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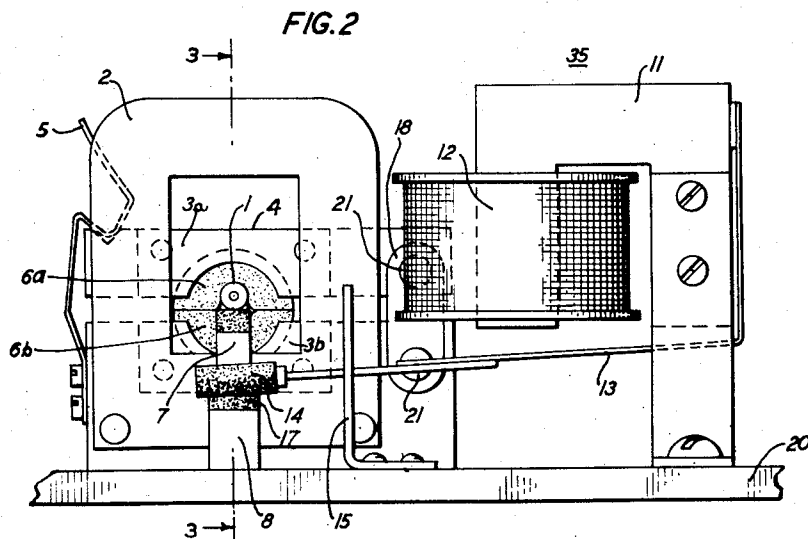
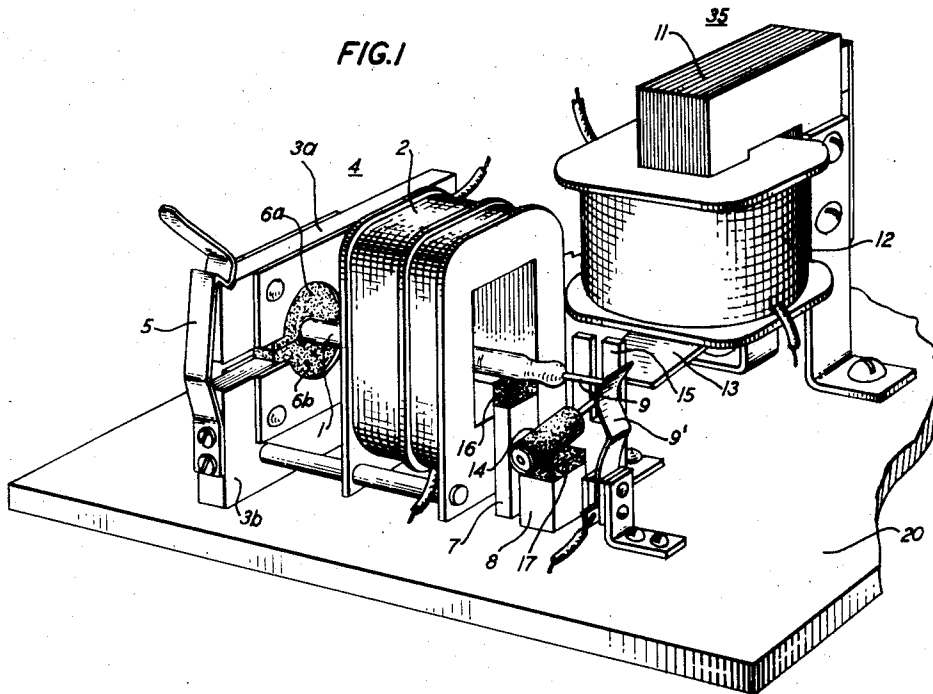
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2,855,017

