Dec. 14, 1965 R. H. MARKS 3,222,758

METHOD OF MAKING A SWITCHING ASSEMBLY

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Fig. 1

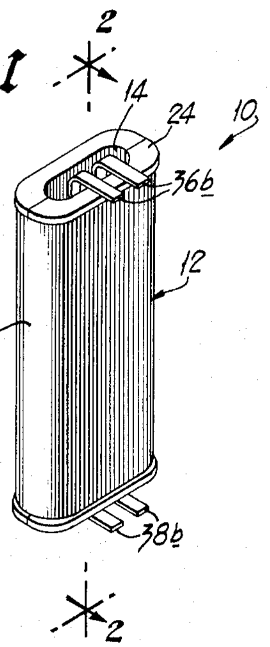


Fig. 2

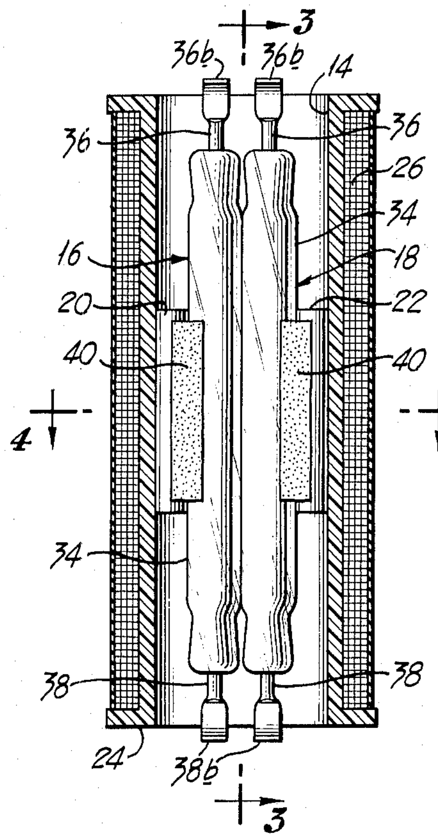
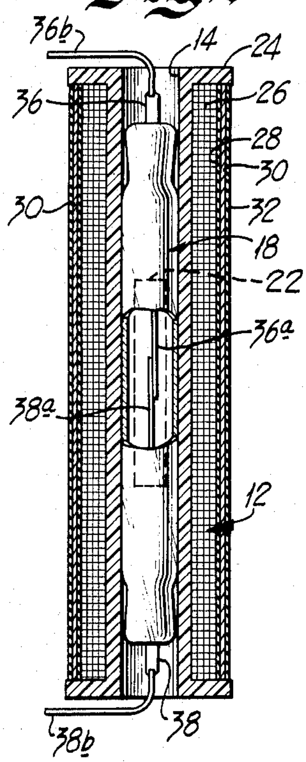


Fig. 3



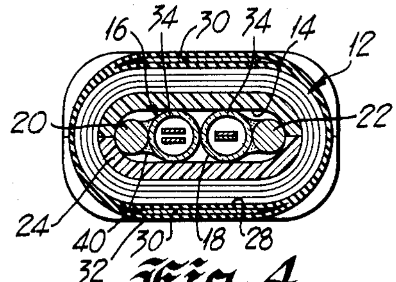


Fig. 4

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METHOD OF MAKING A SWITCHING ASSEMBLY

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This invention relates to a switching assembly and, more particularly, to a new and improved switching assembly using sealed switch units.

With the increased use of individual sealed switch units or capsules to perform switching functions previously performed by conventional telephone type relays, it is often desirable to have arrangements or assemblies including a plurality of individual sealed switch capsules that provide the same contact types or switching functions as telephone relays. One common type of switching arrangement is a nonbridging trasfer or form C contact assembly in which a pair of normally closed contacts are opened before a pair of normally open contacts are closed when the relay is operated . Another arrangement is a bridging (make-before-break) or form D contact assembly in which the operation of the relay closes the normally open contacts prior to the opening of the normally closed contacts. In certain relays, the contacts are selectively operated in dependence upon the polarity of the input voltage or signal.

In the past, form C contact assemblies using sealed switch capsules have been provided by using an unbiased switch unit paired with a switch capsule having a bias magnet that normally holds the biased switch unit in an operated condition. When a magnetic field of the proper polarity is applied,the unbiased switch capsule is operated and the bias capsule is released. However, this arrangement cannot be used to provide either form C or form D contacts and is not capable of providing either a chopper driven by a sinusoidal input voltage or a bistable or latching relay capable of operating on relatively short input pulses.

