June 11, 1968 F. P. WILLCOX 3,388,226

PULSE GENERATING KEYBOARD CONTACT SWITCH

Filed April 12, 1966

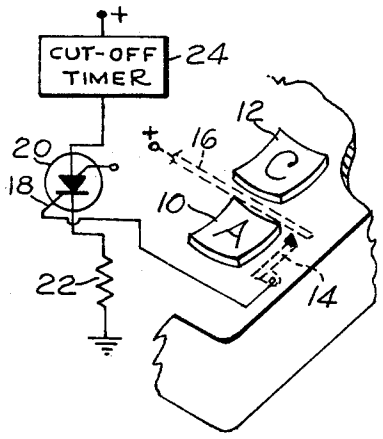

FIG. 1

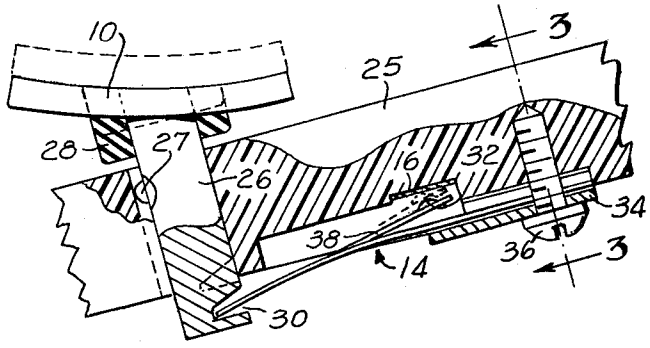

FIG. 2

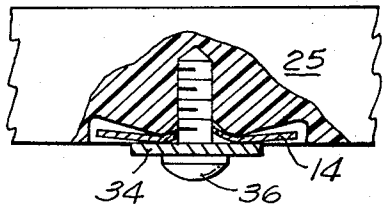

FIG. 3

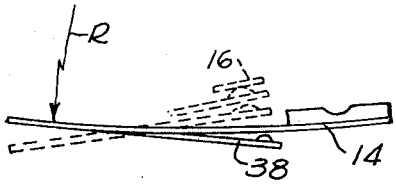

FIG. 4

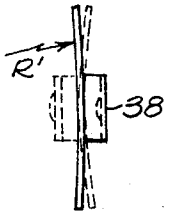

FIG. 7

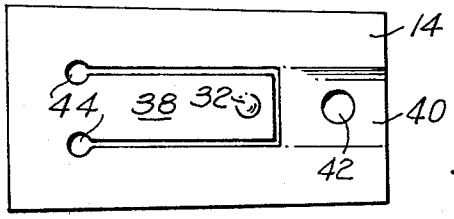

FIG. 5

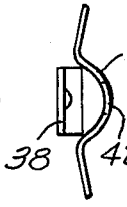

FIG. 6



FIG. 9

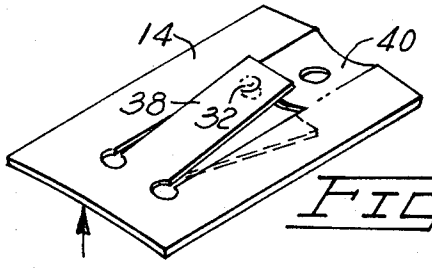

FIG. 8

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PULSE GENERATING KEYBOARD CONTACT SWITCH

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ABSTRACT OF THE DISCLOSURE

A momentary-contact switch especially designed for assembly into keyboard arrays by single-screw mounting, and adapted to provide a short series of contact engagements suitable for turning on a semiconductor switch, by the over-center vibrations of a spring contact tongue forming a portion of a stressed leaf spring arranged for deflection by a manual plunger. The series of contact engagements always terminates in an open-circuit condition within about 10 milliseconds, regardless of whether the plunger has been released by that time.

This invention pertains to a manual function-selecting or connecting switch especially designed for assembly into keyboard arrays for the control of printers, typewriters or the like, and in particular for the control of such apparatus through the intermediary of semiconductor or solid-state switches.

