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(19)



(54) IMPROVEMENTS IN SOLID STATE SWITCH CONSTRUCTIONS

- (71) We, ILLINOIS TOOL WORKS INC., a corporation organized under the laws of the State of Delaware, United States of America, of 8501 West Higgins Road, Chicago, Illinois 60631, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
- This invention relates to solid state switches suitable for use in keyboards utilized for feeding information into data processing equipment.
- Keyboards are well known for use with data processing equipment to feed in signal information corresponding to some particular code. Such keyboards may be provided with electronic switches or mechanical switch components. One well known type of keyboard comprises a number of electric switch contacts each mechanically operated by depressing a keystem. The keystem may have a top face coded with a letter or number. These devices suffer many disadvantages, they are subject to wear and the contacts tend to have a high resistance because of arcing or oxidization. Also, under atmospheric conditions dirt may enter the keyboard and cause unreliable switching.
- More recently, solid state switches have been developed for such keyboards and have generally overcome the above disadvantages of mechanically actuated electrical switch contacts. One form of solid state switch comprises a permanent magnet and a core associated therewith. The permanent magnet, or the core, is fastened to a keystem or actuating member to move the core and magnet relative to one another. The core is generally provided with a drive winding wire and a sense wire threaded through it. An AC signal is applied to the drive winding. The permanent magnet is usually formed by a pair of permanent magnets which are positioned one on each side of the core and so completely saturate the core, when the switch actuator is in the undepressed condition, thus the effective impedance is relatively low and no transformer coupling can take place between the drive wire and the sense wire. When the actuator is depressed, however, the permanent magnets move away from the core and unsaturate it, and thus substantially increase the AC impedance and effect a transformer coupling between the drive wire and the sense wire. While this type of switch construction overcomes the disadvantages of prior keyboards for data processing equipment, it still suffers mechanical failure of the switch body and the magnets within the switch body are not readily replaceable or interchangeable without actually unwiring or disconnecting the drive and sense wires from the circuitry to which they are connected.
- Therefore, it is an object of this invention to provide an improved solid state key construction in which the core within the switch body is readily separable from the switch body without disconnecting or removing the wires wound around or threaded through the core and a new switch body and actuating mechanism is easily connected to the existing core.
- The solid state switch construction of this invention is an improvement on the switch construction described in our British Patent Specification No. 1,327,233. As disclosed in that specification a relatively large number of switches are mounted in a housing to form a keyboard for data processing equipment. Such keyboards are commonly used to feed information into the electronic circuitry of computers. Such computers require pulse signal information at rapid rates and over long periods of time to do the necessary manipulation of the data and produce the desired result. Therefore, keyboard switches are actuated continuously over long periods of time and are often in need of repair. One type of failure is that of the switch body components, they being the actuating mechanism itself or the

arms carrying the permanent magnets within the switch body. Since there is no movement of the magnetic core or the wires passed therethrough, failure of this component is rare. Therefore, replacement of a defective switch requires only that the switch body or actuating mechanism be removed and a new switch body and actuating mechanism positioned about the existing core.

According to this invention a solid state switch comprises a switch body having a recess, a core of magnetic material positioned within the recess, at least two winding means which pass through the core and the ends of which are arranged to be electrically connected to a circuit, permanent magnet means movable within the switch body closely adjacent the core to saturate it when the magnet means is in a first position and to unsaturate it when the magnet means is in a second position, and a releasable securing element, which when in position holds the core within the recess and which on release allows the relative displacement of the core and switch body so that when the switch forms part of an electrical circuit, the switch body and the core may be separated without the winding means being disconnected from the circuit.

Preferably the securing element is formed of paramagnetic material, and the permanent magnet means in its second position is adjacent the securing element which facilitates the unsaturating of the core by providing a magnetic shunt path for the permanent magnet means.