DEVICE FOR ADJUSTING THE RELATIVE POSITION OF THE
CONTACTS IN A GLASS ENCLOSED CONTACT SWITCH

Filed Dec. 28, 1954

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

FIG. 3

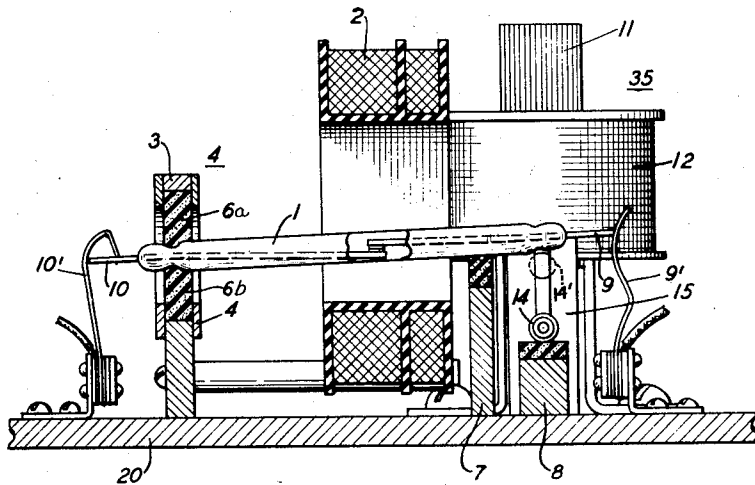
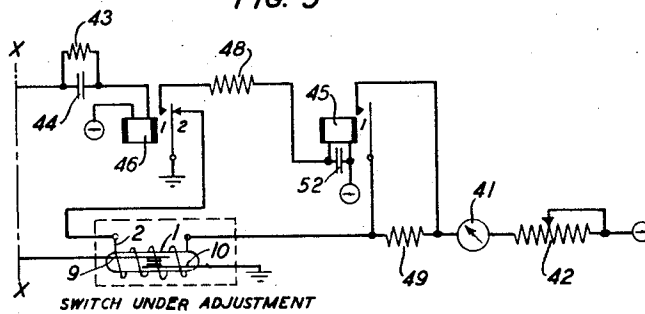


FIG. 5



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DEVICE FOR ADJUSTING THE RELATIVE POSITION OF THE CONTACTS IN A GLASS ENCLOSED CONTACT SWITCH

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7 Claims. (Cl. 153—39)

This invention relates to apparatus for adjusting the separation between resilient members, and more particularly to apparatus for adjusting one or more resilient members cooperating as switch electrodes in an enclosed vessel.

Heretofore, switches of the sealed or dry reed type have been adjusted in a number of ways, but none of these have proved entirely satisfactory from the standpoint of manufacturing simplicity.

Remembering that these types of switches comprise, in general, a pair of essentially parallel overlapping resilient members which are fixedly retained at their opposite ends by the enclosing vessel and whose overlapping portions form cooperating contact surfaces and that the enclosing vessel is ordinarily hermetically sealed under the vacuum or with a protective gas therein, it can be appreciated that adjusting apparatus in many cases has been integrated into the manufacturing operation. Fabrication of sealed reed switches under Bell jars, using tubular reeds, etc. have all proved complex, costly, and inappropriate for mass production techniques. And in all of these attempts to find the best answer, adjustment has had to precede the sealing operations for the reason that there appeared to be no practical apparatus for adjusting such switches after they were formed. Further, when switches had to be adjusted to meet a variety of operate or release conditions, the manufacturing phase had to be interrupted while the desired contact separation was reset. This dead time promoted inefficient use of manufacturing equipment and, as a result, increased costs.

The present invention, however, obviates these difficulties by providing adjustment which follows the manufacturing or forming of the switch. Thus, the sealed switches may be inexpensively fabricated with the contact surfaces of cooperating pairs of reeds in contact, for example, which will remove all of the complicated gears, chucks, etc. heretofore needed to accurately position cooperating reeds before sealing. Such a forming method will also eliminate discontinuities in the manufacturing operation due to resetting, etc.

Once the switch is formed with the contacts either closed or separated, and it does not matter which insofar as the use of applicant's operation is concerned, the invention may be easily utilized to adjust the separation between the reeds to any preselected value. And these prescribed values are easily interchangeable without seriously interrupting production line manufacturing operations nor adjusting line operations.

As a result of these and other advantages, hereinafter enumerated, resulting from the instant invention, an object of the invention is to provide apparatus for adjusting reed switches wherein the switch may be formed initially without accurately separating the reeds with respect to one another, thereby effecting a substantial saving in fabricating costs.

Another object of the invention is to simply and economically adjust reed switches,

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Yet another object of the invention is to automatically adjust magnetic reed separation of switches formed with the reeds in contact.

A further object of the invention is to provide apparatus and associated circuitry so that different types of reed switches may be easily adjusted without great changes in jigs, fixtures, etc.

A feature of the invention pertains to the utilization of means for permanently deforming at least one of the resilient members of a cooperating contact pair by stressing it beyond its elastic limit thereby obtaining proper contact separation.

Another feature of the invention pertains to the use of a power control circuit, an incremental voltage circuit, a test circuit, and an electromagnetic hammer, all of which cooperate to properly adjust a magnetic reed switch formed with its contact closed.

