Aug. 30, 1966 R. E. STEWART 3,270,156

SWITCHING DEVICES WITH CONTACT MEANS WHICH INHIBIT CONTACT BOUNCE

Filed March 23, 1964

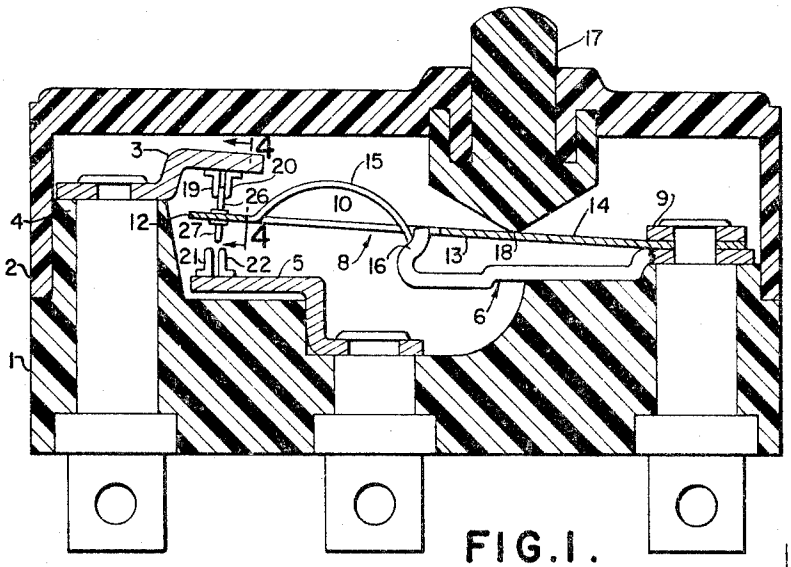


FIG. 1.

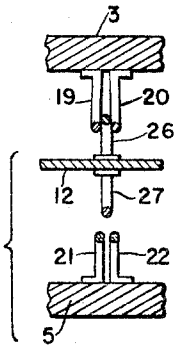


FIG. 3.

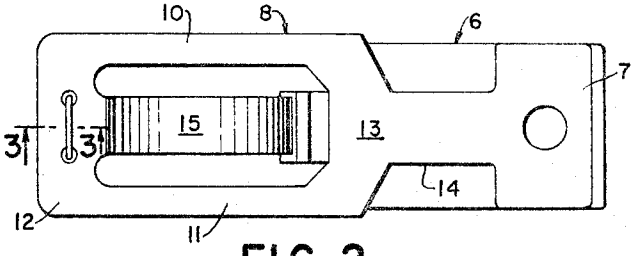


FIG. 2.

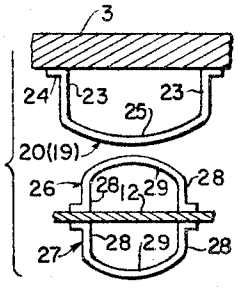


FIG. 4.

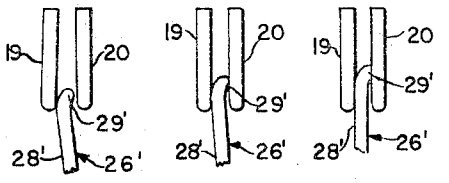


FIG. 5. FIG. 5A. FIG. 5B.

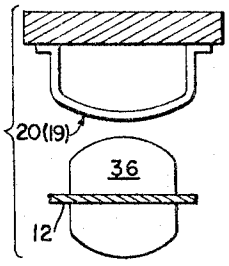


FIG. 6.

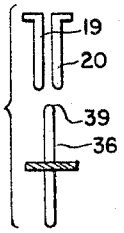


FIG. 7.

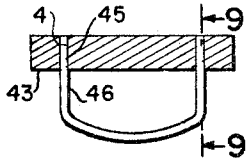


FIG. 8.

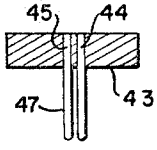


FIG. 9.

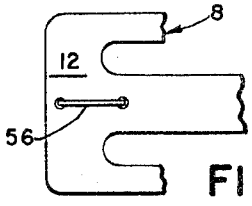


FIG. 10.

