United States Patent

Leno

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[54] **VARIABLE CAPACITIVE APPARATUS**

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[52] **U.S. Cl.** ....**317/249 R,** 200/DIG. 1, 317/246, 317/250

[51] **Int. Cl.** **H01g 5/10**

[58] **Field of Search** ....317/249 R, 246, 245, 250; 200/DIG. 1

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Attorney—J. L. Landis and R. P. Miller

[57] **ABSTRACT**

A variable capacitance apparatus particularly adapted for use with a manually-operated keyboard and having two parallel, conductive plates with a dielectric therebetween. Depression of a key moves one conductive plate farther from the other conductive plate so as to reduce the capacitive coupling between the conductive plates, in order to determine whether the key has been depressed.

18 Claims, 5 Drawing Figures

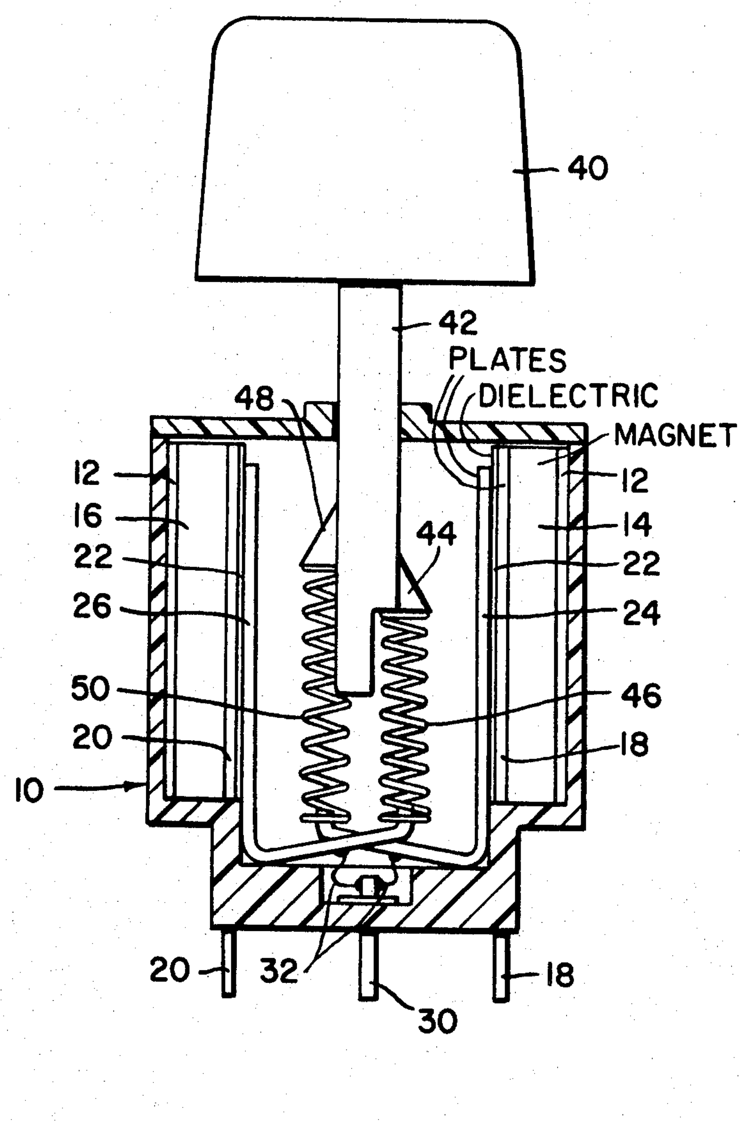

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FIG. 1

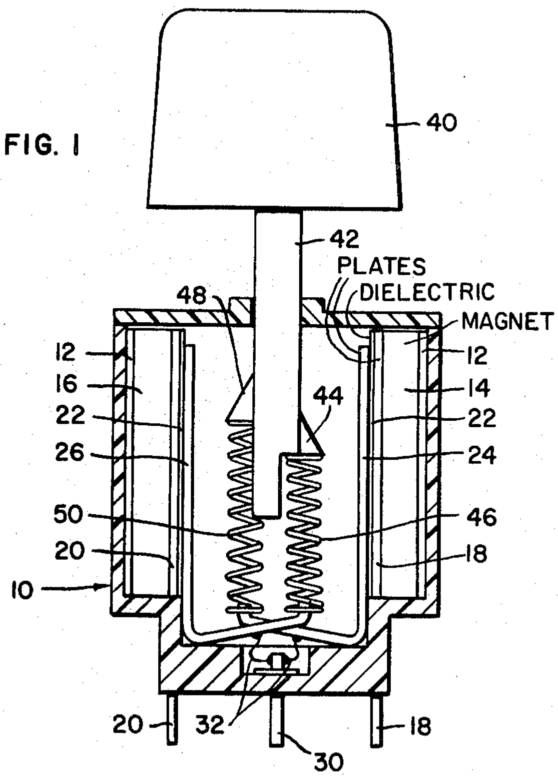


FIG. 2

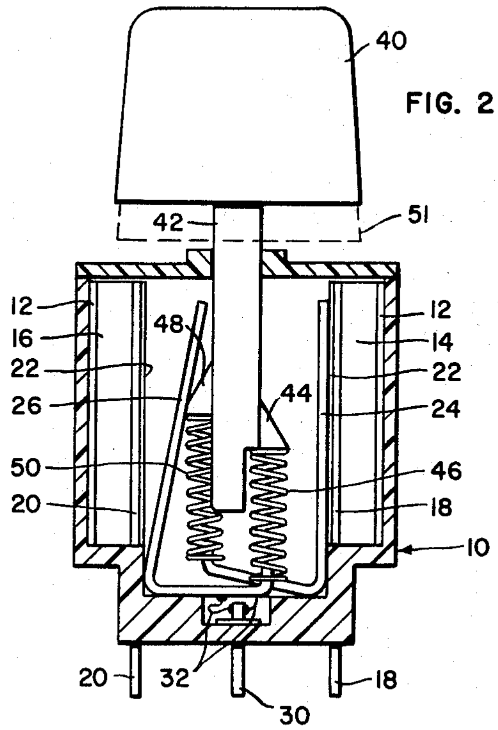
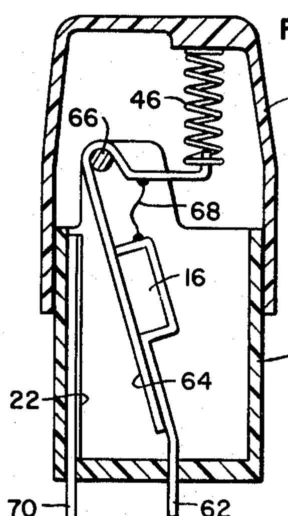


FIG. 4



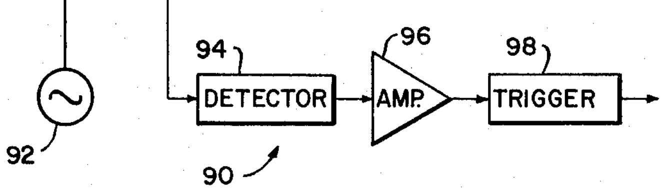


FIG. 5

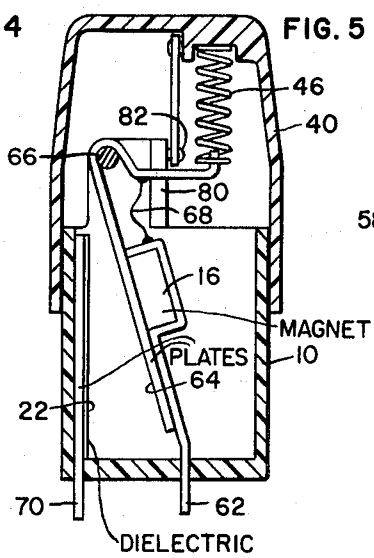
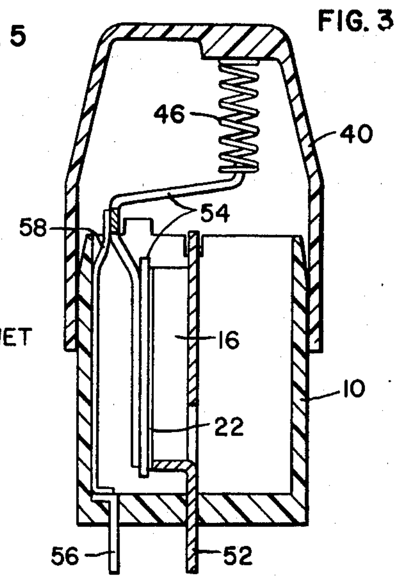


