Aug. 7, 1945. E. U. POWELL 2,381,309

BOWSTRING RELAY

Filed June 10, 1943

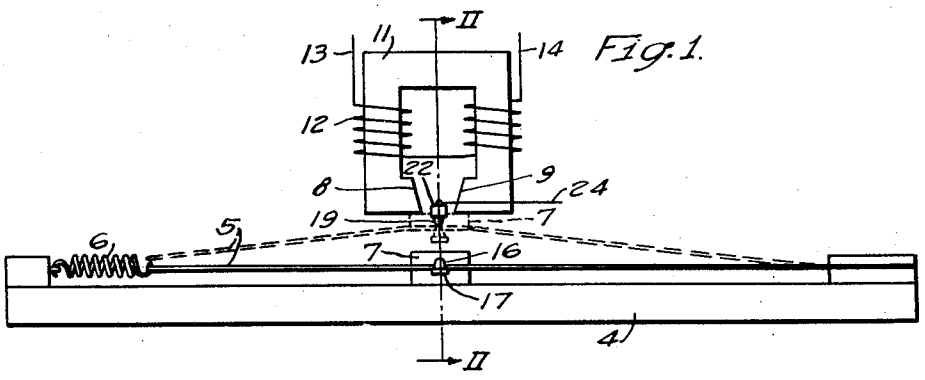


Fig. 1.

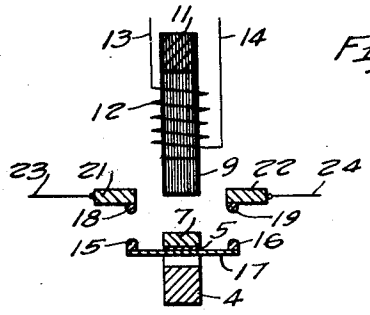
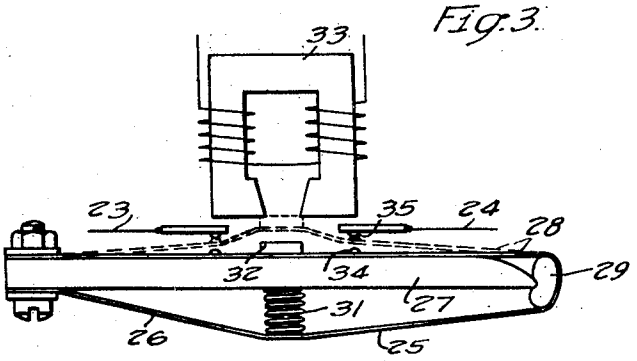


Fig. 2.

Fig. 3.



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Patented Aug. 7, 1945 2,381,309

UNITED STATES PATENT OFFICE

2,381,309

BOWSTRING RELAY

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Application June 10, 1943, Serial No. 490,305

16 Claims. (Cl. 200—87)

My invention relates to high-speed relays or other electric contact make-and-break devices, and it has particular relation to electromagnetic relays or contactors operating on the principle of the bowstring.

The principal object of my invention is to provide a mechanical relay, as distinguished from a tube-type relay, which shall have a fast operating-speed.

A further object of my invention is to provide a damped relay, particularly a damped relay of the bowstring type, which will avoid difficulties of bouncing contacts.

A further object of my invention is to provide a mechanical relay of a novel type in which the mass of the moving parts is quite small in relation to the force which is required to move said parts, so that the speed of operation is very fast.

A more particular object of my invention is to provide a relay utilizing a flexible ribbon which is under tension, and which is displaced, at an intermediate point, like a bowstring, in response to the operating force of the relay.

A still more specific object of my invention is to provide a novel form of contact-means in connection with the aforesaid flexible-ribbon type of relay.

With the foregoing and other objects in view, my invention consists in the parts, apparatus, combinations, systems, and methods hereinafter described and claimed, and illustrated in the accompanying drawing, wherein:

Figure 1 is a diagrammatic side view of circuits and apparatus embodying my invention in a very simple form;

Fig. 2 is a transverse sectional view thereof on the line II—II of Fig. 1; and

Fig. 3 is a view similar to Fig. 1, showing a preferred form of embodiment of my invention.

The general principle of my relay is illustrated in Figs. 1 and 2, in which a rigid bar 4, or other stationary elongated support, is utilized to support a light flexible ribbon 5, or other tension-member, which is constantly held under tension, as by means of a spring 6. The thickness of the ribbon 5 is exaggerated in the drawing, for convenience in showing it. Secured to an intermediate portion of the ribbon 5 is an iron or other magnetizable armature 7.

