June 11, 1957 R. L. CAMPBELL 2,795,669

SEQUENTIAL RELAY

Filed Aug. 24, 1953 2 Sheets-Sheet 1

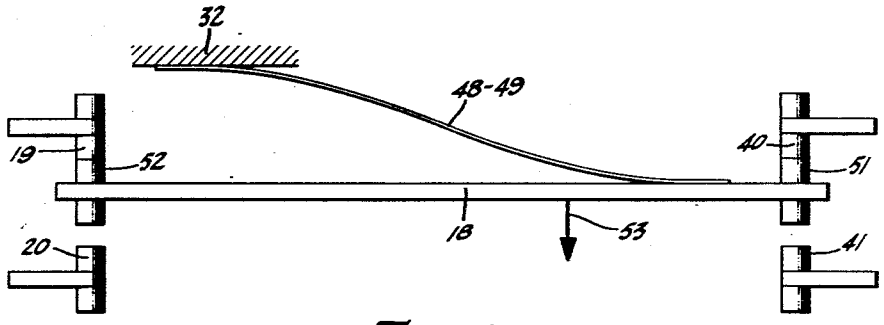

FIG. 1.

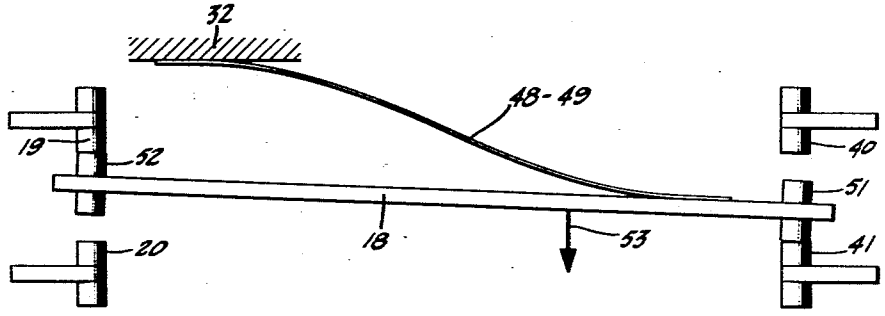

FIG. 2.

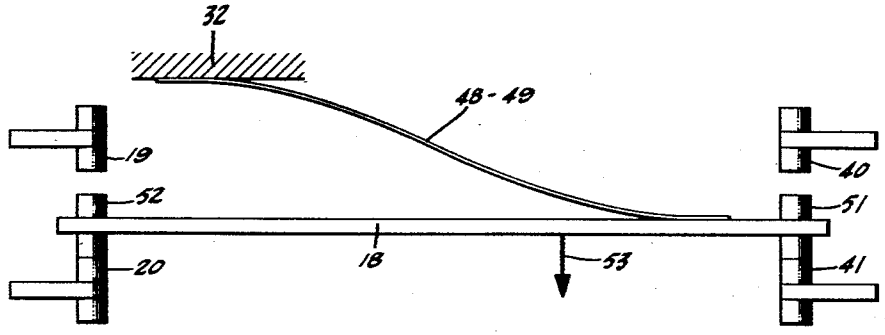

FIG. 3.

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June 11, 1957 R. L. CAMPBELL 2,795,669

