United States Patent [19]

Kawada et al.

[11] **3,749,947**

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[54] **SWITCH DEVICES**

[75] Inventors: **Takehiko Kawada, Hiroaki Takahashi,** both of Yokohama, Japan

[73] Assignee: **Denki Onkyo Company, Ltd.,** Tokyo, Japan

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[30] **Foreign Application Priority Data**

Aug. 28, 1971 Japan 46/65561

[52] **U.S. Cl.** **310/8.3,** 200/181, 200/DIG. 20, 317/144, 310/8.1, 310/8.2, 310/8.7, 310/9.1, 310/26

[51] **Int. Cl.** **H04r 17/00**

[58] **Field of Search** ..... 200/181, DIG. 20; 317/144; 310/8.2, 8.3, 9.1, 9.4, 9.7, 9.8, 8, 8.7, 8.1, 26

[56] **References Cited**

UNITED STATES PATENTS

3,696,259	10/1972	Mori et al.	310/8.3 X
3,395,295	7/1968	Crane	310/8.1
3,112,486	11/1963	Adler	310/8.1 X
3,648,279	3/1972	Watson	310/8.3 X

Primary Examiner—J. D. Miller
Assistant Examiner—Mark O. Budd
Attorney—C. Yardley Chittick, Charles E. Pfund et al.

[57] **ABSTRACT**

A switch device comprises an elongated member made of piezoelectric material and provided with a plurality of spaced apart lateral projections and driving means connected to the member. When the driving means is excited by AC voltage it vibrates the elongated member in the longitudinal direction. The member acts to transform the longitudinal vibration into lateral vibrations in the projections. Output members are disposed to face respective projections and are selectively urged into engagement with the projections to produce output voltages.

7 Claims, 4 Drawing Figures

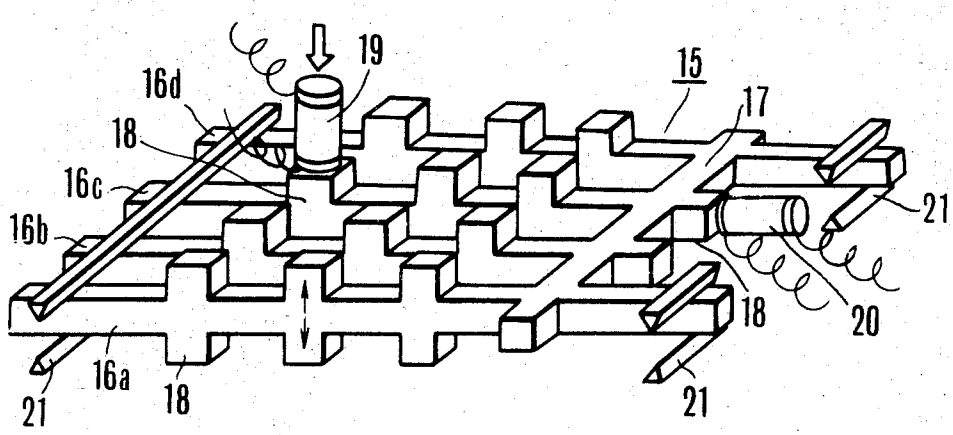

FIG. 1

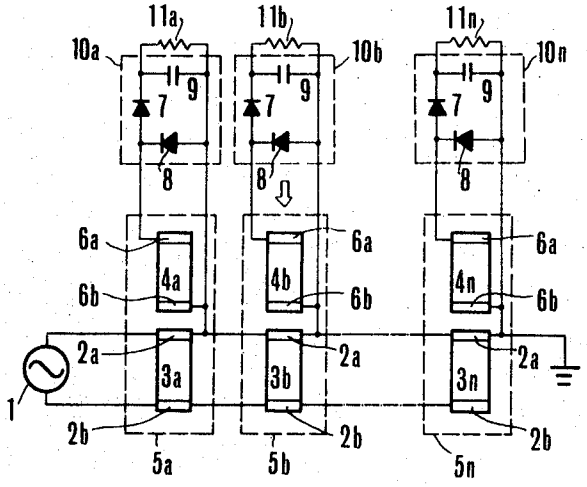
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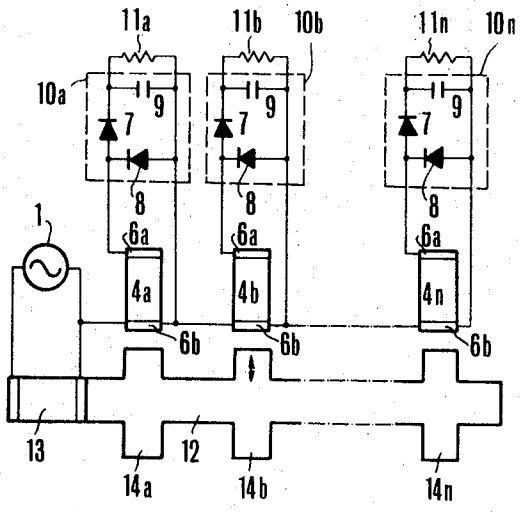
FIG. 2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14b
14n