INVENTOR
Richard E. Stewart

BY Arnold and Roylance
ATTORNEYS

United States Patent Office 3,270,156
Patented August 30, 1966

3,270,156

SWITCHING DEVICES WITH CONTACT MEANS WHICH INHIBIT CONTACT BOUNCE

Richard E. Stewart, Hartsdale, N.Y., assignor to American Machine & Foundry Company, a corporation of New Jersey

Filed Mar. 23, 1964, Ser. No. 353,724
11 Claims. (Cl. 200—67)

This invention relates to switching devices and more particularly to switching devices which are at least substantially free from contact bounce.

In switching devices of the various types which can be manufactured at relatively low cost, there commonly occurs an uncontrolled making and breaking of contacts, as the contacts are moved to closed position, which is known as contact bounce. In some fields of use, contact bounce is not a serious factor. In others, however, substantial contact bounce should, and frequently must, be avoided.

As examples of one application in which contact bounce must be at least minimized, there can be considered the switching devices employed to provide a single electrical pulse as the input to a digital electronic circuit. Prior-art switching devices available for such purposes at reasonable cost exhibit contact bounce over periods measured in milliseconds and have therefore not been capable of providing the "clean" single pulse required for pulse counting circuits and the like. To overcome this problem, prior-art workers have frequently found it necessary to employ relative costly auxiliary circuits for isolating the desired single pulse from the signal caused by contact bounce in the switching device. The problem has also been attacked by attempting to design switching devices with anti-contact-bounce features, but such devices have heretofore proved expensive and frequently still do not afford the high freedom from contact bounce required in digital electronic applications.

A general object of the present invention is to devise electrical switching devices, such as snap switches, relays, and the like, which are characterized by such freedom from contact bounce as to be suitable for digital applications and yet can be manufactured at relatively low cost.

Another object is to provide improved anti-bounce contact structures which can be combined in conventional switching structures without requiring expensive modification thereof.

Stated broadly, the invention embraces switching devices comprising a fixed contact support, a movable contact-carrying member such as a spring arm or a snap spring unit, a first contact structure fixedly attached to the support, and a second contact structure fixedly attached to the movable member, one of the contact structures comprising two generally U-shaped contact elements of fine spring wire arranged side by side with the ends of the legs of the U's being fixed and the bases of the U's spaced toward the other contact structure, the other contact structure comprising a single contact element arranged to enter between the bases of the U's of the two contact elements of the one contact structure in such fashion that the forces causing relative movement of the contact structures to accomplish contact closure are opposed both by sliding frictional forces and by the spring forces resulting from distortion of the two U-shaped elements. Though the contact structures can take various forms, particularly good results in eliminating contact bounce are achieved when the contact structures are so constructed and arranged as to provide for maximum utilization of the sliding frictional forces. In certain embodiments of the invention, the contact structures are such that initial closure of the contacts is opposed primarily by sliding frictional forces and the final relative movement resulting in contact closure

is opposed additionally by spring forces provided by the two U-shaped contact elements.

In order that the manner in which the foregoing and other objects are achieved in accordance with the invention can be understood in detail, particularly advantageous embodiments of the invention will be described with reference to the accompanying drawings, which form a part of this specification, and wherein:

FIG. 1 is a longitudinal sectional view, with some parts shown in elevation, of a snap switch constructed in accordance with one embodiment of the invention;

FIG. 2 is a plan view of the movable contact spring unit of the device of FIG. 1;

FIG. 3 is an enlarged fragmentary sectional view of the contact structure of the switching device, viewed as indicated by line 3—3, FIG. 2;

FIG. 4 is a view, partly in transverse section and partly in elevation, taken on line 4—4, FIG. 1;

FIGS. 5, 5A, and 5B are edge elevational views of a typical contact structure in accordance with the invention, illustrating sequential stages of contact closure;

FIG. 6 is a view similar to FIG. 4 but showing a modified form of contact structure;

FIG. 7 is an edge elevational view of the contact structure of FIG. 6;

FIG. 8 is a fragmentary view illustrating another way for securing the fixed contact elements of the device of FIG. 1 to their support;

FIG. 9 is a view taken on line 9—9, FIG. 8; and

FIG. 10 is a fragmentary plan view showing a modified arrangement of the movable contact element on the movable spring unit of the switching device of FIG. 1.

FIGS. 1–4 illustrate the invention as applied to a plunger-operated snap switch comprising a two-part casing comprising base 1 and cover 2. A first fixed contact support 3 is secured to a pedestal 4 on base 1. A second fixed contact support 5 is secured to the base in such fashion as to be spaced from support 3 by a distance substantially greater than the contact travel for the switch. At the end of base 1 opposite pedestal 4, there are secured to the base a bracket 6, the fixed end 7 of a movable contact-carrying spring unit 8, and a hold down member 9.

