11} and an amplifier including an NPN-type common-emitter transistor TR_{12}.

When there is depressed a given key, the corresponding second keying switch **18** is closed, so that there are obtained from an output terminal **49** of the aforementioned circuitry **191** the signals which are generated by differentiating a pulsative DC voltage from the DC source **20** by the differentiating circuit **46** and further integrating the differentiated signals by the integrating circuit **47**. The resultant signals are supplied to the control terminal of FET **171**, or a gate terminal G.

The reason why the tone pitch of tone-pitched signals from the second tone-pitched signal generator **44** is chosen to be twice or equal to that of tone-pitched signals from the first tone-pitched signal generator **111** is that the noise component included in the sounds of a natural flute essentially consists of that range of tone pitches and that any pitch higher or lower than that range will appreciably depart from the noise component of the natural flute sounds, undesirably resulting in unnatural flute sounds which will render the difference more prominent. For the same reason, white noise signals from the white noise source **44** are first allowed to pass through the high-cut filter **41** to have their high-frequency component cut and then supplied to the input transformer Tin of the balanced modulator **43**.

With the electronic musical instrument of the present invention arranged as described above, when there is depressed a given key, there is obtained from the filter **141** fundamental tone-pitched signals e_5 having a tone color well resembling that of a formant component included in the sounds of a natural flute. Moreover, the tone-pitched signals e_5 are controlled in keying by the aforementioned keying signals from the touch-responsive keyboard section **121** and sustained for a relatively long length of time while said key is depressed, their voltage level being determined in accordance with the magnitude of a force with which the key is depressed. In FIG. 4A, the upper line E_1 indicates an envelope level of the signal when the key is struck strongly, while the lower line E_1 indicates an envelope level of the signal when the key is struck softly. At this time there is obtained from the drain terminal D (or source terminal S) of FET **171** a tone-pitched noise signal component E_2 illustrated in FIG. **4A** which well resembles the noise component included in the sounds of a natural flute. The tone-pitched noise component E_2 is sustained for a relatively short length of time corresponding to the period during which signals obtained by introducing a DC voltage from the DC source **20** through the shaping circuitry **191** consisting of the differentiating and integrating circuits **46** and **47** are supplied to the gate terminal G of FET **171** (The duration is determined by the time constants of the differentiating and integrating circuits **46** and **47**, and, in this embodiment, is chosen to be 50 milliseconds.) Moreover, the voltage level of the noise component E_2 does not vary, though the force of depressing the key may change in magnitude.

Accordingly, the electronic musical instrument of the present invention wherein a fundamental tone-pitched signal component from the filter **141** and a tone-pitched noise signal component from FET **171** acting as a variable-resistance element are composed and musical tones consisting of the composite signals are regenerated through the loudspeaker 22, is capable of producing musical tones more closely resembling the sounds of a natural flute than has been possible with the prior art electronic musical instrument which is designed to simulate the sounds only by generating tone-pitched signals having a tone color approximating a formant component included in the natural flute sounds.

FIGS. **5** and **6** present different modifications of the circuitry of FIG. **1**. In FIG. **1**, output signals from the touch-responsive keyboard section **12** are supplied to the keyer **13** only as keying signals for fundamental tone pitched signals from the fundamental tone-pitched signal generator **11**. In contrast, FIG. **5** represents the case where the touch responsive DC voltage is also, but in a smaller rate, supplied to the wave-shaping circuit **19** in place of the DC source **20**.

In FIG. **6**, the touch responsive DC voltage is further supplied to the variable resistor element **17** in addition to the keying signal from the wave shaping circuit **19**.

According to the arrangement of FIG. **5**, the voltage level of a tone pitched noise signal component E_2 as well as that of a fundamental tone pitched signal component E_1 obtained from the filter **14** is determined in accordance with the magnitude of a force with which there is depressed a key as shown in FIG. **4B**, in which the upper line E_2 indicates an envelope level of the noise signal when the key is struck strongly and the lower line E_2 indicates an envelope level of the noise signal when the key is struck softly. The modification of FIG. **6** displays, as shown in FIG. **4C**, substantially the same effect as that of FIG. **5**, but in addition the tone-pitched noise signal component is kept continuously generated at lower level while there is depressed the corresponding key, like the fundamental tone-pitched signal component, though the voltage level of the former is appreciably more reduced as shown than at the start. In this case, it will be apparent that the voltage level E_2 of the tone-pitched noise signal component varying with the magnitude of a force depressing a key varies to a slightly smaller extent than the variation of the voltage level E_1.

FIG. **7** is a modified schematic block diagram **152** of the tone-pitched noise signal generator **151** of FIG. **2B**. White noise signals from the white noise source **40** are supplied to high Q filters **711**, **712** ... **71*n*** provided for each key through keying switches **701**, **702** ... **70*n*** and switched in interlocking relationship with the corresponding keying switches **16**, **18** and **36**. The same construction is well known in the art as described in the U.S. Pat. No. 2,694,954. When there is depressed the corresponding key, each of said high Q filters **711** to **71*n*** is so designed as to obtain from the respective output terminals **721**, **722** ... **72*n*** tone-pitched noise signal components having a tone pitch twice or equal to that of the formant component E_1. The present inventor's experiments prove that as compared with the case where there is used such a balanced modulator as shown in FIG. **2B**, the arrangement of FIG. **7** slightly decreases in the ability of cutting a high-frequency component included in said while noise signal and that use of the balanced modulator of FIG. **2B** generates musical tones having a tone color more closely resembling that of natural flute sounds.

