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ELECTRICAL SWITCHING DEVICES WITH MOVABLE CONTACT ENGAGABLE WITH V-SHAPED CONTACT

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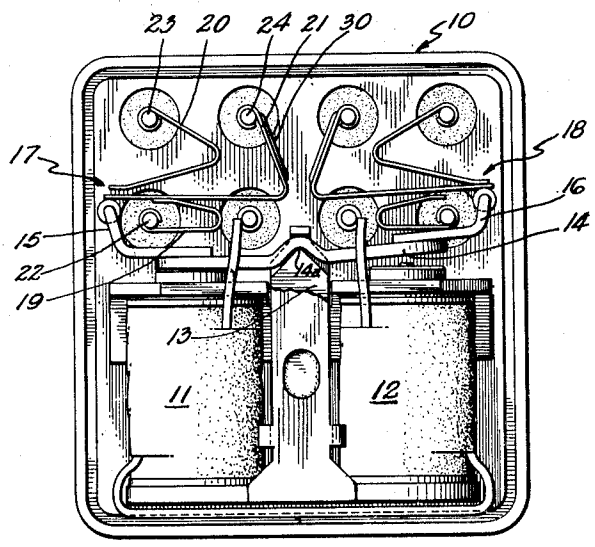


FIG. 1

FIG. 2

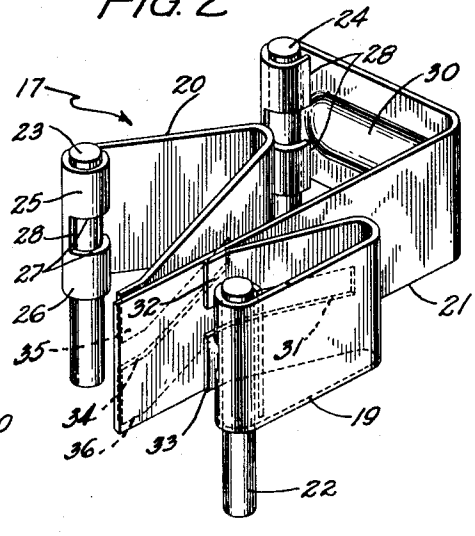
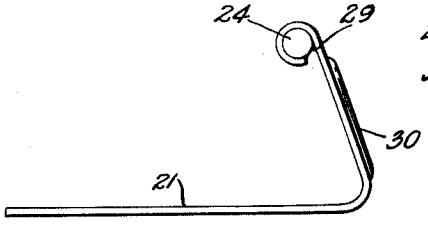


FIG. 3



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ELECTRICAL SWITCHING DEVICES WITH MOVABLE CONTACT ENGAGEABLE WITH V-SHAPED CONTACT

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This invention relates to electrical switching devices and particularly to switching devices, such as electromagnetic relays, employing resilient contact structures.

In various types of electrical switching devices, it is desirable to employ contact structures including resilient contact members which are distorted during switching and, as a result of being distorted, apply definite spring forces to the switch actuating mechanism, such spring forces tending to return moving parts of the switching device to predetermined positions. Typical examples of such switching devices are disclosed in United States Patent No. 2,955,175, Walter J. Richert, issued October 4, 1960. Even in switching devices of relatively large dimensions, the requirement that the contact structure provide definite spring forces to aid operation of the device presents distinct problems, principally because materials which have the best electrical and spring characteristics do not necessarily lend themselves to use in an inexpensive structure which will have the desired mechanical strength and positional stability. These problems become considerably more acute when the switching device, instead of having relatively large dimensions, is of the miniature or sub-miniature type wherein the length of a contact arm may be on the order of 3/16–3/8 inch and the actuating forces involved are very small. In such cases, the resilient material from which the contact members are made is very thin, so that positional stability under conditions of vibration and shock is very difficult to obtain. The foregoing problems are accentuated by the fact that it is frequently necessary to have the terminal pins which support the resilient contact members spaced in a regular system of rectangular coordinates.

A general object of the invention is to devise a resilient contact structure for electrical switching devices, and particularly for miniature and sub-miniature relays and the like, which overcomes the aforementioned difficulties.

