United States Patent

Adachi

[15] **3,699,234**

[45] **Oct. 17, 1972**

[54] **MUSCULAR VOLT AGE-CONTROLLED TONE MODIFYING SYSTEM FOR ELECTRONIC MUSICAL INSTRUMENT**

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

[22] Filed: **April 29, 1971**

[21] Appl. No.: **138,619**

[30] **Foreign Application Priority Data**

May 6, 1970	Japan	45/38514
May 6, 1970	Japan	45/38515
May 28, 1970	Japan	45/45890
May 28, 1970	Japan	45/45891
May 28, 1970	Japan	45/45892
June 6, 1970	Japan	45/49019
June 10, 1970	Japan	45/50111
June 13, 1970	Japan	45/51238
June 24, 1970	Japan	45/54970
July 7, 1970	Japan	45/59316
July 16, 1970	Japan	45/62453

[52] **U.S. Cl.** **84/1.24,** 84/1.12, 84/1.13, 84/1.21, 84/1.25, 84/1.26, 84/1.27, 84/DIG. 7

[51] **Int. Cl.**.....**G10h 1/02**

[58] **Field of Search** 3/1.1; 128/2.06; 84/1.01, 1.24

[56] **References Cited**

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Primary Examiner—Lewis H. Myers
Assistant Examiner—U. Weldon
Attorney—Cushman, Darby & Cushman

[57] **ABSTRACT**

Tone modifying circuits of an electronic musical instrument such as keyers, vibrato circuit, tone coloring circuit, tremolo effect producing circuit, volume circuit and like circuits can be controlled as desired by the player in accordance with the variation of the muscular voltages produced across selected muscles of the player provided with pickup means. To this end, at least one pair of muscular voltage pickup electrodes are attached onto at least one selected portion of the player's skin under which a very low level muscular voltage is generated upon contraction of the electrode-carrying muscle. These pickup electrodes are connected to muscular voltage processing circuits to eliminate unwanted background noise components and to amplify the picked-up muscular voltage to a desired level. The processed voltage is then supplied to control terminals of the modifying circuits in the form of either pulses or DC potentials. In case a plurality of pickup electrodes are mounted on fingers of the player, various touch-responsive tone controls are possible. By summing various levels of muscular voltages obtained from a number of paired pickup electrodes arranged in different portions of the player's skin, random control of the modifying circuits can be achieved to provide tonal effects rich in variety.

18 Claims, 64 Drawing Figures

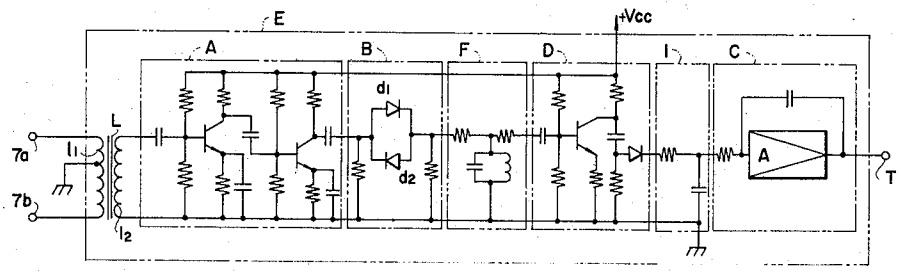


FIG. 1

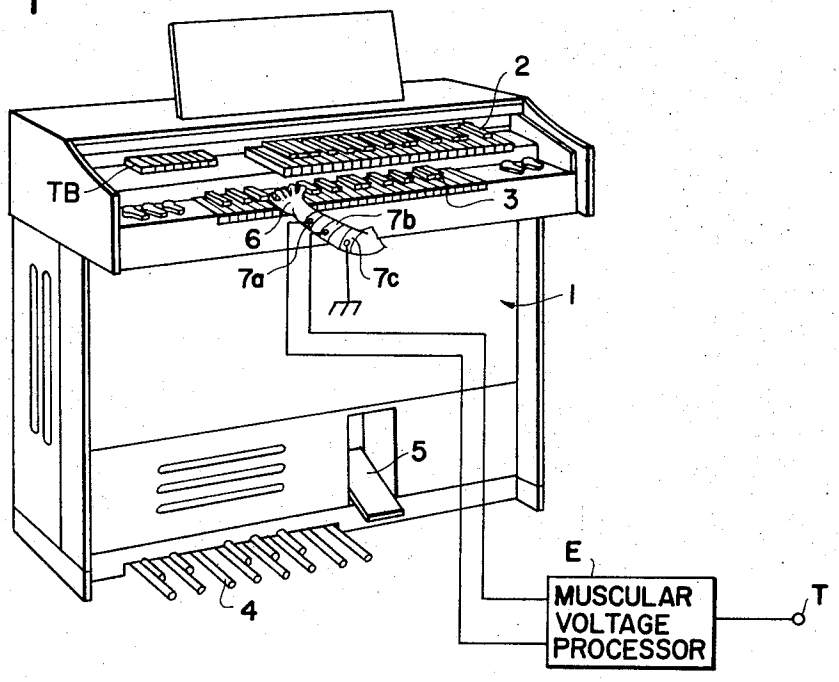
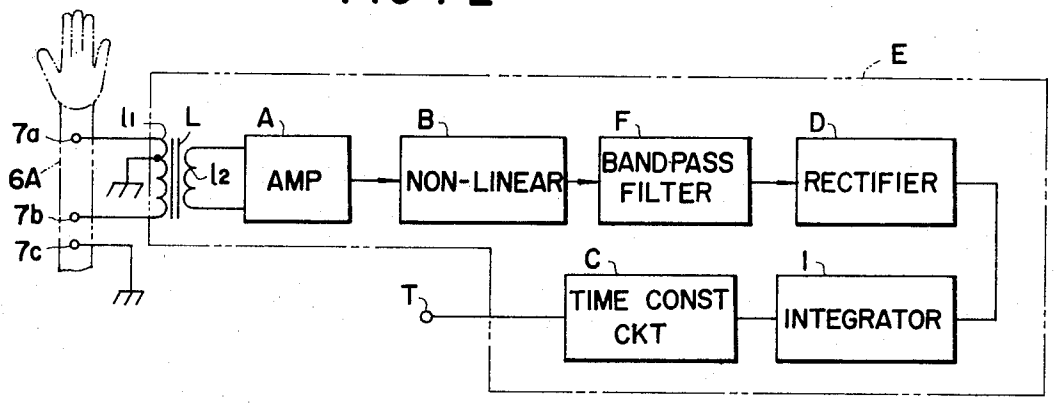


FIG. 2



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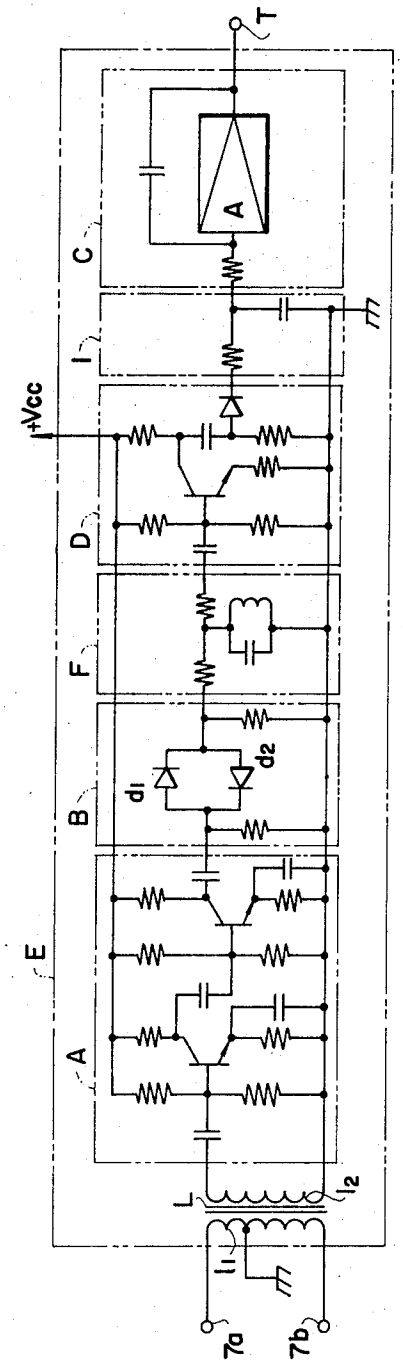


FIG. 3

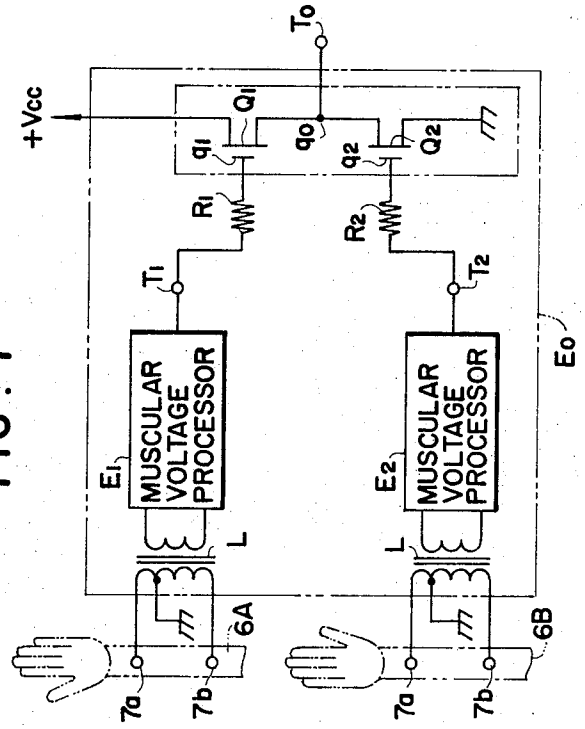


FIG. 7

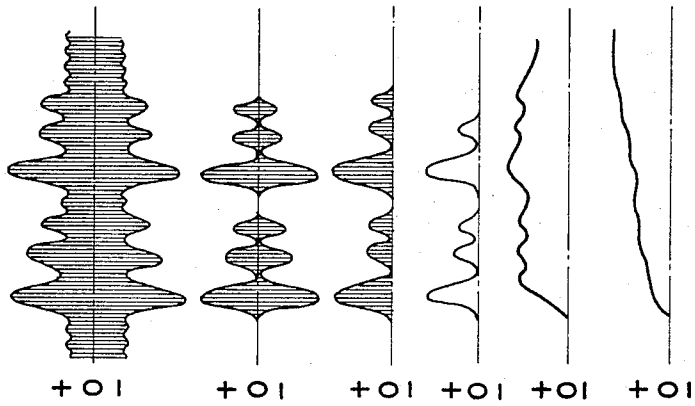


FIG. 4A FIG. 4B FIG. 4C FIG. 4D FIG. 4E FIG. 4F

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FIG. 5

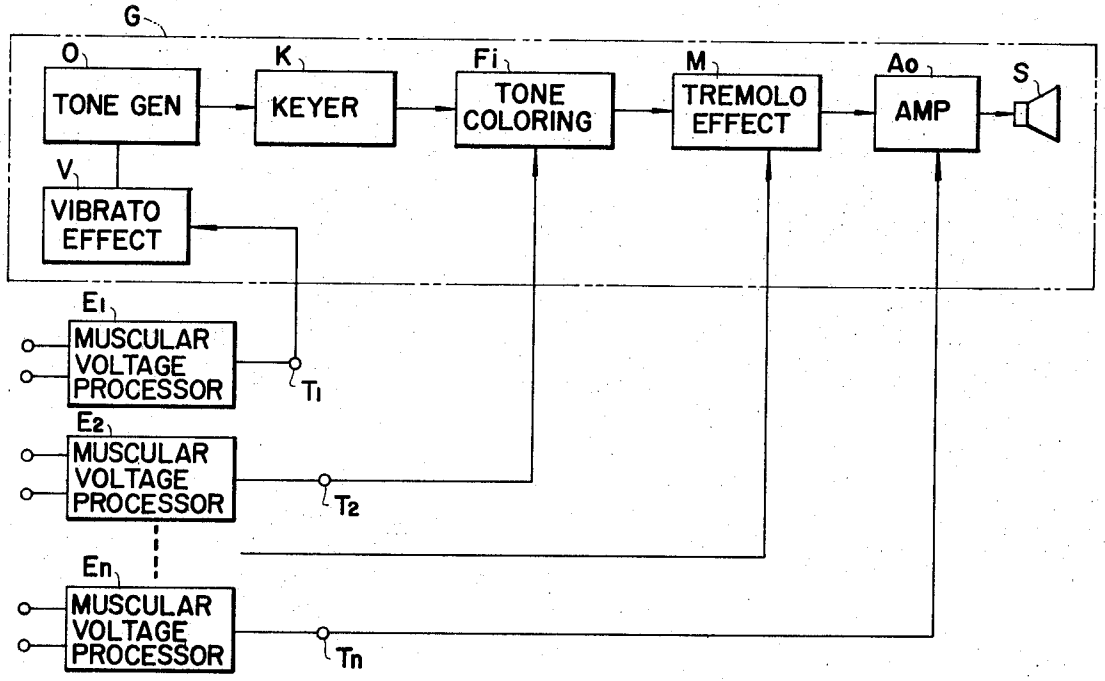


FIG. 6

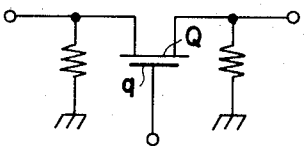
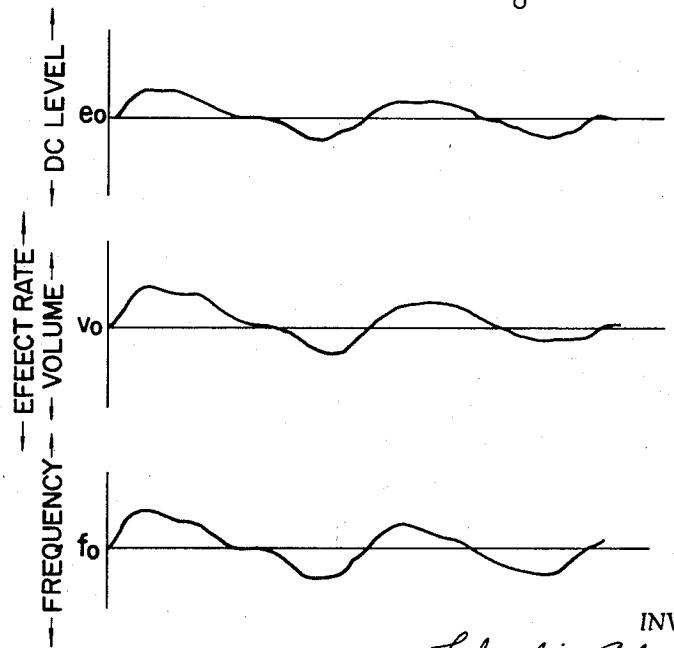


