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3,237,096

METHOD OF MATCHING REED SWITCH OPERATING TIMES

Filed June 28, 1963

2 Sheets-Sheet 1

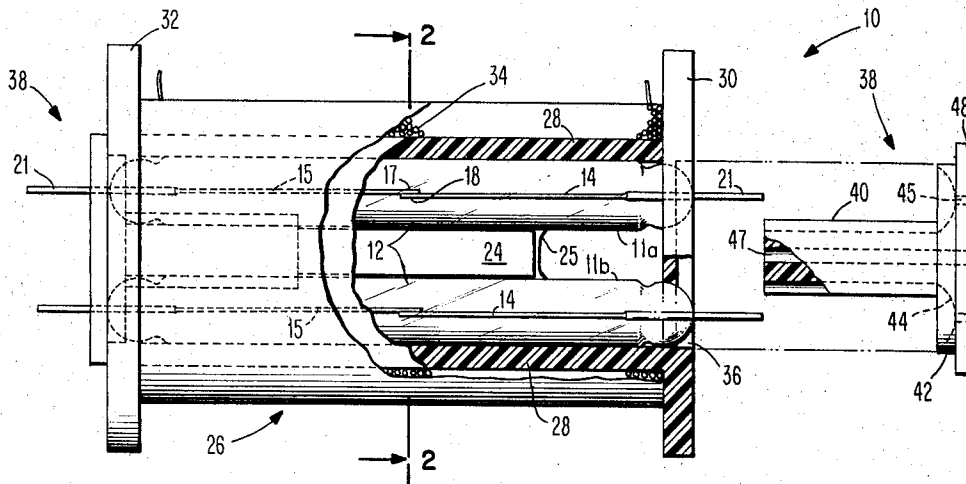


FIG. 1

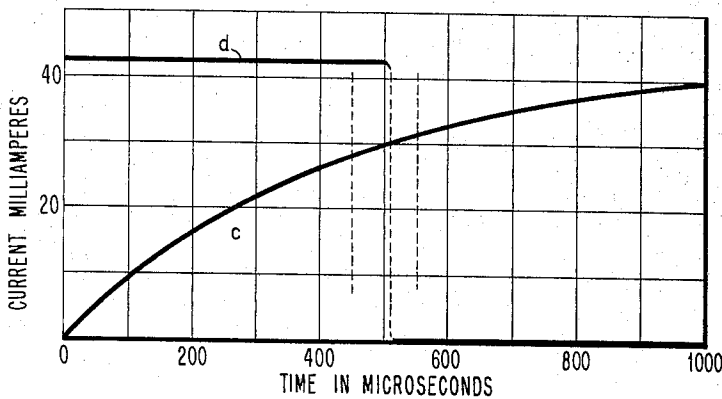


FIG. 4

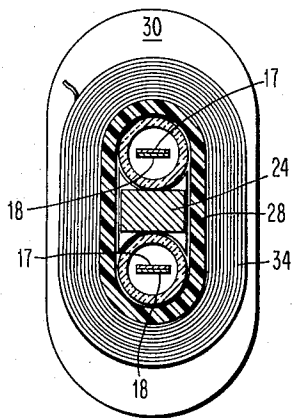


FIG. 2

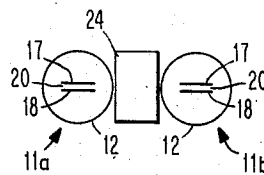


FIG. 3

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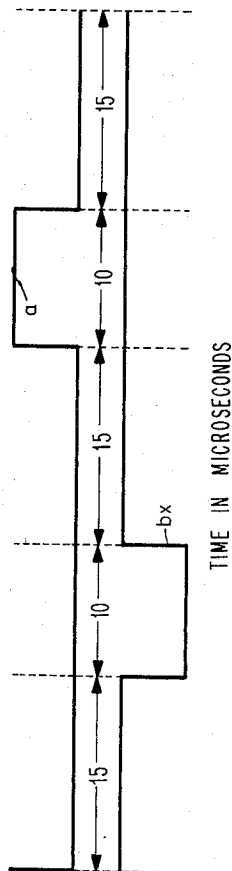
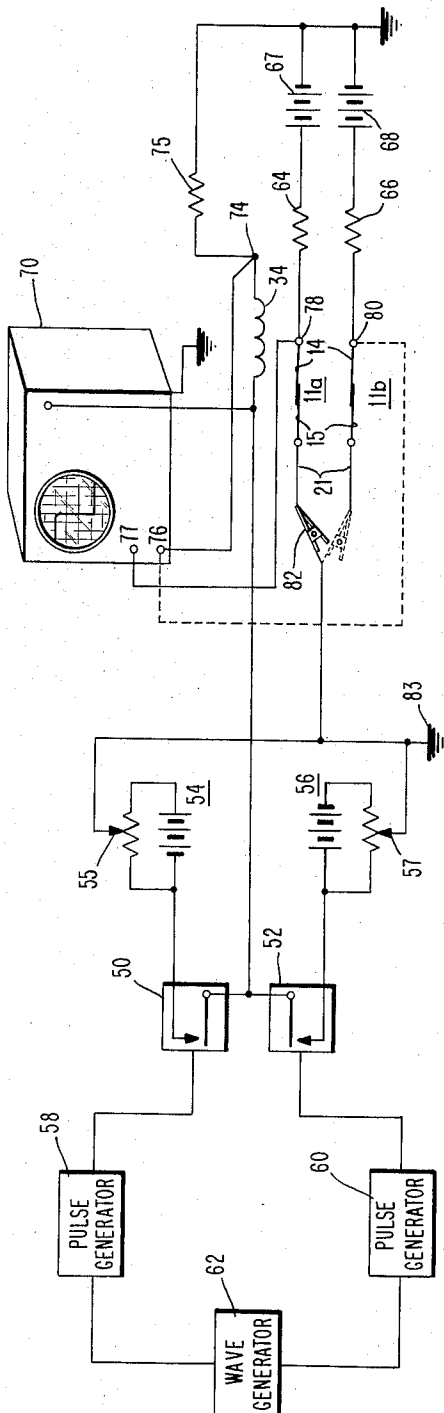
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2 Sheets-Sheet 2



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METHOD OF MATCHING REED SWITCH OPERATING TIMES

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6 Claims. (Cl. 324-28)

The present invention relates generally to reed switches, and it has reference in particular to a reed switch module or package and a method of producing it.

In practicing the present invention in accordance with one of its embodiments, a pair of reed switches, each having a pair of reed contacts of a magnetically deflectable material sealed in a glass envelope and extending longitudinally thereof to present an overlapping contact area, are positioned in spaced apart, side-by-side relation in a bobbin of tetrafluoroethylene resin having a common operating winding thereon. A permanent magnet for biasing the contacts together is placed between the switches with its longitudinal axis parallel to those of the switches, the reed switches being so rotationally oriented, that the overlapping contact areas are in coplanar relation on either side of the permanent magnet. The winding is subjected to periodic positive and negative pulses, the positive pulses being of controllable value and in a direction to produce a magnetic flux in the direction of the magnet, and the negative pulses being of controllable value to effect the necessary demagnetization of the magnet to produce a predetermined minimum range of operating time for the slower one of the switches. The operating times of the switches are observed by selectively connecting the reed switches to an oscilloscope triggered by the current of the operating winding. The faster of the switches may then be rotated axially in the bobbin relative to the permanent magnet to vary the bias effect of the magnet, and the trace of the current through its contacts observed on the oscilloscope until substantially identical operating times are achieved, whereupon a hypodermic needle is used to inject a predetermined amount of an epoxy resin adhesive into the bobbin to secure the reed switches and the magnet in fixed relation. The permanent magnet may then be controlled to achieve the desired final operating time for both of the switches and the integrated package may then be cured by suitable heating and either used in said winding or removed from the winding, which may be used in the same manner to calibrate other pairs of switches.

Generally stated, therefore, it is an object of this invention to provide an improved reed switch module.

More specifically, it is an object of the present invention to provide for producing a reed switch module or package comprising a pair of matched reed switches to be operated by a common operating winding, and so rotationally oriented relative to a common biasing magnet as to have identical operating times.

One object of the present invention is to provide a simple and effective way of matching the operating characteristics of a pair of reed switches having a common permanent magnet bias means.