Spring unit 8 is made as an integral unit from beryllium-copper sheet on the order of .010–.015" in thickness and, as seen in FIG. 2, includes two spaced parallel portions 10 and 11 joined at the free end of the spring unit by a cross portion 12, and at their opposite ends by a portion 13 which is joined to end portion 7 by shank 14. Arms 10 and 11, with cross portions 12 and 13, define an open rectangle which is elongated in the direction of the longitudinal axis of the spring unit. Centered on the longitudinal axis of the spring unit, and extending within the open rectangle from portion 12 toward end portion 7, is a third spring arm 15.

Bracket 6 underlies the spring unit and projects toward pedestal 4, the free tip of the bracket being offset toward the spring unit and including a groove 16 which opens generally toward pedestal 4 and in which the free end of spring arm 15 is engaged, as will be clear from FIG. 1. The length of arm 15, when relaxed, is substantially greater than the space between notch 16 and portion 12. Accordingly, arm 15 is bowed and acts in compression. Arms 10 and 11, on the other hand, are held in tension, by reason of the spring forces applied to the spring unit by arm 15.

Cover 2 has a circular opening which slidably receives the shank of an actuating plunger 17, the tip 18 of the plunger engaging cross portion 13 of the integral spring unit 8. As will be well understood by those skilled in the art, the action of spring unit 8 is such that, when actuating pressure is not applied to plunger 17, the spring unit will

move in generally pivotal fashion toward the plunger, so that the end portion 12 of the spring unit reaches one of its extreme positions, approaching fixed contact support 3. On the other hand, movement of plunger 17 toward base 1 causes the spring unit to snap in generally pivotal fashion so that its free end portion 12 moves to the opposite limit of its allowed travel, approaching fixed contact support 5.

Fixedly attached to the face of support 3 which is directed toward the free end portion of the spring unit are two fixed contact elements 19 and 20. Two fixed contact elements 21 and 22 are fixedly attached to the face of support 5 which is directed toward the free end of the spring unit. Contact elements 19–22 are all identical, being of generally U-shape and formed from fine spring wire of good electrical conductivity. As seen in FIG. 4, each fixed contact element 19–22 comprises two straight, parallel leg portions 23, the free ends of the leg portions 23 being bent outwardly at right angles and flattened so as to be attachable to the appropriate one of the supports 3, 5 by a fused metal joint. Typically, the resulting ears 24 can be attached to their supports by resistance brazing. The base 25 of each element 19–22 is at least generally arcuate, being concave with respect to the support to which the contact element is secured and, therefore, convex with respect to the free end portion 12 of the spring unit 8. The length of legs 23 is large as compared to the rise of the arcuate base portion 25.

Contact elements 19 and 20 are disposed side-by-side so as to lie in adjacent, parallel planes which extend generally transverse to the longitudinal axis of spring unit 8. Similarly, contact elements 21 and 22 are disposed side-by-side in parallel planes transverse to the longitudinal axis of the spring unit. As best seen in FIG. 3, contact elements 19 and 20 are spaced apart by a small distance.

The movable contact structure of the switch includes two identical generally U-shaped spring wire contact elements 26 and 27, element 26 being rigidly secured to one face of end portion 12 of the spring unit and projecting toward support 3, while element 27 is rigidly attached to the opposite face of portion 12 and projects toward support 5. Contact elements 26 and 27 are identical, each comprising two straight parallel legs 28, FIG. 4, the free ends of the legs being bent outwardly at right angles and flattened for attachment to the appropriate surface of spring portion 12, as by resistance brazing. Each contact element 26, 27 also includes an arcurate base portion 29 which is convex with respect to spring portion 12. The spacing between legs 28 is materially smaller than the corresponding spacing between legs 23 of contact elements 19–22.

The spring wire contact elements 19–22 and 26, 27 can be formed from utectic silver wire or from silver-nickel-magnesium alloy wire containing, for example, 99.5% silver, 0.3% nickel and 0.2% magnesium. Typically, for a snap switch of the type illustrated, all of contact elements 19–22 and 26–27 can be formed of wire having a diameter of 0.016".

