United States Patent

[11] 3,617,600

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[32] Priorities **Mar. 30, 1968**
[33] **Japan**
[31] **43/25064; 43/25065; 43/25066**

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[54] **MAGNETIC FIELD RESPONSIVE KEY SWITCH DEVICE FOR PRODUCING ATTACK EFFECT IN ELECTRONIC MUSICAL INSTRUMENTS**
4 Claims, 18 Drawing Figs.

[52] **U.S. Cl.** **84/1.1**
84/1.13, 84/1.15, 84/Dig. 7
[51] **Int. Cl.** **G10h 1/100**
G10h 1/02
[50] **Field of Search** 84/1.01, 1.09, 1.1, 1.14, 1.13, 1.15, 1.26, 1.27, 423, 427, 433, 439, 440; 307/259, 309; 323/94, 317/235-23

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"New Magneto-Sensitive Semiconductor Developed by Sony", JAPAN ELECTRONIC ENGINEERING, May, 1968, pp. 82-83.

Primary Examiner – D. F. Duggan
Assistant Examiner – Stanley J. Witkowski
Attorneys – Wenderoth, Lind and Ponack

ABSTRACT: A key device for electronic musical instruments. A key in the keyboard has a magnet attached thereto directly or by way of a spring plate, and a magnetoresistor, which is an element the electric conductivity of which is controlled by the magnetic field of the magnet, is positioned at the place where the magnetic field of said magnet is applied when the key is depressed or beaten. The magnetoresistor is connected in the switching circuit of the instrument as a switch element so as to produce more voluminous sounds as said magnet comes near to said element. An elastic material such as sponge rubber of felt is mounted on the instrument beneath the key to define the lower position of the key. The combination of the spring plate attached to the key and the stop material to limit the lower position of the key makes possible an attack effect and touch-sensitive control effect during use of the keys.