FIG. 3



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VARIABLE CAPACITIVE APPARATUS

FIELD OF THE INVENTION

This invention relates to electrical switching apparatus and method and more particularly to a switching apparatus and method in which the switching action involves the change of capacitive coupling between two conductive plates.

BACKGROUND OF THE INVENTION

It is well known in the prior art of keyboards that the depression of a key can be used to mechanically close an electrical contact switch in order to indicate to some form of utilization circuitry that the key has been depressed. However, in connection with modern electronic circuitry, conventional electrical contacts have serious limitations due to lint, phenolic vapors, moisture, corrosion and other problems which tend to reduce the reliability of contact closure, especially under low voltage conditions normally associated with transistor circuitry.

Therefore, it is an object of the present invention to provide a more reliable switching device.

It is another object of the present invention to provide a switch which is relatively insensitive to ordinary atmospheric conditions.

It is a further object of the present invention to provide an electronically detectable indication of a manual input.

SUMMARY OF THE INVENTION

In accordance with present invention, a variable capacitor comprises a first planar conductive surface and a second conductive surface separated therefrom by dielectric material wherein the distance between the first and second conductive surfaces is varied in order to vary the capacitive coupling between the conductors.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention may be had by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a cross-sectional view showing a manually-movable, magnetically-biased, key-operated capacitor plate that is held into engagement with a dielectric-covered companion electrode plate;

FIG. 2 is similar to FIG. 1, but showing the key partially depressed;

FIG. 3 is cross-sectional view of an alternate embodiment in which the movable capacitor plate is pivoted on a flexure joint;

FIG. 4 shows another alternative embodiment having a hinged pivot in which the capacitor plates are magnetically biased away from each other and shows a circuit for determining capacitive coupling; and

FIG. 5 shows an embodiment similar to that shown in FIG. 4, but with a push-push mechanism comparable to that used in a retractable ball-point pen.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the accompanying drawings and more particularly to FIGS. 1 and 2, a plastic housing 10 contains a pair of steel, magnetic shielding plates 12 on the interior surfaces of opposite sides of the plastic housing 10. Two permanent magnets 14 and 16 are placed in the housing next to the shielding plates 12. A pair of bronze, fixed electrode plates 18 and 20 are bonded each to one face of the magnets 14 and 16, respectively, and have connector tabs projecting out of the bottom of the plastic housing 10. A dielectric material 22 is used to coat those surfaces of the fixed plates 18 and 20 which face toward the center of the plastic housing 10.

A pair of bent, ferromagnetic, electrode swing plates 24 and 26 are placed so that they can pivot on the bottom of the plastic housing 10 and are magnetically attracted by the permanent magnets 14 and 16, respectively, to positions wherein they press against the dielectric surfaces 22. A common pin 30 extends through the bottom of the plastic housing 10 between the two swing plates 24 and 26. A flexible electrical connection 32 is made between the common pin 30 and each of the swing plates.

In a normal or unenergized condition as shown in FIG. 1, the capacitance between the common pin 30 and either of the fixed electrode plates 18 or 20 is at a maximum. If the capacitance were suitably sampled at this time, it would indicate that the plates 24 and 26 were in their unenergized position; because, a maximum of electrical energy would be coupled through the capacitors formed by the plates 24 and 18 and by the plates 26 and 20.

A keytop 40, FIG. 1, is connected by a push rod 42 to the interior of the plastic housing 10. A shoulder 44 on the push rod 42 is in engagement with a trip spring 46 which is also in engagement with the bent-over portion of the swing plate 26. Similarly, a shoulder 48 on the push rod 42 is connected by a spring 50 to the bent-over portion of the swing plate 24.