In accordance with another feature of the invention, the alternate striking of the switch with impact means and testing the switch for continuity when energized is repeated until a preselected contact separation is effected.

More particularly, a feature of the invention resides in the use of a power control circuit for defining the application of a variable source of alternating-current voltage, which voltage is supplied by an incremental voltage circuit, to an electromagnetic hammer and further, in the provision of means responsive to each release of the power control circuit to increase the magnitude of the voltage supplied by the incremental voltage circuit and to test the continuity of the switch under simulated operating conditions after each impact until continuity is permanently interrupted.

These and other objects and features may be more readily understood from the following detailed description when read with reference to the drawings in which:

Fig. 1 is a perspective view representing a preferred embodiment of the apparatus for adjusting a reed switch;

Fig. 2 is a right side view of the apparatus with certain parts removed;

Fig. 3 is a front cross sectional view of the apparatus taken through line 3—3 of Fig. 2;

Fig. 4 is a schematic representation of a preferred embodiment of the circuit for automatically adjusting reed switches to a preselected operate current value; and

Fig. 5 is a schematic representation of a circuit connectable to the adjusting circuit depicted in Fig. 4 at line X—X in lieu of the equivalent part of Fig. 4 when release current is to be used as a criteria for adjusting a reed switch instead of operate current.

Looking at the apparatus in detail, Figs. 1, 2 and 3 show the use of a frame or base plate 20 upon which are mounted two brackets 4 and 7 for supporting a conventional magnetic reed switch. The switch has a tubular glass envelope 1 and two essentially parallel resilient electrodes 9 and 10, one end of each extending from the opposite ends of the glass envelope 1 and their other ends overlapping within the envelope 1. One end of the switch merely rests upon a resilient bumper 16 which overlays support bracket 7; whereas, the other end of the switch is not only supported, but also clamped tightly in the bracket 4.

Support bracket 4 comprises upper and lower jaws 3a and 3b which are hinged at their rearward portion by flat hinges 18 connected to jaws 3a and 3b by screws 21. Within the jaws 3a and 3b are resilient inserts 6a and 6b which damp out any vibrations induced in the switch structure during adjustment. The outer ends of the jaws 3a and 3b may be locked together by a spring clamp 5. When the two jaws are locked together, the support bracket 4 holds the reed switch to be adjusted tightly in position as illustrated in Figs. 1, 2 and 3.

An electromagnet 35 comprising a core 11, a coil 12,

and an armature 13 is also fixedly mounted on base plate 20. Fixedly attached to the armature 13 of this electromagnet 35 is a rubber insulated hammer 14 which, whenever the electromagnet is not operated, rests upon a support block 8 covered by a resilient portion 17. The block 8 effectively acts as a backstop for armature 13. The proper positioning of this electromagnet 35 locates hammer extension 14 directly under the right end of reed switch 1 (when looking at Fig. 3). The hammer extension 14 is guided in a vertical plane by a slotted guide plate 15 also fixedly attached to base plate 20. Whenever the armature 13 of the electromagnet 35 is operated by the energization of coil 12, the hammer 14 strikes the right end of the reed switch (see dotted line position 14' of hammer 14 in Fig. 3) and upon deenergization of the coil 12 of the electromagnet 35 the hammer 14 returns to its support block 8.

Also mounted on the base plate 20 is a test coil 2, which surrounds the reed switch under adjustment, and pigtail connectors 9' and 10', which are provided to allow a continuity check of the reed switch under adjustment. These components of the apparatus form part of the test circuit (depicted in Fig. 4) which is employed to detect proper adjustment under prearranged circumstances.

Broadly speaking, the technique to be followed to adjust a reed switch can be stated as a series of causes and effects. The energization of coil 12 operates the electromagnet 35 which in turn causes the armature 13 to operate and, as a consequence, the hammer 14 is brought up sharply against the underside of the envelope 1 of the reed switch directly adjacent reed electrode 9 to permanently deform the electrode. As long as the stress induced in the electrode 9 by the force of the impacting hammer 14 is less than the proportional limit (normally coincident with the elastic limit) of the material used for the electrode, no permanent deformation or set occurs. This proportionality, usually expressed as Young's modulus of elasticity of unit stress to unit strain, does not hold above the proportional limit. After the application of a force above the proportional or elastic limit, the metal will not quite return to its original unstressed condition; it acquires a permanent set. It is this characteristic result of stressing an electrode beyond its elastic limit which is used to separate the two electrodes by a proper amount.