SEQUENTIAL RELAY

Filed Aug. 24, 1953 2 Sheets-Sheet 2

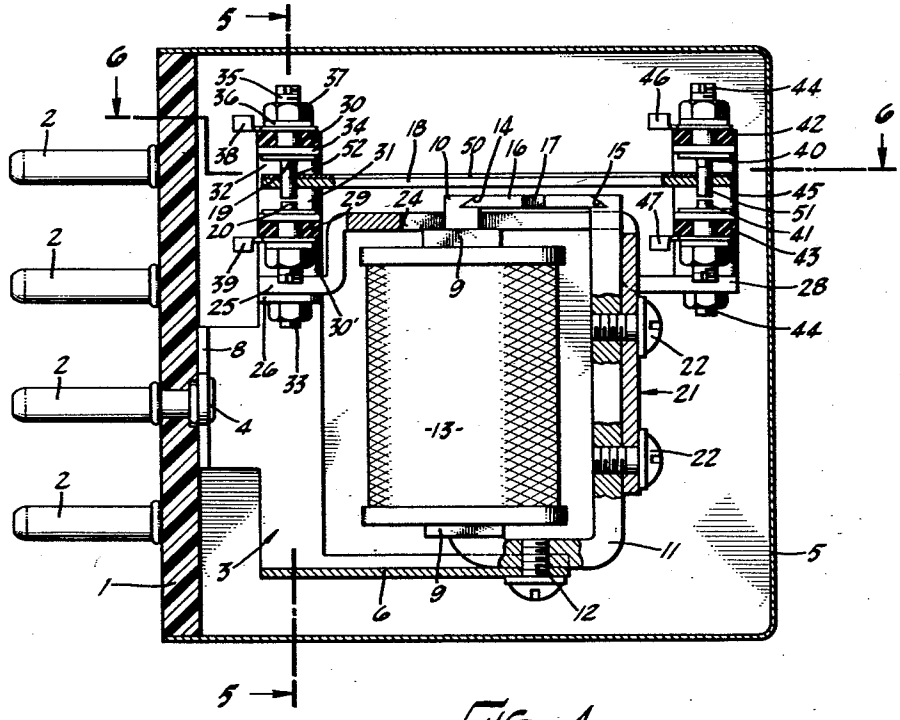

FIG. 4.

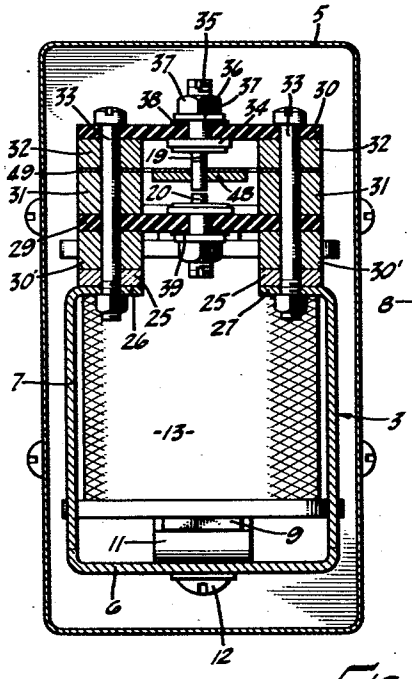

FIG. 5.

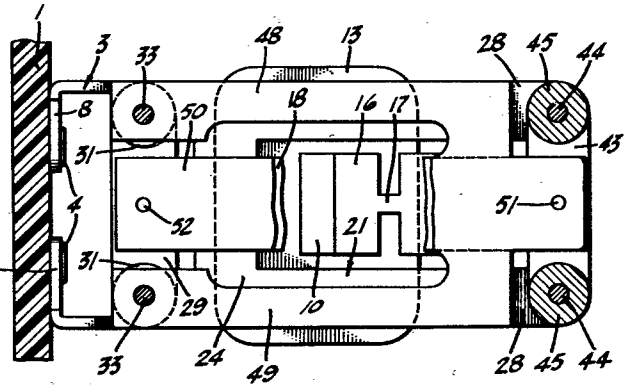

FIG. 6.

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2,795,669

SEQUENTIAL RELAY

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Application August 24, 1953, Serial No. 376,148

7 Claims. (Cl. 200—87)

This invention relates to a relay for controlling electrical circuits.

Electromagnetically operated relays are now well known. They usually include a core having an armature, and a coil, which, when energized, causes the core to attract the armature. The movement of the armature from unattracted to attracted position causes contacts to be engaged or disengaged. These contacts accordingly control one or more circuits.

In such apparatus, the armature is attracted whenever the energizing current reaches a definite value. Any further increase in current merely causes the armature to be more firmly attracted.

It is desirable however, to make it possible sequentially to control circuits, as for example in response to increments or decrements in the current flowing through the relay coil.

It is one of the objects of this invention to provide a relay, responsive to the intensity of energization, for selectively operating circuit controlling means, such as by the making and breaking of contact members.

It is another object of this invention to provide a simple and inexpensive electromagnetic relay that can operate in a sequential manner to control a number of circuits.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of one embodiment of the invention. For this purpose, there is shown a form in the drawings accompanying and forming part of the present specification. The form will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of this invention is best defined by the appended claims.