As the keytop 40 is manually depressed, the trip springs 46 and 50 are compressed and exert increasing amounts of force upon the bent-over portions of their associated swing plates 24 and 26. The trip spring 46 is so constructed that, upon depression of the keytop 40 to the position shown in FIG. 2, the spring 46 finally builds up a sufficient force to overcome the magnetic attraction of the permanent magnet 16, thereby causing the swing plate 26 to separate from its associated dielectric surface 22 as shown in FIG. 2. The trip spring 50 is so constructed that only upon still further depression of the keytop 40 to the position indicated by the dotted lines 51 in FIG. 2 following the separation of the swing plates 26, is sufficient force exerted by the trip spring 50 on the bent-over portion of the swing plate 24 to cause the swing plate 24 to separate from its associated fixed plate 18.

Therefore, as the keytop 40 is initially depressed, nothing happens at first. However, continued depression of the keytop 40 to the position shown in FIG. 2 causes the swing plate 26 to separate from its associated fixed plate 20. Further, continued depression then causes the swing plate 24 also to separate from its associated fixed plate 18.

In a typewriter keyboards, it is sometimes desired to provide a facility for repeating a character in response to a further depression of the key against an increased spring force. It will be appreciated that the embodiment shown in FIG. 1 and 2 is capable of providing one output upon a normal depression of the keytop 40 and of providing a second output to cause repetition of a character upon further depression of the same key.

As an alternative embodiment of the present invention, reference may be had to FIG. 3 wherein the permanent magnet 16 is connected to fixed electrode 52, and the surface of the magnet 16 itself is one plate of the capacitor. A ferromagnetic swing plate 54 is mounted to an electrode 56 by a flexure joint 58. A keytop 40 is constructed so as to fit around the outside of the plastic housing 10. A trip spring 46 is connected between the keytop 40 and the swing plate 54. In the normal, unactuated position of the switch of FIG. 3, the magnet 16 attracts and holds the swing plate 54 firmly against the dielectric material 22 to assure maximum capacitive coupling between the electrodes 52 and 56.

Upon depression of the keytop 40, nothing happens initially except the compression of the spring 46. Upon continued depression of the keytop 40, sufficient force is finally applied by the spring 46 to the swing arm 54 to overcome the attraction of the permanent magnet 16. The swing plate 54 then separates from the magnet 16 and dielectric 22 and rotates clockwise (as shown in FIG. 3) bending the flexure joint 58. Thus, the capacitive coupling between the electrodes 52 and 56 is sharply reduced. Suitable electronic circuitry can then be used to detect the change in capacitance between the two electrodes.

Referring now to FIG. 4, still another alternative embodiment of the present invention is illustrated. A permanent magnet **16** is firmly mounted within a housing on a conductive framework connected to an electrode **62**. A ferromagnetic, conductive swing plate **64** is rotatably mounted on a pivot **66** and is normally attracted by the magnet **16**. A flexible electrical connection **68** assures electrical continuity between the electrode **62** and the swing plate **64**.

As the keytop **40** is depressed, the spring **46** is compressed until sufficient force is exerted by the spring **46** on an arm of the plate **64** to overcome the magnetic attraction of the permanent magnet **16**. This permits the swing plate **64** to separate from the magnet **16** and rotate under the urging of the spring **46** clockwise about the pivot **66** until the swing plate **64** is parallel to and abutting a dielectric material **22** on the surface of a fixed electrode **70**.

In the embodiment shown in FIG. 4, the capacitive coupling between the electrodes **62** and **70** is minimum in the deenergized condition of the switch. However, when the keytop **40** is fully depressed, the swing plate **64** is in closer proximity to the fixed electrode **70**, resulting in increased capacitive coupling between the electrodes **62** and **70**.

Many variations are possible on all three of the embodiments shown. FIG. 5 is a variation which is illustrated with respect to the structure of FIG. 4 but which might readily be applied to the embodiments shown in FIGS. 1, 2 and 3.