Another object is to provide a spring contact structure which can be made very small in size, yet will maintain positional and operational stability during prolonged use under conditions of severe vibration and shock.

A further object is to devise such a contact structure providing an effective contact wiping action during operation of the switching device.

Still another object is to provide a contact structure of the type referred to wherein thin spring arms of a highly heat conductive metal are soldered to terminal pins so that the solder completely fills the space between adjacent surfaces and the arms are fixedly secured in stable fashion.

Another object is to provide a contact structure of the type referred to in which the individual resilient contact arms are fixed to and carried by terminal pins spaced in a regular system of rectangular coordinates, the arrangement of the contacts being such that the various

resilient contact arms have portions which are considerably spaced from the corresponding terminal pins, the construction and configuration of the contact arms being made such as to assure optimum resistance to vibration and mechanical shock.

In order that the manner in which these and other objects are attained in accordance with the invention can be understood in detail, reference is had to the accompanying drawings, which forms a part of this specification, and wherein:

FIG. 1 is a plan view of a polarized relay constructed in accordance with one embodiment of the invention;

FIG. 2 is a perspective view illustrating a contact assembly employed in the relay of FIG. 1; and

FIG. 3 is a side view of a movable contact arm of the relay of FIG. 1, FIGS. 2 and 3 being on enlarged scales relative to that of FIG. 1, for clarity of illustration.

Referring now in detail to the drawing, the invention is shown as applied to a relay of the type disclosed in the copending application of Hugh O. Wells and Ralph E. Probert, Serial Number 78,910, now Patent No. 3,121,148, filed concurrently herewith. The relay includes a metallic base **10** on which are mounted a pair of electromagnets **11** and **12** and a permanent magnet **13**. An armature **14** is pivoted on a bearing edge **14a** provided by one end of permanent magnet **13** and carries a pair of actuators **15** and **16** which engage the movable contact arms of a pair of single pole, double throw, make-break contact assemblies **17** and **18**. The armature is movable into alternate engagement with the pole pieces of electromagnets **11** and **12**, in response to suitable operation of the electromagnets, for actuation of contact assemblies **17** and **18** in the manner disclosed in the above-mentioned application Serial Number 78,910.

Contact assemblies **17** and **18** are identical so that only one need be described in detail. Contact assembly **17** includes a pair of relatively fixed contact arms **19** and **20** and a movable contact arm **21**. Contact arms **19**, **20** and **21** are fixed to terminal pins **22**, **23** and **24**, respectively, the terminal pins being mounted on base **10**. All of the terminal pins are parallel to bearing edge **14a** and thus to the pivotal axis of the armature. Terminal pins **22–24** and the pivotal axis of armature **14** all extend at right angles to base **10**. The terminal pins project completely through the base **10**, being insulated therefrom by the usual glass-to-metal seals, and include contact carrying portions projecting from the base on the side thereof occupied by the electromagnets **11** and **12**, and portions, projecting from the other side of the base, for plugging into suitable sockets (not shown) via which the electrical connections to the relay are established.

All of the terminal pins of the relay are spaced in a regular system of rectangular coordinates, the axes of which system are respectively perpendicular and parallel to the axes of electromagnets **11** and **12**. Accordingly, terminal pins **22** and **23** are spaced along a line which is parallel to the axes of the electromagnets and which extends generally in the direction of movement of armature **14**, and pins **22** and **24** are equidistant from pin **23**.

Each terminal pin is pre-tinned or pre-coated with solder and is constructed from suitable material, such as a nickel-iron or a stainless steel alloy. Further, each terminal pin is dimensioned to provide sufficient rigidity for proper support of the contact arms, to enable the terminal

pins to be plugged into their cooperating sockets (not shown), and to provide the necessary conductivity for carrying a relatively large current.

Each of contact arms 19, 20 and 21 is constructed from a highly-conductive, spring contact material, such as an alloy composed of 99½% silver, the remainder of the alloy being magnesium and nickel or an alloy composed of 90% gold and 10% copper. To insure that the contact arms are secured in a rigid stable fashion, the present invention employs a special construction. As best seen in FIG. 2, each contact arm has at the end of its fixed end portion a pair of parallel, transversely spaced tabs 25 and 26. The end portion of the contact arm and tabs 25 and 26 are curved about and embrace the terminal pin and provide a plurality of side edges, indicated at 27, which extend longitudinally of the contact arm and lie in planes, perpendicular to the axis of the pin, and a plurality of end edges, indicated at 28, which extend transversely of the contact arm and longitudinally of the pin.

