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METHOD OF ADJUSTING SEALED SWITCH RELAYS TO HAVE EQUAL DWELL ON FRONT AND BACK CONTACTS WHEN OPERATED WITH ALTERNATING CURRENT

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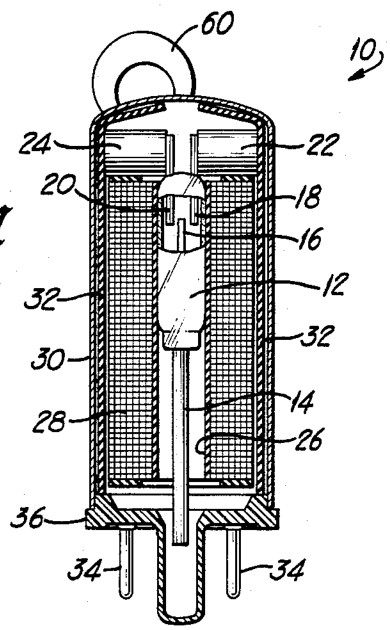
Fig. 1



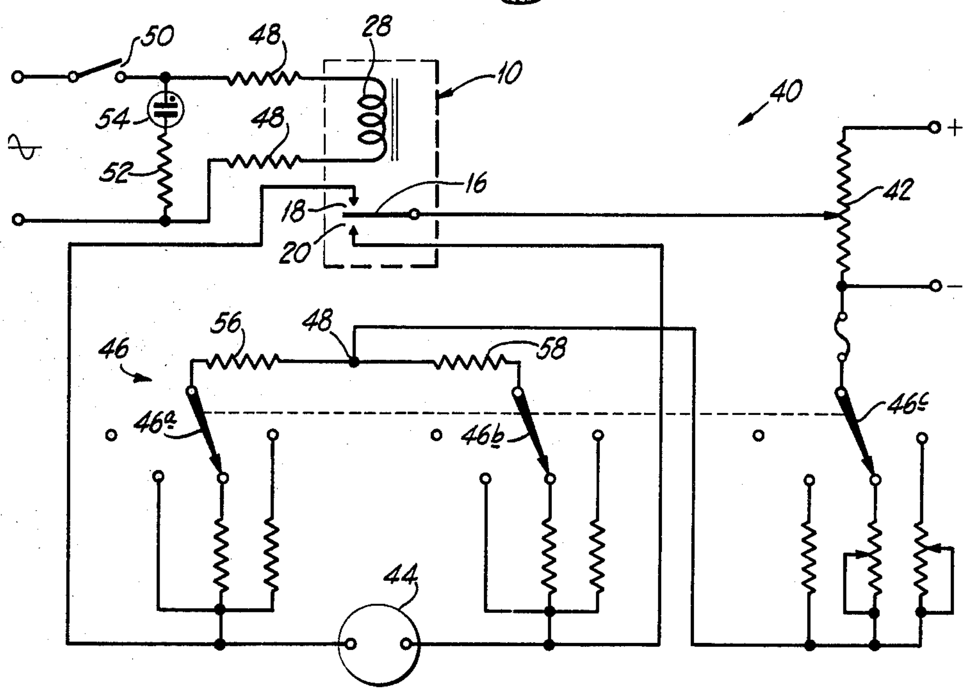


Fig. 2

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METHOD OF ADJUSTING SEALED SWITCH RELAYS TO HAVE EQUAL DWELL ON FRONT AND BACK CONTACTS WHEN OPERATED WITH ALTERNATING CURRENT

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This invention relates to a method of adjusting sealed magnetic switch relays and, more particularly, to a method of adjusting magnetic switch relays with balanced operating characteristics.

Relays constructed using sealed magnetic switches, such as those with mercury-wetted contacts, are frequently used as "choppers" and are quite suitable for use as line relays on telegraph signaling lines in place of the standard electromagnetic polar relays that are not only quite expensive but also require frequent manual adjustment during use. The mercury relay is less costly, requires less installation space, and possesses a uniformity of operating characteristics that obviates the need for manual adjustment. However, these applications commonly require the armature of the sealed magnetic switch to engage the alternately engaged contacts for equal periods of time when input signals of equal magnitude and duration and opposite polarity are applied to the relay winding.