FIG. 8A

FIG. 8B

FIG. 8C



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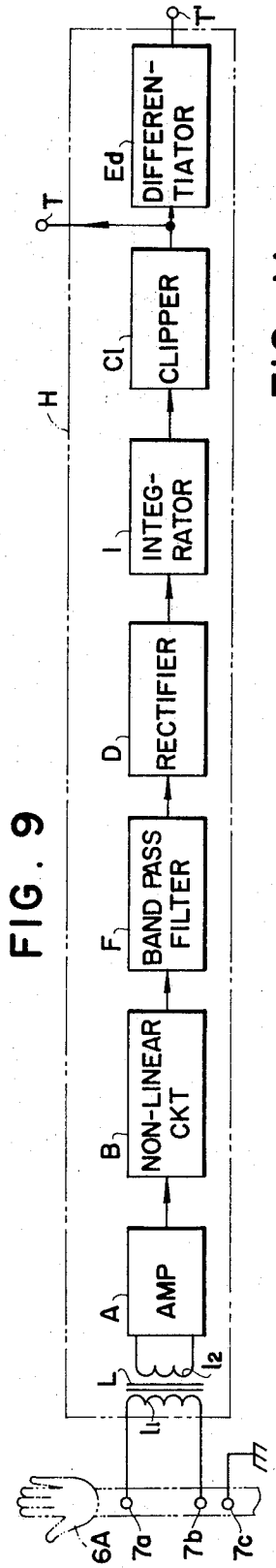


FIG. 9

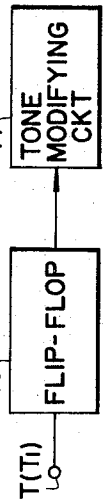


FIG. 11

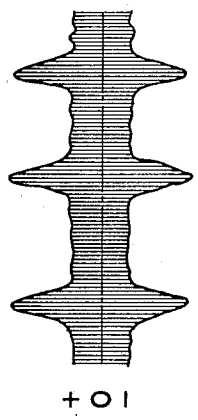


FIG. 10A

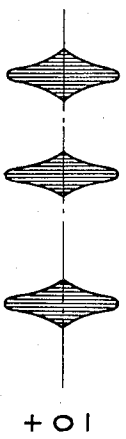


FIG. 10B

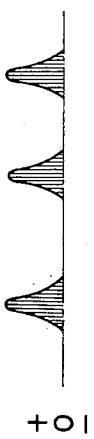


FIG. 10C

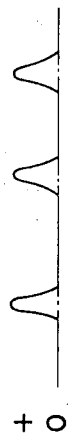


FIG. 10D

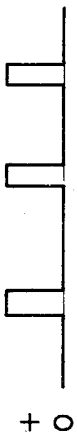


FIG. 10E

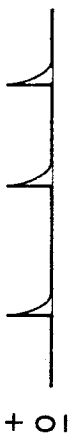


FIG. 10F

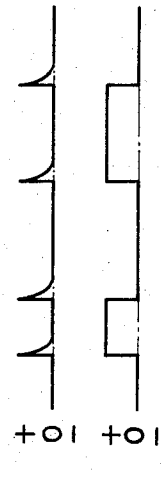


FIG. 12A

FIG. 12B

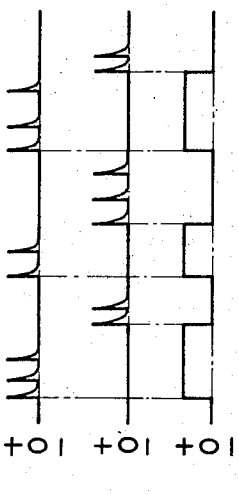


FIG. 14A

FIG. 14B

FIG. 14C

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FIG. 13

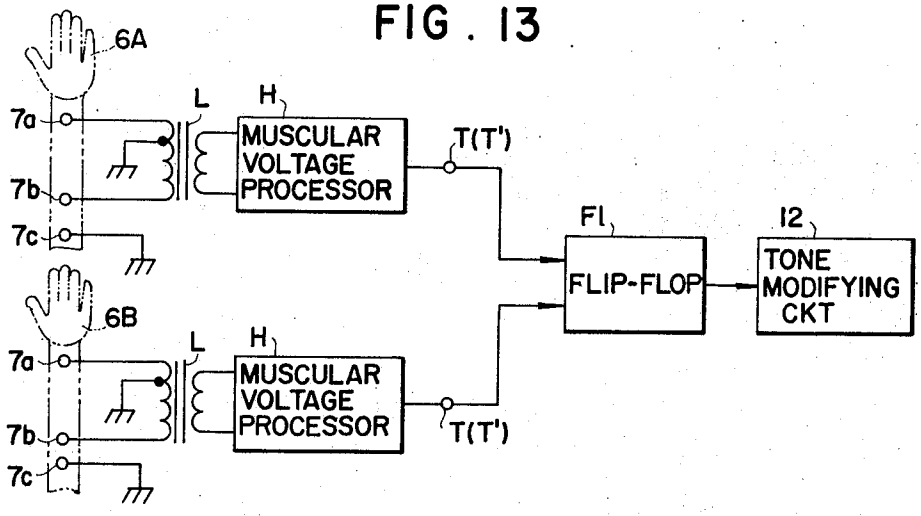


FIG. 15

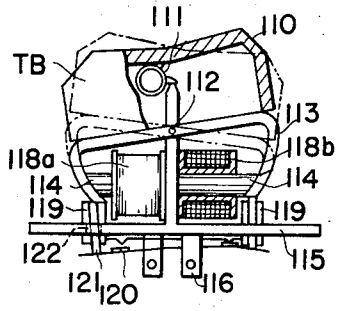
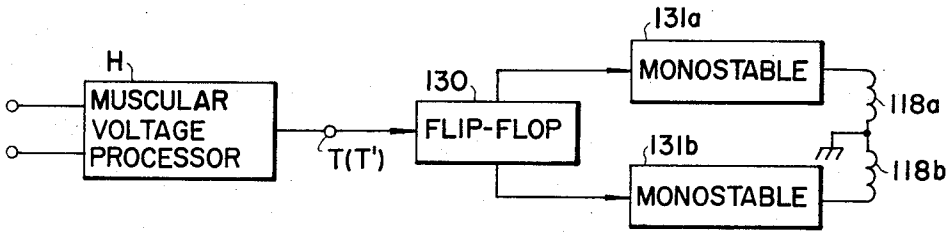


FIG. 16



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FIG. 17

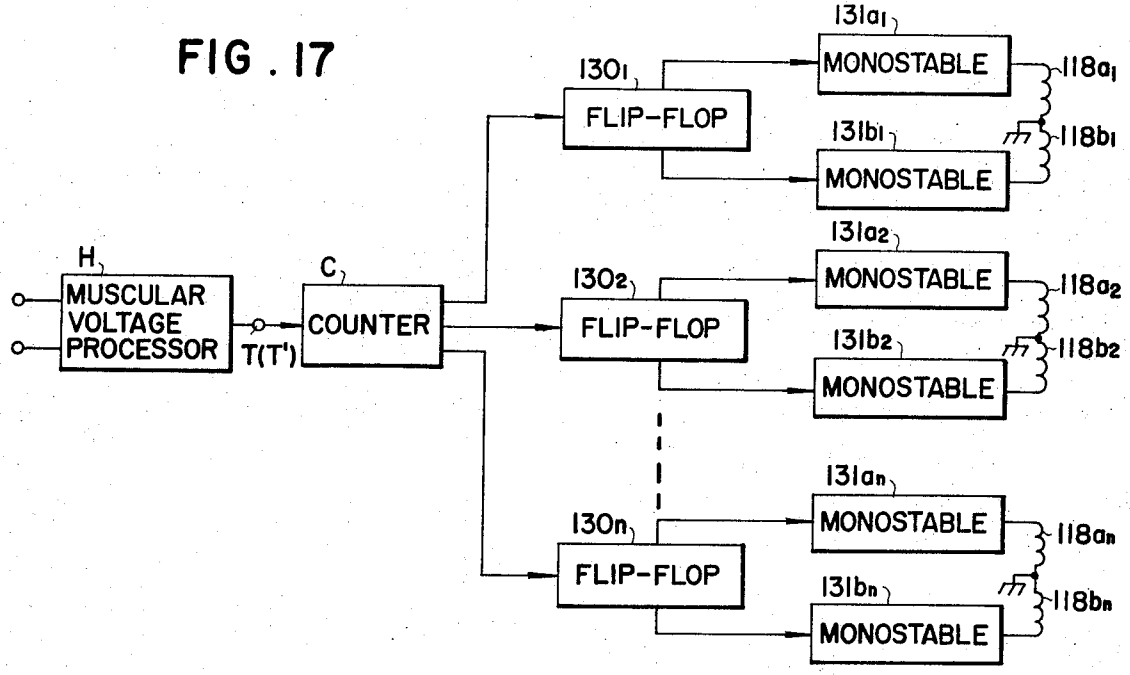
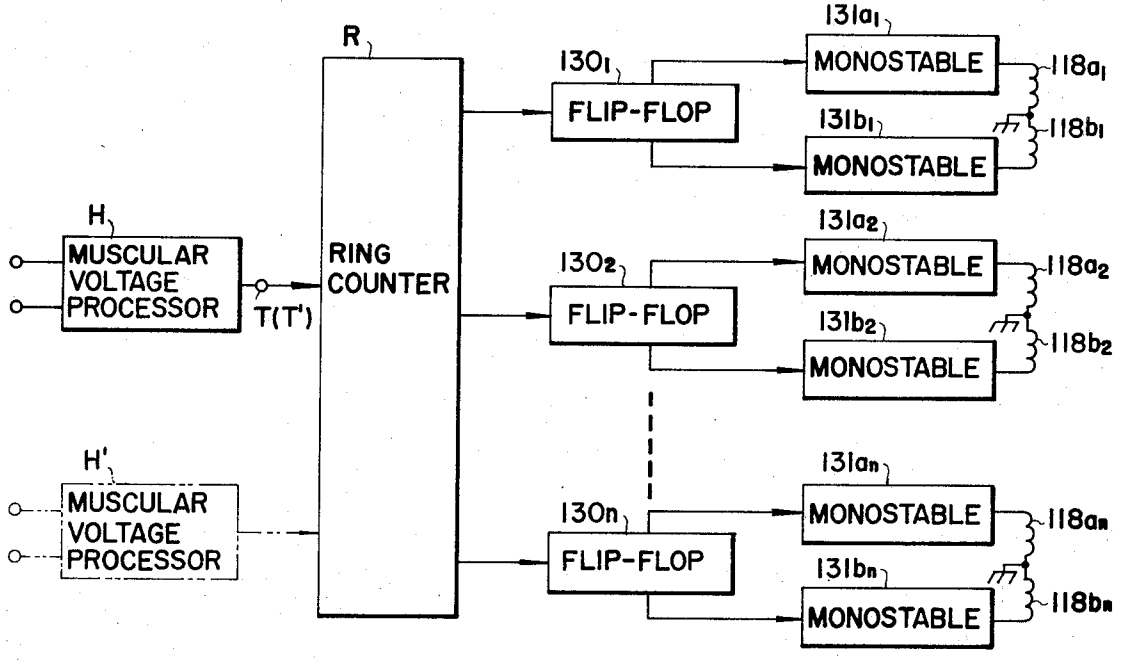
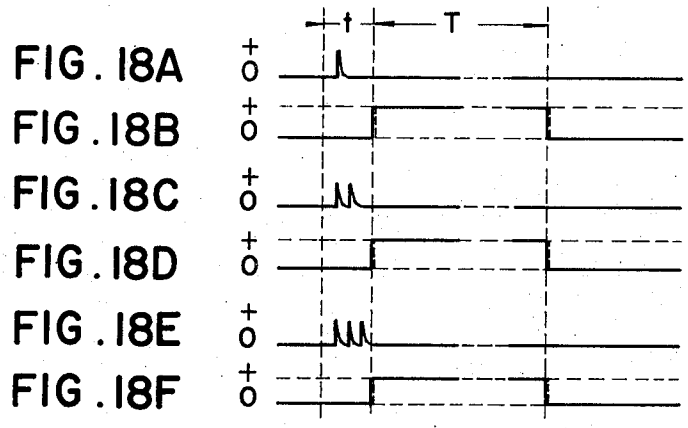