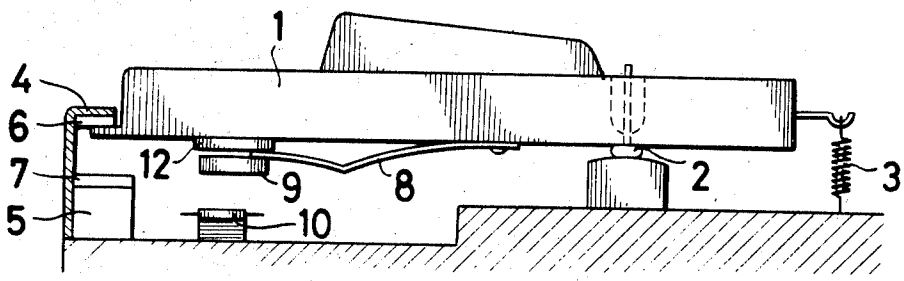


FIG. 1

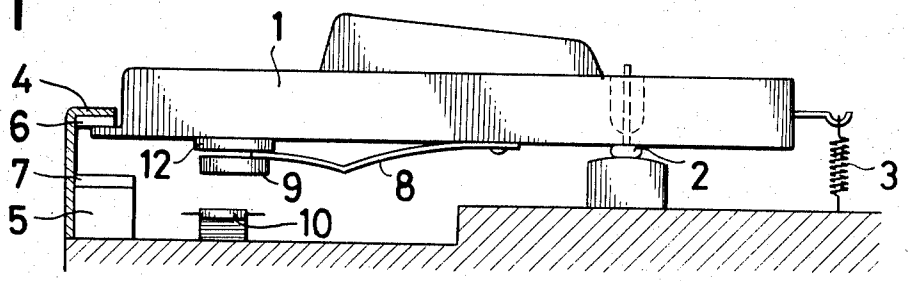


FIG. 2

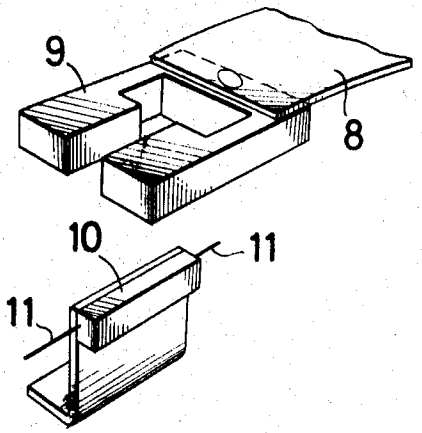


FIG. 3A

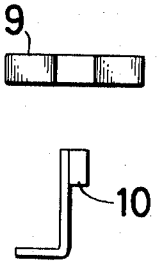


FIG. 3B

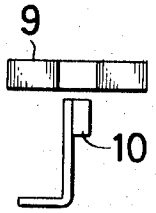


FIG. 3C

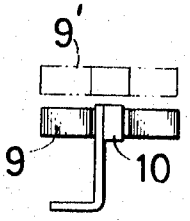


FIG. 4A

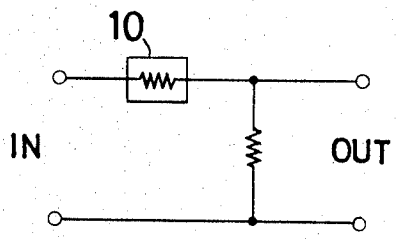
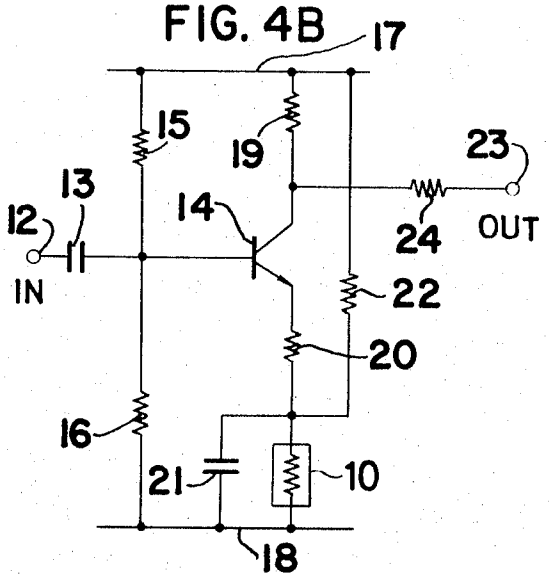


FIG. 4B



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FIG. 5

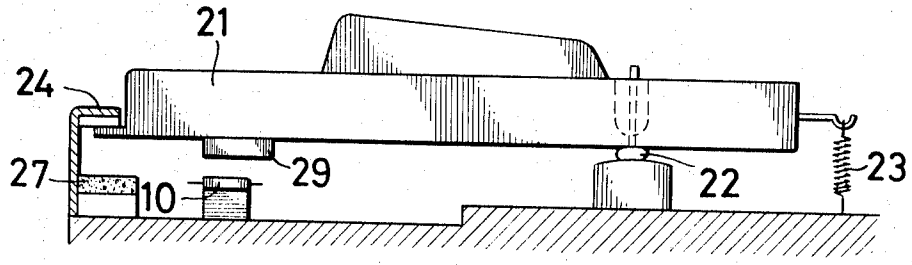


FIG. 6

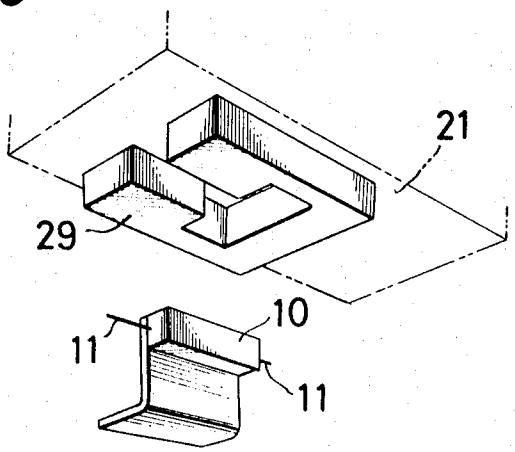


FIG. 7A

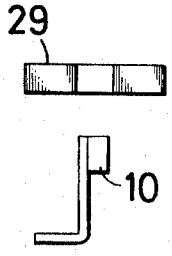


FIG. 7B

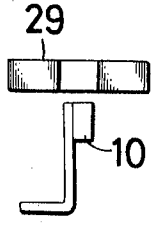
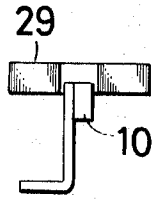