FIG. 3

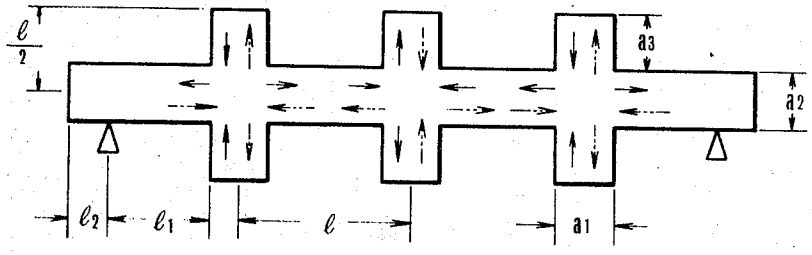
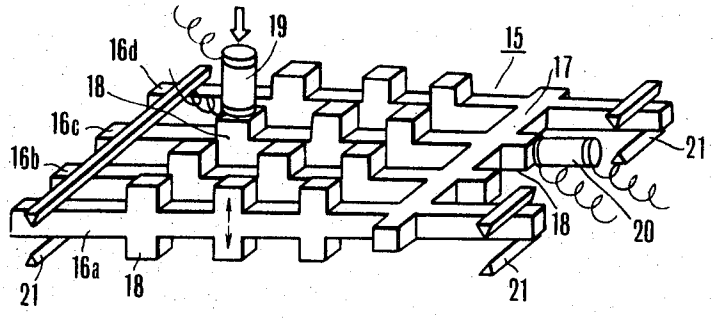


FIG. 4



SWITCH DEVICES

BACKGROUND OF THE INVENTION

This invention relates to a switch device, more particularly a switch device not using any electrical contact.

The prior art switch device utilized in the push button type telephone sets and information processing apparatus comprises a micro-switch or a reed switch connected to a push button for transforming the mechanical displacement of the push button into an electrical signal. However, since such a switch makes or breaks a circuit by closing or opening its electric contact connected in series or parallel with the circuit, troubles are caused by poor contact conditions of the contact although such a switch is simple in construction and hence inexpensive.

The applicant has already proposed an improved switch device not employing any contact as disclosed in a copending patent application Ser. No. 164,401 filed on July 20, 1971. According to the embodiment shown in FIG. 3 of that application which is reproduced herein as FIG. 1, electrodes 2*a* and 2*b* on the opposite ends of polarized elements 3*a* to 3*n* which act as driving elements are connected across a source of alternating current 1 and output elements 4*a* to 4*n* having substantially the same member of mechanical vibration as that of the driving elements 3*a* to 3*n* are disposed respectively in the directions of vibrations of the driving elements. Pairs of driving elements and output elements coaxial therewith constitute switch units 5*a* through 5*n*. Each of the driving elements 3*a* through 3*n* and output elements 4*a* through 4*n* comprises a piezoelectric element or a magnetostriction element made of lead zirconate titanate, barium titanate or the like which undergoes a mechanical vibration when excited by an excitation signal or produces an electrical signal when acted upon by a mechanical vibration. For the sake of description, in the following it is assumed that piezoelectric elements are used. Across the electrodes 6*a* and 6*b* at the opposite ends of the respective output elements are connected rectifiers 10*a* through 10*n*, each comprising diodes 7 and 8 and a capacitor 9, and the outputs of respective rectifiers are connected across load resistors 11*a* through 11*n*, respectively. Although not shown in the drawing, each output element is provided with a push button which urges the output element into engagement with a cooperating driving element.