Automatic test equipment is available for adjusting the direct current operating characteristics, such as the "operate" and "release" sensitivities, of these relays so that the magnetic switch is conditioned for balanced direct current operation. However, symmetrical direct current operating characteristics do not insure balanced operation with oppositely poled pulsating direct current pulses. In the worst case condition commonly used for test purposes, the direct current pulses are considered to be so degraded by line attenuation and phase shift as to be accurately represented by a test signal having a sinusoidal waveform. A sealed mercury-contact relay that is balanced for direct current operation almost always fails to follow a sinusoidal input signal with the fidelity necessary to provide balanced or equal dwell on the front and back contacts within the 3% deviation limits commonly encountered in this type of application. The lack of balance with a sinusoidal input as contrasted with a direct current pulse input is frequently due to small dissimilarities in the magnetic circuits of the switch and minute mechanical variations in the constructon and spacing of the armature and contacts. It is possible to establish pairs of "operate" and "release" sensitivities by trial and error that would not only satisfy direct current operating specifications but also provide balanced alternating current operation within the necessary tolerance range. However, this trial and error determination is extremely time consuming and would substantially increase the cost of the switch.

Accordingly, one object of the present invention is to provide new and improved means for adjusting sealed magnetic switch relays.

Another object is to provide a method of adjusting sealed magnetic switch relays for balanced operation.

A further object is to provide a method of making a balanced polar relay having both balanced alternating current operation and direct current sensitivities falling within a desired range.

Another object is to provide a method of adjusting sealed magnetic relay assemblies in which an adjustable external magnetic field is applied to a sealed magnetic switch to obtain balanced alternating current operation, the direct current operating sensitivities of the switch are measured in the presence of the externally applied magnetic field, the external field is removed, and the sealed switch is provided with the permanent magnetic bias necessary to produce the previously measured direct current sensitivities.

In accordance with these and many other objects, an embodiment of the present invention comprises a method for adjusting a sealed magnetic switch relay for balanced alternating current operation while retaining the "operate-release" sensitivities within a desired range. The magnetic switch to be adjusted can comprise a sealed elongated dielectric housing having a magnetic armature extending into one end with its free end disposed between a pair of magnetic terminals carried on the opposite end of the housing. The armature is without mechanical bias and center-stable disposed midway between the adjacent contacts. The sealed magnetic switch is disposed within the axial opening of an operating winding including one or more individual operating coils, and an individual bias magnet is provided for each of the terminals. The assembly of the bias magnets, the switch capsule, and the winding is disposed within a magnetic housing and connected to a header terminal closing the external housing.

The assembled relay is then placed in a relay adjusting or test set in which both of the biasing magnets are saturated and then "knocked down" in increments until the desired "operate" and "release" direct current sensitivities have been established. The relay is then removed from this test set and placed in a second alternating current test set in which the winding is energized with a sinusoidal input signal. The test circuit indicates whether the armature engages the alternate or front and back contacts for equal periods of time when energized with sinusoidal inputs of equal duration. Virtually all relays adjusted for desired direct current sensitivities will not provide balanced alternating current operation within the required tolerance level of 3% deviation or less.

A permanent magnet is then placed on the outer magnetic housing or can and moved to different positions until the output display of the test set indicates that an alternating current balance has been achieved by providing equal dwell on the two alternately engaged contacts. The relay construction with the permanent magnet still affixed to the outer housing is removed from the alternating current test set and returned to the first test set, and measurements are then made of the direct currents required to operate and release the switch with the additional or external magnetic field applied to the housing. When these measurements have been taken, the permanent magnet is removed from the housing, and the test set is operated to adjust the direct current "operate" and "release" sensitivities to the values previously measured. These values will fall within the specified range for the switch, and when the switch is transferred to the alternating current test set, this test set will indicate that the relay has also been adjusted for balanced alternating current operation.