FIG. 19



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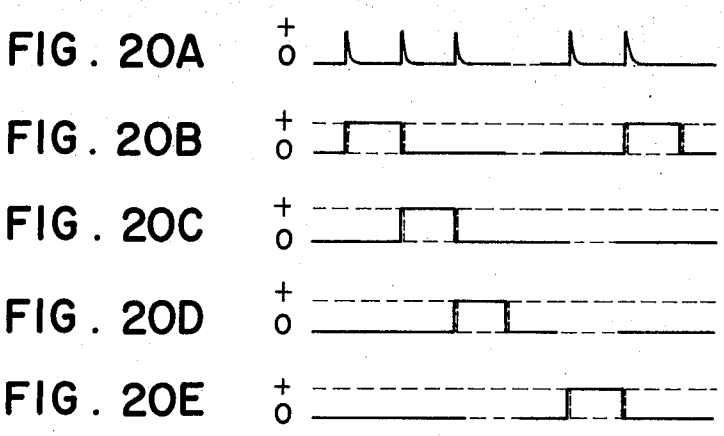
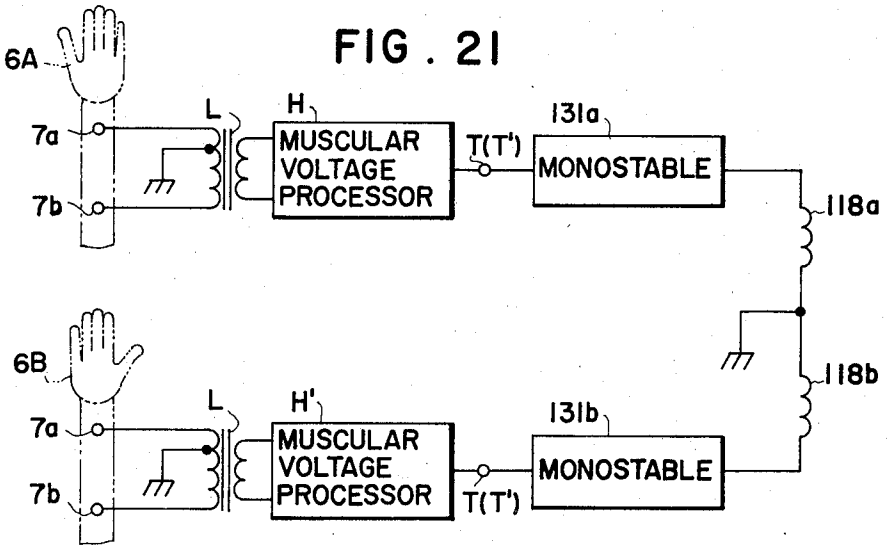


FIG. 21



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FIG. 22

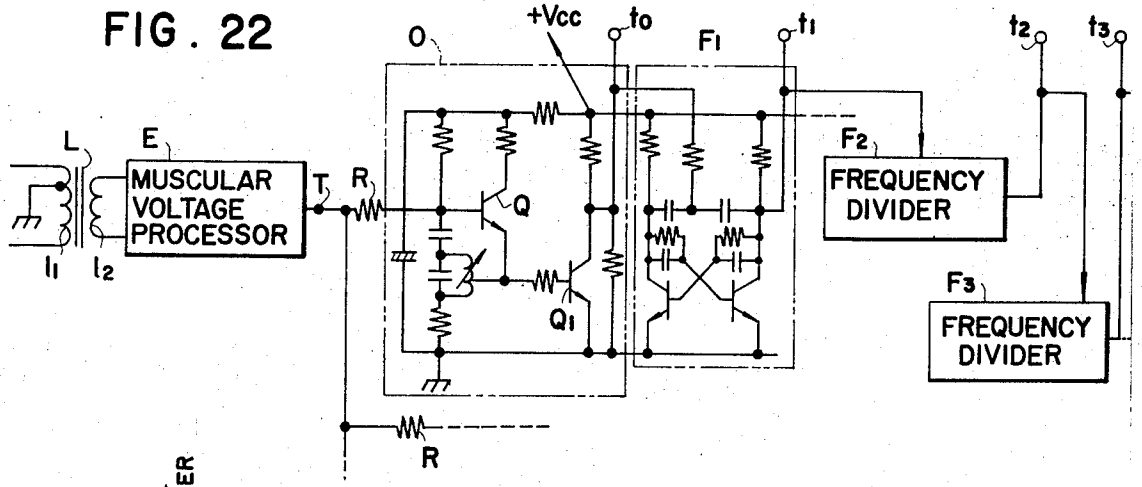


FIG. 23

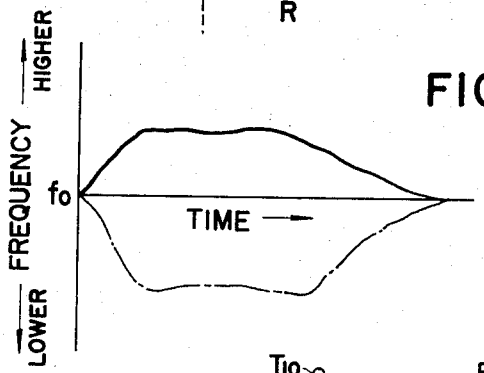


FIG. 24

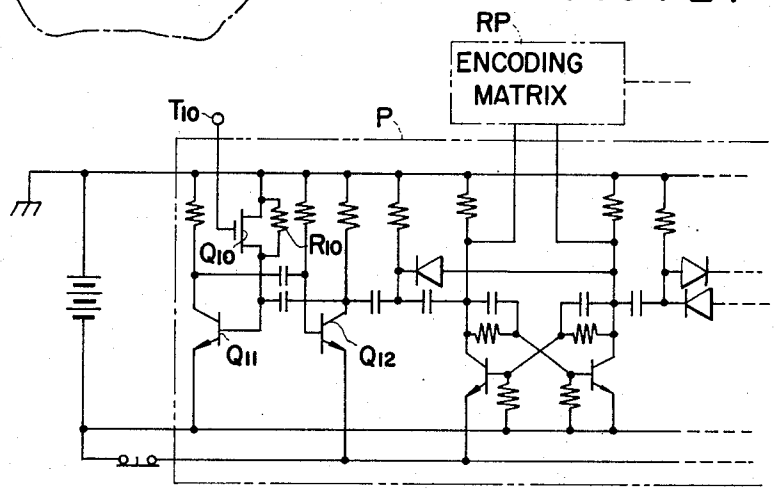
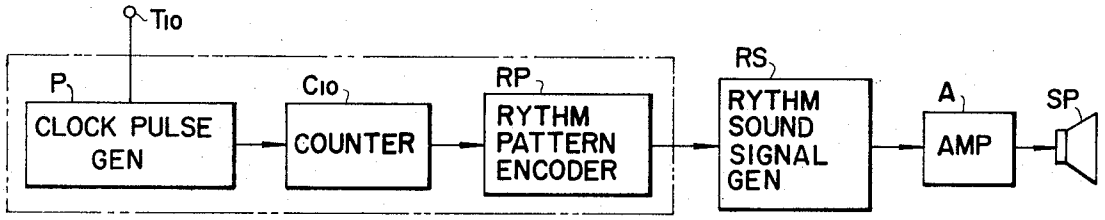
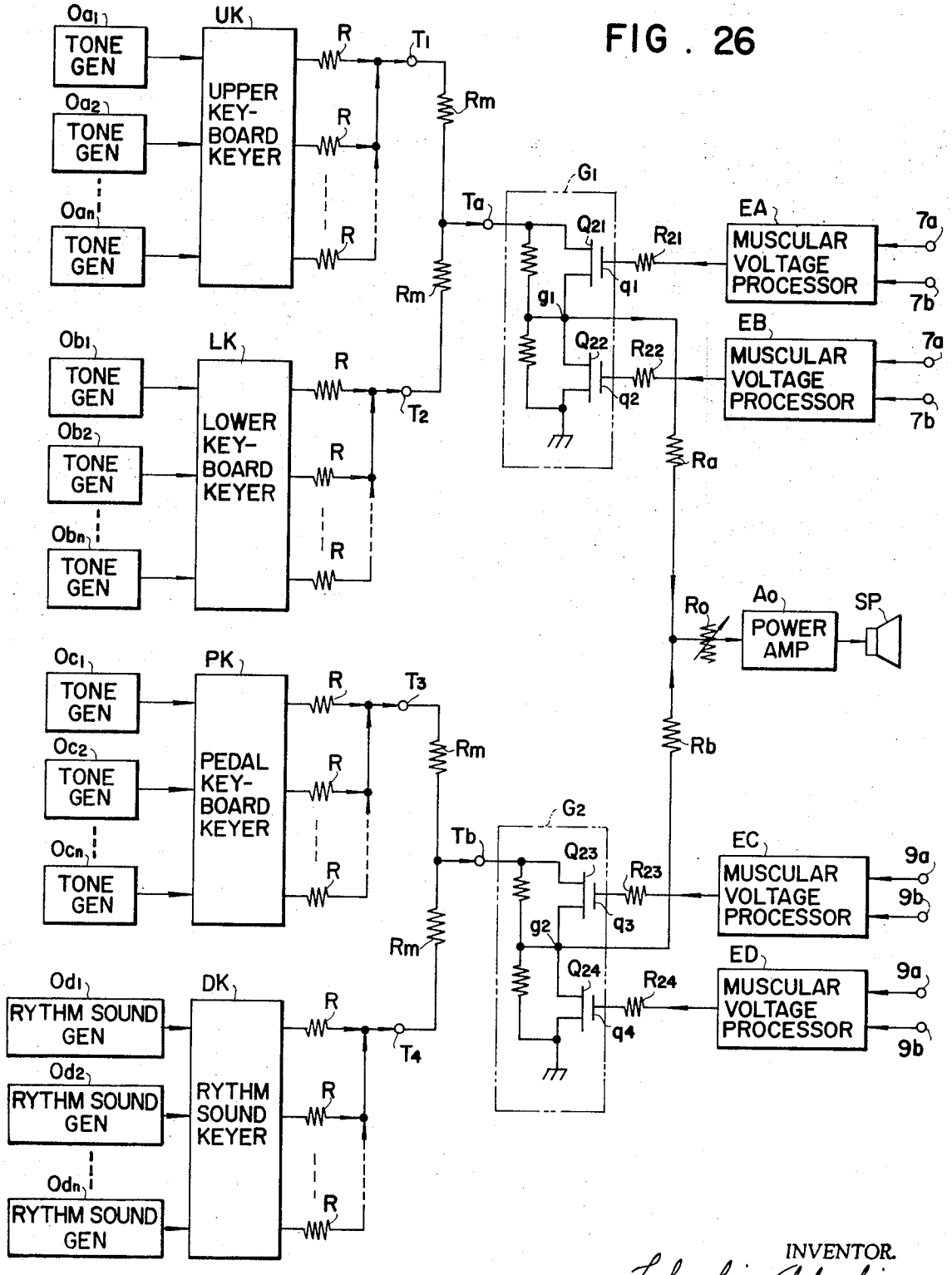


FIG. 25



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FIG. 26



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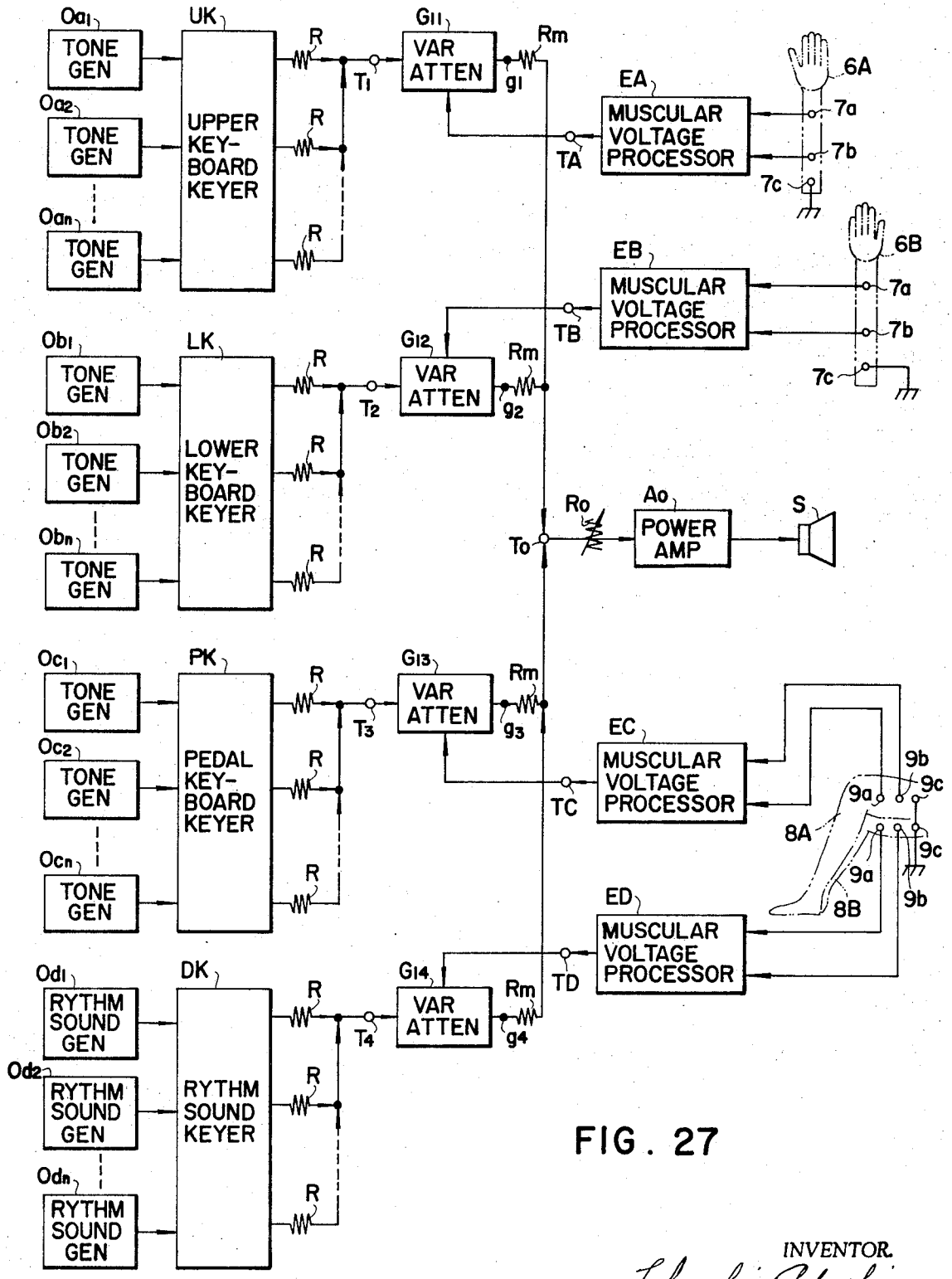