During assembly, tabs 25 and 26 are fitted over a terminal pin and solder and heat are applied to secure the arm to the pin. The spacing between tabs 25 and 26 insures that the solder applied will run between and completely fill the space between adjacent surfaces of the pin and the arm and thereupon, upon solidification of the solder, effect a rigid joint. Without such a spacing, the solder may not completely fill the space between adjacent surfaces so that the resultant joint would be tight. If sufficient solder is applied so that it projects outwardly from the pin and abuts edges 27 and 28, the solder which abuts edges 27 tends to prevent longitudinal movement of the contact arm along the pin and the solder which abuts edges 28, and also that portion of the contact arm indicated at 29 in FIG. 3, tends to prevent rotation between the fixed end of the contact arm and the pin. Although, in effect, this forms a positive interlock, the principal strength of the joint is due to the solder adhering to both the contact arm and the pin. In other words, the contact arm would be fixedly secured to the pin even if the solder did not abut the edges 27, 28 and 29.

Each of contact arms 19, 20 and 21 is formed from an initially flat strip of metal in the form of an elongated rectangle, such strips being extremely thin in the case of miniature and sub-miniature devices, arm 21 advantageously being thicker than arms 19 and 20. Thus, in the typical case of a miniature relay, arms 19 and 20 are formed from sheet stock 5 mils in thickness and arm 21 is formed from stock 8 mils in thickness. Each of contact arms 19, 20 and 21 extends generally in the form of a V, each arm thus having two generally straight portions interconnected by a medially located, arcuate, acute-angle bend. For each arm, one end portion is fixed to the corresponding terminal pin and is hereinafter referred to as the fixed end portion, while the other end portion is movable in a generally arcuate path lying in a plane at right angles to the axes of the terminal pins and parallel to the face of base 10.

The fixed end portion of contact arm 21 has a longitudinally extending stiffening ridge 30, advantageously in the form of an embossed rib, which prevents flexing of the fixed end portion, so that the free end portion acts as a cantilever leaf spring having its fixed end located approximately at the bend in the contact arm. The free end portion of arm 21 is flat and extends from the bend along a line which passes between pins 22 and 23 and is perpendicular to the axes of the electromagnets.

Contact arms 19 and 20 are disposed on opposite sides of arm 21, the free ends of contact arms 19 and 20 being spaced apart generally in the direction of movement of the armature by a distance such that arm 21 can engage one or the other, but not both, at any given time. The normal, relaxed shapes of contact arms 19, 20 and 21 are so chosen that the free ends of arms 19 and 20 occupy predetermined positions relative to the two extreme positions attained by actuator 15 during operation of the relay, the arrangement being such that, when armature 14 engages the core of electromagnet 12, actuator 15 distorts arms 21 and 20 to a definite extent which assures good contact pressure between the free ends of those two arms and applies to the actuator 15 a predetermined spring force tending to pivot the armature toward engagement with the core of electromagnet 11.

The free end of each of the relatively fixed contact arms 19 and 20 is split from its tip along a line extending at least generally longitudinally of the contact arm but terminating short of the intermediate bend in the contact arm. In each case, this split is offset transversely from the longitudinal center line of the contact arm to provide a pair of movable end portions which, while of the same length, have different widths and, therefore, different resonant frequencies, so as to minimize or to completely eliminate unwanted movement of the free ends of contact arms 19 and 20 which might otherwise result because of vibration to which the relay is subjected during use. Thus, contact arm 19 is provided with laterally offset split 31, FIG. 2, and has a narrower tip portion 32 and a wider tip portion 33. Similarly, contact arm 20 is provided with a split 34 and has a narrower tip portion 35 and a wider tip portion 36. The tip portions 32 and 33 are bent along a line extending transversely of contact arm 19 and at right angles to the longitudinal center line of the contact arm, so that the tips of portions 32 and 33 extend approximately parallel to that portion occupied by the adjacent portion of contact arm 21 when the latter moves into engagement with portions 32 and 33. In the same manner, end portions 35 and 36 of contact arm 20 are bent along a transverse line at right angles to the longitudinal center line of that contact arm, so that the tips of portions 35 and 36 normally occupy positions parallel to the end portion of contact arm 21 when the latter approaches engagement with end portions 35 and 36. Accordingly, engagement between movable contact arm 21 and the end portions of the relatively fixed contact arms 19 and 20 occurs over a small rectangular area, the engaged portions of the contact arms coming into flush, face-to-face contact. In this manner, good electrical contact over a substantial surface is accomplished and substantially the same contact action is attained each time the relay is actuated. It is to be understood that cooperating portions of the contact arms can be shaped so that they abut along a line, at a point or over an area having a non-rectangular configuration.