Referring to the drawings:

Figures 1, 2 and 3 are diagrammatic views showing three successive positions of the relay contacts;

Fig. 4 is a view partly in section of a relay structure incorporating the invention; and

Figs. 5 and 6 are sectional views taken respectively along the planes corresponding to lines 5—5 and 6—6 of Fig. 4.

The relay structure is mounted upon a vertical panel member 1 made of appropriate insulation material. This panel member 1 may provide an appropriate mounting for a number of terminal studs 2 adapted to be connected to the appropriate contact members of the relay.

The relay proper is mounted upon the panel 1 by the aid of a bracket structure 3 fastened to the panel 1 as by the aid of the fastening means 4 (Fig. 6) that pass through the side flanges 8 of bracket 3. Furthermore, a sheet metal cover member 5 fastened to the edges of the panel 1 serves to enclose the relay parts.

The bracket 3 has a lower wall 6 and the side wall 7 (Fig. 5) as well as the flanges 8 by the aid of which it may be fastened to the panel 1.

The relay is provided with a magnetic core 9 of rectangular configuration having a reduced rectangular portion 10. Attached to the lower end of the core 9 is a magnetic member 11. This magnetic member 11 is in turn supported on the lower wall 6 of the bracket 3, as by the aid of a screw 12.

Magnetic member 11 is a rectangular cross section. It extends upwardly above the relay coil 13 mounted upon the core 9.

At the upper end of the extension 10, and at the upper end of the magnetic member 11, opposed notches 14 and 15 are provided. Held by the aid of these notches is a bridging magnetic member 16 having tapered edges engaging within the notches 14 and 15. Magnetic member 16 has a reduced central portion 17 (Fig. 6) so as to provide a substantial amount of magnetic flux through the air between core 9 and magnetic member 11.

When the coil 13 is energized, it affects an arm 18 of magnetic material and suspended in a manner to be hereinafter described. In this way the arm 18 serves as an armature. The magnetic force exerted on the armature 18 is localized above the central portion 17 of magnetic member 16.

A pair of stationary spaced contact members is located adjacent each end of the arm 18. Thus above the left-hand end of the arm 18 there is a contact member 19 (see also Fig. 5). Spaced below the contact member 19 and below arm 18 is another contact member 20. These contact members are appropriately supported by the aid of insulation material upon the bracket 3. Thus, for example, a supplemental bracket member 21 is supported as by screws 22 upon the magnetic member 11. This bracket 21 has an upper arm 24. The left-hand portion of arm 24 is bifurcated and has an offset bend 25 resting upon the upper inwardly bent portions 26 and 27 of bracket 3. A similar bifurcated bent end 28, at the right-hand portion of bracket 21, provides a support for another set of stationary contact members.

Supported in spaced relation above the projections 25 are the insulation supporting blocks 29 and 30. These are supported in spaced relation by the aid of the spacer collars 30', 31 and 32. Bolts 33 pass through the blocks 30, 31 and 32, as well as the insulation supports 29 and 30, and portions 26 and 27 for holding these elements in proper spaced relation.

Insulation support 30 serves to support the upper contact member 19. For this purpose the upper contact member has a flange 34 resting against the lower surface of support 30. It has a threaded extension 35 extending through the member 30. A washer 36 and nut 37 serve to hold the flange 34 of contact member 19 tightly against the insulation support 30. A terminal 38 is clamped between the washer 36 and the upper space of the insulation support 30.

The lower contact member 20 is similarly supported upon the insulation block 29. It also is provided with a terminal member 39.

Another pair of spaced contact members 40 and 41 cooperate with the righthand end of arm 18. These are supported in a manner entirely similar to the supports described in connection with contact members 19 and 20. These supports include the insulation supporting blocks 42 and 43 clamped to the extension 28 as by the aid of the screws 44. These insulation supports 42 and 43 are held in spaced-apart relationship by the aid of collars, such as 45 (Fig. 6). The upper contact member 40 is provided with a terminal member 46, and the lower contact member 41 is provided with a corresponding terminal member 47.

The arm 18, comprising the armature member for the relay, is floating and is suspended by the aid of a leaf spring structure. This leaf spring structure, as shown most clearly in Fig. 6, has a pair of outer arms 48 and 49, as well as a wider central arm 50. These arms are

integrally formed. The left-hand ends of the arms **48** and **49**, as shown most clearly in Fig. 5, are clamped between the collars **31** and **32** so as to provide an anchor for this leaf spring device, adjacent the left-hand portion of the arm **18**.