Another object of the invention is to provide for adjustably positioning a pair of reed switches rotatively relative to a common permanent magnet to match the operating times of the switches and for securing the switches and magnet in a selected adjusted relationship.

Yet another object of this invention is to provide in a simple and effective manner for individually rotatively adjusting one of both of a pair of reed switches relative to a common permanent magnet and using a thermosetting resin to maintain the assembly in the desired relationship.

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Another object of the invention is to provide for initially adjusting the strength of a permanent magnet to bias the reeds of a pair of reed switches so as to effect an operating time in at least a predetermined range of operating times for the slower of the switches, rotating one or both of the switches individually about its longitudinal axis relative to match their operating times, then adjusting the strength of the magnet to finalize the operating time at a predetermined value for the matched pair of switches.

It is also an object of this invention to provide for assembling a pair of reed switches in predetermined rotational relation with a common permanent magnet disposed therebetween for effecting selective rotation of at least one of the switches to match the operating times of the switches.

Yet another object of the invention is to provide for removably assembling a pair of reed switches and a common biasing magnet in a tetrafluoroethylene resin bobbin having an operating winding thereon, so that the switches may be rotationally positioned in the bobbin to match their operating times, and inserting a measured quantity of an epoxy resin into the bobbin to secure the switches and magnets together in fixed relationship and permit them to be removed as a unit from the bobbin.

Yet another important object of the present invention is to provide for positioning a pair of reed switches in a common operating winding with a permanent biasing magnet therebetween, periodically pulsing the operating winding and alternately connecting the reed switches to an oscilloscope having a trace of the operating current thereon, and rotating at least one of the switches about its longitudinal axis to vary the biasing effect thereon of the magnet so that identical operating times may be achieved.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is an enlarged, partially exploded and partially sectioned plan view of a reed switch module embodying the invention in one of its forms;

FIG. 2 is a cross-sectional view taken along the line of 2-2 of FIG. 1;

FIG. 3 is a schematic sectional representation of a reed switch module showing the initial orientation of the reed switches relative to the permanent magnet;

FIG. 4 shows curves illustrating the rise time of the operating current and the trace of the current being interrupted by one of the reed switches;

FIG. 5 is a schematic diagram illustrating a typical setup for calibrating a pair of reed switches in accordance with the teachings of the invention; and

FIG. 6 shows curves illustrating the waveform of the pulses applied to the operating winding.

Referring particularly to FIGS. 1 and 2, the reference numeral 10 may denote generally a reed switch module which comprises a pair of glass-sealed reed devices 11a-11b, each such reed device having switch contact reeds 14 and 15 sealed in tubular glass envelopes 12 and extending longitudinally thereof so as to have overlapping contact areas 17 and 18 initially defining an air gap therebetween and disposed to be deflected to engage each other. The contact reeds may be formed of any suitable magnetic material of a high electrical conductivity, such as Carpenter type 52 nickel iron wire of approximately 51% nickel and 48.85% iron, and are generally made from a flat member so as to provide for magnetic deflection in a flatwise direction. The contact

reeds extends endwise from the envelopes to provide terminal extensions 21 at the ends.

The two reed switches 11 are arranged in spaced apart, side-by-side relation and have a common permanent magnet 24 disposed therebetween intermediate the ends for the purpose of biasing the contacts 14 and 15 together to provide either a normally closed switch with the contact areas 17 and 18 touching, or a predetermined biasing effect with the contacts 14 and 15 biased toward each other a predetermined amount for controlling the operating time of the switch. The switches 11a-11b and the magnet 24 are shown as secured together by means of an adhesive such as, for example, a quantity of epoxy resin 25.