FIG. **8** represents a modified circuit of the section of a variable resistance element included in FIG. **2A**. According to FIG. **8**, FET **171** is substituted by a photoelectric converting element, for example, a phototransistor **172**. A light-responsive resistor such as a CdS cell will also do. There is provided light means **80** at a point facing the light receiving plane of the phototransistor **172**, the light means **80** being illuminated or extinguished depending on the type of output signals from the shaping circuit **19**. The arrangement of FIG. **8** is capable of substantially the same operation and effect as in the foregoing embodiments.

I claim:

1. An electronic musical instrument comprising a keyboard having a plurality of juxtaposed keys operatively connected to touch-responsive keyboard sections for generating a DC voltage whose level varies with the magnitude of a force with which the keys of said keyboard are depressed, a first circuit means for forming a fundamental tone-pitched signal component having a tone color resembling that of a formant component included in the sounds of a wind instrument sustainable for a length of time fully controlled by the output from said touch-responsive keyboard section, a second circuit means for forming a tone-pitched noise signal component having a tone

color resembling that of a noise component included in the sounds of said wind instrument sustainable for a relatively short length of time not fully controllable by said keyboard and signal mixing means which compose signal components from both said first and second circuit means into musical tones consisting of composite signals for reproduction through a loudspeaker.

2. The musical instrument according to claim 1 wherein each of said touch-responsive keyboard sections comprises a permanent magnetic piece integrally fitted to the underside of the depressed end of each key, a coil facing the position at which said permanent magnetic piece is depressed when the corresponding key is depressed, so as to cut a magnetic flux from said magnetic piece and rectifying means for rectifying an AC current induced across both ends of said coil.

3. The musical instrument of claim 1 wherein said first circuit means forms a signal component having an envelope of sustained substantially constant level and the pitch of the tone of said noise signal is at least equal to that of said formant component signal.

4. The musical instrument of claim 1 which simulates a natural flute voice and comprises a fundamental tone-pitched signal generator, a key, a keyer associated with said key and keying the signal from said generator with an amplitude responsive to a depressing force applied to said key, a filter giving a tone color as a formant component of the flute voice to the keyed signal from said keyer, a tone-pitched noise generator and a percussion keyer associated with said key for keying the signal from said tone-pitched noise generator with an amplitude not responsive to said depressing force.

5. The musical instrument according to claim 1 wherein said first circuit means comprises fundamental tone-pitched signal generators for generating fundamental tone-pitched signals having a tone pitch corresponding to a given depressed key, keyers for controlling output signals from said generator corresponding to said depressed key in keying action using output signals from said touch-responsive keyboard section as keying signals and filters supplied with output signals from the keyer corresponding to said depressed key.

6. The musical instrument according to claim 1 wherein said second circuit means comprises a white noise signal source for generating white noise signals, a filter for drawing out only a desired frequency component included in said white noise signals, tone signal generators for generating tone signals having a tone pitch corresponding to a given depressed key, balanced modulators for modulating white noise signals obtained from said filter by tone signals from said generator corresponding to said depressed key, variable-resistance elements supplied with output signals from said modulators and provided with a control electrode and control signal sources for supplying control signals to obtain from said resistance elements output signals from said modulators.

7. The musical instrument according to claim 1 wherein said second circuit means comprises a white noise signal source for generating white noise signals, high Q filters which are supplied with said white noise signals through keying switches interlockingly switched with a given depressed key so as to form tone-pitched noise signals having a tone pitch corresponding to said depressed key, variable resistance elements supplied with output signals from said filters and provided with a control electrode and control signal sources for supplying control signals to obtain from said elements output signals from said filters while the control electrode of said elements is supplied with signals.

8. The musical instrument according to claim 6 wherein the end of said variable-resistance elements through which there are supplied output signals from said balanced modulators is also supplied with output signals from said touch-responsive keyboard sections so as to cause the voltage level of output signals from said balanced modulators is vary with the magnitude of a force with which there is depressed a key.

9. The musical instrument according to claim 6 wherein said variable-resistance elements consist of field effect transistors.

10. The musical instrument according to claim 7 wherein said variable-resistance elements consist of field effect transistors.

11. The musical instrument according to claim 6 wherein said variable-resistance elements consist of photoelectric converting elements.

12. The musical instrument according to claim 7 where in said variable-resistance elements consist of photoelectric converting elements.

13. The musical instrument according to claim 6 wherein said control signal sources comprise DC sources and shaping circuits, including differentiating and integrating circuits which are supplied with a DC voltage from said DC sources through keying switches interlockingly switched with a given depressed key.

14. The musical instrument according to claim 7 wherein said control signal sources comprise DC sources and shaping circuits, including differentiating and integrating circuits which are supplied with a DC voltage from said DC sources through keying switches interlockingly switched with a given depressed key.

15. The musical instrument according to claim 6 wherein said control signal sources utilize output signals from said touch-responsive keyboard sections.

16. The musical instrument according to claim 7 wherein said control signal sources utilize output signals from said touch-responsive keyboard sections.

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