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 sectional view illustrating a sealed magnetic switching assembly that can be adjusted by the method of the present invention; and

FIG. 2 is a schematic circuit diagram of an alternating current test circuit that can be used in performing the method of the present invention.

Referring now more specifically to FIG. 1 of the drawings, therein is illustrated a switching assembly indicated generally as **10** which is adapted to provide balanced alternating current operation while retaining direct current "operate" and "release" sensitivities within a desired range of values. The illustrated switching assembly **10** comprises a sealed mercury switch or switching assembly which can be of any of the known constructions, such as those shown in United States Patents Nos. 2,609,464 or 3,054,873. In general, the switching assembly **10** comprises a sealed dielectric or glass housing **12** from the lower end of which a magnetic terminal or header **14** extends. The header **14** provides a support for a movable magnetic armature **16** having an upper end that is disposed between and is adapted to alternately engage a pair of spaced magnetic terminals **18** and **20**. Each of the terminals **18** and **20** is provided with an individual permanent magnet **22** and **24** for applying a magnetic bias that controls the operating characteristics of the switching assembly **10**. The sealed magnetic switch is disposed within an axial opening **26** in an operating winding **28** that can include one or more separate operating coils. The assembled sealed switch and winding means are disposed within a metallic housing or can **30** with dielectric or insulating means **32** interposed therebetween to prevent the inadvertent extension of electrical connections from the magnetic switch to the housing **30**. If desired, the housing **30** can be filled with potting material, such as wax. Connections to the operating winding **28**, to the contacts **18** and **20**, and to the armature **16** are extended by terminals **34** in a plug base or closure **36** which closes the open end of the housing **30** to complete the assembly of the switching assembly **10**.

After the switching assembly **10** has been constructed, the magnetic bias applied by the permanent magnets **22** and **24** to the terminals **18** and **20** is adjusted so that the application of desired values of direct current to the winding **28** results in the alternate engagement of the contacts **18** and **20** by the armature **16** in dependence on the polarity of the input signals. To perform this operation, the switching assembly or relay **10** is connected to the relay adjusting test set shown and described in detail in United States Patent No. 2,806,186. In general, this test set operates by saturating the magnets **22** and **24** in a series magnetic circuit so that oppositely poled magnetic biases are applied to the terminals **18** and **20**. Two test set inputs are then adjusted to provide the "operate" and "release" sensitivities at which the switching assembly **10** should be operated by the alternately poled input signals applied to the winding **28**. The test set then incrementally demagnetizes the permanent magnets **22** and **24** alternately and in sequence until the application of the selected values of direct current of opposite polarity results in the transfer of the armature **16** between the magnetic terminals or contacts **18** and **20**. At this time, the switching assembly **10** has been adjusted to provide the desired direct current sensitivities or operating characteristics.

However, these direct current operating characteristics, even though balanced, do not result in balanced alternating current operation in virtually all instances because of the factors set forth in detail above. Accordingly, the switching assembly **10** must now be further or readjusted so that it provides not only direct current operating characteristics within the desired range but also an equal dwell on the armature **16** on the contacts **18** and **20** when input signals of opposite polarity and equal duration are applied to the winding **28**. As set forth above, the oppositely poled pulses applied to the operating winding **28** from an actuate signaling or telegraph line have been so degraded from the desired square wave, for instance, by line attenuation and phase shift, the switching assembly **10** must be checked for balanced operation by using a sinusoidal input signal representing the worst possible operating condition.

To determine the characteristics of the relay **10** under these conditions, the relay is connected to an alternating current test set **40** illustrated in FIG. 2 of the drawings.

In general, the test set **40** supplies a 60 cycle sinusoidal input signal to the winding **28** of the switching assembly **10**, and an indicating or output means displays the interval in which the armature **16** engages the opposite contacts **18** and **20** with this type of input signal.