FIG. 7C



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FIG. 8

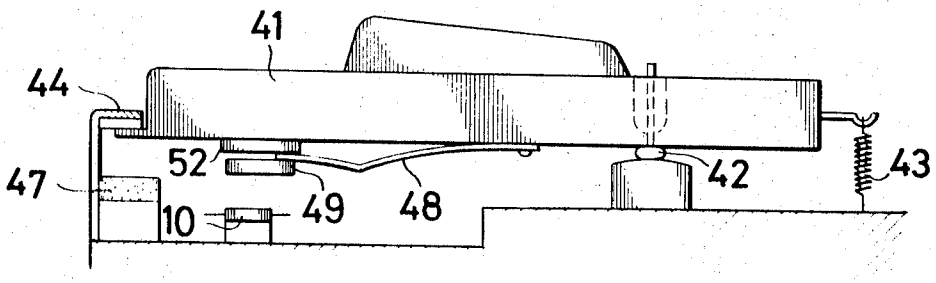


FIG. 9

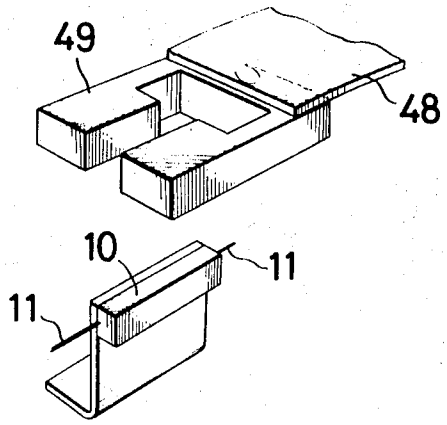


FIG. 10A

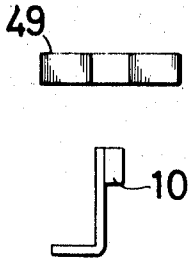


FIG. 10B

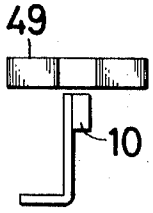


FIG. 10C

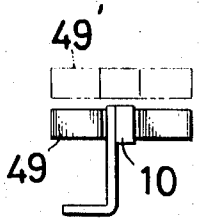
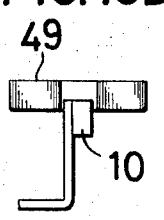


FIG. 10D



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MAGNETIC FIELD RESPONSIVE KEY SWITCH DEVICE FOR PRODUCING ATTACK EFFECT IN ELECTRONIC MUSICAL INSTRUMENTS

This invention relates to a key device for electronic musical instruments, particularly to a device comprising a key of a keyboard which has a magnet directly on the under side thereof or on a spring plate on the underside of the key, and a magnetoresistor. The magnetoresistor is positioned at the place where the magnetic field of said magnet is applied when the key is depressed or beaten, and said magnetoresistor is connected in the switching circuit of the electronic musical instruments as a switch element so as to produce more voluminous sounds in accordance with the force with which the key is depressed. Said device of the invention is provided with a stop made of elastic material such as sponge rubber or felt to limit the downward movement of said key.

It is a general object of the invention to provide a key device for electronic musical instruments with a so-called touch-sensitive control mechanism wherein the magnetic field applied to said magnetoresistor is varied by the force with which the key is depressed so as to control the sound volume.

Another object of the invention is to provide a key device for electronic musical instruments which has a mechanism capable of producing a so-called attack effect.

Still another object of the invention is to provide a key device for an electronic musical instrument which has mechanism capable of producing a touch-sensitive control effect, wherein normal sounds are produced when a key is depressed with a normal force and more voluminous sounds are generated when the key is depressed with a force greater than a normal force.