Recognizing that the free end portion 12 of spring unit 8 follows a predetermined path in its movement between the normal position seen in FIG. 1 and the opposite extreme position, and that this movement is generally pivotal about an axis extending transversely of the longitudinal axis of the spring unit, it will be understood that the pairs of fixed contacts 19, 20 and 21, 22 can be placed in predetermined positions such that the plane in which the movable contact elements 26 and 27 are generally located comes into a definite orientation with respect to the appropriate pair of fixed contact elements as the spring unit approaches the end of its travel. The normal spacing between the fixed contact elements of each pair of fixed contacts, the specific shape of the contact elements, and the relative angular disposition of the fixed and movable contact elements can all be chosen to provide specific contact closing characteristics. As seen in FIG. 3, the fixed contact pairs can have normal positions in which the two contact elements of each pair are parallel and spaced apart by a distance slightly smaller than the diameter of the spring wire from which the movable contacts are formed. The movable contacts 26, 27 can then be so oriented on spring portion 12 that, as the spring unit 8 moves to engage contact 26 with contacts 19 and 20, contact 26 comes into substantial parallelism with contact elements 19 and 20, with the base portion 29 of element 26 at least substantially centered between the base portions 25 of elements 19 and 20. Accordingly, as contact closure occurs, base portion 29 of the movable contact element wedges between base portions 25 of elements 19 and 20 and causes elements 19 and 20 to spread apart progressively during the actual closing of the contacts. In this regard, it will be noted that the circular cross-section of the spring wire from which these contact elements are formed provides rounded leading edges for the contact elements so that a smooth wiping action occurs as element 26 enters between elements 19 and 20. Movement of element 26 between elements 19 and 20 results in sliding frictional forces which progressively damp the movement of the spring unit and the movable contacts. These frictional forces are supplemented by spring forces built up in elements 19 and 20 as contact closure is completed. Considering FIGS. 1 and 3, it will be obvious that the same action just described occurs between movable contact element 27 and fixed contact elements 21, 22 when spring unit 8 moves in the opposite direction.

Considering the engagement of the movable elements 26, 27 with the corresponding pair of fixed contact elements in the general fashion just described, it will be noted that maximum frictional forces occur as the base portion 29 of the movable contact element passes between the base portions of the appropriate pair of fixed contact elements, since larger surface portions of the contact elements are in sliding contact as the base portion 29 proceeds between the two base portions 25 than when only the legs 28 of the movable contact are engaged between the two fixed contact elements. Since the legs 28 of the movable contact elements are separated by a smaller space than are the legs 23 of the fixed contact elements, maximum wedging action occurs in this embodiment when the full diameter of the wire of the movable contact element is engaged between the two fixed contact base portions 25. Accordingly, the spring forces involved also reach their maximum value as soon as base portion 29 has been fully engaged between the two base portions 25 and do not increase thereafter during contact closure. Further movement of the movable contact element in the contact-closing direction produces only additional sliding frictional forces. Hence, in this embodiment, initial engagement of the movable contact with the two fixed contacts results in immediate production of maximum forces tending to resist the contact-closing forces, and further movement of the movable contact in the contact-closing direction simply produces additional opposing forces as a result of sliding friction. The overall effect of the coaction between the fixed and movable contacts in this embodiment is to limit contact bounce to a period in the lower microseconds.

With small changes in the configuraton of the convex structure, the sliding frictional and spring forces occurring during contact closure can be capitalized upon in various ways to minimize or eliminate contact bounce. Thus, for example, as seen in FIGS. 5–5B, the movable contact element 26' can be made with the same plan configuration seen in FIG. 4, but with the base 29' thereof slightly bent to cause the base to be offset from the plane occupied by the straight legs 28'. Fixed contact elements 19 and 20 have precisely the same configuration as hereinbefore discussed with reference to FIGS. 1–4, but are spaced apart by a distance slightly greater than the diameter of