It will also be understood that, due to the fact that the free end portions of the resilient, relatively fixed contact arms 19 and 20 are longitudinally split and shaped in the manner just described, portions 32, 33 and 35, 36 conform precisely to the contact face disposition of the free end portion of contact arm 21, even though the latter might not precisely occupy its intended position. Thus, the particular construction and configuration of the contact assembly allows somewhat less rigorous manufacturing tolerances than would otherwise be required. Also, the particular construction and configuration of the several contact arms is such that a good wiping action is accomplished between the relatively fixed and movable contact arms during actuation of the relay.

As will be clear from FIG. 1, the relatively fixed contact arm 19 is disposed between contact arm 21 and armature 14 and is made effectively shorter than contact arm 20. This arrangement allows the insulated tip of actuator 15 to engage movable contact arm 21 at a point approximately opposite the contact faces presented by the tips of end portions 35 and 36 of contact arm 20. Such relative disposition of actuator 15 and tip portions 35 and 36 of contact arm 20 not only assures that good engagement between contact arm 21 and contact arm 20 will be attained but also allows use of substantially all of the free end portion of contact arm 21 as a cantilever

spring operative to resiliently bias armature **14** when the latter is actuated to engage the core of electromagnet **12**.

It will be noted that arms **19–21** all have different effective lengths and therefore different resonant frequencies, so that there is no tendency for the contact structure as a whole to resonate when the relay is subjected to vibration during use.

Also, it will be noted that the tip portions of contact arms **19–21** are movable along arcuate paths having different radii of curvature, the centers of such radii being displaced from each other. This factor aids in establishing good wiping action of the contacts. Thus, when actuator **15** moves upwardly, as viewed in FIG. 1, it raises the free end portion of arm **21** and therefore allows arm **19** to move to its unstressed or relaxed position. The initial movement of the two contact arms includes a slight relative longitudinal movement between the two arms which creates a stress directed longitudinally of the arms, causing the engaged surfaces to wipe, so that contact sticking will not occur.

In the particular embodiment chosen for illustration, the terminal pins **22–24** are spaced on a regular system or rectangular coordinates with, for example, .2 inch between centers. Such an arrangement allows the relay to be plugged into a standardized socket assembly. However, this arrangement inherently requires that contact pin **24** which mounts movable contact arm **21** be spaced a substantial distance away from armature **14**. Since the movable contact arm **21** develops a substantial part of the spring force tending to oppose movement of the armature, such location of terminal pin **24** makes it more difficult to attain proper action of the resilient contact arm **21**. This difficulty is overcome by use of the longitudinally extending stiffening ridge **30** in that portion of contact arm **21** extending between terminal pin **24** and the intermediate bend in the contact arm. Presence of the stiffening ridge, in effect, allows contact arm **21** to act as if its pivot axis were disposed more closely adjacent to the armature, and thereby minimizes sliding movement between the actuators and the movable contact arms.