The data input keyboards of modern information systems are conventionally merely mechanical keyboards whose keylevers have been supplied with contact sets, and they are not only excessively bulky and costly, but do not provide efficient operation from the human engineering standpoint. It is therefore a principal object of the invention to provide an improved keyboard, and improved contact sets for use therein, which will be extremely simple and of low cost, and whose momentary circuit closures will be particularly effective in controlling external circuits and equipment through the mediation of triggered solid-state devices such as silicon-controlled switches or rectifiers.

Briefly, the invention utilizes a finger-operated plunger for each key position of a keyboard, the plunger being arranged to flex a unitary contact spring so designed as to furnish a calibrated string or series of contact closures upon each operation of the key. The mechanical design is such that the contacts, after executing their circuit closing operation, are restored to open-circuit condition regardless of whether the operating plunger has then been released, and such that the duration of the pulse series is extremely short compared to the normal attack and release time of the human finger. Such a pulse-series output is especially useful in the reliable triggering of semiconductor switch devices. It will be recognized by those skilled in the art, from what follows, that the invention actually turns to useful account the so-called noise or chatter of known contact spring devices, so controlling these heretofore objectionable phenomena as to produce a highly improved mode of operation.

Other advantages of the invention reside in the extreme mechanical simplicity of the design, each switch requiring only a simple plunger, a single low-cost flexing contact, and a combined retaining plate and mounting screw. The counter-contact is conveniently a bus bar common to a whole row of contact springs. When mounted in arrays on a keyboard or console panel, the operating plungers are retained in place by the contact springs themselves, and the latter also provide the required plunger-restoring force.

In the drawings:

FIG. 1 is a fragmentary perspective view of corner of a keyboard array showing the typical arrangement of keys in rows and staggered columns, with one key contact and its associated common bus, connected for control of a solid-state switching circuit.

FIG. 2 is a longitudinal section through a typical key of FIG. 1.

FIG. 3 is a sectional view taken on line 3—3 of FIG. 2.

FIG. 4 is a side edge view of the flexing spring element of the key contact, with the operated (flexed) condition indicated in dash lines.

FIG. 5 is a plan view of the spring of FIG. 4.

FIGS. 6 and 7 are respective end views of the spring of FIG. 4.

FIG. 8 is a perspective view looking at the under side of the spring as shown in FIGS. 4 and 5, and

FIG. 9 is a graphical representation of a wave train of voltage pulses produced by a switch operation.

FIG. 1 shows one corner of a typical keyboard array according to the invention, the concaved finger pieces **10** and **12** bearing alphabetic symbols. The circuit of one key is indicated by its flexing spring **14** and a fixed bus bar strip **16** common to an entire row. The contact-closure (actually a calibrated sequence of closures) operates the external circuit by supplying a minute current to the gate electrode **18** of an SCR or SCS element **20**, whose load impedance is indicated at **22**. The anode supply is indicated by the "+" sign, and a conventional turn-off circuit is shown at **24**. Such circuits are described on pages 401–409 (and others) of the 7th edition of the General Electric Company's "Transistor Manual," 1964.

While FIG. 1 shows a key directly controlling the semiconductor device, it will be understood that for keyboard use, the large number of key contacts can be connected to control a conventional diode matrix to supply output to a limited number of code busses, in which case only one semiconductor switch is required for operation by each bus. The turn-off time provided by circuit **24** will be slightly greater than the total duration of the sequence of contact closures mentioned above; typically, the SCS will be switched "off" something more than 10 milliseconds after the first of the contact closures.

It is characteristic of simple solid switches that, once turned on by a pulse or pulses of current, minute in size but of specified minimum duration, the conductive state of the switch cannot be cut off by opening the gate circuit. In the present case, as will appear, each operation of a key contact produces a spaced series of contact closures each very short and constituting in effect a "noise" burst. The spring damping factor restricts the duration of the whole series to something of the order of 10 milliseconds, and such a series is produced regardless of the speed or slowness (attack) of the operator's finger when depressing the operating plunger, or the time required for him to remove his finger. Thus, the effective duration of total contact closure is much shorter than would be obtained if the removal of the operator's finger were relied upon to terminate the contact-closed condition.

