Jan. 30, 1968 K. H. STEWARD 3,366,808

KEYBOARD KEY TRANSDUCER

Filed Jan. 3, 1966

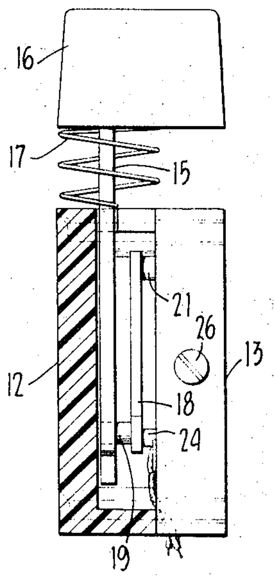

FIG_3

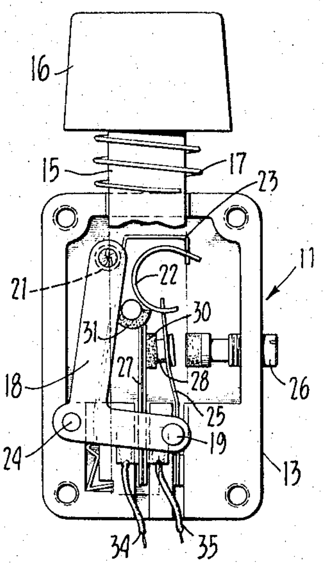

FIG_2A

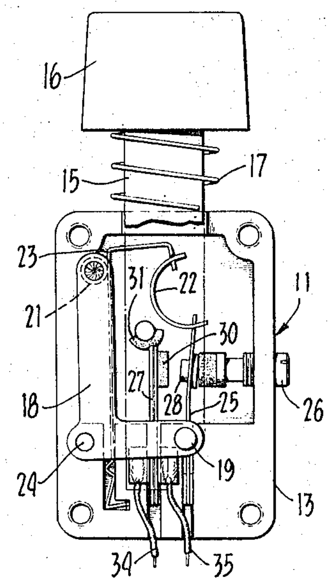

FIG_2

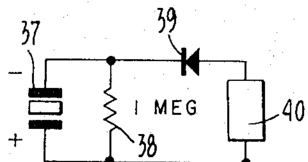

FIG_4

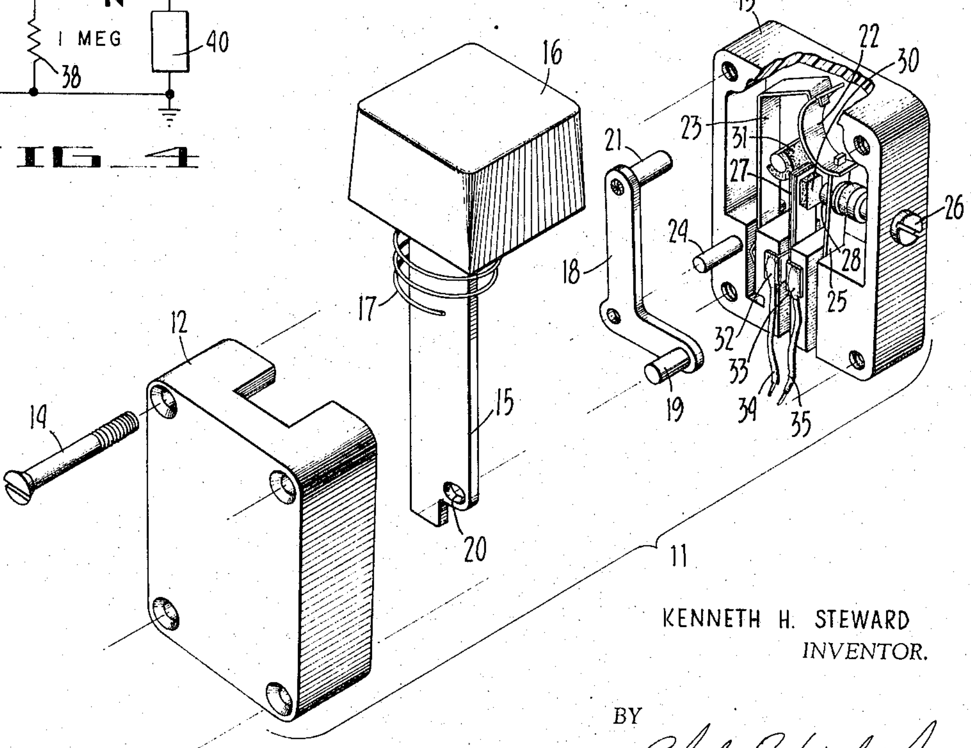

FIG_1

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KEYBOARD KEY TRANSDUCER

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This invention relates to keyboard transducers, and more particularly to a keyboard key transducer that utilizes a piezoelectric crystal.