The cental leg **50** overlies the armature arm **18** and is fastened to the armature **18** as by the aid of the contact members **51** and **52**. These contact members **51** and **52** are grounded upon the armature **18** and have upwardly and downwardly extending portions intended to cooperate respectively with the upper and lower contact members **19**, **40** and **20**, **41**, respectively.

The armature **18** accordingly is suspended adjacent its right-hand end by the spring construction. The spring is normally so arranged that when the coil **13** is unenergized or energized only by a weak current, the armature **18** is urged upwardly by the spring so that contact members **52** and **19** are in engagement, as well as contact members **51** and **40** (Fig. 1). When the current value reaches a definite intermediate value the armature **18** produces a magnetic force exerted upon it at a location corresponding to the arrow **53** (Figs. 1, 2 and 3) in line with the reduced central portion **17** (Fig. 6) of the magnetic member **16**. This force is localized at a point intermediate of the arm **18** and spaced to the left of the place where the spring structure exerts a force upwardly upon the arm **18**.

Accordingly, for an intermediate current value the contact member **51** is pulled downwardly away from contact member **40** and into engagement with contact member **41** (Fig. 2). The contact member **52** at the left-hand end of the arm **18** provides a fulcrum about which this tilting action may take place.

However, when a sufficiently strong current passes through the relay coil **13** the arm **18** is pulled to the position illustrated in Fig. 3. In this position the lower contact members **20** and **41** are in engagement respectively with contact members **52** and **51**.

The reverse operation is effected upon reducing the current through the coil **13**. After the elements are in the position of Fig. 3, a reduction of the current through the relay coil **13** causes the armature **18** to tilt to the position of Fig. 2, and, if the current is still further reduced the armature assumes the position of Fig. 1.

The suspension of the armature **18** by the aid of a flat spring member **48** and **49**, together with the manner in which the electromagnetic force is applied to the armature **18**, causes these successive positions to take place and sequentially in accordance with the strength of the current through the coil **13**.

Thus in the position of Fig. 1, circuits are established through contact members **19** and **52** and contact members **40** and **51**. In the intermediate position of Fig. 2, the circuit remains established between contacts **19** and **52**. However, it is interrupted between contact members **40** and **51** and established between contact members **51** and **41**. In the last position corresponding to Fig. 3, the contact between the members **19** and **52** is interrupted, as well as between members **40** and **51**. However, the circuit through contact members **52** and **20** is established, as well as the circuit through contact members **51** and **40**.

In this manner a sequential operation of the circuits is effected.

The inventor claims:

1. In combination: an arm carrying contact members respectively near its ends; a leaf spring member formed of a pair of legs and a central leg all joined integrally together at one end of the legs and also joined to the arm at said end, and near the end of the arm; the central leg overlying the arm; means anchoring the free ends of the outer arms; a first pair of spaced stationary abutments between which one end of the arm is placed; a second pair of spaced stationary abutments between which the other end of the arm is placed; said spring member exerting a force urging the ends of the arm toward abutments located on one side of the arm; and means for applying a force to the arm at an intermediate location thereof, and opposed to the force of the spring.

2. In combination: an arm carrying contact members respectively near its ends; a leaf spring member formed of a pair of legs and a central leg all joined integrally together at one end of the legs; the central leg overlying the arm and securing the arm for movement therewith; means anchoring only the free ends of the outer legs; a first pair of spaced stationary abutments between which one end of the arm is placed; at least one of the abutments forming a contact member; a second pair of spaced stationary abutments between which the other end of the arm is placed; at least one of said second pair forming a contact member; a movable contact member carried by the arm and cooperating with one of the stationary contact members; said spring member exerting a force urging the ends of the arm toward abutments located on one side of the arm; and means for applying a force to the arm at an intermediate location thereof, and opposed to the force of the spring.