Breaking up the effective contact-closed period into a series of brief contacting-time segments has several advantages, especially for the control of low-energy circuits such as the gate circuits of solid-state devices. The effectiveness of the pulse series to turn on such a device no longer depends upon the microscopic perfection of the contact areas, since the contact vibration introduces an element of redundancy into the physical engagements, and the slight chattering (combined in the instant design with a wiping action) improves the self-cleaning action. The contacts close with a force of many pounds per square inch, as a result of the impacting action on a very minute superficial contacting area, and this also improves circuit-

closure reliability. If a dust mote or oxide particle prevents initial contact, it is likely to be dislodged or missed on succeeding contacts. It is understood that each of the component circuit closures making up the series produced by one key operation is adequate, from the duration standpoint, to fire the solid-state switch—typically, 1.4 microseconds. Hence, their repetition greatly increases the dependability of firing even for very fast keyboard operation. Also, since the duration of the series of closures is strictly limited by mechanical resonance and damping factors, the probability of superposed coding by a two-slow release action is greatly reduced, making unnecessary mechanical full-stroke interlocks, which are complex and severely limit keyboard speeds.

FIG. 2 of the drawings shows in detail the general arrangement of one of the contact mechanisms of the invention. The keyboard or console panel **25** is assumed to be of plastic insulating material and is bored at each key position to receive a sliding cylindrical plunger **26** (keyed as at **27** to prevent rotation) carrying the spherically dished finger button **10**. A resilient bumper ring **28** surrounds the plunger beneath the button, to reduce any impact noise when the key is depressed. At the lower end of the plunger, it is notched as at **30** to engage one end of the generally flat contact spring **14**, whose opposite end is secured to the console panel by a clamping plate **34** and mounting screw **36**. The underside of the panel is suitably recessed to provide free movement of the central part of the contact spring, which is constituted by a tongue **38**. The counter contact is, as indicated above, a bus bar **16** set in a groove in the panel body, and preferably extending along the common to a complete row of keys.

The full line position of tongue **38** in FIG. 2 corresponds to the ultimate rest position of the tongue which it assumes after plunger **26** has reached its lowest position, also indicated by full lines. However, during the flexing the spring **14** by downward motion of the plunger, the tongue **38** initially springs upward toward and past the full line position, and travels beyond that position (as indicated in dashed lines) sufficiently to engage the bus bar **16**. The tongue **38** may be dimpled convexly where it will touch the bus bar **16**, as at **32**. Due to the spring resonance of the tongue and spring, the tongue in fact vibrates or bounces with sufficient amplitude (about this full-line position as an interim rest position) to make several successive contacts with the bus bar, producing the short burst of forceful contact closures described above, finally coming to rest in the full line position, out of contact with the bus **16**. When the plunger is released, the tension in spring **14** lifts said plunger again to its dash line position. The engagement of the flat end of the spring **14** in notch **30** also limits the upward motion of the plunger (because the edges of spring **14** rest upon the body of the panel **25** in this position).

As will appear below, the spring **14** is deformed from flat spring stock in manufacture, to provide the tongue **38** as well as to introduce the proper shape to provide the desired snap action. Before assembly, the tongue **38** in FIG. 2 would (at rest) diverge downwardly from the general plane of spring **14** (see the full line position in FIG. 4), but after assembly its "returned" position is defined by the clamping plate **34** as in FIG. 2, which acts as a back-stop for the tongue.