In the normal, or deenergized, condition of the relay, the armature 7 is spaced from the poles 8 and 9 of a stationary electromagnet-frame 11, which is provided with a winding 12 energized from a control-circuit 13—14. The magnet-poles 8 and 9 are normally spaced from the armature 7, at such a distance that the magnet is capable of attracting the armature whenever the magnet is energized with a predetermined value of current. The attraction of the armature 7 to the magnet-poles 8 and 9 results in displacing the intermediate portion of the ribbon 5, after the manner of a bowstring, as illustrated in dotted lines in Fig. 1, wherein the magnet 7 is dotted in position against the faces of the pole-pieces 8 and 9.

Any suitable form of electric-contact device may be operated by the movement of the ribbon 5 or other tension member. In the particular form of embodiment of my invention shown in Figs. 1 and 2, a more or less conventional type of contact-means is shown, including two movable contacts 15 and 16 which are carried by a light flexible contact-spring 17 carried by the ribbon 5 underneath the armature 7, and two cooperating stationary contacts 18 and 19 which are carried by rigid stationary members or supports 21 and 22. A circuit 23—24, to be controlled, is connected to the stationary contact-members 21 and 22 respectively, so that a circuit is completed from the conductor 23 to the stationary contact-member 21—18, the movable contact 15 which engages the same when the relay is operated, the movable contact-spring 17, the other movable contact 16, and the stationary contact-member 19—22, and thence to the conductor 24. Any other type of contact-device may be utilized in my novel bowstring type of relay.

It will be observed that I have provided a special type of spring-mechanism in which the effective mass of the movable part is reduced to the very minimum. Since the time-constant of any relay is dependent upon the ratio of the operating force to the mass of the moving parts, it will be obvious that I have provided a quick-acting mechanical relay. It will further be noted that I have provided a relay which is extremely simple and extremely rugged, and experience has shown that it is capable of long-continued operation without the necessity for adjustment or replacement, while carrying heavy current-burdens.

In Fig. 3, I have illustrated a preferred form of my invention, in which the bendable or flexible tension-member 25 is a two-part member, one part 26 being underneath the elongated support 27, while the other part 28 of the tension-member is above the support 27, the two parts 26 and 28 of the tension-member being connected by an oscillatable bellcrank or pivoted member 29 for pulling lengthwise on one part of the two-part bendable tension-member when an inter-

mediate portion of the other part is displaced. The lower and upper parts 26 and 28 of the tension-member 25 are kept under tension by means of a compression-spring 31 which is interposed between an intermediate portion of the support 27 and an intermediate portion of the lower part 26 of the tension-member 25.

A suitable force-applying means is utilized for displacing an intermediate portion of the upper part 28 of the tension-member 25. In Fig. 3, as in the preceding figures, this force-applying means is of an electromagnetic type, although I wish it to be understood that, in its broader aspects, my invention is not limited to the use of an electromagnetic operating-force. As shown in Fig. 3, the intermediate portion of the upper part 28 of the flexible tension-member 25 carries a magnetizable armature 32 which is adapted to be attracted by a relatively stationary electromagnet 33 which may be similar to the armature-and-magnet structure already described in connection with Figs. 1 and 2.

In Fig. 3, I have illustrated two special features which contribute importantly to an advantageous use of my invention. In the first place, the support 27 is so constructed that, when the relay is in its normal or deenergized position, the upper part 28 of the flexible tension-member 25 is flat against the upper side of the support, so that said upper side of the support constitutes a distributed back-stop for the flat side of the tension-member. When the tension-member 25, particularly the aforesaid upper part 28 thereof, is in the form of a flat ribbon, as illustrated, this extended or distributed back-stop, which is provided by the upper side of the support 27, produces very good air-damping which becomes effective only as the ribbon 28 returns to its normal undisplaced position, when the relay is deenergized after a period of energization. This provides damping at the exact time which is desirable for the purpose of preventing vibration of the ribbon, namely, near the very end of the travel of the displaced portion of the ribbon 28. Different widths of ribbon produce different amounts of damping, so that the vibration can be suitably controlled by this means.