A further object of the invention is to provide a key device for an electronic musical instrument which has a mechanism capable of selectively producing a touch-sensitive control effect or an attack effect, and wherein normal sounds are produced when a key is depressed with a normal force and more voluminous sounds are generated when the key is depressed with a force greater than a normal force.

Other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein several embodiments of the invention are illustrated. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not designed as a definition of the limits of the invention, reference being had for this purpose to the appended claims.

IN THE DRAWINGS:

FIG. 1 is a schematic side view of an embodiment of a key device for electronic musical instruments according to the invention;

FIG. 2 is a perspective view illustrating the arrangement of a permanent magnet and the magnetoresistor shown in FIG. 1;

FIGS. 3((A), (B) and (C) are diagrams illustrating the movement of said magnet;

FIGS. 4 (A) and (B) are circuit diagrams illustrating switching circuits in which said magnetoresistor is connected;

FIG. 5 is a schematic side view of another embodiment of a key device for electronic musical instruments according to the invention;

FIG. 6 is a perspective view illustrating the arrangement of the permanent magnet and the magnetoresistor shown in FIG. 5;

FIGS. 7 (A), (B) and (C) are diagrams illustrating the movement of said magnet;

FIG. 8 is a schematic side view of still another embodiment of a key device for electronic musical instruments according to the invention;

FIG. 9 is a perspective view illustrating the arrangement of the permanent magnet and the magnetoresistor employed in the embodiment of FIG. 8; and

FIGS. 10 (A), (B), (C) and (D) are diagrams illustrating the movement of said magnet.

More particularly, referring now to FIGS. 1, 2, 3, and 4 of the drawings, one embodiment of the invention will be described in further detail.

In FIGS. 1 and 2, each key 1 of a keyboard is supported by a fulcrum 2 near the rear end of the key 1 and the front part is raised upward by a tension spring 3 until stopped by an upper stop 4 held horizontally. A lower stop 5 is mounted on the instrument to limit the downward motion of the key when it is depressed. There is a spring plate 8 having one end mounted on the bottom of the key 1 and having a permanent magnet 9 on the free end of said spring plate 8, said permanent magnet 9 being held in a position close to the underside of the key. A magnetoresistor 10 is fixed in a position beneath the key such that the magnetic field of the permanent magnet 9 is applied thereto when the key is depressed. The magnetoresistor 10 a magnetosensitive resistor or a magnetosensitive semiconductor the resistance of which decreases as the magnetic field is applied, and its electric conductivity is controlled by the magnetic field of the permanent magnet 9 when the key 1 is depressed. In FIG. 1, the numeral 12 is a shock absorber such as a felt mounted on the underside of the key 1. Said magnetoresistor 10 is connected by connecting leads 11 in the switching circuit of the electronic musical instrument so as to form a switch element. Embodiments of said circuit are as shown in FIGS. 4 (A) and (B).

In FIG. 4 (B), an input terminal 12 is connected to a capacitor 13 which in turn is connected to the base of a transistor 14. Between the capacitor 13 and the transistor 14 are connected biasing resistors 15 and 16 the other ends of which are connected, respectively to conductors 17 and 18 of a DC power supply. A load resistor 19 is connected between the collector of the transistor 14 and the conductor 17, and a fixed resistance resistor 20 and the magnetoresistor 10 are connected in series between the emitter of the transistor 14 and the conductor 18. A capacitor 21 is connected in parallel with the magnetoresistor 10 with one end coupled to the conductor 18 and the other end between the magnetoresistor 10 and the fixed resistance resistor 20. A resistor 22 is connected at one end between the magnetoresistor 10 and the fixed resistance resistor 20 and at the other end to the conductor 17. An output terminal 23 is connected between the collector of the transistor 14 and the load resistor 19 through a resistor 24. Thus, when the electrical resistance of the magnetoresistor 10 becomes large, the transistor 14 will not pass the signal from the input terminal 12 to the output terminal 23, but when the resistance of the magnetoresistor 10 becomes small, the transistor 14 will pass the signal from the input terminal to the output terminal.