the wire from which movable contact element **26'** is formed. Fixed contact elements **19** and **20** are so located on support **3**, and movable contact element **26'** so located on spring portion **12**, that, as the leading edge portion of the movable contact enters between fixed contacts **19** and **20**, the leading edge of the movable contact slides **19** which faces toward element **20**, as seen in FIG. 5. Further movement of element **26'** in the contact-closing direction causes further sliding movement of the movable contact along element **19** and this movement is accompanied by a swinging movement of element **26'**, causing that element to approach parallelism with the planes occupied by elements **19** and **20**, as typically illustrated in FIG. 5A. Such swinging movement is the result both of the pivotal motion of spring unit **8** and resilient distortion of the engaged contact elements. As the element **26'** moves still further in the contact-closing direction, the offset base portion **29'** thereof comes into engagement with fixed contact element **20**, as seen in FIG. 5B, and movement of the movable contact is finally terminated. Employing the contact arrangement seen in FIGS. 5–5B, the movement of the spring unit and movable contact element **26'** in the contact-closing direction is initially opposed primarily by sliding frictional forces and only secondarily by spring forces. As closure of the contacts proceeds, however, the spring forces are increased, reaching a maximum when element **26'** engages both fixed contact elements **19** and **20** in the fashion seen in FIG. 5B. Thus, in this embodiment, contact bounce is eliminated by using the sliding frictional forces and the spring forces mainly in succession, rather than simultaneously.

Regardless of the specific configuration of the contact structures, embodiments of the invention constructed in the general fashion indicated in FIG. 1 have been found to have such freedom from contact bounce that all manifestations of contact bounce terminate within periods on the order of 15 microseconds. An embodiment constructed as seen in FIG. 1 but with the contact structures illustrated in FIGS. 5–5B has been found to exhibit no contact bounce at all.

Though it is advantageous to employ, as the movable contact element, a generally U-shaped spring wire member, other configurations are possible within the scope of the invention. Thus, for example, a flat, rigid, electrically conductive plate **36**, FIGS. 6 and 7, can be used, the plate having the same plan configuration as the spring wire contact element **26**. All of the exposed edges of plate **36** are rounded, particularly including the leading edge **39**, to assure smooth entry between the fixed contact elements **19**, **20**. Plate **36** can be completely flat, or can have other configurations, including that providing the offset leading edge seen in FIGS. 5–5B. Contact plate **36** can be secured to spring portion **12** by resistance brazing or a similar fused metal joint.

It is particularly helpful to have the fixed contact elements offer considerable compliance and this is most conveniently accomplished by making the leg portions of the generally U-shaped fixed contact elements long as compared to the rise of the arcuate base portion thereof. Considering the length of the leg portions, and the fine diameter of the wire employed, particular attention must be given to obtaining a good, rigid joint between the free ends of the leg portions and the appropriate one of the supports **3** and **5**. To this end, other modes of attachment than those illustrated in FIGS. 1–7 can be employed. For example, as seen in FIGS. 8 and 9, the support **43** for the fixed contact elements can be provided with a plurality of small diameter through bores **44** each accommodating a different one of the straight free end portions **45** of the legs **46** of the fixed contact element **47**. The straight end portions **45** can be secured within bores **44** by brazing, soldering or the like. Such arrangements assure not only a strong rigid attachment of the fixed contact elements to their support but also accurate control of the orientation of the fixed contacts relative to the support and the spacing between the fixed contacts.

Referring again to FIG. 1, and recognizing the general pivotal nature of the movement of spring unit **8**, arrangement of the contact elements **19–22** and **26**, **27** in planes transverse to the longitudinal axis of the spring unit has the advantage of allowing the contact structure to be designed with more than a simple wedging action. Thus, for example, the wiping action hereinbefore described with reference to FIGS. 5–5B, providing first sliding frictional forces and then predominant spring forces, is possible with this contact structure. In some applications, however, an accurately controlled simple wedging action of the movable contact element between the fixed contact elements is desirable. In those applications, as indicated in FIG. 10, the movable contact or contacts **56** can be secured to portion **12** of the spring unit in such fashion as to lie in a plane which is at right angles to the plane of portion **12** and includes the longitudinal center line of the spring unit. In the arrangement shown in FIG. 10, the contact **56** moves only in its own plane, and pivotal motion of the spring unit causes only a pivotal sliding of the movable contact relative to the fixed contacts during the wedging action which occurs upon contact closure.

While particularly advantageous embodiments of the invention have been chosen for illustrative purposes, it will be understood by those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention, as defined in the appended claims.

What is claimed is:

1. A switching device characterized by at least substantial freedom from contact bounce, comprising in combination

a contact carrying blade member free to move at one end thereof;

a fixed contact support;

actuating means operatively associated with said blade member to actuate the free end thereof toward and away from said support to make and break an electrical connection;

first contact means fixedly attached to the free end of said blade member; and

second contact means fixedly attached to said support,

one of said first and second contact means comprising two generally U-shaped electrically conductive spring wire contact elements arranged side-by-side and substantially parallel with the leg portions of the U's thereof projecting away from said other contact means and being fixed to the corresponding one of said blade member and said support,

the other of said first and second contact means comprising a single contact element fixed to the other of said blade members and said support and projecting therefrom in such position as to enter between and substantially parallel to said generally U-shaped contact elements and wipe along at least one thereof to cause sliding frictional forces and resilient deformation of said at least one generally U-shaped element as said free end of said blade is actuated toward said support.