The vibrations induced in the switch as a result of the impact of the hammer 14 are dissipated by the resilient damper inserts 6a and 6b and resilient material 17. Means, operative after the vibrations induced in the switch have been sufficiently mitigated, are provided to test the continuity through the switch by way of flexible pigtail connectors 9' and 10' with the test coil 2 energized.

Simply stated then, the basic plan is to alternately strike a switch adjacent one of the electrodes to permanently deform that electrode by stressing it beyond its elastic limit, and then to test the continuity of the reeds under simulated operating conditions to determine if they have been separated sufficiently to permanently interrupt the continuity therethrough. Concurrent with these basic operations of the apparatus, the incremental voltage circuit, previously mentioned, incrementally increases the magnitude of the power applied to the coil 12 of the electromagnet which concomitantly increases the force of impact of the hammer 14 upon the switch envelope 1. This increasing force tends to permanently deform the reed 9 to successively greater extents as the cycle is repeated.

Referring to Fig. 4, which illustrates schematically a preferred embodiment of the circuit for automatically adjusting a reed switch which has been formed with its electrodes closed or nearly so, it can be appreciated that what is desired is a circuit to sequentially energize the hammer 14 to strike the switch, pause while the resulting vibrations are damped, test for continuity, and then re-

peat the cycle with a greater striking force behind the hammer. Further means must be provided, of course, effective upon a detection of a discontinuity through the electrodes, to disable the apparatus and its circuitry. The circuit for automatically performing these functions comprises a power control circuit, an incremental voltage circuit, an electromagnetic hammer, and a testing circuit including the particular reed switch to be adjusted.

Basically, relays E, F and A and their associated circuitry form the power control circuit which determines at what point in time along an alternating-current wave form a circuit including the electromagnetic hammer 35 will be completed and at what point in time it will be interrupted.

The incremental voltage circuit comprising rotary switches A1, A2, B and C, relays 50 and 60, transformers T3 and T4, variac V2 and their associated circuitry increases the magnitude of alternating voltage which is placed across the electromagnetic hammer 35 upon each operation of the power control circuit.

Lastly, relay 40, ammeter 41, rheostat 42, and their associated circuitry comprise the test circuit, whereas the switch under adjustment and the electromagnetic hammer 35 are both indicated and identified in a manner consistent with previous notations. Relay 30 (Fig. 4) acts as a gating circuit to apply ground to the power control circuit when appropriate and to disable the entire circuit upon the proper adjustment of a reed switch.

Before describing the operation of the circuit shown on Fig. 4 (based on operate current requirements), the method of determining the magnitude of the current flowing through the test coil 2 must be explained. The setting determines the operate current adjustment value and can be chosen when switch W2 is closed which places negative battery 65 upon one side of relay 40 (denoted by an encircled minus sign), and when key 24 is placed in the "operate" position (contacts 2 and 3 closed and contact 1 open). With these conditions obtaining, rheostat 42 is adjusted, and by observing ammeter 41 the magnitude of the current through test coil 2 may be set to any pre-selected value. The number of ampere turns, or the amount of current for any given test coil 2, selected is a value slightly below the desired operate current value for the switch under adjustment because the failure of the reeds to contact each other is used to stop the adjusting process. That is, whenever the two electrodes are separated a sufficient amount such that the energization of coil 2 does not bring them together, their discontinuity causes relay 30 to release which in turn disables the overall circuit. The release of relay 30 indicates that the reed switch has been properly adjusted to the test value and lamp 55 is lighted to so signify. Therefore, by selecting a test value a few ampere-turns below the desired operating value of ampere-turns it is possible to correctly adjust a switch within narrow limits. Once the proper value of test current is set, the key 24 is returned to the "adjust" position (as shown). With key 24 in the "adjust" position and switches W1 and W2 closed, the circuit will automatically adjust a reed switch to the pre-selected value of operate current and will thereafter stop.

When switch W2 is closed, negative battery 65 (positive grounded) is placed at all terminals indicated by the minus sign with a circle around it.

Observing the power control circuit, comprising relays E, F and A, the closure of switch W2 places negative battery 65 upon the swinger of relay E. This completes a direct-current path for relay E from the swinger thereof over contact 1 of relay E, through "percent make" potentiometer P2, resistor R1, the coil of relay E, and the lower portion of potentiometer P1 to make contact 2 of relay 30. Whenever relay 30 is operated, its grounded swinger engages contact 2 and completes the direct-current circuit for relay E.