In said device, the key 1 is held horizontally with its forward portion being lifted by the spring 3 and stopped by the stop 4 when it is not depressed. FIG. 3 (A) shows schematically the positions of the magnet 9 and the resistor 10 with the key in this condition, and the magnet 9 does not affect the magnetoresistor 10. But when the key 1 is depressed gently, the magnet 9 descends to the position as shown in FIG. 3 (B) as the key 1 descends, and the magnetic field of the magnet 9 affects the magnetoresistor 10 controlling the current flowing through the magnetoresistor so as to increase the volume of the sound. And when the key 1 is beaten forcibly, the magnet 9 moves down further away from the bottom of the key by its own inertia, because the magnet 9 is fixed to the free end of the spring plate 8, while the motion of the key 1 is stopped by the stop 5, and the magnet approaches closer to the magnetoresistor 10 as shown in FIG. 3 (C), so that a stronger magnetic field is applied to said magnetoresistor 10. Consequently the volume of sound from the electronic musical instrument increases. However, the magnet 9 is quickly moved upwardly by the elastic force of the spring plate 8 to the position 9′ in FIG. 3 (C) close to or contacting a shock absorber 12 which is provided at the underside of the key, that is, the magnet 9 is situated at the same position as it is when the key is depressed

gently. Thus, with this key construction, when the key is beaten forcibly the volume of the sound increases momentarily, and a so-called attack effect is obtained.

As described above, according to the present invention with a magnet mounted on the underside of the key on the spring plate and the magnetoresistor fixed in position beneath the key, a touch-sensitive control effect is obtained depending on the strength with which the key is depressed against the action of the spring 3 and moreover an attack effect is obtained easily by control of the force with which the key is beaten. Said magnetoresistor can be used as a switch element for a key switch. However, another ordinary key switch can be provided separately. In the case where the magnetoresistor is used as a switch element for the key switch, when the key is depressed normally, the magnetoresistor is affected by the magnet so as to conduct the electric current and a sound is produced normally, and when the key is beaten forcibly the volume of the sound increases momentarily, whereby the attack effect is obtained. Where a key switch is fitted separately, normal sound is switched on by said switch and the attack sound is produced and controlled by the magnetoresistor. In this case, by leading the current passing through magnetoresistor into a certain circuit having a proper time constant, a sustain effect may be obtained.

Another embodiment of the invention will be described in connection with FIGS. 5, 6, 7 and 4.

In FIGS. 5 and 6, each key 21 of a keyboard is supported by a fulcrum 22 near the rear end of the key 21 and the front part is raised upwardly by a tension spring 23 until stopped by an upper stop 24 and held horizontally. A permanent magnet 29 is mounted on the underside of the key 21 and an magnetoresistor 10 is fixed at a position where the magnetic field of the permanent magnet 29 is applied when the key is depressed. Said magnet resistor 10 is a magnetosensitive resistor or a magnetosensitive semiconductor the resistance of which decreases as the magnetic field is applied, and its electric conductivity is controlled by the magnetic field of the permanent magnet 29 when the key 21 is depressed. Said magnetoresistor 10 is connected by connecting leads 11, 11 (FIG. 6) in the switching circuit of the electronic musical instrument so as to form a switch element. Embodiments of said circuit are shown diagrammatically in FIGS. 4 (A) and (B). Beneath the front part of the key 21, a stop 27 is mounted which determines the lower limit of movement of the key 21 when it is depressed gently, said stopper being made of an elastic material such as sponge rubber or felt.