A second useful innovation which I have introduced, in the form of my invention shown in Fig. 3, relates to the particular type of novel contact-device in which the movable contact or contacts 34 are carried by the upper side of the upper ribbon 28 at an intermediate point which is displaced from the intermediate point carrying the armature 32. The stationary contact or contacts 35 are disposed so that, when the relay is operated, the movable contact or contacts 34 come into contact with the stationary contact or contacts 35 before the armature 32 has reached the stationary electromagnet-structure 33. Since the armature 32 continues to move until it comes into contact with the contacting portion of the electromagnet 33, the upper ribbon-member 28 bends over the stationary contact or contacts 35, thus producing a second bend in the ribbon, providing a good wiping contact, and eliminating the usual contact-springs (such as the spring 17 in Fig. 2) which must ordinarily be used if one is to avoid having a very critical contact-adjustment.

In operation, when electrical energy is supplied to the electromagnet 33 in Fig. 3, the armature 32 pulls up the upper ribbon 28 after the manner of a bowstring, slightly rocking the bell-crank or other oscillatable member 29, and pulling longitudinally upon the lower part 26 of the flexible tension-member 25, thus straightening out the lower part and still further compressing the compression-type biasing-spring 31. At an intermediate point in the movement of the upper ribbon 28, the stationary contact or contacts 35 are engaged by the movable contact or contacts 34, and as the armature 32 continues to move toward the stationary electromagnet 33 a positive contact-pressure is applied at 34—35 so as to positively keep the contacts closed, against rebound. A second bend is thus introduced in the upper ribbon 28, forcibly holding the contacts closed.

When the electromagnet 33 is deenergized, in Fig. 3, the upper ribbon 28 quickly returns to its normal or deenergized position, after first opening the contacts at 34—35. Vibration of the ribbon is damped by the air which is entrapped between the flat underside of the ribbon and the flat top surface of the support 27, just as these two parts come together, thereby avoiding vibrational or rebounding difficulties.

With my invention, it is possible to adjust the relay so as to have either the same, or different, times for making and breaking contacts. In one application of my invention, I prefer to make the adjustment so as to give the shortest equal opening and closing times. As measured by an oscilloscope, this time is about $^1/_{600}$ of a second. Extended tests have shown that this relay is capable of a very large number of repeated operations, without a single faulty operation, even when carrying relatively heavy currents, and it requires no adjustment whatever during the operation, and produces no contact-bounce which could be detected by an oscilloscope.

I claim as my invention:

1. A wiping contact make-and-break device having a bowstring type of spring-mechanism comprising a flexible tension-member, means for keeping said tension-member under tension, force-applying means for displacing an intermediate portion of the tension-member, and contact-means including stationary means interposed in the path of the tension-member for displacing a second intermediate point therein as the force-applying means approaches the end of its travel.

2. A damped, wiping contact make-and-break device having a bow-string type of spring-mechanism comprising a flexible flat ribbon for a bendable tension-member, a distributed back-stop for the flat side of the ribbon, means for keeping said ribbon under tension, force-applying means for displacing an intermediate portion of the ribbon, the arrangement being such that the ribbon comes into engagement with said back-stop when released by said force-applying means, and contact-means including stationary means interposed in the path of the ribbon for displacing a second intermediate point therein as the force-applying means approaches the end of its travel.

3. A contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, force-applying means for displacing an inter-

mediate portion of the other part of said two-part bendable tension-member, and contact-means operated by the movement of the tension-member.

4. A contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, force-applying means for displacing an intermediate portion of the other part of said two-part bendable tension-member, and contact-means operated by the movement of the last-mentioned part of the two-part bendable tension-member.

5. A contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, force-applying means for displacing an intermediate portion of the other part of said two-part bendable tension-member, said last-mentioned part of the two-part bendable tension-member being a flat ribbon, said support having a portion comprising a distributed back-stop for the flat side of the ribbon when released by said force-applying means, and contact-means operated by the movement of the tension-member.

6. A contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, force-applying means for displacing an intermediate portion of the other part of said two-part bendable tension-member, said last-mentioned part of the two-part bendable tension-member being a flat ribbon, said support having a portion comprising a distributed back-stop for the flat side of the ribbon when released by said force-applying means, and contact-means operated by the movement of the ribbon when the latter is displaced by said force-applying means.

7. A contact make-and-break device comprising an elongated substantially rigid support, a two-part flexible tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, force-applying means for displacing an intermediate portion of the other part of said two-part bendable tension-member, and contact-means including stationary means interposed in the path of said last-mentioned part of the two-part flexible tension-member for displacing a second intermediate point therein as the force-applying means approaches the end of its travel.