FIG. 27

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FIG. 28

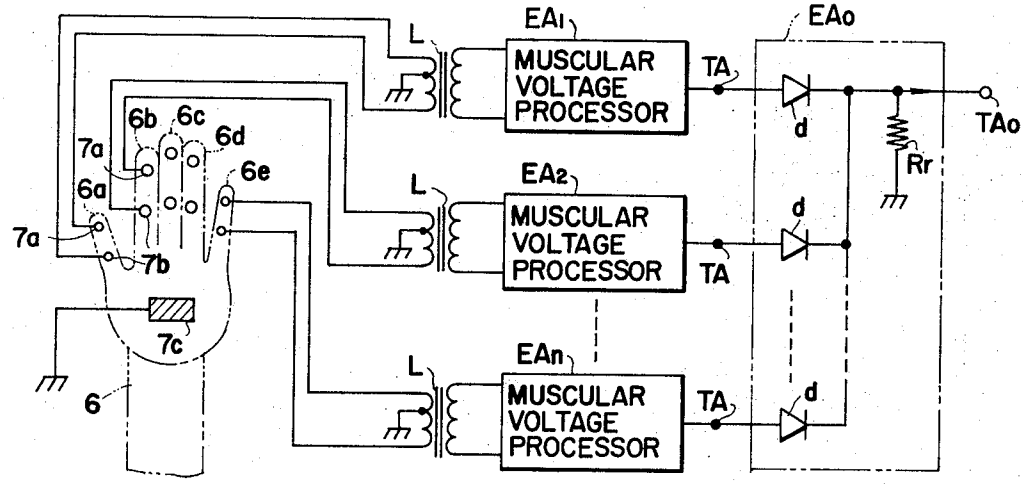
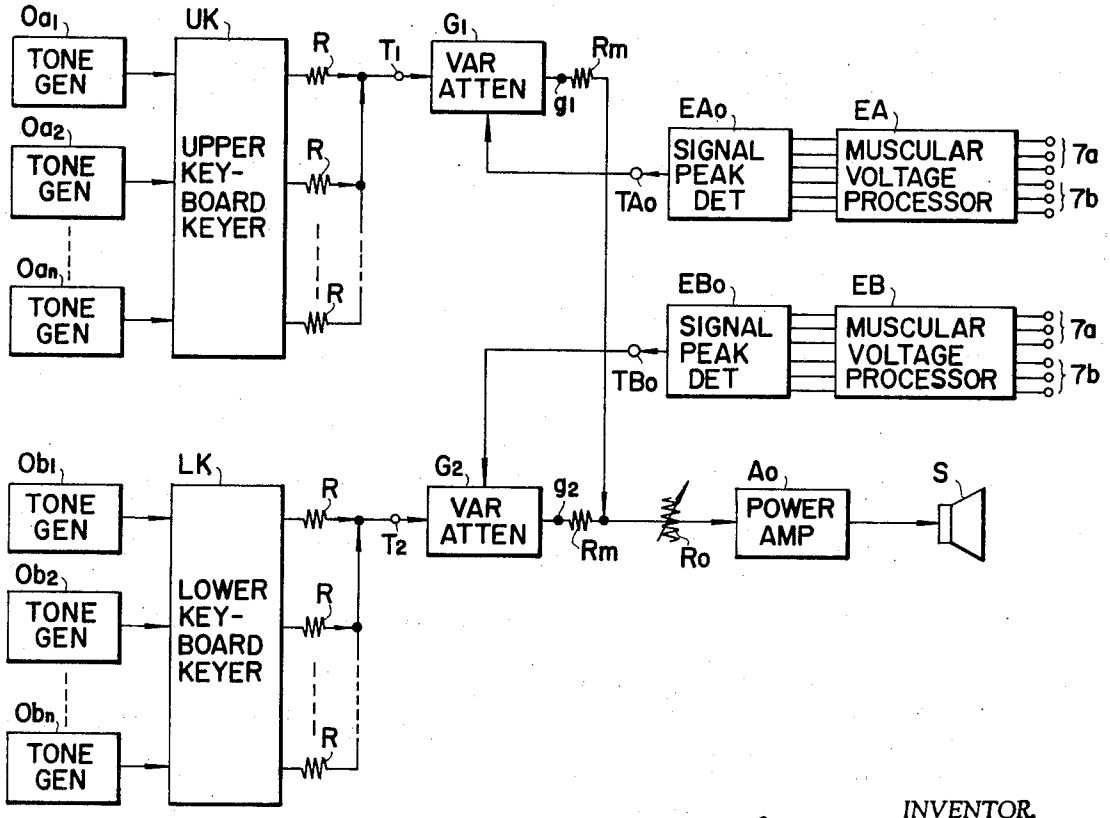


FIG. 29



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FIG. 30

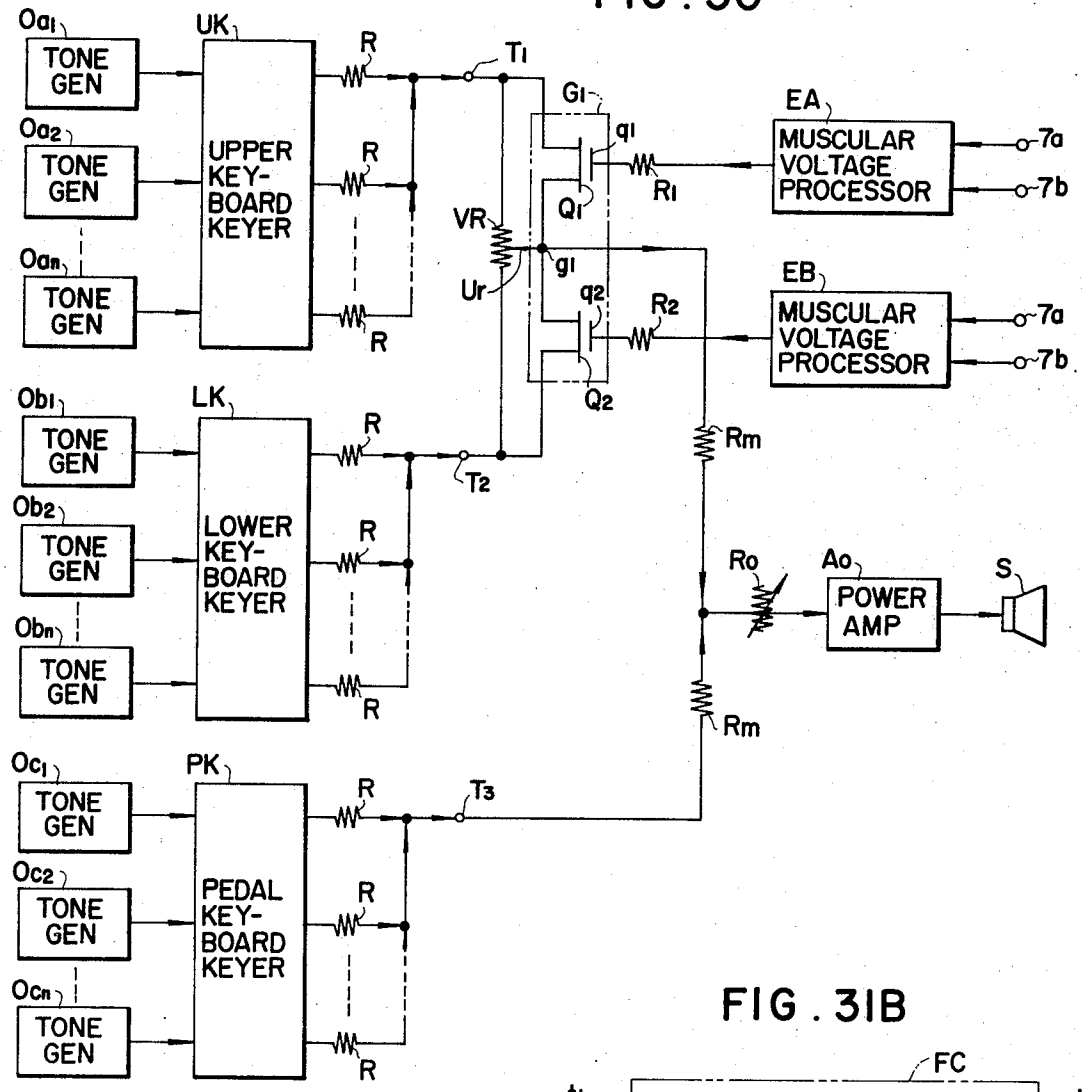


FIG. 31A

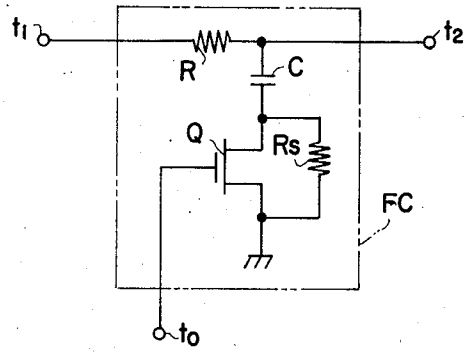
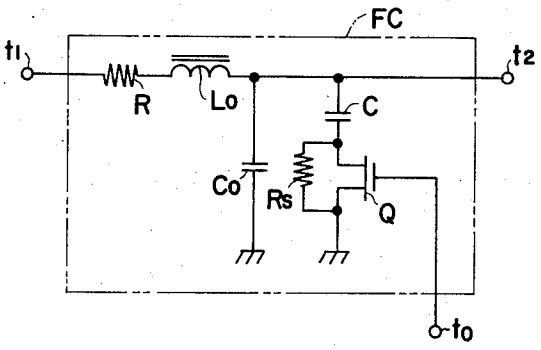


FIG. 31B



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FIG. 31C

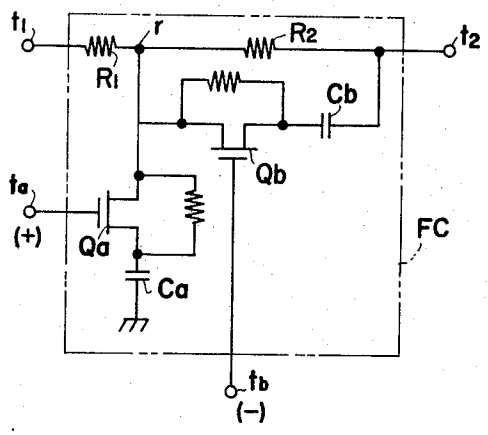


FIG. 32A

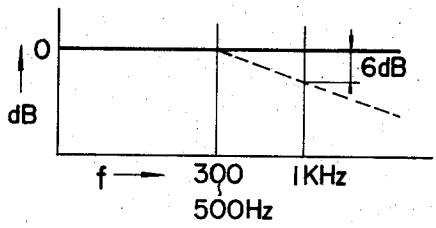


FIG. 32B

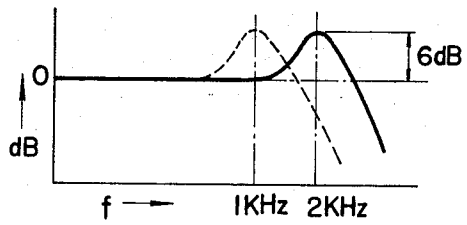


FIG. 32C

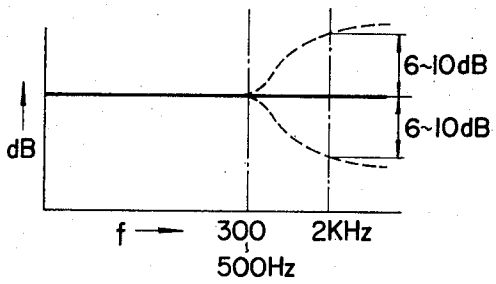


FIG. 33

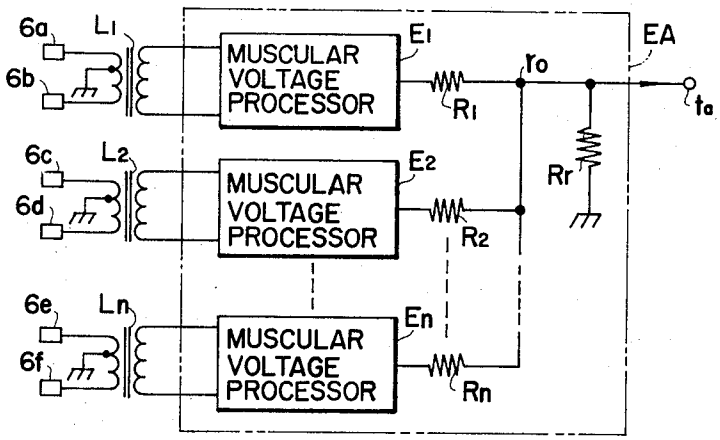
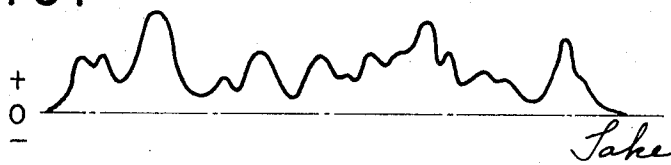