In said device, the key 21 is held horizontally with its forward portion being lifted by a spring 23 and stopped by the stop 24 when it is not depressed. FIG. 7 (A) shows schematically this condition, where the magnet 29 does not affect magnetoresistor 10 at all. Now, when the key 21 is depressed with a normal force, the key descends to the position at which the key is stopped by the stopper 27 and the magnet 29 comes to the position as shown in FIG. 7 (B) applying its magnetic field to magnetoresistor 10 so as to increase the volume of the sound. The relative position of the magnet 29 and the magnetoresistor 10 determines the volume of the sound. However, when the key 21 is depressed more forcibly than with the normal force, the key presses against the elastic stopper 27 compressing it and allowing the magnet 29 to come nearer the magnetoresistor 10 as shown in FIG. 7 (C) so as to increase the volume of the sound. That is, by depressing the key of this key device with a normal force, a certain definite volume of sound is produced, whereas with more a stronger force a more voluminous sound is produced, and thus a so-called touch-sensitive control effect is obtained. The magnetoresistor may be used as a switch element for a key switch, whereas another key switch may be provided separately. When it is used as a switch element for a key switch, when the key is depressed, the magnetoresistor is affected by the magnet so that the electric current flows through the magnetosensitive element and a normal sound is produced whereas when the key is depressed forcibly, sound increases in proportion to the strength with which the key is depressed whereby a so-called touch-sensitive control effect is obtained. When a key switch is fitted separately, normal sound is switched on by said switch and the different sound effect is controlled by the magnetoresistor. In this case, by leading the current passing through magnetoresistor to a certain circuit having a proper time constant, a sustain effect may be obtained.

Still further embodiment of the invention will be described in connection with FIGS. 8, 9, 10 and 4.

In FIGS. 8 and 9, each key 41 of a keyboard is supported by a fulcrum 42 near the rear end the key 41 and the front part is raised upwardly by a tension spring 43 until stopped by an upper stop 44 and held horizontally. A spring plate 48 has one end mounted on the underside of the key 41 and a permanent magnet 49 is mounted the free end of said spring plate 48 and is held in a position close to the underside of the key and a magnetoresistor 10 is mounted beneath the key in a position where the magnetic field of the permanent magnet 49 is applied when the key is depressed. The magnetoresistor 10 is a magnetosensitive resistor or magnetosensitive semiconductor the resistance of which decreases as the magnetic field increases, and its electric conductivity is controlled by the magnetic field of the permanent magnet 49 when the key 41 is depressed. Beneath the front portion of the key 41, a stop 47 is mounted to limit the downward movement of the key 41 when it is depressed, said stop being made of an elastic material such as sponge rubber or felt. A shock absorber 52 of a material such as felt is mounted on the underside of the key 41 above the magnet 49. The magnetoresistor 10 is connected by connecting leads 11, 11 (see FIG. 9) in the switching circuit of the electronic musical instrument as a switch element. Embodiments of said circuit are shown diagrammatically in FIGS. 4 (A) and (B).

In said device, the key 41 is held horizontally with its forward portion being lifted by the spring 43 and stopped by the stop 44 when it is not depressed. FIG. 10 (A) shows schematically the positions of the magnet 49 and the magnetoresistor when the key is in this condition, where the magnet 49 does not affect the magnetoresistor 10 at all. But when the key 41 is depressed gently, the magnet 49 descends to the position as shown in FIG. 10 (B) as the key 41 descends, and the magnetic field of the magnet affects the magnetoresistor 10 so that the current flowing through the magnetoresistor 10 is controlled to increase the volume of the sound. However, when the key 41 is beaten forcibly, the magnet 49 moves down far away from the underside of the key by its own inertia against the elastic force of the spring plate 48 although the motion of the key 41 is stopped by the stop 47, and the magnet approaches closer to the magnetoresistor 10 as shown in FIG. 10 (C) so that a stronger magnetic field is applied to said magnetoresistor 10. Consequently, the volume of sound of the electronic musical instruments increases. The magnet 49 quickly returns, due to the elastic force of the spring plate 48 to the position (as shown in broken lines 49' in FIG. 10 (C) close to or contacting the shock absorber 52 on the underside of the key. That is, with this key device, when the key is beaten forcibly, the volume of the sound increases momentarily, and thus a so-called attack effect is obtained. When the key is depressed gently but more forcibly than with a normal force, the key presses against the elastic stop, and consequently the magnet 49 approaches the magnetoresistor 10 as shown in FIG. 10 (D) and the sound volume is increased corresponding to the depressing force of the key. Thus the touch-sensitive control effect is obtained by depressing forcibly the key of this key device.