An example of a key switch, according to our invention and its use in a keyboard will now be described with reference to the accompanying drawings, in which:—

Figure 1 is an exploded perspective view of the key switch;

Figure 2 is a plan view of a portion of a keyboard fitted with key switches according to our invention, showing four key switches in position;

Figure 3 is an end elevation of the switch showing the position of the fascia of the keyboard in long chain dotted lines and the short chain dotted lines show the degree of flexure of the switch body;

Figure 4 is a side elevation of the switch in place in the fascia of the keyboard showing a magnetic core member and its associated wires which extend outwardly for connection into a circuit;

Figure 5 is a side elevation showing the switch body above the keyboard and dismantled from the magnetic core which remains beneath the fascia of the keyboard;

Figure 6 is an enlarged view of the underside of the switch shown in Figure 1 showing the relative positions of the retainer clip and the magnetic core;

Figure 7 is a section along line 7—7 of Figure 6, showing an alternative way of fixing the magnetic core member; and,

Figures 8 and 9 illustrate the relative position of the permanent magnets within the switch body relative to the magnetic core for respectively saturating and unsaturating the core to effect the switching action.

Referring to Figure 1, a solid state switch is designated generally by the reference number 10. The solid state switch 10 is formed from a switch body 12 into which a keystone 14 placed over a coil spring 16 are inserted, the coil spring 16 resiliently urges the keystone 14 upwardly into a de-actuated condition when assembled. The keystone 14 is held partly within the body 12 by a top wall member 18 which is secured to a recess 19 in the key body 12 by ultrasonic welding or other suitable means.

A pair of permanent magnets 20 and 22 are respectively, firmly held by two spaced-apart legs 21 and 23, formed on the keystone 14. The magnets 20 and 22 may be insert moulded in the keystone. Also mounted within the switch body 12 is a magnetic core member 24, this has a drive wire 26 and sense wire 28 extending from it and they extend through recesses 30 which are formed in the end walls of the switch body. The magnetic core 24 is mounted within the switch body 12 from the underside.

Most advantageously, the magnetic core 24 is firmly but removably held within the switch body by a removable clip 32 which frictionally engages the interior side walls of the switch body when it is in place. Upon the removal of the clip 32 the entire switch body structure can be removed from the magnetic core 24 and its associated wires 26 and 28 without disconnecting the leads from the associated electric circuitry.

Referring now to Figure 2, a part of a fascia 34 of a keyboard 36 is shown, supporting four solid state switches, each of which is designated by the reference numeral 10. The switches 10 may be arranged in a ten-by-ten matrix, or any other suitable configuration to form the keyboard, and may include caps secured to the top of the keystone 14 on which letters or numbers may be displayed.

Figure 3 illustrates the switch 10 secured to the fascia 34 and further illustrates the flexible nature of the leg portions 38 and 40 of the switch body 12, showing how they may be moved in the opposite directions, as shown by the short chain dotted line, to allow the removal of the clip 32 from the recess 30. Once the clip 32 is removed, holding tabs 33 formed in the end walls of the body 12, see Figure 1, are squeezed together so that the switch body 12 can

be moved upwardly and the magnetic core 24 can be disengaged from its position within the switch body 12 without the disconnection of the wires 26 and 28 from their associated circuits, as shown in Figures 4 and 5. The switch 10 is shown in Figure 4 with the magnetic core 24 located between the permanent magnets 20 and 22 within the switch body 12 and with the magnetic core 24 held firmly therein by the removable clip 32. The wires 26 and 28 extend outwardly from the switch body 12 through the recesses 30, as best seen in Figures 1 and 3. Figure 5 shows the switch body 12, together with its keystone 14 and other associated components, completely removed from the fascia 34 of the keyboard so that the magnetic core 24 and its associated wires 26 and 28 remain below the fascia 34 in electrical connection with their associated circuitry. It can be seen that none of the associated electrical circuitry of for example data processing equipment is disturbed when the body part of a switch is replaced, so that only a short down time will be experienced.