FIG. 34



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FIG. 35

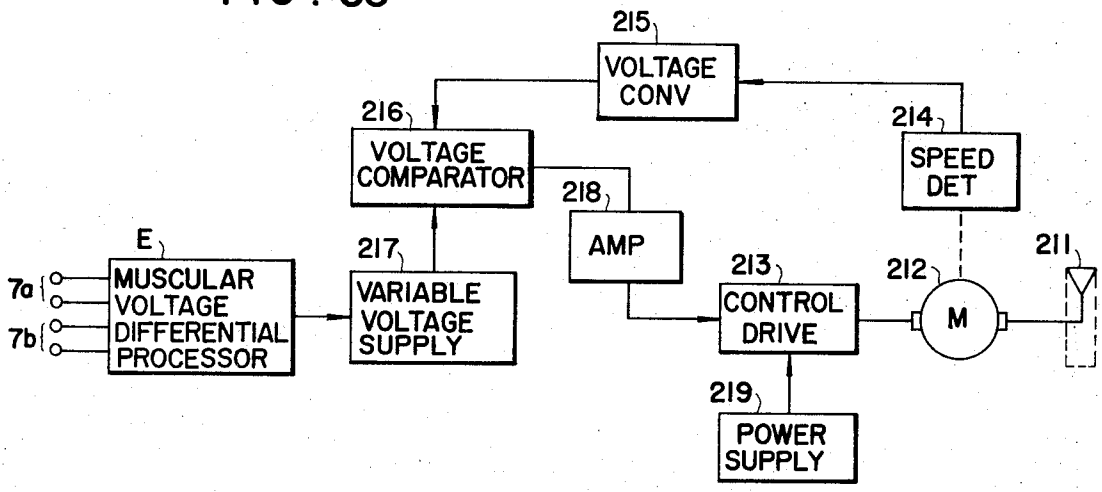
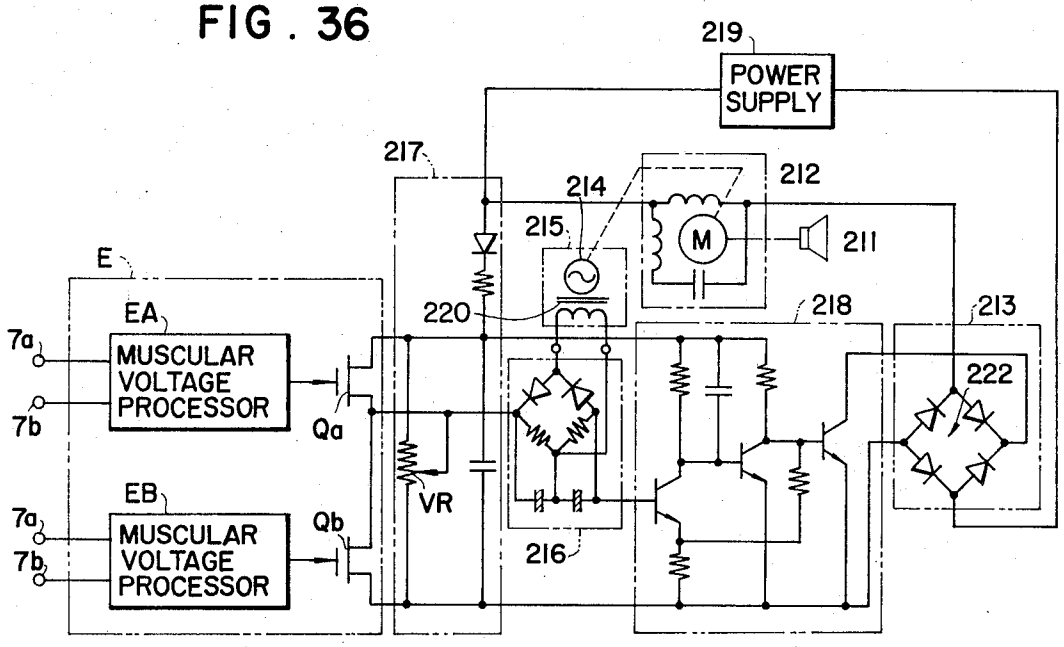
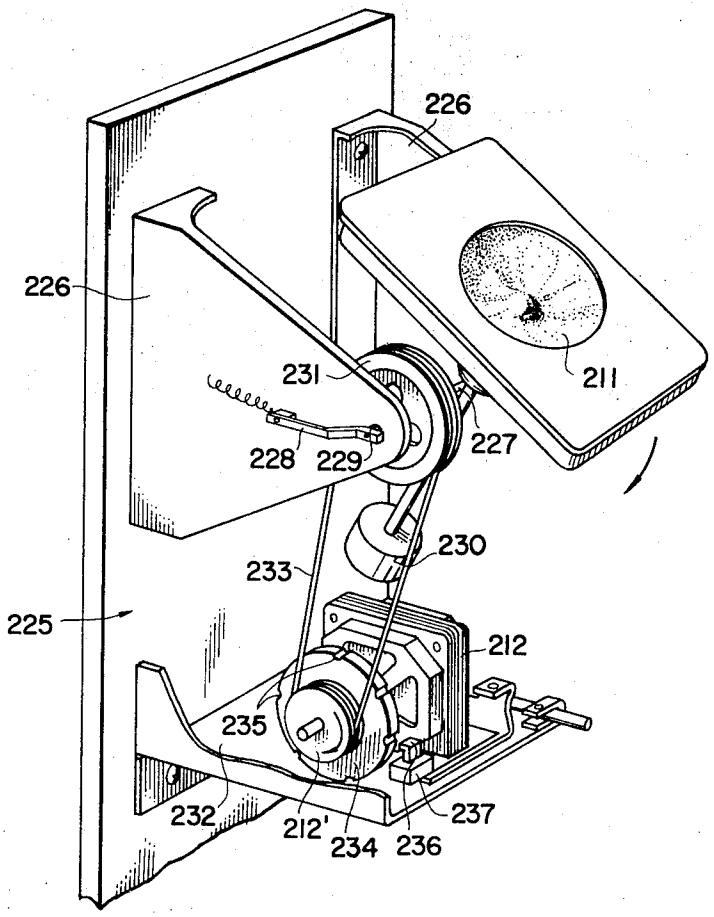


FIG. 36



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FIG. 37



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MUSCULAR VOLT AGE-CONTROLLED TONE MODIFYING SYSTEM FOR ELECTRONIC MUSICAL INSTRUMENT

BACKGROUND OF THE INVENTION

a. Field of the Invention

The present invention is concerned generally with an electronic musical instrument provided with tone modifying systems, and more particularly, it relates to an improvement in the tone modifying systems of electronic musical instrument by the provision of tone modifying circuits which are controlled in accordance with the variation of the muscular voltages picked up from selected muscles of the player.

b. Description of the Prior Art

Various types of conventional electronic musical instruments, such as electronic organs and the like, are generally provided with tone generators for producing audible frequencies and with means for modifying the waveform or envelope of the produced tone frequencies to provide desired tonal effects. These means are actuated primarily by manual operation of the player using his fingers, feet and/or knees. Recently, however, an attempt has been made to control tone modifying circuits of an electronic musical instrument by utilizing the muscular voltages which appear across selected muscles of the player upon contraction thereof so as to serve as the control input signals to provide various tonal effects as desired by the player without relying on the afore-mentioned manual operation, which means without depending on manual actuation of the manipulation switches such as tablet switches and knee lever switches, an expression pedal for output volume control, or the like. Apart from such an attempt, various proposals have been made to pick up a muscular voltage which is very weak and delicate and to process this picked-up voltage and to transmit — as an instrument control signal — the processed voltage to various tone modifying circuits housed in the console of the instrument. However, those muscular voltage-controlled tone modifying systems of the prior art have failed to produce perfect emotional expressions of the music being played and/or to produce various different tonal effects such as random rythms or combined tonal effects because of the incapability of the systems to make effective use of various different magnitudes and envelopes of the muscular voltages. Thus, there has been the demand for the development of improved control systems of the type described for tone modifying purposes, which are free of the inconveniences and drawbacks of the prior art and which insure the production of desired emotional expressions as well as tonal effects — either singular or mixed, without requiring any manual operation.

SUMMARY OF THE INVENTION

An aspect of the present invention, therefore, is to provide an improved muscular voltage-controlled tone modifying systems for an electronic musical instrument so that various characteristics of the muscular voltages generated upon contraction of electrode-carrying muscle or muscles of the player who is at the instrument may be made use of effectively to produce, as desired by the player, outstandingly good emotional expressions by the player and/or various kinds of tonal effects of music being played.

Another aspect of the present invention is to provide an improved controlling systems of the type described which permit desired complicated control of the tonal effects without inconveniently complicating the instrument circuitries.

A further aspect of the present invention is to provide an improved control means for controlling the muscular voltage-controlled tone modifying systems of the type described, which are capable of selecting special effects during the playing of the instrument and which are easy for the player to operate.

A still further aspect of the present invention is to provide an improved muscular voltage-controlled tone modifying systems for the instrument, which permit random vibrato effect to be produced as desired.

A yet further aspect of the present invention is to provide an improved muscular voltage-controlled tone modifying circuits, which by the provision of muscular voltage pickup means on the fingers of the player allow the so-called touch-respective tone control to be achieved, upon depression of the playing keys of the instrument.

Another aspect of the present invention is to provide an improved muscular voltage-controlled tone modifying systems which are adapted to be subjected to integrated operation by the weak muscular voltages occurring momentarily to thereby insure the operation of the tone modifying systems.

Still another aspect of the present invention is to provide an improved muscular voltage-controlled tone modifying systems of the type described, which are capable of performing differential control of tone modifying circuits from a plurality of pickup means attached onto different portions of the player's skin.

Yet another aspect of the present invention is to provide an improved control systems of the type described having a simple structure, which enable a plurality of tone modifying circuits to be controlled independently with easiness as desired by the player in either analog or digital form without applying any specific manual operation onto the keys, switches, tablets, knee lever, and the like of the instrument.

These and other objects, features and advantages of the present invention will become apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic perspective view of an electronic musical instrument having a system for controlling tone modifying circuits by muscular voltages, embodying the present invention.

FIG. 2 is a schematic block diagram showing an example of a muscular voltage processing circuit used in the present invention.

FIG. 3 is a circuit diagram showing the details of FIG. 2.

FIGS. 4A to 4F are graphs showing various waveforms obtained at several output sides of blocks of FIGS. 2 and 3.

FIG. 5 is a schematic block diagram in general showing an example of a muscular voltage-controlled tone effect control or tone modifying system.

FIG. 6 is a circuit view, showing an example of a variable impedance circuit used in the present invention.

FIG. 7 is a diagram showing a modification of a differentially controllable circuit of the present invention.

FIGS. 8A to 8C are waveforms for explaining the operation of FIG. 7.

FIG. 9 is a schematic block diagram showing another example of a muscular voltage processing circuit used in the present invention.

FIGS. 10A to 10F are waveforms developed at several output sides of the blocks in FIG. 9.

FIGS. 11 and 13 are schematic views showing examples of an adaptation circuit cooperating with the circuit of FIG. 9, and a modification thereof, respectively.

FIGS. 12 and 14 are pulse waveforms shown for explaining the operation of FIGS. 11 and 13, respectively.

FIG. 15 is a structural view of an electromagnetically actuated tablet switch, by way of example, which is under control of a muscular voltage appearing across a muscle of the player.

FIGS. 16, 17 and 19 are block diagrams showing several examples for controlling one or more tone-modifying circuits, respectively.

FIGS. 18 and 20 are pulse waveforms shown for explaining the operation of FIGS. 17 and 19 respectively.

FIGS. 21 is a diagram showing a muscular voltage-controlled tablet switch system utilizing the circuit of FIG. 13.

FIG. 22 is a schematic circuit diagram showing a muscular voltage-controlled tone generator system.

FIG. 23 is a diagram for explaining the operation of the circuit shown in FIG. 22.

FIGS. 24 and 25 are diagrams each showing circuits including an automatic rythm playing device which is adapted to be controlled by muscular voltages.

FIG. 26 is a circuit diagram showing an embodiment of a muscular voltage-controlled tone volume control system in the instrument.

FIG. 27 is a circuit diagram showing another embodiment of a muscular voltage output volume control system.

FIG. 28 is a circuit diagram showing a muscular voltage-controlled tone volume control system for a touch-responsive keyboard performance.

FIG. 29 is a block diagram showing a modification of the volume control system of FIG. 28.

FIG. 30 is a circuit block diagram showing a muscular voltage-controlled differentially operable tone output volume control system of the instrument.

FIGS. 31A, 31B and 31C are circuit diagrams of muscular voltage-controlled tone color control circuits of the instrument, respectively.

FIGS. 32A, 32B and 32C are graphs shown for explaining the circuits of FIGS. 31A, 31B and 31C, respectively.

FIG. 33 is a block diagram of an arrangement of a plurality of muscular voltage pickup means and muscular voltage processing circuits for use in providing a muscular voltage of a random waveform as well as of a large amplitude.

FIG. 34 is a waveform chart of a signal which may be obtained at the output of the circuit of FIG. 33.

FIG. 35 is a block diagram of a muscular voltage-controlled tremolo effect producing circuit arrangement.

FIG. 36 is a circuit diagram showing an example of the details of the block diagram of FIG. 35.

FIG. 37 is a view of a speaker system used in the arrangement of FIGS. 35 and 36 for producing a tremolo effect under control of a muscular voltage.

It is to be understood that like references and numerals indicate like parts.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1 there is shown a perspective view of an electronic musical instrument such as an electronic organ generally indicated at 1 which comprises — as its playing actuators — manual keyboards 2 and 3 in multiple stages, a pedal keyboard 4, an expression control pedal 5, an electromagnetically actuated tablet switches TB, and so forth. A pair of electrodes 7*a* and 7*b* electrically associated with a grounded electrode 7*c* are adapted to be fixedly mounted on the body of the player at suitable positions of an arm 6 of the player, for example, on the skin surface on the inside of the forearm by means of an electrically conductive paste or electrically conductive bonding tape, so that a muscular voltage produced upon contraction of a muscle of the arm and appearing at the skin on which the electrodes are mounted may be picked up or detected.