While one particularly advantageous embodiment of the invention has been chosen for illustrative purposes, it is to be understood that various changes and modifications therein can be made without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In an electrical device, the combination of a plurality of parallel terminal pins; a fixed contact arm secured at one end to one of said terminal pins; a movable contact arm secured at one end to another of said terminal pins; each of said contact arms being in the form of an elongated strip of electrically conductive spring material having a bend intermediate to the ends forming an acute angle, said fixed contact arm including an end portion having at least one longitudinally extending off-center split which divides said end portion into a plurality of movable portions having different resonant frequencies, said movable contact arm having a movable end portion normally engaged with said movable portions of said fixed contact arm, and a tip portion which extends beyond said movable portions; a second fixed contact arm secured at one end to another of said terminal pins; said second fixed contact arm being in the form of an elongated strip of electrically conductive spring material having a bend intermediate the ends thereof forming an acute angle, said second fixed contact arm including an end portion having at least one longitudinally extending off-center split to provide a plurality of movable portions having different resonant frequencies, said movable portions of said second fixed contact arm being engageable with said tip portion of said movable contact arm on the side thereof opposite from the point of engagement with said actuator and being normally spaced from the movable end of said movable contact arm, and a movable actuator engageable with said tip portion of said movable contact arm, movement of said actuator being effective to break contact between said first-mentioned fixed contact arm and said movable contact arm and to make electrical contact between said movable contact arm and said second fixed contact arm.

2. A device constructed in accordance with claim 1 wherein each of said contact arms is provided at the end secured to its associated terminal pin with a pair of transversely spaced, curved tabs embracing said associated terminal pin, said contact arm being fixedly secured to said terminal pin by fused metal.

3. A device constructed in accordance with claim 1 wherein said actuator is mounted for pivotal movement about an axis parallel to the axes of said terminal pins.

4. A device constructed in accordance with claim 3 wherein the ones of said terminal pins to which said first fixed contact arm and said movable contact arm are secured are equidistant from the one of said terminal pins to which said second fixed contact arm is secured.

5. In an electrical device, the combination of first, second and third parallel terminal pins; first and second fixed contact arms each in the form of an elongated strip of electrically conductive spring material having a medial bend so that said first and second contact arms are generally V-shaped, said first and second fixed contact arms being fixedly secured at ends thereof to said first and second terminal pins respectively, each of said fixed contact arms having a free end movable along an arcuate path which lies in a plane normal to the axes of said terminal pins, the free ends of said fixed contact arms being adjacent to but spaced from each other in a direction generally parallel to a line extending between said first and second terminal pins; a movable contact arm of an elongated strip of electrically conductive spring material, said movable contact arm being fixedly secured at one end to said third terminal pin and having a free end portion which extends between said free ends of said first and second fixed contact arms and is movable along an arcuate path which lies in a plane normal to the axes of said terminal pins, said free end portion of said movable contact arm being biased toward engagement with the free end of said first fixed contact arm; and an actuator mounted for pivotal movement about an axis parallel to the axes of said terminal pins, said actuator being engaged with said free end portion of said movable contact arm and operative to move the same against the resilient bias thereof out of engagement with the free end of said first fixed contact arm and into engagement with the free end of said second fixed contact arm.

6. A device constructed in accordance with claim 5 wherein said third terminal pin is located on a line which passes through said second terminal pin in a direction generally perpendicular to said line extending between said first and second terminal pins.

7. A device in accordance with claim 6 wherein said first and third terminal pins are equidistant from said second terminal pin.

8. In an electrical device, the combination of a terminal pin carried by a support, a first one piece resilient contact arm comprising a thin elongated body portion having one end affixed to said pin, said body portion having a medial bend, stiffening means for stiffening the portion of said contact arm between said terminal pin and said bend, the other end of said body portion being freely movable through an arc in a plane which lies substantially at right angles to the axis of said terminal pin, a second one piece resilient contact arm comprising a thin elongated generally rectangular body portion carried by said support and having a medial bend forming an acute angle, the other end thereof being split off-center of its longitudinal centerline to provide a pair of movable rectangular end portions of different widths which have different resonant frequencies, said movable end portions being engageable with the free end of said first contact arm, said movable

contacting end portions of said second contact arm further being arranged to lie substantially parallel to the cooperating contacting portion of said freely movable end of said first contact arm when in engagement therewith, and means for effecting relative movement between said arms for making and breaking electrical contact therebetween.

9. An electrical device in accordance with claim 8 in which said stiffening means is a stiffening ridge integral with the portion of said first contact arm between said terminal pin and said bend.

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