Referring to Figure 6, in which the underside of the switch 10 is shown. The leg portions 38 and 40 of the switch body 12 are hollow to receive the movable permanent magnets 20 and 22. The magnetic core 24 is located centrally within the switch body 12 and held in place by an enlarged portion 41 of the clip 32, the enlarged portion being substantially in the middle of the clip. Outwardly extending projections 42 and 44 are formed on the clip 32 to engage and dig into the material of the switch body so that the clip 32 is firmly held in place. This is best illustrated in Figure 3 which shows the gripping end portion 42 slightly embedded in the material of the switch body. The outward flexure of the leg portions 38 and 40, as shown in Figure 3, will enable the clip 32 to be removed for removing the magnetic core 24. In an alternative, the projections 42 and 44 may engage recesses 43 and 45, respectively, formed within the switch body as shown in Figure 7. In this case the clip 32 is held in position between the recesses 43 and 45 and the core member 24.

Figures 8 and 9 illustrate the operating positions of the keystone 14 relative to the magnetic core 24. In Figure 8 the keystone is in an upper deactuated position in which the permanent magnets 20 and 22 are positioned immediately adjacent the magnetic core 24 to completely saturate the magnetic material thereof. The retaining clip 32 has little or no effect on diverting magnetic flux from passing through the magnetic core 24. However, upon actuation of the switch by moving the keystone 14 downwards into a position shown in Figure 9, the permanent

magnets 20 and 22 are also moved downwards and the magnetic core 24 is freed from substantially all the magnetic flux so that the core 24 is unsaturated and AC coupling can take place between the wires 26 and 28 to cause a switching action to take place.

Preferably, the retaining clip 32 is constructed of paramagnetic material and so acts as a magnetic shunt between the permanent magnets 20 and 22 when they are lowered. Any stray magnetic flux which would otherwise tend to enter the magnetic core 24 will be shunted by the metal clip 32. This feature helps to create a more definite switching of the solid state switching device as the keystone 14 is moved downward. That is, as the keystone 14 is moved downwards a position is reached whereupon magnetic flux is quickly diverted from the magnetic core 24 and so fast switching is accomplished by the instantaneous transformer coupling between the drive and sense wires 26 and 28.

WHAT WE CLAIM IS:—

1. A solid state switch comprising a switch body having a recess, a core of magnetic material positioned within the recess, at least two winding means which pass through the core and the ends of which are arranged to be electrically connected to a circuit, permanent magnet means movable within the switch body closely adjacent the core to saturate it when the magnet means is in a first position and to unsaturate it when the magnet means is in a second position, and a releasable securing element, which when in position holds the core within the recess and which on release allows the relative displacement of the core and switch body so that when the switch forms part of an electrical circuit, the switch body and the core may be separated without the winding means being disconnected from the circuit.

2. A switch according to claim 1, in which the securing element is formed of paramagnetic material, and the permanent magnet means in its second position is adjacent the securing element which facilitates the unsaturating of the core by providing a magnetic shunt path for the permanent magnet means.

3. A switch according to claim 1 or claim 2, in which the core of the magnetic material has an annular configuration.

4. A switch according to claim 2 or claim 3 when dependent on claim 2, in which the securing element is formed of a flat piece of material having outwardly extending projections at its ends to be embedded into the sides of the recess in the switch body, and the release of the securing element is accomplished by the out-

be moved upwardly and the magnetic core 24 can be disengaged from its position within the switch body 12 without the disconnection of the wires 26 and 28 from their associated circuits, as shown in Figures 4 and 5. The switch 10 is shown in Figure 4 with the magnetic core 24 located between the permanent magnets 20 and 22 within the switch body 12 and with the magnetic core 24 held firmly therein by the removable clip 32. The wires 26 and 28 extend outwardly from the switch body 12 through the recesses 30, as best seen in Figures 1 and 3. Figure 5 shows the switch body 12, together with its keystone 14 and other associated components, completely removed from the fascia 34 of the keyboard so that the magnetic core 24 and its associated wires 26 and 28 remain below the fascia 34 in electrical connection with their associated circuitry. It can be seen that none of the associated electrical circuitry of for example data processing equipment is disturbed when the body part of a switch is replaced, so that only a short down time will be experienced.