Keyboard keys on many electronic and electrical devices, when activated, cause electrical switch contacts to close so that a current path is completed which indicates or signals to associated equipment or circuits that the particular key has been actuated or selected. Such prior art switches require a source of external voltage, and closing of the switch contacts causes arcing and burning which necessitates maintenance and replacement of the contacts. The contacts are also likely to become dirty so that activation of their associated keyboard key will not complete the current path to produce the required signal. Further, the contacts of many such switches are likely to bounce when activated or when subject to shock or vibration, thereby causing erroneous signals to be generated. One object of this invention, accordingly, is to provide a keyboard key transducer which overcomes these and other disadvantages of the prior art.

Another object of this invention is to provide an improved keyboard key transducer.

Another object of this invention is to provide a keyboard key transducer which is economical to fabricate and which is reliable in operation.

Another object of this invention is to provide a keyboard key transducer which does not require an external power source.

Another object of this invention is to provide a keyboard key transducer unit which does not utilize electrical contacts that are subject to arcing and burning so as to require maintenance and replacement.

Another object of this invention is to provide a keyboard key transducer which provides an output voltage without the necessity of an external power source.

Another object of this invention is to provide a keyboard key transducer having an output voltage which is independent of operator actuating force.

Another object of this invention is to provide a keyboard key transducer which, when activated, produces an output voltage pulse, the magnitude and/or width of which is readily varied.

Briefly described, a keyboard key transducer or assembly according to the present invention includes a manually operated keyboard element. A flat crystal section having a portion thereof held rigid to form a cantilever also has electrical conducting means coupled to opposite sides. Mechanical means are coupled to the manually operated element for striking the crystal in response to the activation or selection of the manually operated element so as to produce a voltage pulse across the electrical conducting means. To prevent damage to the crystal due to excess deflection of the crystal cantilever, resilient damping means are associated with at least a portion of the crystal cantilever.

This invention, as well as other objects, features, and advantages thereof will be readily apparent from consideration of the following detailed description with reference to the accompanying drawings in which:

FIG. 1 illustrates a partially exploded perspective view of a preferred embodiment of the present invention;

FIG. 2 is an elevational view, with the housing removed, and illustrates the key transducer of FIG. 1 in its normal inoperative position;

FIG. 2A is a view similar to FIG. 2 and illustrates the key transducer of FIG. 1 in its actuated position;

FIG. 3 is a partial sectional elevational view of the device illustrated in FIGS. 1, 2 and 2A; and

FIG. 4 is a schematic illustration of a circuit which may be utilized with the embodiment of the present invention illustrated in FIGS. 1 through 3.

Referring now to the drawings, like reference characters designate like or corresponding parts throughout several views, there is shown in FIG. 1 a housing **11** which comprises a first preformed housing portion **12** and a second preformed housing portion **13** which are secured together by any suitable fastening means, such as, for example, a plurality of screws **14**. Each housing portion **12** and **13** is preformed from any suitable material, such as plastic, which may be molded or otherwise formed in a well-known manner.

Adapted to be received by the housing is a key stem **15**, one end of which contains a manually operated key element, or top, **16**. The other end of the stem **15** is slidably mounted within the housing **11**. A spring **17**, located between the housing **11** and the key element **16**, returns the key and stem to their normal position after the key element **16** is manually depressed or selected by an operator. The upper portion or face of the key element **16** may contain the numeric, alphabetical or symbolic notation which the key transducer represents.

A bellcrank **18** is pivoted about a pin or stud **24** extending from the housing portion **13**. A pin or stud **19** extending laterally from the lower leg of the bellcrank **18** passes through a slot **20** provided in the lower portion of the key stem **15** such that depression of the key element **16** causes the bellcrank **18** to rock in a clockwise direction, as viewed in FIG. 2, around its pivot point. Another pin or stud **21** extends from the other leg of the bellcrank **18**, with the pin **21** being positioned such that clockwise rotation of the bellcrank **18** around its pivot **24** causes an overcenter toggle mechanism to be actuated. The spacial relationship of the steam **15** with the stud **19** on the bellcrank **18** is illustrated in FIG. 3.

The overcenter toggle mechanism, which is well-known in the art, includes a curved metallic strip portion **22** having one of its ends coupled to an end of the striking or snapping portion **25** of the toggle mechanism and its other end coupled to an end of the actuating portion **23** of the toggle mechanism. Both the actuating portion **23** and the striking or snapping portion **25** of the toggle mechanism have their other ends secured in the preformed housing portion **13**. Secured to the striking or snapping metallic strip portion **25** of the toggle mechanism is a hammer or striking element **28**.