Since a module or package comprising a pair of reed switches 11 and a common permanent magnet 24 often has applications where it is desirable to have identical operating times for both of the reed switches, it is the purpose of this invention to provide for calibrating or matching a pair of switches in conjunction with a common biasing magnet to provide such a matched pair of reed switches. While such a module or package of a pair of reed switches may be disposed in any suitable type of operating windings, in use, such a pair of reed switches is herein disclosed as disposed in a spool type bobbin 26, comprising a central hub portion 28 which, as shown particularly in FIG. 2, comprises generally a flattened oval section which is arranged to receive the pair of reed switches 11a-11b and the permanent magnet 24 with a minimum of clearance thereabout, and locate them in substantially fixed relation with each other. The hub 28 is provided with flanged ends 30 and 32 for receiving an operating winding 34. The flanged ends may be recessed as at 36 to receive end caps 38 having a central hub portion 40 disposed to fit closely between the envelope 12 of the reed switches 11a-11b and engage opposite ends of the permanent magnet 24 so as to retain the reed switches and permanent magnet in substantially fixed spaced relation within the bobbin. The boss portion 40 of the bobbin is provided with a flanged end portion 42 having dish recesses 44 to receive the end portions of the reed switches 11a-11b and provided with openings 45 to permit the terminal connections 21 and 22 to pass therethrough. A central axial opening 47 is provided in at least one of the end plugs 38 to permit the entry of a cementitious material such as an epoxy resin for securing the reed switches 11a-11b and permanent magnet 24 together in fixed relation when the desired operating characteristics are achieved. The flange 42 of the end plug 38 is shown having an outer flanged portion 48 disposed to seat against the outer surface of the end flange 30 of the bobbin. This outer flange portion may be omitted if desired, since the inner flange portion 42 seats in the recess 36 to secure the end plug in the proper position.

In order to provide for matching the operating characteristics of the pair of reed switches 11, they may be initially positioned within the bobbin 26 and substantially the relationship is shown in FIG. 3. As shown, the reed switches are so oriented relative to the permanent magnet 24 that the two air gaps 20 between the overlapping contact areas are initially substantially coplanar and are on opposite sides of the permanent magnet 24 with the overlapping portions 17 and 18 of the reed switches substantially horizontal. The operating winding 34 is connected as shown in FIG. 5 by means such as mercury relays 50 and 52 so as to be alternately connected to an adjustable source of D.C. voltage 54 for providing positive pulse electrical energy as shown by curve *a* of FIG. 6 through the operating winding in a direction to aid the flux of permanent magnet 24 for effecting release of the contact reeds 14 and 15, and to an adjustable source of D.C. voltage 56 for applying variable amplitude reverse pulse *b* for effecting demagnetization of permanent magnet 24, if necessary.

This operation of the relays 50 and 52 may be effected by connecting them to a pair of pulse generators 58 and 60 which may be connected to a waveform generator 62 so as to be driven in synchronism for producing positive and negative pulses of timed duration as shown in FIG. 6. By connecting the contacts 14 and 15 of the reed switches through resistors 64, 66 and D.C. source means such as the batteries 67 and 68, the switching time of the reed switches may be observed on an oscilloscope 70. The oscilloscope may be of the dual trace type having upper and lower beam terminals 77-76 and is connected to have its trigger terminal T connected to one terminal of the operating winding 34 as at terminal 72. Either an operating coil current trace connection may be made from a terminal 74 intermediate the operating winding and a resistor 75 to one beam terminal 76 of the oscilloscope, and a reed switch current trace connection such as at terminal 78 may be connected to the other beam terminal 77. The reed switches may be simultaneously connected at terminals 78 and 80 to the oscilloscope beam terminals 77 and 76 for observing the relative opening times of the contacts. Selective connection to the reed switches for displaying their current traces on a dual trace oscilloscope may be made by means such as a pair of tongs or tweezers 82, which may be utilized to both provide a ground connection as at 83 for either both or one of the other of the reed switches, and at the same time may be used to effect rotational manipulation of the particular reed switch relative to the permanent magnet for the purpose of changing the biasing effects of the permanent magnet on the contacts of the reed switch being so adjusted. Simultaneous connection of both reed switches can be used if a four trace oscilloscope is used.