Accordingly, one object of the present invention is to provide a new and improved switching assembly.

Another object is to provide a switching assembly providing either bridging or nonbridging transfer contacts.

Another object is to provide a switching assembly that can be used as a chopper driven by a sinusoidal input voltage or a bistable or latching relay capable of operating on short duration input pulses.

A further object is to provide a switching assembly including a pair of sealed switch units that are provided with common operating means and individual and oppositely poled biasing means to provide either form D contacts or form C contacts.

Another object is to provide a switching assembly including a pair of sealed switch units that are provided with relatively heavy and oppositely directed biases to provide form D contacts or with relative light and oppositely directed biases to provide form C contacts.

Another object is to provide a method of making switching assemblies having either bridging or nonbridging contacts.

In accordance with these and many other objects, an embodiment of the invention comprises a common winding means having an axially extending opening in which are disposed a pair of sealed switch units or capsules. Each of the sealed switch units includes a pair of magnetic elements which are moved into engagement in response to the application of a magentic field of a first value or strength and which are held in engaged position until the applied magnetic field drops to a second or release value or strength less than the first strength. Each of the

sealed switch units is provided with an individual bias magnet, and the bias fields for the two switch units are oppositely directed. The strength of the bias field provided by each of the bias magnets is in the range between the first and second values, and one of the sealed switch units is operated in the normal condition of the switching assembly.

When the switching assembly is to provide form C or nonbridging transfer contacts, the strength of the bias magnets is adjusted so as to fall closer to the first strength than the second strength. When an input signal of a proper polarity is applied to the common winding means so as to oppose the field produced by the bias magnet associated with the normally operated switch unit, the effective field acting on the engaged magnetic elements is first reduced to a strength below the second strength so that these contacts open. A subsequent increase in the flux field produced by the energization of the operating winding then closes the normally open contacts so that the normally open contacts are closed following the opening of the normally closed contacts to provide form C contacts.

When the switching assembly is to provide bridging or form D contacts, the strength of the field provided by the bias magnets is increased in the range between the first and second strengths to be closer to the second strength. When the winding means is energized with a signal of a polarity to oppose the field of the bias magnet associated with the normally closed magnetic contacts, the effective field acting on the normally open contacts first reaches the first strength so that the normally open contacts are closed and, thereafter, the bias field applied to the normally closed contacts is overcome to open these contacts. Thus, the normally open contacts are first closed followed by the opening of the normally closed contacts to provide form D contacts. Since both of the bias magnets provide fields exceeding the second strength in both form C and form D contact assemblies, the switching assembly remains in the condition to which it was operated when the energizing signal is removed. An oppositely poled input signal returns the switching assembly to its original condition.

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawings, in which:

FIG. 1 is a perspective view of a switching assembly embodying the present invention;

FIG. 2 is an enlarged sectional view taken along line 2—2 in FIG. 1;

FIG. 3 is a sectional view taken along line 3—3 in FIG. 2; and

FIG. 4 is a sectional view taken along line 4—4 in FIG. 2.

Referring now more specifically to the drawings, therein is illustrated a switching assembly, indicated generally as **10**, which embodies the present invention and which includes a winding means **12** defining an axially extending opening **14** in which are disposed two sealed switch units **16** and **18**. A pair of permanent magnets **20** and **22** are individually disposed adjacent the sealed switch units **16** and **18** and provide oppositely directed biasing fields for the magnetic elements in the switch units **16** and **18**. By adjusting the magnitude or strength of the fields provided by the biasing magnets **20** and **22**, the sealed switch capsules **16** and **18** can be made to provide form C or form D switching functions when the common winding means **12** is energized. These magnets make the switching assembly **10** bistable so as to provide a latching relay capable of operating on short pulses and also render the switching assembly capable of providing a chopper driven by a sinusoidal input signal.

The winding means **12** includes a coil bobbin **24** which defines the axially extending opening **14** and on which a winding **26** is disposed. The outer surface of the winding **26** is covered by a dielectric layer **28** (FIGS. 3 and 4). A pair of magnetic plates **30** are disposed on opposite sides of the winding **26** along the flat sides thereof to provide a magnetic return path for the flux or magnetic field generated by the energization of the coil or winding **26**. The magnetic plates **30** are held in place by an outer layer of dielectric material **32**.