Referring now to FIG. 5, a push-to-latch, push-to-release cam **80** is mounted on the plastic housing **10**. The keytop **40** is connected to the cam follower **82** and is thus held in the depressed condition every second time that it is depressed. Push-push mechanisms such as the cam **80** and follower **82** are well known in the prior art and will not be described further herein.

One typical capacitance sampling circuit **90** is shown in connection with the structure of FIG. 4. The circuit **90** could be used equally well with the structures of FIGS. 1, 2 and 3. Other types of capacitance sampling circuits will be readily apparent to one of ordinary skill in the art.

In FIG. 4, an AC generator **92** delivers a constant amplitude AC signal to the electrode **70**. The input of a rectifying detector **94** is connected to the electrode **62**, and the detector **94** delivers an output that is a DC voltage having a magnitude that is representative of the amplitude of the AC voltage coupled from the electrode **70** to the electrode **62**. An amplifier **96** delivers an amplified DC signal to a Schmitt Trigger **98** or other voltage threshold sensor which produces an output signal only when its signal input exceeds a predetermined magnitude. The voltage levels can then be predetermined or adjusted at such magnitudes that the Schmitt trigger will produce an output voltage only when the voltage coupling between the electrodes **62** and **70** is equal to or greater than the coupling that exists when the swing plate **64** is pressed up against the dielectric **22** of FIG. 4.

Although various specific embodiments of the invention are shown in the drawings and described in the foregoing specification, it will be understood that invention is not limited to the specific embodiments described, but is capable of modification and rearrangement and substitution of parts and elements without departing from the spirit of the invention.

What is claimed is:

1. A variable capacitance device comprising:
a first conductor with at least one planar surface;
a second conductor with at least one planar surface;
a third conductor with at least one planar surface and having at least one edge;
a fourth conductor with at least one planar surface and having at least one edge;
means for mounting the edge of the third conductor substantially in the plane of the surface of the first conductor;
means for mounting the edge of the fourth conductor substantially in the plane of the surface of the second conductor;
a push button;
means responsive to at least some movement of the push button for pivoting the third conductor substantially along the edge thereof for altering the average distance between the surface of the first conductor and the surface of the third conductor, whereby the capacitive coupling between the first and third conductors is altered; and
means responsive to further movement of the push button for pivoting the fourth conductor along the edge thereof for altering the average distance between the surface of the second conductor and the surface of the fourth conductor, whereby the capacitive coupling between the second and fourth conductors is altered after the alteration of the capacitive coupling between the first and third conductors.

2. A device according to claim 1, wherein the two pivoting means comprise:
first means for normally biasing the third conductor to a position adjacent to the first conductor;
second means for normally biasing the fourth conductor to a position adjacent to the second conductor;
means responsive to at least some movement of the push button for overcoming the first biasing means and for moving the third conductor to a position remote from the first conductor; and
means responsive to further movement of the push button for overcoming the second biasing means and for moving the fourth conductor to a position remote from the second conductor.

3. A variable capacitance device comprising:
a first conductor with at least one planar surface;
a second conductor constructed of magnetically permeable material and having at least one planar surface and at least one edge;
means for mounting the edge of the second conductor substantially in the plane of the surface of the first conductor;
a permanent magnet for normally biasing the second conductor to a position adjacent to the first conductor; and
means for overcoming the bias of the permanent magnet and for pivoting the second conductor substantially along the edge thereof for increasing the average distance between the surface of the first conductor and the surface of the second conductor, whereby the capacitive coupling between the first and second conductors is altered.

4. A variable capacitance device comprising:
a first conductor with at least one planar surface;
a second conductor constructed of a magnetically permeable material and having at least one planar surface and at least one edge;
means for mounting the edge of the second conductor substantially in the plane of the surface of the first conductor;
a permanent magnet for normally biasing the second conductor to a first stop position either adjacent to or away from the first conductor;
leverage means for overcoming the attraction of the magnet in response to the application of force thereto and for moving the second conductor to a second stop position opposite to the first stop position; and
means for applying force to the leverage means.

5. A device according to claim 4, wherein the force-applying means comprises a spring mounted at one end to the leverage means and having the other end positioned for manual energization.