The electrodes 7*a* and 7*b* are connected, through lead wires or shielded wires, with a muscular voltage processing circuit E which will be described hereinafter. That is to say, these lead wires are connected with the opposite ends of a primary winding 1_1 of a coupling transformer L as shown in FIGS. 2 and 3 whose secondary winding 1_2 is connected to an input side of an amplifier circuit A of which the output is connected subsequently with a non-linear circuit B composed of two diodes having non-linear characteristics which are connected in parallel with and in reverse polarity with each other, for cutting off said background noise components contained in the weak muscular voltage picked up by the electrodes, a bandpass filter F, a rectifier circuit D, an integrator circuit I such as a Miller circuit and a time constant circuit C, whose output is connected to a terminal T. Thus, the block E enclosed by two-dotted chain line represents a muscular voltage processing circuit. In this processing circuit, a muscular voltage having the waveform of FIG. 4A which appears — for example, upon bending the arm 6 or the finers thereof — may be obtained at the output of the amplifier A. Then, the background noise component of the voltage is cut off through the non-linear circuit B and the bandpass filter having a pass band between 120 and 500 Hz whereby any minimal variations in the envelope of the voltage are suppressed into a waveform of FIG. 4B, and then it is rectified by a rectifier D into a unidirectional waveform as shown in FIG. 4C, the rectified envelope component being shown in FIG. 4D. The rectified voltage is integrated into a waveform of FIG. 4E and then it is passed through the time constant circuit to be formed into a waveform of FIG. 4F, which has a sustaining varying DC characteristic.

Reference is now made to examples of the manner in which tone modifying circuits of an electronic musical instrument or the like are controlled by means of the above-mentioned muscular voltage processing circuit E continuously in amplitude, phase or frequency.

Referring to FIG. 5, there is illustrated an example of circuits of the type described, in which 0 represents tone generators which are provided corresponding in number to the playing keys arranged in a usual electronic musical instrument.

A tone signal which is generated from each tone generator 0 is keyed by a key-controlled keyer K and is passed through a tone coloring circuit Fi including a filter. The output of the circuit Fi is supplied to a tremolo effect producing circuit M and then it is power-amplified by a power amplifier A_o and converted to a sound by an electro-acoustic transducer such as a speaker S. Thus, the block G indicates a complete arrangement of an electronic organ. For the tone generator 0 is also provided a vibrato effect producing circuit V for varying the oscillation frequency of each tone generator. The tremolo effect producing circuit M makes amplitude modulation of the tone signal supplied from the preceding stage, i.e., the tone coloring circuit Fi.

E_1, E_2 . . . E_n represent muscular voltage processing circuits of which each is constituted in the same manner as described above in connection with FIGS. 2 and 3. That is, at the input side of each of these circuits E_1, E_2 . . . E_n signals from muscular voltage pickup means provided on different positions of the player's muscles — such as trapezius, biceps of a thigh, biceps, extensor digitiform communis, sternocleido-mastoid, vastus lateralis and vastus medials in the muscular system of the man — are adapted to be supplied.

At the output side of the each circuit, a varying DC signal is provided for controlling the vibrato effect producing circuit V, tone coloring circuit Fi, or tremolo effect producing circuit M, whereby the impedance of each variable impedance element thereof may be varied so that the frequency characteristics of the filter of the tone coloring circuit, the oscillation frequency of the vibrato effect circuit and the amplification of the power amplifier may be varied accordingly upon receipt of the muscular voltages.

For example, the amplifier A_o may be so arranged as to have a variable impedance element such as an insulated gate-controlled field effect transistor as shown in FIG. 6 for varying its output level to thereby vary the output volume of the speaker S in accordance with the degree of extension or bending of the muscle, utilizing a DC signal having the waveform shown in FIG. 4E or 4F, which varies in level in accordance with the degree of contraction of the muscle. Thus, the use of the variable impedance element of which impedance can be increased or decreased depending on the degree of contraction of the muscle permits the provision of the same effects as thus produced by the conventional expression pedal or knee lever, for example, by bending the arm or fingers onto which the muscular voltage pickup means are mounted, or by applying a force thereto. In particular, in case the pickup means are attached onto the trapezius or the biceps of a thigh, the output volume of the instrument may be adjusted by vertical motion of a shoulder or a leg. Such muscular voltage-controlled variable impedance element may also be used in the vibrato effect producing circuit V, the tone coloring circuit Fi or the tremolo effect producing circuit M to provide continuously varying effects.

FIG. 7 illustrates an example of a muscular voltage processing circuit arrangement intended for performing differential control of the tone-modifying circuits which are provided in an electronic musical instrument, by picking up muscular voltages of at least two different but mutually associated muscles — forming a pair or pairs — selected from among the various muscles of the player's body, and by processing the pick-up muscular voltages. To this end, at least two pairs of pickup electrodes 7*a* and 7*b* are attached to, for instance, the right forearm 6A and the left forearm 6B of the player, respectively. The outputs of these electrodes are connected through transformers L to muscular voltage processing circuits E_1 and E_2 of the type described above, respectively. Output terminals T_1 and T_2 of the respective circuit E_1 and E_2 are connected via resistors R_1 and R_2 to gate electrodes q_1 and q_2 of field effect transistors Q_1 and Q_2 (hereunder referred to as FET's), respectively. The drain of FET Q_1 is connected to a power source +Vcc and the source of FET Q_2 is grounded, while the source of FETQ_1 and the drain of FET Q_2 are connected to a common connection point q_o and led to an output terminal T_o, thus constituting a muscular voltage controlled differential synthesizer E_o shown by a two-dot chain line block. The output of the circuit arrangement may be connected to, for example, the control terminal of the tone volume amplifier A_o of FIG. 5. In the circuit E_o, two unidirectional voltage signals obtained from the processing circuits E_1 and E_2 are differentially synthesized, developing a signal having the waveform shown in FIG. 8A at the output terminal T_o. The synthesized signal is utilized to control various tone modifying circuits as shown in FIG. 5, e.g., for the control of the speaker volume of the instrument as described above, in such a manner as shown in FIG. 8B. For example, by the extension and bending of the right forearm 6A, the tone volume of the speaker may be adjusted through the variation of the impedance of the variable impedance element used for an increase with respect to a predetermined level v_o of volume, whereas by the extension and bending of the left forearm 6B, the output volume of the speaker S may be adjusted therethrough for a decrease with respect to the above-mentioned level v_o. Thus, expression pedal effects simulating tonal effects may be easily attained.

The differentially operable circuit E_o can produce a processed DC potential signal having a desired amplitude envelope characteristic which is suitable for the control of the tone modifying circuits, merely by making a contraction of the related muscles or by imparting a force to the muscle on which the above-mentioned type pickup means are mounted, for a relatively short period of time, for example one second or less. As a result, the fatigue of the player can be reduced to a great extent during the playing of the instrument. In case the processed signal is used as a control signal for controlling the tremolo effect producing circuit M or the vibrato-effect producing circuit V, the tremolo frequency or the vibrato frequency can be varied as desired in a manner as shown in FIG. 8C depending upon the degree of contraction of the muscles. In these cases, the control signal from the circuit E_o is supplied to an impedance-varying element such as an FET incorporated in a bias circuit or a CR coupling feedback

circuit of an oscillating circuit of the tremolo circuit M or the vibrato circuit V, whereby variations in the tremolo speed or vibrato speed with respect to a reference frequency f_o may be sustained for a predetermined period of time in response to the degree of contraction of the related muscles.

As a second embodiment of the present invention, reference is now made to a muscular voltage processing circuit for processing the picked-up muscular voltage into a pulse form, which is of a constant amplitude, to thereby control the keyers of the instrument or to control various kinds of control switches of the instrument.

Referring to FIG. 9, there is illustrated — as a muscular voltage processing circuit H — a circuit arrangement for producing pulse wave signals on the basis of a muscular voltage which appears across the muscle of the player upon contraction thereof, which comprises a transformer L having a primary winding 1_1 connected with a muscular voltage pickup means of the above-mentioned type and a secondary winding 1_2, an amplifier A connected with the said secondary winding 1_2, for amplifying a very feeble muscular voltage picked up by the pickup means, a non-linear circuit B, a bandpass filter F, a rectifier circuit D intended for eliminating background noise components, an integrator circuit I, a clipper circuit C1 having an output terminal R at its output side, and a differentiator Ed having a terminal T' at its output, all of which are made in subsequent cascade connection.

In the operation of the above-mentioned circuit H, the amplifier A amplifies a muscular voltage having such a waveform as shown in FIG. 10A which may be picked up by the muscular voltage pickup means mounted on, for example, an arm, upon stretching or bending of either the arm or the fingers. Then, two diodes connected in parallel and in mutually opposing polarities in the non-linear circuit B cut off the background noise component which is of a relatively low level and which is superposed on the picked-up muscular voltage, producing the waveform of FIG. 10B. The resulting waveform voltage is fed to the bandpass filter F whose pass band is between, for example, 120 and 500 Hz, whereby minimal variations in the envelope of the input voltage are eliminated. After the voltage is amplified, it is rectified through the rectifier D, developing a unidirectional voltage as shown in FIG. 10C. The rectified voltage is then integrated by the integrator I into a signal of the waveform of FIG. 10D, and fed to the clipper C1 formed of a saturated type amplifier to provide a square wave signal having a predetermined level as shown in FIG. 10E. The square wave signal may be derived at the terminal T. It is to be noted that the signal may be derived in the form of a pulse signal having such a waveform as that shown in FIG. 10F through the differentiator Ed.

In FIG. 11, there is illustrated an example of the manner for controlling tone-modifying circuits in an electronic musical instrument or the like by making use of the muscular voltage which has been processed in the manner as described in connection with the second embodiment, which is one of the simplest examples. The system of FIG. 11 comprises an output terminal T(T') of a muscular voltage processing circuit H, which is capable of producing a pulse signal having the waveform as shown in FIG. 12A and a flip - flop circuit 10 adapted to receive the pulse signal at its input side and to make its conducting state and non-conducting state alternately for each receipt of the successive pulse input, thus producing a square waveform signal as shown in FIG. 12B. This flip-flop circuit is connected to tone-modifying circuit, such as tone keyers, an automatic rythm playing device, and starter-stoppers of the rythm device for providing several kinds of tonal effect, which starters-and-stoppers are provided in the form of switching means, respectively. For example, in case the muscular voltage pickup means are mounted on the arm, shoulder or foot of the player, this system permits a first motion of the pickup-carrying portion of the muscle to serve to start the tone modifying circuit or to impart the tonal effects, while a second motion thereof serves to stop the operation of the circuits or to release the application of the tonal effects in the instrument. Thus, the system provides an increased expression power for the music being played.

Referring to FIG. 13, there is illustrated another example of a muscular voltage-controlled tone modifying circuit system which produces two-way pulse signals as shown in FIGS. 14A and 14B by the use of separate muscular voltage processing circuits H, each being connected through an individual transformer L to a corresponding muscular voltage pickup means.

The separate pulse signals of FIGS. 14A and 14B are produced in association with contraction of muscles of the left and right hands 6A and 6B of the player to which pairs of electrodes 7*a* and 7*b* of the pickup means are attached. These pulse signals are fed to two separate input terminals of an R-S flip-flop circuit F1, respectively, and hence, the flip-flop is rendered in its conducting state and its non-conducting state, alternately, to develop a square pulse shown in FIG. 14C, depending upon the pulse inputs for the flip-flop F1, as illustrated in FIG. 14. The output signal of the flip-flop F1 is coupled with the tone modifying circuit 12 — in the instrument — of the various types described above. The pickup electrodes 7a and 7b may be attached to selected skin portions of the shoulder or the legs of the player instead of the arms 6A and 6B.

The advantages of this arrangement are in that even if the pickup means-carrying muscle is successively moved, the state of the flip-flop is not altered except by the application of an initial pulse input thereto. Accordingly, a fail-safe playing is attained with this instrument. In other words, any unexpected erroneous operation by the player can be avoided.

Referring to FIGS. 15 to 21, an embodiment of the present invention is described in which a muscular voltage which is picked up from the skin of the player is processed in a pulse form and is applied to an electromagnetically actuated tablet provided in an electronic musical instrument or like instrument to drive it, for the selective control of the playing effects.

In FIG. 15, the structure of the tablet switch TB is illustrated by way of example, in which numeral 110 indicates a tablet knob, 111 a coil spring for snap action, 112 a rotary shaft, 113 a movable yoke coupled with the tablet knob 110 by, for example, bonding; 114 an iron core, 115 a mount, 118*a* and 118*b* coils, 119 a stopper for the movable yoke 113, 120 a contact piece, 121 an actuator rod made of insulating material, and 122 an opening in the mount 115.

The movable yoke **113** is pivotably supported by the rotary shaft **112** in a vertical member extending from the central portion of the mount **115** so that the center of the movable yoke becomes a rotary shaft for the tablet knob **110**, the top of this yoke **113** being capable of making free pivotal segmental movement. Around the iron core **114** are wound two coils **118***a* and **118***b* with the vertical projection of the mount being interleaved there-between, forming two separate magnetic circuits. The actuator rod **121** mounted on an end portion of the contact piece **120** extends through the opening **122** upwardly, whose end portion is in position to engage an end of the movable yoke **113** whereby a contact of the contact piece is actuated. Inside the tablet knob **110**, the coil spring **111** is provided between it and the knife top edge of the vertical member of the mount **115** to allow snap action of the knob by manual manipulation. In operation, when the left side coil **118***a* is energized to enable the magnetic circuit at the left side, the movable yoke **113** turns counterclockwise so that the end portion of the yoke serves to drive the contact piece **120** through the actuator rod **121**, whereas when the right side coil **118***b* is energized, the movable yoke **113** is rotated clockwise so that the contact piece **120** is restored to its initial position.

Some examples of muscular voltage-controlled, electromagnetically actuated tablet switche systems will be described hereunder with reference to FIGS. **16** to **20**.

FIG. **16** is somewhat similar to FIG. **11** in construction and operation. That is to say, the former provides a concrete arrangement of the tone-modifying circuit **11**, which comprises a pair of monostable multivibrators **131***a* and **131***b* connected with the output side of a flip-flop **130**, and the left side coil **118***a* and the right side coil **118***b* of the tablet TB which are connected with the output side of the multivibrators **131***a* and **131***b*, respectively, whereby these coils are energized alternately in response to the state of the flip-flop **130**. Each of the monostable multivibrators **131***a* and **131***b* serves to determine a time duration, for the energization of the tablet switch. Such a system enables application and release of tonal effects in accordance with first and second motions of the pickup-carrying portion of the muscle of the player, as mentioned above.