The sealed switch units **16** and **18**, which are disposed in the axial opening **14**, can be of any of the well known constructions, such as a "dry type" switch or a "mercury wetted" switch. The switch units **16** and **18** illustrated in the drawings are identical and are of the "dry type" in including an elongated dielectric or glass envelope **34** in which are disposed a pair of magnetic elements **36** and **38**. The inner ends **36*a*** and **38*a*** of the magnetic elements **36** and **38** overlap and are normally maintained in a spaced relation to define a gap. When a magnetic field of a first strength or value is applied to the magnetic elements **36** and **38**, the overlapping portions **36*a*** and **38*a*** move into engagement to complete an electric circuit through the switch unit **16** or **18**. The switch units **16** and **18** also have the characteristic that once the magnetic elements **36** and **38** have been moved into engagement, they can be retained in this condition by the application of a magnetic or flux field of a second value or strength substantially less than that of the field required to move these elements into engagement.

In one switching assembly **10** manufactured in accordance with the present invention, the magnetic elements **36** and **38** are moved into engagement by a magnetic field having a strength of 100 ± 15 ampere-turns and released when the applied magnetic field is reduced to a strength of 30 ± 10 ampere-turns. The switch units **16** and **18** can be provided with bent or offset end portions **36*b*** and **38*b*** on the magnetic elements **36** and **38**. These bent portions can provide means for electrically connecting the switch units **16** and **18** to a printed circuit pattern and means for physically mounting the switching assembly **10** on the printed circuit panel.

The permanent magnets **20** and **22** provide means for biasing the sealed switch units **16** and **18** with magnetic fields having strengths falling between the first value at which these switches are operated and the second or lower value at which the switches are released. This bias renders the switching assembly **10** capable of remaining in the condition to which it was operated by a prior input signal, i.e., bistable, and provides means by which the adjustment of the strengths of the fields of the magnets **20** and **22** within the range controls the switching units **16** and **18** to provide either bridging or nonbridging assemblies. The permanent magnets **20** and **22** are secured to the housings or envelopes **34** of the switch units **16** and **18** in proximity to the gaps defined by the overlapping ends **36*a*** and **38*a*** of the magnetic elements **36** and **38** by a quantity of epoxy resin cement **40**. The switch capsules **16** and **18** are disposed within the axial opening **14** with the permanent magnets **20** and **22** spaced from each other so as to reduce magnetic interaction between the permanent magnet **20** and the switch unit **18** and between the permanent magnet **22** and the switch unit **16**. These magnets are also disposed so as to lie substantially within a plane passing through the gaps defined by the overlapping portions **36*a*** and **38*a*** of the magnetic elements **36** and **38** (FIG. 4).

In one method of making the switching assembly **10**, the permanent magnets **20** and **22** are first mounted on the dielectric envelopes **34** of the switch units **16** and **18**, and a single one of these switch units is placed in a test fixture in which the connected permanent magnet **20** or **22** is saturated. A winding forming a portion of the test fixture is then energized to reduce the strength of the field provided by the bias magnet **20** or **22** to the point at which the desired operating characteristics are obtained. If the sealed switches **16** and **18** are to be used in an arrangement providing form C contacts, the strength of the permanent magnet **20** or **22** is reduced to a point at which it provides a bias of a strength closer to the second value, for instance 45 ampere-turns. Alternatively, if the switch units **16** and **18** are to be used in an arrangement providing for D contacts, the strength of the bias field provided by the magnet **20** or **22** is reduced to a value closer to the first value, for instance 75 ampere-turns. A pair of switches **16** and **18** having substantially identical operating characteristics are then assembled with the winding means **12**.

Another method of forming the switching assembly **10** is to insert a pair of switches **16** and **18** within the axial opening **14** in the winding means **12** with the permanent magnets **20** and **22** secured in position thereon. The magnets **20** and **22**, which are saturated prior to insertion into the winding means **12**, are then simultaneously demagnetized to reduce their field to a value between the operate (first) and release (second) values and located closer to either the operate or release values in dependence on whether form D or form C contacts are desired.