When the switching assembly **10** is connected to the test circuit **40**, the armature **16** is connected to the tap on a potentiometer or a voltage divider **42**, the input terminals of which are connected to a suitable direct current potential source supplying a nominal 45 volts. The contacts **18** and **20** are connected to the opposite terminals of a galvanometer or percentage make-break meter **44**. These two terminals are also connected through a resistive network controlled by two wipers **46*a*** and **46*b*** of a selector switch **46** to a common point indicated as **48**. The common point **48** is returned to the other side of the potentiometer **42** through a resistive network and a third wiper **46*c*** of the switch **46**. When the switch **46** is in its left-hand position, the test circuit **40** is in an off condition. The wipers **46*a*–46*c*** of the switch **46** can be adjusted in a counterclockwise direction to three different settings representing, for instance, the 100%, 6% and 3% scale ranges on the meter or output indicator **44**.

To provide means for energizing the switch **10** to be adjusted, the operating winding **28** is connected to a source of alternating current potential through a pair of series resistance elements **48** and a normally open switch **50**. The winding **28** is shunted by a resistance element **52** and a neon lamp **54**. When the switch **50** is closed to energize the winding **28**, the lamp **54** is energized to provide a visible indication that the test circuit **40** is in operation.

When the switch **50** is closed to energize the winding **28**, the armature **16** alternately moves into engagement with the contacts **18** and **20** during the oppositely poled half cycles of the input alternating current signal. This alternately connects the potential supplied by the potentiometer **42** to the opposite terminals of the percentage make-break meter or galvanometer **44**. As an example, when the contacts **18** are closed, current flows through the contact engaged by the wiper **46*a*** and a resistance element **56** to the common point **48**. Current also flows from the contacts **18** through the meter **44**, the corresponding contact engaged by the wiper **46*b***, and a resistance element **58** to the common point **48**. During the next alternation of the input signal when the contacts **20** are closed, the direction of flow of current through the meter **44** is reversed. Thus, the meter **44** provides an indication of the relative periods of time during which the contacts **18** and **20** are engaged. When these two contacts are engaged equal periods of time, i.e. when the relay **10** is adjusted for balanced alternating current operation, the indicating needle in the meter **44** is not deflected to either the left or the right but remains in a center position representing equal dwell on the contacts **18** and **20**.

Assuming that the relay **10** under adjustment provides a deflection to either the left or the right of the center position on the meter **44**, the dwell of the armature **16** on either the contact **18** or the contacts **20** is too long. In accordance with one of the important facets of the present invention, the lack of symmetry or balance in alternating current operation is corrected by applying an external magnetic field in the vicinity of the terminals **18** and **20** and the permanent magnets **22** and **24** and varying the position of this magnetic field in virtually a random manner until such time as the meter **44** indicates that the relay **10** is operating in a balanced condition. As an example, a permanent magnet **60** is placed on the housing or can **30** (FIG. 1) and is moved around in any manner to any position until the display **44** indicates that the armature **16** has an equal dwell on both of the contacts **18** and **20**. Experience obtained by using this method on a production line indicates that this operation usually requires less than one minute. The external field provided by the permanent magnet **60** combines with the bias fields provided by the magnets **22** and **24** to adjust the operating characteristics of the switch **10**. If desired, a layer of plastic or soft material can be interposed between the surfaces of the permanent magnet **60** and the can **30** to avoid scratching the can **30**. When the permanent magnet **60**, which can comprise permanent magnetic material formed in a bar or any other suitable configuration, has been adjusted to the position in which the indicator **44** indicates that the armature **16** engages the contacts **18** and **20** for equal periods of time, the switch **50** is opened, and the switching assembly **10** is removed with the permanent magnet **60** remaining held in its adjusted position on the housing **30** by magnetic attraction.