The desired over-center snapping action of the spring is produced by the distoring of the initially flat stock of spring **14**. The extent and kind of the deformation are indicated in FIGS. 4 through 8. Thus, looking at FIG. 5, the originally rectangular profile of the spring has been distorted by the forming of the depression **40** in the end margin at which the hole **42** for mounting screw **36** is provided. The profile of the spring has thus become, as shown in FIG. 5, trapezoidal due to the shortening of the right-hand margin. The central tongue **38** was previously, of course, blanked out of the flat spring metal, along with the circular holes **44** which minimize stresses around the points of connection of the tongue to the body of the spring. This forming of the spring also produces the curvature of the spring on radius R and causes the tongue to project out of the plane of the spring as a whole, as shown in the full lines of FIG. 4. It also produces slight bowing of the left margin of the spring on radius R′ (FIG. 7), and the double curvature of the right margin (FIG. 6). The perspective view of FIG. 8, which shows the appearance of the finished spring from underneath, more graphically represents the movement of the tongue from its "rest" position, in full lines, to its oppositely deflected position in dash lines, when the spring as a whole is deflected by application of the operating force as indicated by the arrow.

The underside of the mounting panel is preferably recessed, in the region of the mounting screw **36**, as indicated best in FIG. 3 of the drawings, so that the clamping action of the screw does not tend to flatten out the spring, and so that the single screw will adequately retain the spring against angling about the axis of the screw. The wiring connections can be made by soldering, welding or in any convenient manner to the bus bar contact strip **16** and to a relatively immovable portion of the spring **14**.

In a typical design, for operation by a force of about 1 to 2 ounces applied to the plunger tip **10** at normal typing speed, the spring **14** was formed of Phosphor bronze, hard temper spring stock 0.005 inch thick, and having profile (FIG. 5) dimensions of 0.375 x 0.700 inch.

The succession of vibratory contact closures produced upon each depression of the plunger is indicated by the typical pulse train diagrammed in FIG. 9. Each of the square pulse outlines is about ½ a millisecond in time width, and actually represents a group of noisy or chattering contact closures produced when the tongue **38** engages bus bar **16**. Typically there will be up to 10 of these pulses for each key depression, and the pulse repetition rate shown corresponds to a natural frequency of tongue vibration of 1 kc. per second. The entire series of pulses thus occupies up to 10 milliseconds, and terminates when the spring tongue vibration damps out to the point where the tongue or its contact dimple no longer reaches the bus bar **16**. Thus, the total length of the pulse series forming one over-all circuit closure is fixed, and cannot be prolonged regardless of how slowly the operator may allow plunger **26** to rise again; the total duration of contact is defined by the "bounce" characteristic of the spring and tongue.

It will also be observed that the contact so made is necessarily a "momentary" one, because the cantilever nature of spring **14** (FIG. 2) results in pulling tongue **38** farther away from bus bar **16** if plunger **26** is depressed below the full line position shown.

What is claimed is:

1. A key-operated momentary-contact switch comprising a mounting panel, a leaf spring secured at one end to said panel, a plunger mounted slidably in said panel with one end engaging said spring for flexing the latter, and a counter-contact mounted on said panel in spaced relation to said spring; said spring being provided with a central deflectable tongue connected to the body of said spring only near its end which is more remote from the point at which said spring is secured to the panel, and said spring being so deformed that said tongue is normally deflected from the general plane of the spring in the direction away from said counter-contact, so that upon each flexing of said spring by the plunger said tongue is deflected in the opposite direction with an over-center vibrating travel sufficient to contact said counter-contact only by a limited succession of vibratory contact instants, and thereafter comes to rest out of engagement with said counter-contact.

2. A switch in accordance with claim **1**, in which the effective resonant frequency of said tongue is such as to terminate said succession of contact instants within a maximum time of about 10 milliseconds.

3. A switch in accordance with claim 1, in which said panel is surface configured, at the region at which said spring is secured, to interfit with the latter and prevent angular disorientation thereof.

4. A snap action spring contact device comprising a relatively fixed contact element and a relatively movable spring contact element normally out of electrical contact with said fixed contact element, said movable contact element including a vibratory portion constructed and arranged so that upon deflection of said movable contact element, said vibratory portion executes a vibratory movement momentarily bringing it into a succession of electrically noisy engagements with the fixed contact element, the vibratory movement decaying in amplitude so as ultimately to leave the contact elements out of engagement with one another.

5. A contact device in accordance with claim 4, and back-stop means for limiting the maximum travel of said vibratory portion in the direction away from said fixed contact element.

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