6. A device according to claim 5, wherein a manually depressible key is attached to the other end of the spring.

7. A variable capacitance device comprising:
a first conductor having at least one planar surface;
a second conductor having at least one planar surface;
a third conductor having at least one planar surface arranged to be positioned substantially parallel with the planar surface of the first conductor;
a fourth conductor having at least one planar surface arranged to be positioned substantially parallel with the planar surface of the second conductor;

a dielectric surface on at least one of the first and third conductors;

a dielectric surface on at least one of the second and fourth conductors;

a manually movable push button;

first means responsive to at least some movement of the push button for altering the distance between the first and third conductors in a direction substantially perpendicular to the planar surface of at least one of the first and third conductors, whereby the capacitive coupling between the first conductor and the third conductor is altered; and

second means responsive to further movement of the push button for altering the distance between the second and fourth conductors in a direction substantially perpendicular to the planar surface of at least one of the second and fourth conductors, whereby the capacitive coupling between the second conductor and the fourth conductor is altered after the capacitive coupling between the first and third conductors is altered.

8. A device according to claim **7**, further comprising:

first means for biasing the first and third conductors in close proximity to each other;

second means for biasing the second and fourth conductors in close proximity to each other;

wherein the first altering means comprises means responsive to some movement of the push button for overcoming the first biasing means; and

wherein the second altering means comprises means responsive to further movement of the push button for overcoming the second biasing means after the first biasing means has been overcome.

9. A variable capacitance device comprising:

a first conductor having at least one planar surface;

a second conductor having at least one planar surface arranged to be positioned substantially parallel with the planar surface of the first conductor;

at least one of the first and second conductors being constructed of a ferromagnetic material;

a sheet of solid dielectric material adhered to the surface of at least one of the first and second conductors;

means for biasing the first and second conductors in close proximity to each other;

means responsive to a mechanical input for overcoming the biasing means and for altering the distance between the first and second conductors in a direction between substantially perpendicular to the planar surface of at least one of the first and second conductors, whereby the capacitive coupling between the first conductor and the second conductor is altered.

10. A device according to claim **9**, wherein the biasing means comprises a magnet.

11. A device according to claim **10**, wherein the magnet is a permanent magnet.

12. A device according to claim **11**, wherein the permanent magnet is positioned adjacent the other of the first and second conductors and on the side opposite the ferromagnetic conductor, wherein the ferromagnetic conductor is attracted toward the other conductor.

13. A device according to claim **9**, wherein only one of the conductors is constructed of ferromagnetic material and the other of the conductors is disposed so that the biasing means comprises magnetic force normally attracting the ferromagnetic conductor toward the permanent magnetic conductor.

14. A variable capacitance device comprising:

a conductor with at least one planar surface;

a second conductor with at least one planar surface and having at least one edge;

said second conductor being shaped to form a bend at the edge thereof with an elongated projection from said bend, said projection having an end remote from said bend;

a corner substantially in the plane of the surface of the first conductor;

the second conductor positioned with the bend thereof pivotally mounted substantially in the corner; and

means for applying a force to the end of the elongated projection of the second conductor for pivoting the second conductor substantially along the edge thereof at its bend for altering the average distance between the surface of the first conductor and the surface of the second conductor, whereby the capacitive coupling between the first and second conductors is altered.

15. A device according to claim **14**, wherein the pivoting means comprises:

means for normally biasing the second conductor to a position adjacent to the first conductor; and

means for overcoming the biasing means and for moving the second conductor to a position remote from the first conductor.

16. A device according to claim **15** wherein the overcoming means comprises:

a push button; and

means interconnecting the push button with the end of the projection on the second conductor.

17. A device according to claim **16** wherein the coupling comprises a spring.

18. An improved capacitive switch of the type including a pair of spaced conductive plates, one of which is movable between first and second positions to vary the spacing between the plates and thus the capacitance, wherein the improvement comprises:

a magnet for normally biasing the movable plate to the first position, the movable plate being made of ferromagnetic material; and

a mechanical linkage for shifting the movable plate to the second position against the biasing action of the magnet, for changing the state of the switch.

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