FIGS. **17** and **19** are modifications of the system of FIG. **16**, of which each comprises a plurality of flip-flops 130_1, 130_2, - - - 130_n. In FIG. **17**, the plurality of the flip-flops are connected to a counter circuit C connected with the muscular voltage processing circuit H which is of the type shown in FIG. **9**. In operation, the counter C performs the counting of the number of pulse signals received from the processing circuit H every time of occurrence of contraction of the muscle on which muscular voltage pickup means are mounted, per unit time, and produces several different kinds of signals each being specified to its mating flip-flop in accordance with the result of the pulse counting, whereby a number of paired multivibrators may be selectively actuated. When one pulse per unit time (FIG. **18A**) is applied to the counter C, one of a first pair of multivibrators 131_{a1} and 131_{b1} is enabled to become conductive for a predetermined period of time T (FIG. **18B**) during which one of the paired coils 118_{a1} and 118_{b1} of the first tablet switch are energized, whereby application or release of a first tonal effect may be performed automatically. When two pulses are successively applied to the counter C (FIG. **18C**), one of a second pair of multivibrators 131_{a2} and 131_{b2} alone is enabled, in its conducting state, to render only the second tablet's coil of the paired coils 118_{a2} and 118_{b2} operative to impart a second tonal effect or select a tone-coloring effect to the music being played, or release these actions to return to the initial ordinary state of playing. It will be understood easily that one of n^{th} multivibrator pair and the corresponding one of tablet coil pair are also operated in a manner similar to that described above, for example as is understood from the diagrammatical relation between FIGS. **18E** and **18F**.

In FIG. **19**, a ring counter R is provided in place of the counter C of FIG. **17**, whereby a number of multivibrator pairs which are connected in parallel with the counter R are energized and de-energized sequentially. For example, when a series of pulses shown in FIG. **20A** are fed to the counter R, one of the corresponding monostable multivibrator pairs are enabled sequentially in their conducting state, as shown in FIGS. **20B** to **20E**. Such sequential actions are useful, for example, for selectively changing rythm from slow tempo to fast tempo or sequentially changing tonal effects or tone colors one by one among many.

FIG. **21** may be assumed to be an application of FIG. **13**, in which a pair of monostable multivibrators **131***a* and **131***b* are connected at their input side with separate muscular voltage processing circuits H and H', respectively, whose output sides are connected with paired coils **118***a* and **118***b* of the electromagnetically actuated tablet switch TB. Thus, corresponding one of the tablet coils are enabled to be energized, and therefore, they may be used as starter and stopper for an automatic rythm device, or for other tonal effect generators. In the arrangement of FIG. **21**, the use of two monostable multivibrators ensures fail-safe in case of occurrence of errorneous operation at the same pickup means side.

Referring to FIGS. **22** and **23**, there is illustrated an example of a muscular voltage-controlled tone frequency control system, utilizing a control DC signal obtained by the processing of a muscular voltage and thereby providing a so-called "glide effect" and "portamento effect" easily. The system includes a muscular voltage processing circuit E same in type as the processing circuit shown in FIG. **2**, a number of tone generators **0** which include twelve of them producing notes from for example C-note to B-note in the highest octave, each of which having a transistor Q whose base is connected, through an individual resistor R, to an output terminal T of the processing circuit E so that the generated DC signal is applied to the base of the transistor Q to thereby vary the base potential with respect to its predetermined value, that is, to vary the oscillation frequency of the said transistor, in accordance with the degree of contraction of the muscle on which the muscular voltage is picked up. The same connection is provided for all of the tone generators so that they may be operated simultaneously and in the same way. The oscillation output of each tone generator is derived from the emitter of the transistor Q and fed to the base of a transistor Q_1 forming a buffer stage, whose collector is connected to a terminal t_o for deriving a highest (master) frequency signal *f* corresponding

to a specific tone (for example, C_7 note signal). This signal is applied the input side of a frequency divider F_1 of a subsequent stage composed of a flip-flop circuit and is derived in sub-multiple form of $f/2$ as C_7 note at terminal t_2 connected to the output side of the frequency divider F_1. The sub-multiplied frequency signal is subsequently subjected to frequency-division through a number of frequency dividers F_2, F_3 - - - F_n, and is derived as $f/4, f/8$ - - - $f/2^n$ tone signals representative of C_5, C_4, C_3 - - - notes at terminals t_2, t_3 - - - t_n, respectively. An example of the variations in oscillation frequency of the generator is illustrated in FIG. **23**, in which a dotted chain curve indicates a frequency variation in a lowering direction. The actuation of the system is made easily possible without interfering with any normal operation of playing.

Now, description will be made on a muscular voltage-controlled automatic rythm playing system with reference to FIGS. **24** and **25**, in which the tempo of a rythm sound is intended to be varied in accordance with the degree of contraction of the muscle carrying muscular voltage pickup means.

In FIG. **24**, there is illustrated a circuit arrangement of the type described which comprises a clock pulse generator P. having a free-running multivibrator operable with the repetition frequency of 16 Hz, the said circuit P including two transistors **Q11** and **Q12**. To the base of the transistor **Q11** are connected the source-drain of an FET **Q10** and a base resistor **R10** of the transistor **Q11** in parallel and the base of the FET **Q10** is connected to an output terminal of a muscular voltage processing circuit to produce a differential DC signal as shown in FIGS. **7** and **8**. The impedance of the source-drain of the FET **Q10** varies in response to the variation in its base potential. Accordingly, the constant of a time constant circuit of the multivibrator which is composed of two capacitors and resistance elements is varied in association with the variation of the source-drain impedance, thus varying the repetition frequency of the clock pulse generator P. The output signal of the pulse generator P is applied to a counter circuit C_{10} composed of a flip-flop, a rythm pattern encoder RP, rythm sound signal generator RS, a power amplifier A_o, and a speaker SP, subsequently, as shown in FIG. **25**. In accordance with such a rythm playing system, a desired rythm sound such as in tango or waltz may be produced. Since the tempo control can be made by the use of a portion of the muscular system of the player which he uses seldom during the playing, there occurs no fear of unwanted control of the tempo circuit by the normal operation of the instrument.

FIG. **26** shows an example of a muscular voltage-controlled tone volume control system incorporating therein a variable attenuator circuit and a variable gain amplifier circuit which are subjected to voltage control by a muscular voltage in a DC form, in which $\mathbf{0}_{a1}$, $\mathbf{0}_{a2}$ - - - $\mathbf{0}_{an}$, and $\mathbf{0}_{b1}$, $\mathbf{0}_{b2}$ - - - $\mathbf{0}_{bn}$ indicate tone generators provided, corresponding to the upper stage keyboard **2** and the lower stage keyboard **3** of the instrument, respectively. A number of tone signals obtained from the tone generators are fed to upper keyboard keyers UK and lower keyboard keyers LK, and through mixing resistors R to intermediate terminals T_1 and T_2. On the other hand, a number of tone signals obtained from tone generators of lower tone ranges $\mathbf{0}_{c1}$, $\mathbf{0}_{c2}$ - - - $\mathbf{0}_{cn}$ and rythm sound generators $\mathbf{0}_{d1}$, $\mathbf{0}_{d2}$ - - - $\mathbf{0}_{dn}$ are passed through pedal keyboard keyers PK and rythm sound keyers DK, respectively and through mixing resistors R to intermediate terminals T_3 and T_4, respectively. The tone signals at terminals T_1 and T_2, and T_3 and T_4, are mixed through mixing resistors Rm, respectively to be derived in the form of two summing tone signal at terminals T_a and T_b.

Muscular voltage processing circuits EA, EB, EC and ED are connected with respective muscular voltage pickup means mounted on different portions of the player's body. Each of these processing circuits produces a control signal as shown in FIG. **4E** or **4F**, whose construction is substantially of the type as shown in FIG. **2**. Respective output signals of these circuits EA and EB are fed through respective resistors R_{21} and R_{22} respectively to gate electrodes q_1 and q_2 of two FET's Q_{21} and Q_{22} whose drain-source electrodes are connected in series with each other, while the tone signal applied to the drain electrode of the FET Q_{21} is subjected to differential level control by the outputs of the circuits EA and EB and is derived from a common connection point g_1 between the source and the drain of FET's Q_{21} and Q_{22}. The block G_1 is termed a tone signal differential control circuit, and together with the circuits EA and EB it is similar to that of FIG. **7**. Also, a circuit including muscular voltage processing circuits EC and ED, resistors R_{23} and R_{24}, FET's Q_{23} and Q_{24}, is arranged in the same manner as described above, to terminal T_b. The signals at common points g_1 and g_2 are passed through resistors Ra and Rb and summed. The summed signal is applied to a power amplifier A_o through a variable resistor which varies in resistance in association with the operation of the expression pedal **5**.

FIG. **27** shows a modification of the system shown in FIG. **26**, in which — in place of two differentially operable variable attenuator circuits G_1 and G_2 — four variable attenuator circuits G_{11} to G_{14} are provided individually to be connected with the four keyer circuits UK, LK, PK and DK, respectively.

Now, description is directed to an embodiment of a muscular voltage-controlled tone level control system of the present invention utilizing the muscular voltage which appears across the muscle of a finger of the player upon contraction of this finger, with reference made to FIGS. **28** and **29**.

In FIG. **28**, on the inside of each of the five fingers *6a*, *6b*, *6c*, *6d* and *6e* of the player's hand, a pair of muscular voltage pickup electrodes *7a* and *7b* are mounted together with a grounded electrode *7c* by means of an electrically conductive paste or electrically conductive bonding tape. Five pairs of pickup electrodes *7a* and *7b* are connected through individual lead wires to muscular voltage processing circuits of the type as mentioned above EA_1, EA_2 - - - EA_n, at their input side, respectively. Outputs of the processing circuits are summed via the respective diodes at a common point, at which a resistor R_r grounded at its one end is connected and an output terminal TA_o is connected also, whereby a maximum value of the processed muscular voltages at the respective processing circuits may be derived at this point. Thus, block EA_o constitutes a maximum value detection circuit for the processed muscular voltages. The output

terminal TA_o is connected to tone level control circuits. An example thereof is shown in FIG. 29, in which 0_{a1}, 0_{a2} - - - 0_{an} indicate tone generators for an upper keyboard 2, whereas 0_{b1}, 0_{b2} - - - 0_{bn} tone generators for a lower keyboard 3. Outputs of tone generators 0_{a1}, 0_{a2} - - - O_{an} are passed, through the respective upper keyboard keyer circuits UK and respective mixing resistors R, to a common intermediate terminal T_1, while outputs of tone generators 0_{b1}, 0_{b2} - - - O_{bn} are applied, via respective lower keyboard keyer circuits LK and mixing resistors R, to a common terminal T_2.

At terminals T1 and T2 are connected variable attenuators or variable gain amplifiers G_1 and G_2, for keyed tone signals, respectively, at the output terminals g_1 and g_2 of which mixing resistors Rm connected at a common point to each other are connected, individually, thus summing the output tone signals of two separate attenuators or amplifiers. The summed tone signal is fed via a potentiometer R_o and a power amplifier A_o to a speaker S. The variable attenuators or amplifiers are provided with voltage-controlled variable impedance elements which are associated with output terminals TA_o and TB_o which are connected with maximum voltage detection circuits EA_o and EB_o, respectively, as described above. The potentiometer such as a voltage-controlled variable resistance element R_o may be associated with the expression pedal 5 so as to vary the impedance thereof in accordance with a depression of the pedal. In such an arrangement, the amount of muscular voltage depends upon a force applied to the pickup electrode-carrying fingers of the player. Thus, it will be understood that the so-called "touch-responsive" keyboard performance is made possible in this embodiment. Furthermore, the manner of applying a force to the individual pickup-bearing fingers permits great dynamic range of touch-responsive tone level control effect, representing the ratio of the maximum tone level to the minimum tone leve in the instrument.

FIG. 30 shows a similar example of FIG. 29 applied from the differential control arrangement of FIG. 7, in which a pedal key-operated tone circuit is added including tone generators 0_{c1}, 0_{c2} - - - 0_{cn}, pedal keyboard keyer circuits PK and a bank of resistors R connected with each keyer individually subsequently, whose common output is connected via a resistor Rm, potentiometer R_o to power amplifier A_o, whereas the terminals T_1 and T_2 are connected to two input terminals of the differential control circuit, respectively. The upper keyboard keyer circuits and lower keyboard keyer circuits may be arranged by lower tone range keyboard keyers and higher tone range keyboard keyers, respectively.

Referring to FIGS. 31 and 32, there are shown various examples of a tone quality control circuit provided between a tone coloring filter circuit and a tone output amplifier, which is adapted to be controlled by muscular voltage appearing across muscle of the player which is processed in a desired form in a processing circuit, thus providing so-called mute effects, boost or attenuation in higher and lower tone frequency ranges.

In FIG. 31A, a first example of the tone quality control circuit FC is illustrated which has an input and output terminals t_1 and t_2 for tone signals from the coloring circuit and a control terminal t_o for receiving a DC signal from a muscular voltage processing circuit as described above. Between terminals t_1 and t_2 is provided a resistor R. A source-grounded FET Q is connected at its drain through a capacitor C to one end of the resistor R at the side of terminal t_2, and whose base is connected to terminal t_o. A resistor R_s is also connected between the source and the drain of the FET. Accordingly, when the base is supplied with a DC signal as shown in FIG. 4D or 4E, the source-drain impedance of the FET Q varies in accordance with the motion of the muscular voltage pickup-carrying shoulder of the player, and as a result, the frequency characteristics of tone signals at the output terminal t_2 exhibit a down slope of about 3 to 6 decibels per one octave, at a high frequency range above 300 Hz or 500 Hz, as shown in FIG. 32B, due to the existence of capacitor C. Thus, within such a frequency range, the frequency characteristics of an output tone signal can be varied in accordance with the motion of the player's shoulder as desired.