2. A switching device characterized by at least substantial freedom from contact bounce, comprising in combination

a movable contact carrying blade member; free to move at one end thereof;

a fixed contact support;

actuating means operatively associated with said blade member to actuate the free end thereof toward and away from said support;

fixed contact means including two generally U-shaped, electrically conductive, spring wire contact elements,

said spring wire contact elements being arranged side-by-side and substantially parallel with the ends of the legs of the U of each of said elements fixedly attached to said support and the base of the U of each of said elements spaced from said support in the direction of said blade member; and

a movable contact element fixedly attached to the free end of said blade member and projecting toward said support,

said movable contact element having a leading edge spaced from said blade member and dimensioned to enter between the bases of the U's defined by said spring wire contact elements and so wedge said spring wire contact elements apart,

said movable contact element lying in a plane so oriented relative to said blade member that, when said blade member is actuated toward said support to bring said leading edge into initial engagement with said spring wire contact elements, the plane occupied by said movable contact element is centered between and parallel to said spring wire contact elements.

3. A switching device in accordance with claim 2 and wherein

said leading edge of said movable contact element is generally arcuate and convex relative to said support.

4. A switching device in accordance with claim 2 and wherein

said blade member is mounted for movement about an axis parallel to the plane occupied by said movable contact.

5. A switching device in accordance with claim 2 and wherein

said blade member is mounted for movement about an axis at right angles to the plane occupied by said movable contact.

6. A switching device in accordance with claim 2 and wherein said movable contact element is generally U-shaped and of spring wire.

7. A switching device in accordance with claim 2 and wherein

the spacing between the legs U-shaped of each of said spring wire fixed contact elements is materially greater than the width of said movable contact element.

8. A switching device in accordance with claim 2 and wherein

the base of the U of each of said spring wire fixed contact elements is generally arcuate and concave with respect to said support,

said spring wire fixed contact elements are at least essentially identical, and

the length of the legs of the U's defined by said spring wire fixed contact elements is markedly greater than the rise of the generally arcuate base portions of the U's defined by said spring wire fixed contact elements.

9. A switching device in accordance with claim 8 and wherein

said movable contact element has a generally arcuate

leading edge which is convex with respect to said support.

10. A switching device in accordance with claim 8 and wherein

the radius of curvature of the arcuate base portions of the U defined by each of said spring wire fixed contact elements is large as compared to the length of the legs of the U.

11. A switching device characterized by at least substantial freedom from the contact bounce, comprising in combination

a fixed contact support;

an elongated movable contact carrying spring blade;

means fixedly mounting said spring at one end portion thereof,

the other end portion of said spring being free to move toward and away from said fixed contact support;

two generally U-shaped, electrically conductive, spring wire fixed contact elements,

said spring wire fixed contact elements being arranged side-by-side with the ends of the legs of the U of each of said elements fixedly attached to said support and the base of the U of each of said elements spaced from said support in the direction of said spring,

said spring wire fixed contact elements lying in parallel planes which extend transversely of the longitudinal axis of said spring,

a movable contact element fixedly attached to said other end portion of said spring and projecting toward said support,

said movable contact element having a thickness less than twice the diameter of the spring wire of said fixed contact elements and a width which is great as compared to said thickness,

said movable contact element lying in a plane which extends transversely of the longitudinal axes of said spring and is so located that, when said other end portion of said spring moves toward said support, the leading edge of said movable contact element enters between the bases of the U's defined by said fixed contact elements and said fixed contact elements are elastically deformed away from each other; and

actuating means operatively associated with said spring for causing said other end portion, and said movable contact element, to move toward and away from said support.

References Cited by the Examiner

UNITED STATES PATENTS

2,901,565 8/1959 Frantz ---------- 200—51.1

FOREIGN PATENTS

511,855 10/1920 France.
1,170,621 9/1958 France.

ROBERT K. SCHAEFER, *Primary Examiner.*

KATHLEEN H. CLAFFY, *Examiner.*

D. SMITH, JR., *Assistant Examiner.*