In operation, the reed switches 11 (designated 11a and 11b for purposes of identification) and the magnet 24 are inserted in the bobbin 26, and the end plugs are inserted so that terminals 21, project through openings 45, maintaining the rotational relationship shown in FIG. 3. The operating winding 34 is then connected as shown in FIG. 5 so that the positive pulse from the source 54 produces a magnetic field which is in the same direction as the magnetic flux of permanent magnet 24. The potentiometer 55 is then adjusted to set the operating winding current at a predetermined value. In the present instance, with a winding having 1800 turns of #36 wire, a current of 41 milliamperes was found to be satisfactory. The oscilloscope may be set at 100 microseconds per division of horizontal deflection and the operating pulse from the source 54 is applied to check the reed switches for operation. This operation may be performed with the terminals 78 and 80 of the two switches 11a-11b connected to the two beam terminals of the oscilloscope 77 and 76 and the tongs 82 alternately connected to the terminal 21 of first one switch and then the other. The oscilloscope connections may then be changed to connect the terminal 74 of the operating winding to oscilloscope beam terminal 76 to provide a current trace, and to leave the slower of the two switches 11a and 11b connected to oscilloscope terminal 77. The amplitude of the negative demagnetizing pulses may then be adjusted by varying the potentiometer 57 to increase the value of the negative or demagnetizing pulses until the operating time of the slower of the reed switches is on the order of 900-1,000 microseconds.

Next, the terminal 74 is disconnected and terminal 80 of the other reed switch is connected to oscilloscope terminal 76. Assuming reed switch 11a operating time is less than the operating time of the reed switch 11b, and that reed switch 11b is operating at 900-1,000 microseconds, the rotational position of reed switch No. 11a is then adjusted to increase the bias effect of magnet 24 and slow down the operating time of switch 11a by rotating the reed switch either clockwise or counterclockwise until the operating time of reed switch 11a approximates the operating time of reed switch 11b. This opera-

tion may be performed with the reed switches both connected to the oscilloscope and by selectively transferring the tweezers 82 from the terminal of reed switch 11a to reed switch 11b. When the operating time of reed switch 11a is within 50 microseconds of the operating time of reed switch 11b, this can be considered as within the desired operating range.

One reed switch, for example 11b, may be now disconnected from the oscilloscope and the current connection from terminal 74 returned to the other beam terminal, for example, terminal 76 of the oscilloscope, tweezers 82 being connected to the terminal of the reed switch 11a which remains connected to the oscilloscope. The demagnetizing pulses may now be increased by further operating the potentiometer 57 until the operating time of the reed switch 11a substantially coincides with the desired operating point on the current curve *c* of FIG. 4, for example. This point is achieved when the vertical portion of the current through the reed switch represented by the curve *d* intersects the trace *c* of the current in the operating winding. When the desired operating point is reached, a quantity of any suitable adhesive, for example an epoxy resin, such as ¹ Hysol 2002 resin, together with a catalyst XH-20721, may be injected into the bobbin by means of a hypodermic through the axial opening 47 to secure the reed switches 11a-11b and permanent magnet together. The resin may be cured by baking at 230 degrees for 15 minutes whereupon the assembly of the pair of matched reed switches 11a-11b and the common permanent magnet 24 may be either left in the bobbin and used in the bobbin as an operating entity, or may be removed from the bobbin to provide a matched reed switch module in which each of the switches requires substantially the same number of ampere turns to operate it.

While the invention has been described with particular reference to normally closed reed switches, it will be realized that normally open switches may likewise be matched, as also may combinations of normally open and normally closed switches in the same manner.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A method of calibrating the operate time of a reed switch having a pair of contact reeds mounted at respective ends of a tubular envelope and extending longitudinally of the axis of the envelope so as to present overlapping contact areas which define a gap therebetween comprising,

- (a) locating the reed switch within an operating winding,
- (b) positioning a bar permanent magnet in side-by-side relation with the reed switch within the operating winding to pass magnetic flux through the contacts to bias the contacts together,
- (c) orienting the reed switch relative to the magnet so that the magnet is transversely disposed of the air gap,
- (d) applying operating pulses to the operating winding to overcome the biasing effects of the permanent magnet,
- (e) rotating the reed switch about its longitudinal axis to different positions relative to the magnet to vary the biasing effect of the magnet on the contacts to obtain a predetermined operating time in one of said positions, and
- (f) applying a resinous material to the envelope and magnet in position to secure them in said one position.