FIG. 31B shows a modification of the circuit of FIG. 31A, in which between the resistor R and the capacitor C is provided an inductor L_o and another capacitor C_o grounded at one end thereof is connected in parallel with the capacitor C, in addition to the arrangement of FIG. 31A. The addition of the said coil L_o and capacitor C_o provides variations in peak values of output tone signal frequencies, as shown in FIG. 32B.

FIG. 31C shows another example of a tone quality control circuit having two control input terminals. That is to say, between the input terminal t_1 and the output terminal t_2 are connected series resistors R_1 and R_2 at the central point r of which the drain and source of a FET Q_a and a capacitor C_a are in series grounded, whereas the source and the drain of another FET Q_b and a capacitor C_b are connected across the resistor R_2. The bases of both FET's Q_a and Q_b are connected to separate control terminals t_a and t_b, respectively. Between the source and the drain of each of the FET's a resistor is connected. Accordingly, when to the terminals t_a and t_b are applied DC signals having the waveforms of FIG. 4E and 4F and having opposite polarities — that is, a positive going and a negative going processed muscular voltages — the frequency characteristics of a tone signal passing through the tone quality control circuit become as shown in FIG. 32C due to changes in the drain-source impedance of each transister in association with the motion of the muscular voltage pickup mounted shoulder. In the characteristic curves, a dotted line curve represents a boost characteristic in a high band, a solid line represents a flat characteristic, and a one dot chain line represents a down characteristics in a high band. Particularly, by combining the two control terminals skillfully, it will be understood that various frequency characteristics of the tone signals may be obtained.

FIG. 33 shows an arrangement for providing a composite DC signal having a random envelope characteristic, which should be regarded as a low frequency range noise signal. A plurality of paired pickup electrodes *6a* and *6b*, *6c* and *6d*, and *6e* and *6f* are mounted on separate portions of several muscles of the player. These paired electrodes are connected through respective coupling transformers L_1, L_2 - - - L_n to corresponding muscular voltage processing circuits E_1, E_2 - - - E_n, each output of which is summed through a mixing re-

sistor R_1, R_2 - - - or R_n at a common junction r connected with an intermediate terminal t_a. This terminal t_a is grounded via a resistor R_r, and thus the block EA constitutes a muscular voltage synthesizing and processing circuit for providing a random waveform, for example, as shown in FIG. 34, which is used as a control signal for several tone modifying circuits as described before. A random vibrato effect with this random waveform signal applied to the tone generators for frequency variation is one of the preferable examples.

An example of a muscular voltage-controlled tremolo effect producing circuit according to the present invention will now be described with reference to FIGS. 35 to 37.

Referring to FIG. 35, there is shown a schematic circuit diagram of the tremolo effect producing circuit which is controlled by a differentially varying DC signal obtained by a muscular voltage adaptation circuit as shown in FIG. 7.

Numeral 211 represents a loudspeaker for producing the whole or a Partial sound to be played, and 212 a single phase induction motor for rotationally driving the above-mentioned loudspeaker. The speaker is so mounted that the direction of sound radiation is perpendicular to the rotational axis adapted to be driven by the motor 212. Accordingly, the sound produced from the speaker is radiated along a plane perpendicular to the said axis as the axis is rotated so that the radiated sounds somewhat provide a periodical increase or decrease in frequency and amplitude due to Doppler effect.

The drive motor 212 is controlled by a motor drive control circuit 213. The rotational speed of the motor is detected by a speed detector 214 in the form of an analog signal proportional to the rotational speed of the speaker. The detected signal is converted to a voltage signal at a voltage conversion circuit 215. In this case, in case the speed detector 214 is constituted by an electro-motive force generator to generate a voltage proportional to the rotational speed of the motor, the voltage conversion circuit 215 may be dispensed with. In other words, the detected voltage signal is of the nature which is proportional to the rotational speed of the motor 212 and the speaker 211. The detected voltage signal is applied to a voltage comparator 216 at one input terminal thereof. At the other input terminal of the comparator, a voltage of a variable voltage supply 217 is applied for determining the rotational speed of the motor 212, so that the detected voltage is compared with the pre-set speed which is determined by the voltage supply 217. Thus, the variable voltage supply 217 predetermines the desired rotational speed of the speaker 211, that is, the pre-set voltage corresponding to the variation period in the frequency of sound to be radiated from the speaker. A differentially operable circuit E including separate muscular voltage processing circuits EA and EB, as described in connection with FIG. 7, is connected to the variable voltage supply 217, for developing the pre-set voltage in accordance with the voltage signal from the circuit E. As the input of the circuit E, muscular voltages occurring upon the motion of the pickup-carrying muscle are used. Pickup electrodes 7*a* and 7*b* may be attached to the selected portions of the shoulder of the player. As the pre-set voltage of the variable voltage supply 217, a DC voltage having the waveform as shown in FIG. 8A in which separate muscular voltages are differentially processed is preferably used. A difference voltage is provided as the result of voltage comparison in the comparator 216, and it is amplified by a voltage amplifier 218 and is then applied to the motor control circuit 213. The circuit 213 controls a power supply 219 so that a power voltage applied to the motor 212 may be adjusted to vary the rotational speed of the motor 212 depending upon the polarity and magnitude of the difference voltage. Thus, the rotational speed of the motor is variably and automatically adjusted to the pre-set speed determined by the supply 217.

FIG. 36 shows a circuit diagram embodying in detail the construction of the block diagram of FIG. 35. In the arrangement, the rotational speed of the motor 212 is picked up by the generator 220 which is adapted to rotate coaxially with the rotational axis of the motor, in a voltage form, the voltage thus generated is compared with the voltage developed at the output terminal T of the processing circuit E shown in FIG. 7, which waveform varies in response to the contraction of the pickup-attached muscles. Then a difference voltage caused by the comparison of two input voltages at the comparator 216 is transferred, through the voltage amplifier 218 composed of a transistor, to the motor operation control circuit 213. The circuit 213 includes a diode bridge 222 constituting a full wave rectifier for the AC current from the power supply 219 to flow through the last stage transistor of the amplifier 218 in one direction. The last stage transistor serves as a variable resistor in response to the compared output from the comparator 216, thereby controlling the power current to be supplied to the motor 212, that is, the rotational speed thereof.

In accordance with the above-mentioned rotatable loudspeaker system in the instrument, the rotational speed of the motor 212, i.e., that of the loudspeaker 211 can be varied in response to the motion of pickup-carrying shoulders of the player, as desired, under control of the output voltage of the variable voltage supply 217 which is differentially effected by the movements of both of the shoulders. As a result, the period of variations in tone to be radiated, that is, the tremolo speed can be arbitrarily varied in accordance with the degree of contraction of the pickup-carrying muscles of the player, as illustrated by the waveform of FIG. 8B, and thus, the capability of the instrument in expression for music being played may be extremely enhanced as compared with that of the conventional instruments. Furthermore, it is advantageous in that the variation in the tremolo speed can be performed without interfering with the normal playing operations. In particular, it is to be noted that though the tremolo speed in the conventional instruments has been varied by manually varying the resistance of a variable resistor discretely in a relatively narrow range, the above-described tremolo effect system enables the tremolo speed to be continuously adjusted in a wide range by 10 to 15 times that of the conventional instruments.

An example of the above-described rotatable speaker system is shown in FIG. 37, in which numeral 225 indicates a base plate; 226 a pair of support members mounted on the base plate 225; 227 a pivotal shaft

on which the speaker **211** is rotatably mounted with being supported by said support members **226**; **228** a brush for feeding a tone signal from the power amplifier to the voice coil of the speaker **211**; **229** a contact fixed to the pivotal shaft **227** through an insulating member and adapted to resiliently contact the brush; and **230** a plumb connected to the speaker for making a balance during the rotation of the speaker.

On the pivotal shaft **227**, a pulley **231** is mounted axially thereof. Numeral **232** indicates a support plate attached to a lower portion of the base plate **225** for fixedly mounting thereon the motor **212** having a rotatable pulley **212'**; **233** a belt connecting pulleys **231** and **212'**; **234** a non-magnetic disk connected axially to the pulley **212'** on the periphery of which magnets **235** are embedded at a predetermined distance to each other. A coil **237** wound around a core **236** for picking up magnetic fields established by the magnets **235** is secured on an appropriate portion of the support plate **232**. Thus, the generator **220** is constituted by the magnet **235** and the coil **237**, and hence, the above-mentioned speed detector **214** is arranged to detect a voltage proportional to the rotational speed of the motor through the coil **237**. The proportional voltage is used to compare with the reference voltage established by the variable voltage supply **217** which voltage is varied in level depending upon the degree of contraction of the pickup-carrying muscles. Furthermore, as the reference voltage, a random voltage as shown in FIG. **34** may be used so as to additionally provide unexpected expression for the music being played.

I claim:

1. In an electronic musical instrument including tone signal modifying circuits, a system for controlling said tone-modifying circuits by muscular voltages, comprising:

pick-up means having at least one pair of electrodes adapted to be mounted on a selected portion of the skin of the player for detecting a muscular voltage appearing across the related muscle upon contraction thereof and producing an electrical output signal which varies as a function of the deleted voltage,

at least one muscular voltage processing circuit including amplifier means connected with said pick-up means for receiving and amplifying said output signal voltage, background noise rejector means connected to said amplifier for removing the background noise component from the amplified voltage, and rectifier means connected to said rejector means for providing a unidirectional signal, and

at least one voltage-controlled variable circuitry having a controlled terminal which is connected to the output of said muscular voltage processing circuit and having other terminals which are connected to said tone signal modifying circuits for controlling the modifying characteristic thereof, including means for receiving said unidirectional signal and providing an output voltage which varies as a function of said unidirectional signal.

2. The system according to claim **1**, in which the said processing circuit includes a time constant means for delaying the detected muscular voltage to provide a control DC signal proportional to the amplitude characteristic of the picked-up muscular voltage.

3. The system according to claim **1**, in which the said receiving and providing means includes a voltage-controlled variable impedance element.

4. The system according to claim **3**, in which the said variable impedance element is a transistor.

5. A system according to claim **3** in which said voltage-controlled variable impedance element is a field effect transistor having a gate electrode used as said control terminal.

6. The system according to claim **1**, in which said processing circuit includes an integrator circuit, a clipper circuit and a differentiation circuit in series connection, a terminal at the output side of the said clipper circuit for deriving a square waveform signal, and another terminal at the output side of the said differentiator circuit for providing a pulse wave signal, and the said receiving and providing means includes at least a flip-flop, monostable circuit means connected to the said flip-flop, at their input side and paired actuating coils of a electromagnetically actuated tablet at their output side for selectively energizing the coils.

7. The system according to claim **5** in which the said receiving and providing means further includes counter means for controlling the respective plurality of tablets as a function of pulse count.

8. The system according to claim **6**, in which the said receiving and providing means includes a ring counter for receiving a signal from the said terminals in front of the flip-flops and a plurality of paired monostable multivibrators, each paired multivibrators being connected to the coils of each of said tablets to effect predetermined control of the said tablets in response to the number of pulses received at the said counter.

9. The system according to claim **1**, in which the said receiving and providing means includes means for varying the bias voltage of an oscillative element of each tone generator.

10. The system according to claim **1**, in which the said receiving and providing means includes a field effect transistor whose base is connected to the output of the said processing circuit and whose source and drain electrodes are connected in parallel with a resistor forming a feedback time constant circuit of a free-running multivibrator, the said multivibrator constituting a clock pulse generator of an automatic rythm generator, thereby the frequency of the oscillation being varied in response to the muscular voltage input.

11. The system according to claim **1**, in which the said receiving and providing means includes a voltage-controlled variable attennator means provided between various keyer circuits and an electro-acoustic transducer means.

12. The system according to claim **1**, in which the said pickup means are adapted to be mounted on fingers of the player, whereby a touch-responsive muscular voltages may be provided.

13. The system according to claim **1**, in which the said receiving and providing means includes a first and a second field effect transistors (FET's) whose bases are connected to output terminals of the said muscular voltage processing circuit means which are separate from each ather, and the drain of the said first FET and the source of the said second FET are connected at a common point to which an electro-acoustic transducer means is connected through a resistor, and the source of the first FET and the drain of the second FET are

connected to the output side of separate keyboad keyer circuits, respectively, between which a potentiometer is connected whose contact point is connected to the common point.

14. The system according to claim 1, in which a voltage summing circuit is provided to a plurality of the said processing circuit means to provide a composite DC signal having a random envelope as a control signal.

15. The system according to claim 1, in which the said adapting means includes a voltage-controlled variable voltage source connected to said processing circuit means, a motor carrying thereon an electro-acoustic transducer means and moving the direction of said transducer, a speed detector for detecting the speed of the motor being moved, a speed to voltage converter circuit receiving information of the speed detector, a voltage comparator circuit comparing the voltage of said variable voltage source with a converted voltage from the voltage convertor, a motor control drive circuit receiving the result of comparison in said comparator, and a power source energizing the motor through said drive circuit.

16. A system according to claim 1, in which said receiving and providing means further includes an oscillator followed by frequency dividers to form tone generators, and said tone signal modifying circuit includes said frequency dividers.

17. The system according to claim 1, in which said muscular voltage processing circuit includes an integrator circuit with its input being connected to the output of said rectifier means, a clipper circuit with its input being connected to the output of said integrator circuit, a differentiation circuit with its input being connected to the output of said clipper circuit, a first terminal connected to the output side of said clipper circuit for deriving a square waveform signal, and a second terminal connected to the output side of said differentiation circuit for providing a pulse wave signal.

18. The system according to claim 17, in which said receiving and providing means includes at least a flip-flop and monostable circuit means connected to said flip-flop at their input side and paired actuating coils of an electromagnetically actuated tablet switch provided at the output side of said monostable circuit means for selectively energizing the coils.

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