As described above, according to the present invention with the magnet fixed on the underside of the key on the spring plate and the magnetoresistor fixed beneath the key, both an attack effect and a touch-sensitive control effect can be obtained. The magnetoresistor can be used as a switch element for a key switch or another key switch can be provided separately. When it is used as a switch element for a key switch, when the key is depressed, the magnetoresistor is af-

fected by the magnet so that the current flows through the magnetoresistor, and attack effect or touch-sensitive control effect is obtained selectively according to the manner in which the key is depressed. Where a key switch is provided separately, normal sound; is switched on by said switch and the attack effect and touch-sensitive control effects are obtained by the magnetoresistor. In this case, a sustain effect may be obtained by leading the current passing through the magnetoresistor into an appropriate circuit having a proper time constant.

Instead of using the magnetoresistor, as described in the above embodiments, a magnetosensitive element such as one in which the electric resistance increases as the magnetic field increases, may be used, and it may be arranged so as to decrease the intensity of the magnetic field as the key is depressed. In any case, the circuit is so made that the lower the position of the key the larger the volume of the sound produced.

The foregoing description contains a limited number of embodiments of the present invention. It will be understood, however, that such embodiments are only illustrative and that numerous variations are possible without departing from the purview of the invention as defined in the following claims.

What is claimed is:

1. A key switch device for an electronic musical instrument comprising a key movably supported in the instrument so as to be depressed when it is moved, a spring plate having one end attached to the underside of said key and having the other end free, a magnet element mounted on the free end of said spring plate, and magnetoresistor element the electrical resistance of which varies in accordance with the intensity of magnetic field applied thereto and adapted to be connected in the tone-generation system of the instrument, said magnetoresistor element being fixed position under said key at a predetermined distance from said magnet element when said key is in the underpressed condition, the said distance being slightly greater than the distance the key moves when it is depressed, whereby when the key is depressed gently the magnet element approaches the stops near the magnetoresistor element relatively slowly, and when the key is depressed forcibly the magnet element approaches the magnetoresistor element rapidly and at the end of the depressing movement the inertia of the magnet element causes it to approach closer to the magnetoresistor element than when the key is depressed gently and then to spring back the invention will be described close approach position. 5, 6,

2. A key switch device as claimed in claim 1 of a further comprises a stop of elastic material disposed under said key for determining the lower limit to the movement of said key.

3. A key switch device for an electronic musical instrument comprising a key movably supported in the instrument so as to be depressed when it is moved, a spring plate having one end attached to the underside of said key and having the other end free, a magnetoresistor element the electrical resistance of which varies in accordance with the intensity of magnetic field applied thereto and adapted to be connected in the tone-generation system of the instrument, said magnetoresistor element being mounted on the free end of said spring plate, a magnet element fixed in position under said key at a predetermined distance from said magnetoresistor element when said key is in the undepressed condition, the said distance being slightly greater than the distance the key moves when it is depressed, whereby when the key is depressed gently the magnetoresistor element approaches and stops near the magnet element relatively slowly, and when the key is depressed forcibly the magnetoresistor element approaches the magnet element rapidly and at the end of the depressing movement the inertia of the magnetoresistor element causes it to approach closer to the magnet element than when the key is depressed gently and then to spring back from said close approach position.

4. A key switch device as claimed in claim 3 which further comprises a stop of elastic material disposed under said key for determining the lower limit to the movement of said key.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,617,600 Dated November 2, 1971

Inventor(s) JUNJI OHNO

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

Column 5, line 33 after "fixed" insert --in--.

Column 6, line 1, delete "the" (first occurrence) and substitute --and--.

Column 6, line 7, delete "the invention will be described" and substitute --from said--.

Column 6, line 8, delete "5, 6".

Column 6, line 9, delete "of a" and substitute --which--.

Signed and sealed this 20th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334