When the output from the AC source 1 is applied across respective driving elements 3*a* through 3*n*, these elements vibrates mechanically in their direction of polarization. When the push button associated with switch unit 2*b* is depressed, the output element 4*b* is moved in the direction shown by an arrow to come into contact with the driving element 3*b* with the result that the mechanical vibration of the driving element 3*b* is transmitted to the output element 4*b* causing it to vibrate at the same frequency.

When the output element 4*b* is driven in this manner an electrical signal corresponding to the mechanical vibration is created in the direction of polarization in a manner well known in the art. The output signal is supplied to rectifier 10*b* through output electrodes 6*a* and 6*b* to be rectified and smoothed out, and the rectified voltage is applied across the load resistor 11*b*.

When the push button is released, the output element 4*b* is separated from the driving element 3*b* thus removing the output voltage from the load resistor 11*b*. Thus, the voltage across the load resistor 11b comprises a switch signal corresponding to the operation of the push button.

As the electric switch of the type described above does not include any mechanical contact, it is highly reliable and durable. However, since it requires a mechanical vibration each time it is operated, the construction of the switch is relatively complicated and expensive.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved switch device which can eliminate various difficulties described above.

Another object of this invention is to provide a switch device of simplified construction in which only one driving member is used for a plurality of output members.

Briefly stated, according to this invention there is provided a switch device comprising an elongated member provided with a plurality of substantially equally spaced apart lateral projections along the length thereof, driving means secured to the elongated member, means to apply an excitation signal to the driving means to cause it to vibrate mechanically, the elongated member acting to transform the longitudinal vibration imparted thereto by the driving member into lateral vibrations in the projections, a plurality of output members capable of generating electric signals when applied with mechanical vibrations, the output members being disposed to respectively confront the projections, and means to bring a selected one of the output members into engagement with a corresponding projection thereby producing an electric signal from the selected output member.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawing :

FIG. 1 is the reproduction of FIG. 3 of said copending application Ser. No. 164,401;

FIG. 2 shows a connection diagram of one example of the switch device embodying the invention;

FIG. 3 is a view to explain the operation of the member for changing the direction of vibration shown in FIG. 2; and

FIG. 4 is a perspective view of a modified embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 2 shows a preferred embodiment of the invention in which the same or corresponding portions are designated by the same reference numerals as in FIG. 1. The embodiment shown therein comprises a member 12 for transforming the direction of vibration with a driving element 13 excited by a source of alternating current, fixed to one end. The member 12 resonates to the vibration of the driving element 1 and is provided with a plurality of equally spaced apart lateral projections 14*a* through 14*n* along the length thereof. The output elements 4*a* through 4*n* are disposed to opposed the projections 14*a* through 14*n*, respectively, with a definite gap therebetween.

In operation, when the output voltage of the AC source 1 is impressed across the driving element 13, the element 13 vibrates with the frequency of the AC

source 1 to drive member 12. When the member 12 is driven by a mechanical vibration having frequency nealy equal to the natural frequency thereof, it vibrates in the longitudinal direction, and a portion of the vibration is connected into lateral vibrations in the projections 14*a* through 14*n*, as shown by solid line and dotted lines shown in FIG. 3. As a result lateral mechanical vibrations of the opposite phase mode are created in the projections so that it is possible to drive the output members 4*a* through 4*n* in the same manner as in FIG. 1. If the frequency of the driving vibration is increased slightly, the member 12 creates a mechanical resonance of the same phase mode.

When a push button, not shown is depressed, an output element, for example 4*b* associated with the push button is caused to engage projection 14*b*. As above described, since the projection 14*b* is caused to vibrate in its longitudinal direction the vibration thereof is transmitted to the output member 4*b* to generate an output voltage across its output electrodes 6*a* and 6*b*. This output voltage is rectified and smoothed out by the rectifier and the rectified voltage is supplied to the load resistor 11*b* whereby a switch signal is produced across the resistor while the push button is depressed or during the internal in which the output member 4*b* is in engagement with the projection 14*b*. With this improved construction it is not necessary to provide independent driving members for respective switch units. Moreover, as the member 12 resonates to the frequency of vibration of the driving member there is no time lag between the vibrations of respective projections. For this reason, it is possible to fabricate the member 12 with materials of high mechanical Q.