Surrounded by the overcenter toggle mechanism is a flat, rectangular crystal section or portion **27**, one end of which is secured to the preformed housing portion **13** so as to form a cantilever. Opposite sides of the crystal **27** are coated with a suitable electrical conductor, such as silver. The electrically conductive coating on each side of the crystal at the end held secure by the housing portion **13** is electrically coupled to terminals **32** and **33** to which are coupled the electrically conducting leads **34** and **35**, respectively. The free end of the crystal cantilever rests on a resilient pad **31** which is formed of any suitable material, such as neoprene rubber. A pad **30** of resilient material, such as neoprene rubber, is also secured to the surface of the crystal **27** which lies adjacent the hammer **28** on the striking portion **25** of the overcenter toggle mechanism. In accordance with the preferred embodiment of the present invention which was constructed, the crystal **27** comprised a "Clevite Co." PZT–5 Bimorph crystal which was .020 inch thick, .125 inch wide and .500 inch long. About .200 inch of the crystal length was clamped in the housing portion **13** thereby producing an effective cantilever length of .300 inch.

The operation of the keyboard key transducer comprising the subject invention can be best understood by referring to FIGS. 1, 2 and 2A wherein FIG. 2 illustrates the key transducer mechanism in its normal position and FIG. 2A illustrates the key transducer mechanism after the key has been selected or actuated by being depressed. Reference to FIG. 2 shows that the striking or snapping portion **25** of the overcenter toggle mechanism which carries the hammer **28** rests against an adjustable stud **26** which extends through the preformed housing portion **13**. The key transducer is actuated by manually pressing the key top **16** downward. The resulting downward movement of the stem **15** causes the bellcrank **18** to rock clockwise around the pin or stud **24** from the position shown in FIG. 2 to that shown in FIG. 2A. The clockwise movement of the other pin or stud **21** pushes the actuating metallic strip portion **23** of the overcenter toggle mechanism to the right which, in turn, causes the upper portion of the curved metal strip section **22** to also move to the right. This movement of the curved portion **22** continues until a position is reached at which the lower portion of the curved metal section **22** snaps or is suddenly driven to the left. This causes the hammer **28** on the striking portion **25** of the toggle mechanism to hit the pad of resilient material **30** on the face of the crystal **27** cantilever as illustrated by FIG. 2A. The application of this transient force to the crystal **27** causes a voltage pulse to appear across the insulated leads **34** and **35** due to the resulting deflection of the crystal cantilever.

One characteristic of the overcenter toggle mechanism is that the force or impact of the hammer portion **28** on the pad of resilient material **30** is substantially independent of the speed of the rightward movement of the upper portion of the curved metallic strip **22** and the actuating portion **23** of the toggle mechanism. Accordingly, the hammer **28** directs a force to the crystal cantilever **27** which is substantially constant and independent of the operator actuating force which depresses the key element **16**. The resulting electrical pulse appearing across the insulated leads **34** and **35** is characterized as having a relatively high voltage magnitude but low current. However, the voltage pulse is sufficient to actuate associated equipment or circuitry whenever the key transducer is actuated.

After the key **16** has been depressed, the spring **17**, located between the housing **11** and the key element **16**, restores the key transducer to its normal condition due to the resulting upward movement of the stem **15** causing the bellcrank **18** and the overcenter toggle mechanism to return to their normal positions, as indicated by FIG. 2. As will be obvious to those skilled in the art, various other snapping mechanisms can be utilized in lieu of the overcenter toggle mechanism to transmit a relatively constant force to the crystal cantilever **27** in such a manner that the force transmitted to the crystal cantilever is substantially independent of the operator actuating force applied to the manually operated key element **16**.