In the normal condition of the switching assembly **10**, one of the switch units **16** or **18** is in an operated condition in which the magnetic elements **36** and **38** are in engagement, and the other of the switch units **16** or **18** is in a normal condition in which a gap is provided between the overlapping ends **36*a*** and **38*a*** of the magnetic elements **36** and **38**. In FIG. 4 of the drawings, the switch unit **16** is shown in a normal or open condition, and the switch unit **18** is shown in an operated or closed condition. Assuming that the assembly **10** provides form C contacts with the permanent magnets **20** and **22** providing fields of strengths around 45 ampere-turns, the winding **26** is energized with an input signal of a polarity such that the induced flux field opposes the field provided by the bias magnet **22** on the normally closed switch unit **18** and aids the field of the magnet **20** associated with the normally open switch unit **16**. When the field due to the energized winding **26** has increased to a value around 15 ampere-turns, the effective field applied to the magnetic elements **36** and **38** in the switch unit **16** is only 60 ampere-turns, and these contacts do not close.

However, the 15 ampere-turn field provided by the energized winding **26** opposes the 45 ampere-turn bias provided by the magnet **22** and reduces the effective field applied to the magnetic elements **36** and **38** in the normally closed switch unit **18** to around 30 ampere-turns. In this range, the inherent resilience of the magnetic elements **36** and **38** in the switch unit **18** is effective to separate these elements so that the normally closed contacts provided by this switch unit are opened. As the magnetic field produced by the energization of the winding **26** increases, the effective field acting on the elements **36** and **38** in the switch unit **16** produced by the addition of the induced field from the energized winding **26** and the bias field provided by the permanent magnet **20** reaches the range of 100 ampere-turns. At this time, the magnetic elements **36** and **38** in the normal switch unit **16** are moved into engagement to complete a conductive circuit therethrough. Accordingly, the switching assembly **10** provides form C contacts in which the normally closed contacts in the switch unit **18** are opened prior to the closure of the contacts provided by the switch unit **16**.

The switching assembly **10** remains in this condition with the contacts in the unit **16** closed and the contacts in the unit **18** open when the energizing signal is removed from the winding **26** because the 45 ampere-turn bias provided by the magnets **20** and **22** exceeds the release range of around 30 ampere-turns. When a signal of reversed polarity is applied to the winding **26**, the contacts **16** are opened prior to the closure of the contacts **18** in the manner described above.

Assuming that the permanent magnets **20** and **22** provide a bias of around 75 ampere-turns, the switching assembly **10** provides form D contacts. The energization of the winding **26** with an input signal of a polarity producing a field opposing that of the bias magnet **22** associated with the normally operated switch **18** provides a field aiding the bias field from the magnet **20**. When the induced field reaches a value of approximately 25 ampere-turns, the effective field applied to the elements **36** and **38** in the normally open switch unit **16** is around 100 ampere-turns, and the magnetic elements **36** and **38** in this switch unit move into engagement to complete a conductive circuit therethrough. As the induced field due to the energization of the winding **26** increases to approximately 45 ampere-turns, the effective field applied to the magnetic elements **36** and **38** in the operated switch unit **18** is reduced to around 30 ampere-turns, and the inherent resilience of these elements moves them out of engagement so that the contacts in the switch unit **18** are opened. Thus, the energization of the winding **26** first closes the contacts in the open switch unit **16** and then opens the normally closed contacts in the switch unit **18** to provide form D contacts. The switching assembly **10**, when providing form D contacts, is also bistable inasmuch as the bias of 75 ampere-turns provided by the magnets **20** and **22** exceeds the release value of 30 ampere-turns. Accordingly, when the energizing signal is removed from the winding **26**, the contacts in the switch unit **16** remain closed and the contacts in the switch unit **18** remain in an opened condition. The switch units **16** and **18** are restored to their alternate condition by the application of an energizing signal of reversed polarity to the winding **26**.

Although the present invention has been described with reference to a single illustrative embodiment thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method of making switching assemblies using sealed switch units that are operated by the application of a field of a first strength and are released when the applied field drops to a second strength less than said first strength, which method comprises the steps of disposing magnetically saturated permanent magnets of opposite polarities adjacent a pair of the sealed switch units, and adjusting the strengths of the fields of said permanent magnets to fall in the range between said first and second strengths and closer to said first strength than said second strength.