8. A contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, force-applying means for displacing an intermediate portion of the other part of said two-part bendable tension-member, said last-mentioned part of the two-part bendable tension-member being a flat flexible ribbon, said support having a portion comprising a distributed back-stop for the flat side of the ribbon when released by said force-applying means, and contact-means including stationary means interposed in the path of said flat flexible ribbon for displacing a second intermediate point therein as the force-applying means approaches the end of its travel.

9. An electromagnetically operated wiping contact make-and-break device having a bowstring type of spring-mechanism comprising a flexible tension-member, means for keeping said tension-member under tension, a magnetizable armature carried by an intermediate portion of the tension-member, a relatively stationary electromagnet-member for attracting said armature and displacing said intermediate portion of the tension-member, and contact-means including stationary means interposed in the path of the tension-member for displacing a second intermediate point therein as the armature approaches the relatively stationary electromagnet-member.

10. An electromagnetically operated, damped, wiping contact make-and-break device having a bowstring type of spring-mechanism comprising a flexible flat ribbon for a bendable tension-member, a distributed back-stop for the flat side of the ribbon, means for keeping said ribbon under tension, a magnetizable armature carried by an intermediate portion of the ribbon, a relatively stationary electromagnet-member for attracting said armature and displacing said intermediate portion of the ribbon, the arrangement being such that the ribbon comes into engagement with said back-stop when the armature is released by the relatively stationary electromagnet-member, and contact-means including stationary means interposed in the path of the ribbon for displacing a second intermediate point therein as the armature approaches the relatively stationary electromagnet-member.

11. An electromagnetically operated contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, a magnetizable arma-

ture carried by an intermediate portion of the other part of said two-part bendable tension-member, a relatively stationary electromagnet-member for attracting said armature and displacing said other part of said two-part bendable tension-member, and contact-means operated by the movement of the tension-member.

12. An electromagnetically operated contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, a magnetizable armature carried by an intermediate portion of the other part of said two-part bendable tension-member, a relatively stationary electromagnet-member for attracting said armature and displacing said other part of said two-part bendable tension-member, and contact-means operated by the movement of the last-mentioned part of the two-part bendable tension-member.

13. An electromagnetically operated contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, a magnetizable armature carried by an intermediate portion of the other part of said two-part bendable tension-member, a relatively stationary electromagnet-member for attracting said armature and displacing said other part of said two-part bendable tension-member, said last-mentioned part of the two-part bendable tension-member being a flat ribbon, said support having a portion comprising a distributed back-stop for the flat side of the ribbon when said armature is released by the relatively stationary electromagnet-member, and contact-means operated by the movement of the tension-member.

14. An electromagnetically operated contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, a magnetizable armature carried by an intermediate portion of the other part of said two-part bendable tension-member, a relatively stationary electromagnet-member for attracting said armature and displacing said other part of said two-part bendable tension-member, said last-mentioned part of the two-part bendable tension-member being a flat ribbon, said support having a portion comprising a distributed back-stop for the flat side of the ribbon when said armature is released by the relatively stationary electromagnet-member, and contact-means operated by the movement of the ribbon when the latter is displaced by the attraction of the armature.

15. An electromagnetically operated contact make-and-break device comprising an elongated substantially rigid support, a two-part flexible tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, a magnetizable armature carried by an intermediate portion of the other part of said two-part bendable tension-member, a relatively stationary electromagnet-member for attracting said armature and displacing said other part of said two-part bendable tension-member, and contact-means including stationary means interposed in the path of said last-mentioned part of the two-part flexible tension-member for displacing a second intermediate point therein as the armature approaches the relatively stationary electromagnet-member.

16. An electromagnetically operated contact make-and-break device comprising an elongated substantially rigid support, a two-part bendable tension-member having its two parts on opposite sides of said support, an oscillatable member for pulling lengthwise on one part of the two-part bendable tension-member when an intermediate portion of the other part is displaced, compression-spring biasing-means interposed between an intermediate portion of said support and an intermediate portion of one part of said two-part bendable tension-member, a magnetizable armature carried by an intermediate portion of the other part of said two-part bendable tension-member, a relatively stationary electromagnet-member for attracting said armature and displacing said other part of said two part bendable tension-member, said last-mentioned part of the two-part bendable tension-member being a flat flexible ribbon, said support having a portion comprising a distributed back-stop for the flat side of the ribbon when said armature is released by the relatively stationary electromagnet-member, and contact-means including stationary means interposed in the path of said flat flexible ribbon for displacing a second intermediate point therein as the armature approaches the relatively stationary electromagnet-member.

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