In the specification of U.S. Pat. No. 3,395,295, dated July 30, 1968 there is disclosed a solid state detector comprising a crystal having an electrostrictive characteristic and excited by an AC voltage and rod like follower elements disposed along the length of the crystal with a small gap between the follower elements and the crystal so that when the crystal is excited by a signal at a given frequency the upper surface thereof vibrates up and down to collide with the lower ends of the follower elements thus creating an elastic collision between them. With this arrangement, however, the vibration energy applied to one end of the crystal is transmitted longitudinally to the crystal at the sonic speed so that the vibration energy transmitted to a particular one of the follower elements is delayed by a time proportional to the distance between that follower element and one end of the crystal across which the driving voltage is applied. In contrast, according to this invention, as the member 12 vibrates at the resonance frequency all projections vibrate simultaneously without time lag therebetween as shown by the solid and dotted lines in FIG. 3.

For example, a member 12 having a resonance frequency of 135 KHz was manufactured. It had following dimensions: lateral width a_2 = length of the projections a_3 = width of the projections a_1 = 6 mm. The length of driving element and the output elements was both 10 mm. The spacing between adjacent projections 1 = 18 mm. The spacing 1_1 between a support and one side of the projection on one end = 14.75 mm. The spacing 1_2 between the support and one end surface of the member = 8.75. Since at the positions of the supports, there is no interference on the waveform by the projection, the member vibrates smoothly thereby shortening the wave length.

FIG. 4 shows a modified embodiment of this invention wherein a member 15 for changing the direction of vibration comprises a plurality of parallel longitudinal elements 16*a* to 16*b* which are connected together by a cross-bar 17, each element having the same configuration as the member 12 of the first embodiment. Projections 18 of the elements 16*a* to 16*d* are arranged in a matrix. Although only one is shown, a plurality of output elements 19 connected with push buttons, not shown, are disposed to oppose the upper surface of respective projections with small gaps therebetween. These output elements are normally biased away from the projections.

A driving element 20 connected to a source of alternating current, not shown, is fixedly secured to the projection of the cross-bar 17. As before, the member 15 for changing the direction of vibration is supported by supports having a triangular cross-sectional configuration.

When the driving member 20 is driven by the output voltage of the source its vibration is transmitted to respective longitudinal elements 16a-16d to create transverse vibrations in respective projections 18. Under these conditions when any one of the push buttons is depressed, the output element associated therewith is brought into engagement with one of the projections 18 to generate a switch signal in the same manner as the previous embodiment.

With this modified construction wherein the projections and a plurality of driven elements are disposed in a matrix, it is possible to drive any one of the driven elements by a single driving element. Although in the above described embodiments the driving element and the output elements take the form of piezoelectric elements the driving element may be of any type that can generate mechanical vibrations when excited by an electric signal and the output element may also be of any type that can generate electric signal when energized by mechanical vibrations. Further, it should be understood that the driving element may be secured to any projection of the member for changing the direction of vibration.

As above described the invention provides an improved switch device of simplified construction which can selectively drive a plurality of switch units with a single driving unit.

What is claimed is:

1. A switch device comprising an elongated member provided with a plurality of substantially equally spaced apart lateral projections along the length thereof, driving means secured to said member, means to apply an excitation signal to said driving means to cause it to vibrate mechanically, said member acting to transform the longitudinal vibrations imparted thereto by said driving member into lateral vibrations in said projections, a plurality of output members capable of generating electric signals when applied with mechanical vibrations, said output members being disposed to respectively confront said projections, and means to bring a selected one of said output members into engagement with a corresponding projection, thereby producing an electric signal from said selected output member.

2. The switch device according to claim 1 wherein said driving member comprises a piezoelectric element

including a polarized bar of piezoelectric material and a pair of driving electrodes.

3. The switch device according to claim 1 wherein each one of said output members comprises a piezoelectric element including a polarized bar of piezoelectric material and a pair of output electrodes.

4. The switch device according to claim 1 wherein said driving member comprises a magnetostrictive element.

5. The switch device according to claim 1 wherein each of said output members comprises a magnetostrictive element.

6. The switch device according to claim 1 wherein each one of said output member includes a rectifier connected across a load resistor across which an output signal is formed.

7. The switch device according to claim 1 wherein said member for changing the direction of vibration comprises a plurality of parallel longitudinal elements, each provided with a plurality of spaced apart lateral projections along the length of the elements, the lateral projections being disposed in a matrix, a cross-bar interconnecting one ends of said longitudinal elements, and a driving member attached to said cross-bar.

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