2. A method of making switching assemblies using sealed switch units that are operated by the application of a field of a first strength and are released when the applied field drops to a second strength less than said first strength, which method comprises the steps of disposing magnetically saturated permanent magnets of opposite polarities adjacent a pair of the sealed switch units, and adjusting the strengths of the fields of said permanent magnets to fall within the range between said first and seconds strengths and closer to said second strength than said first strength.

3. A method of making switching assemblies using a pair of sealed magnetic switches that operate in a first mode to provide transfer contacts and in a second mode to provide make-before-break contacts, the sealed magnetic switches having the characteristic of being operated by the application of a field of a first strength and being released when an applied field falls below a second strength, which method comprises applying permanent magnetic bias fields of opposite polarities to the pair of sealed magnetic switches, and selectively adjusting the strengths of both bias fields to have a value falling between the first and second strengths and closer to the second strength than the first strength when the switching assembly is to operate in the first mode and to have a value falling between the first and second strengths and closer to the first strength than the second strength when the switching assembly is to operate in the second mode.

4. A method of making switching assemblies using a pair of sealed magnetic switches that operate in a first mode to provide transfer contacts and in a second mode to provide make-before-break contacts, the sealed magnetic switches having the characteristic of being operated by the application of a field of a first strength and being released when an applied field falls below a second strength, which method comprises disposing a pair of permanent magnetic means adjacent the pair of sealed magnetic switches to apply magnetic bias fields of opposite polarities to the pair of switches, magnetically saturating the permanent magnetic means, and selectively reducing the strengths of both bias fields to have a value falling between the first and second strengths and closer to the second strength than the first strength when the switching assembly is to operate in the first mode and to have a value falling between the first and second strengths and closer to the first strength than the second strength when the switching assembly is to operate in the second mode.

5. A method of adjusting switching assemblies containing at least two sealed magnetic switches each biased by one of a pair of oppositely poled permanent magnetic means to operate in a first mode providing transfer contacts and in a second mode providing make-before-break contacts, the sealed magnetic switches having the characteristic of being operated by the application of a field of a first strength and being released when an applied field falls below a second strength, which method comprises magnetically saturating the permanent magnetic means, and selectively adjusting the strengths of the bias fields applied to the sealed magnetic switches by the permanent magnetic means to have a value falling between the first and second strengths and closer to the second strength than the first strength when the switching assembly is to operate in the first mode and to have a value falling between the first and second strengths and closer to the first strength than the second strength when the switching assembly is to operate in the second mode.

6. A method of making switching assemblies using a pair of sealed magnetic switches that operate in a first mode to provide transfer contacts and in a second mode to provide make-before-break contacts, the sealed magnetic switches having the characteristic of being operated by the application of a field of a first strength and being released when an applied field falls below a second strength, which method comprises applying permanent magnetic bias fields of opposite polarities to the pair of sealed magnetic switches, and selectively adjusting the strength of the bias field applied to each switch to have a value falling between the first and second strengths and closer to the second strength than the first strength when the switch is to operate in the first mode and to have a value falling between the first and second strengths and closer to the first strength than the second strength when the switch is to operate in the second mode.

7. A method of adjusting switching assemblies using a pair of sealed magnetic switches that operate in a first mode to provide transfer contacts and in a second mode to provide make-before-break contacts, the sealed magnetic switches having the characteristic of being operated by the application of a field having a strength on the order of 100 ampere-turns and being released when the strength of the applied field falls below a value on the order of 30 ampere-turns, which method comprises applying permanent magnetic bias fields of opposite polarities to the pair of sealed magnetic switches, and selectively adjusting the strengths of both bias fields to have a value on the order of 45 ampere-turns when the switching assembly is to operate in the first mode and to have a value on the order of 75 ampere-turns when the switching assembly is to operate in the second mode.

8. A method of adjusting switching assemblies using a pair of sealed magnetic switches to operate in a first mode providing transfer contacts and in a second mode providing make-before-break contacts, the sealed magnetic switches having the characteristic of being operated by the application of a field having a strength on the order of NI and being released when the applied field falls below a strength on the order of NI/3, which method comprises applying permanent magnetic bias fields of opposite polarities to the pair of sealed magnetic switches, and selectively adjusting the strengths of both bias fields to a value on the order of NI/2 to NI/2.5 when the switching assembly is to operate in the first mode and to have a

value on the order of NI/1.2 to NI/1.5 when the switching assembly is to operate in the second mode.

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