3. In combination: an arm carrying contact members respectively near its ends; a leaf spring member formed of a pair of legs and a central leg all joined integrally together at one end of the legs; the central leg overlying the arm and securing the arm for movement therewith; means anchoring only the free ends of the outer legs; a first pair of spaced stationary abutments between which one end of the arm is placed; at least one of the abutments forming a contact member; a second pair of spaced stationary abutments between which the other end of the arm is placed; at least one of said second pair forming a contact member; a movable contact member carried by the arm and cooperating with one of the stationary contact members; said spring member exerting a force urging the ends of the arm toward abutments located on one side of the arm; and an electromagnet for applying a magnetic force to the arm at a locality spaced from the locality where the spring is joined to the arm, and opposed to said resilient means.

4. In combintation: an arm carrying contact members respectively near its ends; a leaf spring member formed of a pair of legs and a central leg all joined integrally together at one end of the legs; the central leg overlying the arm and securing the arm for movement therewith; means anchoring only the free ends of the outer legs; a first pair of spaced stationary abutments between which one end of the arm is placed; at least one of the abutments forming a contact member; a second pair of spaced stationary abutments between which the other end of the arm is placed; at least one of said second pair forming a contact member; a movable contact member carried by the arm and cooperating with one of the stationary contact members; said spring member exerting a force urging the ends of the arm toward abutments located on one side of the arm; and an electromagnet for applying a magnetic force to the arm at a locality spaced from the locality where the spring is joined to the arm, and opposed to said resilient means; the strength of said magnetic force determining the position of the arm between the abutments.

5. In combination: an electrically conductive switch arm; a leaf spring member formed of a pair of legs and a central leg all joined integrally together at one end of the legs and also joined to the arm at said end, and near the end of the arm; the central leg overlying the arm; means anchoring the free ends of the outer arms; a first pair of spaced stationary abutments between which one end of the arm is placed, at least one of said abutments being an electrical contact; a second pair of spaced stationary abutments between which the other end of the arm is placed, at least one of said abutments being an electrical contact; a pair of contact members at opposite ends of said arm securing said arm to said central leg of said leaf spring; said spring member exerting a force urging the ends of the arm toward abutments located on one side of the arm; and means for applying a force to

the arm at an intermediate location thereof, and opposed to the force of the spring.

6. In combination: a light switch arm made of magnetic material; a first pair of opposed stationary abutment means; a second pair of opposed stationary abutment means; said pairs of abutment means being respectively cooperable with spaced portions of the arm for limiting transverse movement of said arm in opposite directions respectively; means providing a resilient suspension for said arm and applying a resultant resilient force lightly urging said arm toward one limited position; the spacing between the abutment means with respect to the length of the arm permitting one arm portion to move between its corresponding abutment means while the other arm portion remains stationary, thereby providing at least three positions of the arm; and an electromagnet, including a circuitous core member providing a low reluctance path; said abutment means defining a limited range of movement of said switch arm in which said switch arm may closely approach but not engage said core member; said core member having provisions for producing a localized leakage of magnetic flux at a place spaced from the line of action of said resultant force, the extent of the localized flux leakage being determined in accordance with the energization of said electromagnet, the extent of energization of said electromagnet determining the position of said arm.

7. In combination: a first pair of stationary spaced opposed abutments; a second pair of stationary spaced opposed abutments; a magnetic armature having spaced portions respectively located between the abutment pairs; a floating suspension for the armature, permitting said armature to assume three positions corresponding to: engagement of one portion with one abutment of the first pair and the other portion with one abutment of the second pair, engagement of said one portion with the other abutment of said first pair and the other portion with said one abutment of said second pair, and engagement of both said portions respectively with the other abutments of said first and second pairs; resilient means producing a resultant force urging the one portion to engage said one abutment of said first pair and said other portion to engage said one abutment of said second pair; and an electromagnet cooperating with the armature and including circuitous core means providing a low reluctance path, said core means having provisions for producing a localized leakage of magnetic flux adjacent said armature at a place spaced from the line of action of said resultant force; said localized leakage of magnetic flux producing a force on said armature opposing said resilient means; a predetermined energization of said electromagnet causing the armature to assume a position in which said one portion engages the other abutment of said first pair and said other portion engages said one abutment of said second pair; a greater predetermined energization of said electromagnet determining a position of said armature in which said armature portions respectively engage the other abutments of said first and second pairs; the other abutments of said first and second pairs preventing engagement of said arm with said core means.

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