Referring to Figure 6, in which the underside of the switch 10 is shown. The leg portions 38 and 40 of the switch body 12 are hollow to receive the movable permanent magnets 20 and 22. The magnetic core 24 is located centrally within the switch body 12 and held in place by an enlarged portion 41 of the clip 32, the enlarged portion being substantially in the middle of the clip. Outwardly extending projections 42 and 44 are formed on the clip 32 to engage and dig into the material of the switch body so that the clip 32 is firmly held in place. This is best illustrated in Figure 3 which shows the gripping end portion 42 slightly embedded in the material of the switch body. The outward flexure of the leg portions 38 and 40, as shown in Figure 3, will enable the clip 32 to be removed for removing the magnetic core 24. In an alternative, the projections 42 and 44 may engage recesses 43 and 45, respectively, formed within the switch body as shown in Figure 7. In this case the clip 32 is held in position between the recesses 43 and 45 and the core member 24.

Figures 8 and 9 illustrate the operating positions of the keystone 14 relative to the magnetic core 24. In Figure 8 the keystone is in an upper deactuated position in which the permanent magnets 20 and 22 are positioned immediately adjacent the magnetic core 24 to completely saturate the magnetic material thereof. The retaining clip 32 has little or no effect on diverting magnetic flux from passing through the magnetic core 24. However, upon actuation of the switch by moving the keystone 14 downwards into a position shown in Figure 9, the permanent

magnets 20 and 22 are also moved downwards and the magnetic core 24 is freed from substantially all the magnetic flux so that the core 24 is unsaturated and AC coupling can take place between the wires 26 and 28 to cause a switching action to take place.

Preferably, the retaining clip 32 is constructed of paramagnetic material and so acts as a magnetic shunt between the permanent magnets 20 and 22 when they are lowered. Any stray magnetic flux which would otherwise tend to enter the magnetic core 24 will be shunted by the metal clip 32. This feature helps to create a more definite switching of the solid state switching device as the keystone 14 is moved downward. That is, as the keystone 14 is moved downwards a position is reached whereupon magnetic flux is quickly diverted from the magnetic core 24 and so fast switching is accomplished by the instantaneous transformer coupling between the drive and sense wires 26 and 28.

WHAT WE CLAIM IS:—

1. A solid state switch comprising a switch body having a recess, a core of magnetic material positioned within the recess, at least two winding means which pass through the core and the ends of which are arranged to be electrically connected to a circuit, permanent magnet means movable within the switch body closely adjacent the core to saturate it when the magnet means is in a first position and to unsaturate it when the magnet means is in a second position, and a releasable securing element, which when in position holds the core within the recess and which on release allows the relative displacement of the core and switch body so that when the switch forms part of an electrical circuit, the switch body and the core may be separated without the winding means being disconnected from the circuit.

2. A switch according to claim 1, in which the securing element is formed of paramagnetic material, and the permanent magnet means in its second position is adjacent the securing element which facilitates the unsaturating of the core by providing a magnetic shunt path for the permanent magnet means.

3. A switch according to claim 1 or claim 2, in which the core of the magnetic material has an annular configuration.

4. A switch according to claim 2 or claim 3 when dependent on claim 2, in which the securing element is formed of a flat piece of material having outwardly extending projections at its ends to be embedded into the sides of the recess in the switch body, and the release of the securing element is accomplished by the out-



ward flexure of the sides of the switch body to enlarge the opening of the recess.

5. A switch according to any one of the preceding claims, in which a depressable keystem having first and second legs extends on opposite sides of the core, and the magnet means are formed by first and second permanent magnets mounted on the first and second legs, respectively, the permanent magnets being positioned on the legs to be opposite the core when the keystem is not depressed, so that a flux path is established from one of the magnets to the other through the core to saturate it, the keystem carrying the magnets out of saturating relation with the core when the keystem is depressed.

6. A switch according to claim 2 or claim 3 or claim 5 when dependent upon claim 2 or claim 3, in which the securing element is formed from a flat piece of material having outwardly extending projections which are engaged into recesses formed in the switch body.

7. A switch according to claim 1 constructed substantially as described with reference to the accompanying drawings.

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