The switching assembly **10** is then returned to the first test circuit, and the "operate" and "release" sensitivities of the switch **10** with the magnet **60** in position thereon are now determined by measurements. The magnet **60** is removed, and the automatic test set is adjusted to establish the "operate" and "release" sensitivities measured with the magnet **60** in place by changing the biases provided by the permanent magnets **22** and **24** in the manner described above. When the bias provided by the magnets **22** and **24** has been changed to provide the "operate" and "release" sensitivities previously measured before the removal of the permanent magnet **60**, the switching assembly **10** is conditioned for balanced alternating current operation with direct current sensitivities within the desired range.

This permits the switching assembly **10** to be used as a line relay on telegraph signaling lines and in "chopper" and other applications in which equal dwell on the front and back or make and break contacts is desirable. Sealed magnetic switch assemblies of the type described in the above-identified patents do not fall within a 3% deviation from perfect balance when adjusted to provide suitable direct current sensitivities in the usual manner and when operated by an alternating current signal. By the practice of the present invention, it has been found that virtually all of these switches can be adjusted to provide a deviation of less than ½ of 1% from perfect alternating current balance.

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 obtained by Letters Patent of the United States is:

1. A method of adjusting a relay including a sealed magnetic switch biased by permanent magnetic means for balanced alternating current operation in which an armature engages opposed contacts for equal time intervals, which method comprises measuring the alternating current operating characteristics of the relay to determine the time intervals that the opposed contacts are engaged, applying an adjustable external magnetic field to the magnetic switch to obtain baalnced operation, measuring the direct current energy required to operate the switch when the external magnetic field is applied, removing the external magnetic field, and adjusting the permanent magnetic means so that the switch operates with the measured direct current energy.

2. A method of adjusting a relay including a magnetic switch which is provided with a permanent magnet bias and which is enclosed in a magnetic housing, which method comprises operating the switch with an undulating potential to alternate conductive states, measuring the time intervals in which the switch is in its alternate conductive states while the switch is operated by the undulating potential, magnetically mounting a permanent magnet on the housing in an adjusted position in which the time intervals in which the switch is in its alternate conductive states have predetermined values, measuring the direct current energy required to obtain the time intervals of predetermined values with the permanent magnet mounted on the housing, removing the permanent magnet from the housing, and adjusting the permanent magnet bias so that the switch operates with the measured direct current energy.

3. A method of adjusting the armature for a magnetic switch to have an equal dwell on each of a pair of alternately engaged contacts which method comprises the steps of operating said switch so that the armature alternately engages the contacts, determining the interval each contact is engaged by the armature, applying an adjustable magnetic field to the switch to obtain an equal dwell on each contact, measuring the energy required to operate the switch when equal dwell has been obtained, removing the adjustable magnetic field, and applying a permanent magnetic bias to the magnetic switch in an amount to cause the switch to operate with the measured energy.

4. A method of adjusting a sealed magnetic switch including permanent magnet biasing means for operation to its alternate states for predetermined periods of time, which method comprises adjusting the permanent magnet bias to cause the switch to operate with direct current energization of a predetermined value, operating the switch to its alternate states with an undulating potential, measuring the periods that the switch is in its alternate states, applying an external magnetic field to the switch and biasing means to adjust the times that the switch is in its alternate states to the predetermined periods, measuring the direct current energization of the switch required to obtain the predetermined periods with the external magnetic field applied, removing the external field, and adjusting said predetermined value of the direct current energization to the direct current energization measured with the external magnetic field applied.

5. A method of adjusting the direct and alternating current operating characteristics of a relay including a sealed magnetic switch with contacts and a winding contained in an outer enclosure for controlling the contacts, which method comprises applying a magnetic bias to the switch to cause the contacts to be controlled by direct current energization of the winding at predetermined values, energizing the winding with an alternating current voltage, measuring the control over the contacts effected by the winding during the period in which the winding is energized by the alternate current voltage, temporarily altering the magnetic bias by the application of a magnetic field external to the housing to alter the response of the contacts to the alternating current energization of the winding, determining the new values of the direct current energization of the winding required to effect the altered contact response with the altered magnetic bias, removing the external magnetic field, and adjusting the magnetic bias to obtain the new values of direct current energization determined while the external magnetic field was applied.

No references cited.

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