2. In a method of calibrating the operating time of a reed switch having a pair of magnetically deflectable reeds mounted at respective ends of a tubular envelope and ex-

tending longitudinally thereof so as to present overlapping contact areas normally defining an air gap therebetween the steps comprising,

- (a) positioning the reed switch within an operating winding,
- (b) disposing a contact biasing permanent magnet alongside said envelope to one side of the air gap,
- (c) periodically energizing the operating winding at a predetermined level to overcome the bias effect of the magnet and at a variable level to demagnetize said magnet and reduce the bias effect of the magnet to effect operation of the switch within a predetermined range of operating times,
- (d) rotatably adjusting the envelope about its longitudinal axis to finalize the bias effect of the magnet and obtain the desired operating switch time, and
- (e) securing the reed and magnet together in the finalized position before removal from the operating winding.

3. A method of matching the operating times of a pair of reed switches each comprising an elongated tubular envelope having a pair of magnetically deflectable reed contacts mounted at respective ends of the envelope and extending longitudinally thereof to present overlapping contact areas, said reed switches having a common elongated permanent magnet disposed in side-by-side relation between said envelopes comprising steps of,

- (a) positioning the reed switches in a common energizing winding in side-by-side relation with the permanent magnet between them,
- (b) applying operating pulses of a predetermined value to said winding,
- (c) rotatably adjusting at least one of the switches about its longitudinal axis to different rotational positions to vary the bias effect of the magnet thereon and cause its operating time to change in a direction to approach the operating time of the other switch, and
- (d) securing the envelope and magnet in fixed relation by applying a cementitious material thereto.

4. In a method of matching the operating times of a pair of reed switches each of which comprises a tubular envelope having a pair of magnetically deflectable contact reeds mounted therein at respective ends of the envelope and extending longitudinally thereof so as to present overlapping contact areas, said switches being disposed in side-by-side spaced apart relation with a permanent magnet therebetween for biasing the contacts together the steps comprising,

- (a) positioning the switches and permanent magnet in a common operating winding with the switches both so oriented that the magnet is located opposite the edges of the two air gaps,
- (b) applying pulses of electrical energy to the winding to effect opening of the contacts,
- (c) determining the faster one of the switches,
- (d) rotating said faster switch about its longitudinal axis to increase the bias effect of the magnet on such switch and decrease its operating time to more nearly match operation of the switches and,
- (e) applying an adhesive to the magnet and envelopes to secure the switches and magnet together to maintain such operation.

5. In a method of matching the operating times of a pair of reed switches each having an elongated envelope with a pair of magnetically deflectable reed contacts mounted at respective ends of said envelope and extending longitudinally thereof so as to present overlapping contact areas, said switches being disposed in side-by-side relation with a permanent magnet therebetween to bias the contacts closed, the steps comprising

- (a) locating the switches and magnet in a common operating winding with the switches oriented so that the contact areas of the switches are substantially coplanar,

¹ Registered trademark of Houghton Laboratories, Inc.

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- (b) applying pulses of electrical energy of opposite polarities to the winding to operate the switches and demagnetize the magnet.
- (c) increasing the demagnetizing pulses until the slower of the switches operates in a predetermined interval of time, 5
- (d) rotating the other one of the switches about its longitudinal axis to a position to increase the bias effect of the magnet on said other switch and decrease its operating time to match that of the slower one, and 10
- (e) applying epoxy resin to the magnet and envelopes to secure them together in such relative positions.
- 6. In a method for matching the operating times of a pair of reed switches each having a tubular envelope with magnetically deflectable reed contacts supported therein at respective ends and extending longitudinally thereof to present overlapping contact areas, said switches having a common permanent magnet therebetween for biasing the contacts together, the steps comprising, 15
 - (a) placing the reed switches in side-by-side spaced apart relation in a common operating winding,
 - (b) orienting the reed switches about their longitudinal areas so that the contact areas are coplanar with the permanent magnet between, 20
 - (c) applying alternately to the operating winding pulses of electrical energy of opposite polarity to respectively operate the switches and effect demagnetization of the magnet, 25

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- (d) increasing the demagnetizing pulses in value until the operate time of the slower of the switches approximates a predetermined time range,
- (e) rotatably adjusting the other of the switches about its longitudinal axis to increase the effect of the bias and slow down the operating time of said other switch to match said slower one,
- (f) altering the value of the demagnetizing pulses to make the operating times of both switches approximate a desired value in said range,
- (g) applying a measured amount of an epoxy resin to secure both switches and the magnet in fixed relation to each other and provide an integrated assembly, and
- (h) removing the integrated assembly of both switches and magnet from the operating winding.

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