The force imparted to the crystal cantilever by the hammer **28** on the striking portion of the toggle mechanism is dependent upon the rest position of the hammer **28**. The normal or rest position, which is illustrated by FIG. 2, and the resulting force applied to the crystal cantilever can be varied by varying or adjusting the rest position of the striking portion of the toggle mechanism. This can be accomplished by varying the position of the adjustable stud **26** which extends through the preformed housing **13** and is threadedly engaged therewith. Since the striking portion of the toggle mechanism rests upon this stud, movement of the stud **26** inwardly or outwardly of the housing portion **13** varies the normal or rest position of the striking mechanism and, therefore, the force which is imparted to the crystal cantilever when the key transducer is actuated. The amplitude of the voltage pulse appearing

across the insulated leads **34** and **35** is dependent upon the force which is imparted to the crystal cantilever. With the crystal described hereinabove, a pulse amplitude of ten to fifteen volts was readily obtained with the overcenter toggle mechanism illustrated in FIGS. 1, 2 and 2A. The width of the voltage pulse appearing across the insulated terminals **34** and **35** was found to be dependent upon the area of the crystal cantilever and with the crystal described above, voltage pulses having a rise time of 100 microseconds and a pulse length of 150 microseconds were produced. The pad of resilient material **30** insures that the surface of the crystal **27** is not chipped or cracked by the hammer **28**. The pad of resilient material **31** insures that the crystal cantilever is not excessively deflected and also damps any vibrations that may tend to occur. With the crystal described hereinabove, a crystal deflection of .0005 inch produced the above described voltage pulse. As will now be apparent, the use of a crystal eliminates the need for an external power source and electrical contacts which burn and arc, resulting in necessary maintenance and replacement. Also, due to the overcenter toggle mechanism, the amplitude of the voltage output is independent of operator actuating force and the magnitude and width of the voltage output pulse is readily variable. Further, it was found that the force required to produce a ten to fifteen volt output signal was far below the fracture point of the crystal and that the operation of the key transducer is substantially independent of humidity and temperature; it being operable even when submerged in boiling water. Also, the voltage output from the crystal cantilever does not degenerate with time. Due to the modular type of construction of the key transducer, various keyboard configurations can readily be constructed.

FIG. 4 is a schematic illustration of a circuit which may be utilized with the key transducer wherein the crystal **27** of FIGS. 1, 2 and 2A is designated by the reference character **37**. A resistor **38** coupled across the crystal **37** functions as a bleeder resistor, a diode **39** insures that the output pulses produced by the crystal are unipolar and the impedance **40** represents a load to which the key transducer may be coupled.

What has been described is an improved keyboard key transducer which does not require an external power source, does not utilize electrical contacts which are subject to arcing and burning and which overcomes other disadvantages of prior art keyboard switches.

What is claimed is:

1. A keyboard key transducer assembly comprising a manually operated key element adapted to be received by a keyboard, a substantially flat crystal section having a portion thereof held rigid to form a cantilever, electrical conducting means coupled to opposite sides of said crystal, mechanical striking means coupled to said manually operated key element for transmitting a transient force to an exposed surface of said crystal in response to operation of said key element in order to produce a voltage pulse across said electrical conducting means.

2. The key assembly of claim **1** further including resilient damping means associated with at least a portion of said crystal cantilever which prevents excessive deflection of said crystal.

3. The key assembly of claim **1** wherein said crystal has an electrically conductive coating on opposite sides thereof.

4. The key assembly of claim **1** wherein said mechanical switching means causes a substantially constant force to strike said crystal, which force is substantially independent of the force used to actuate said manually operated key.

5. The key assembly according to claim **4** wherein said striking means includes an overcenter toggle.

6. The key assembly according to claim **1** wherein said electrical conducting means are located at that portion of said crystal which is held rigid.

7. The key assembly according to claim **1** further including a resistor coupled across said electrical conducting means.

8. The key assembly according to claim 7 further including a diode having one of its two elements coupled to one end of said resistor.

9. The key assembly according to claim 1 further including a resilient member interposed between said transient force and said exposed surface on said crystal which inhibits chipping and cracking of said crystal.

10. The key assembly according to claim 1 wherein said voltage pulse has a width determined by the area of said crystal.

11. A keyboard transducer comprising a manually operated keyboard element, a crystal having a portion thereof held rigid to form a cantilever, electrical conducting means coupled to opposite sides of said crystal, mechanical means coupled to said manually operated element for striking said crystal in response to operation of said manually operated element in order to produce a voltage across said electrical conducting means, and damping means associated with a portion of said crystal cantilever to prevent excess deflection of said crystal.

12. A keyboard key transducer comprising a manually operated keyboard element, a flat rectangular crystal having an electrically conductive coating on each side thereof and having an end portion held rigid to form a cantilever, electrical conducting means coupled to opposite sides of

said crystal portion which is rigidly held, mechanical snapping means coupled to said manually operated element for striking an exposed surface of said crystal in response to operation of said manually operated element in order to produce a voltage pulse across said electrical conducting means, and resilient damping means associated with the other end portion of said crystal cantilever to prevent excess deflection of said crystal.

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MILTON O. HIRSHFIELD, *Primary Examiner.*

J. D. MILLER, *Assistant Examiner.*