When the key 24 is returned to the "adjust" position, after the value of test ampere-turns has been set, and

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switch W2 is closed, a circuit is completed for operating relay 30, which circuit may be traced from ground through the electrodes 9 and 10 of the switch under adjustment (formed in contact with each other), contact 1 of key 24, resistor 31, the winding of relay 30 to negative battery 65 (positive grounded). Capacitor 32 shunts the winding of relay 30. Therefore, moderate interruptions of the direct-current circuit of relay 30 do not release it because capacitor 32 discharges in a circuit including the winding of relay 30. As long as the direct-current circuit for relay 30 is completed to recharge capacitor 32 each time a switch under adjustment is tested (and the repetition rate is not too low), relay 30 will remain operated over the period during which reeds 9 and 10 are separated due to the impact of the hammer.

Therefore, ground on the lower side of the power control circuit (contact 2 of relay 30) in conjunction with the closure of switch W2 completes a direct-current circuit including relay E. Due to capacitor C2 being substantially in shunt of the coil of relay E, the current through the coil does not immediately reach a maximum. Instead, it slowly builds up as the capacitor C2 becomes fully charged. In the absence of alternating current and assuming that the magnitude of the direct current through the coil of relay E is sufficient to operate it, the direct-current circuit is interrupted when relay E operates because negative battery 65 is removed from contact 1 of relay E. Hence, relay E starts to release as soon as it operates, and does release when capacitor C2 has sufficiently discharged through its discharge circuit including the coil of relay E. The magnitude of direct current flowing through relay E is regulated by the "percent make" potentiometer P2 so that it does not operate more than approximately one time per second. Potentiometer P2 is named the "percent make" control because its adjustment also determines the percentage of the time during which relay E is operated (swinger against make contact 2) as compared to the time during which it is both operated and released (i. e., goes through a complete cycle). It is desirable to set this control, in the preferred embodiment of the invention, so that the "percent make" of relay E is approximately fifty percent; that is, the swinger of relay E will engage contact 2 approximately fifty percent of the time and engage contact 1 approximately fifty percent of the time.

The closure of switch W1 allows alternating current from source S to flow through the primary windings of transformers T1, T2, T3 and T4, and through the winding of variac V2. The magnitude of the alternating-current voltage derived from the secondary winding of transformer T1 is determined by the coarse adjustment V1 and the fine adjust potentiometer P1. The level of alternating current is adjusted such that in combination with the direct current flowing through relay E it will operate relay E approximately four times a second. After relay E operates and thereby removes negative battery 65 from its winding, when the composite current comprising alternating current and direct current reaches the release value of relay E, the relay releases to allow the cycle of operation to be repeated. Note that, upon the operation of relay E, the alternating current applied to the coil of the relay is not interrupted as is the case with the direct current. It can be appreciated therefore that relay E acts effectively as a relaxation oscillator of approximately equal periods of make and break.

Whenever relay E is operated, the negative battery 65, connected to the swinger of relay E, is applied to one side of the winding of relay F through contact 2 of relay E, the "pulse start" potentiometer P3, and the resistance R2. The other (left) side of the winding of relay F extends through the secondary winding of transformer T2 to ground. The application of battery to contact 2 on relay E completes a direct-current circuit for relay F. When the secondary winding of transformer T2 is energized by the closure of switch W1, an alternating-current

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circuit is also completed through the same path as described for the direct-current circuit. The completion of this circuit causes relay F to operate. No appreciable delay in operation occurs (except for variations caused by potentiometer P3 as will be discussed hereinafter) because there is no capacitor shunting its winding as was the case with relay E.

Upon the operation of relay F, ground is placed by way of its swinger and contact 1 upon the right side of relay A, which completes a circuit for relay A since the left side of the winding of relay A is connected through the parallel resistance-capacitor circuit including potentiometer P4 and capacitor C4 to negative battery 65 (positive grounded). The completion of this circuit for relay A causes it to operate. Each operation of relay A connects the incremental voltage circuit to the electromagnetic hammer 35.

As a result of the above-described operation of the power control circuit, a circuit is completed to operate the electromagnetic hammer whenever the contacts of relay A are closed and is interrupted whenever relay A's contacts are open. If oscilloscope leads are placed across resistor R3 at terminals X and Y and the alternating-current wave form observed, variation of the "pulse-start" potentiometer P3 will change the point along the alternating-current wave form at which the contacts of relay A close. On the other hand, variation of the "pulse-stop" potentiometer P4, will determine the point or instant in time along the alternating-current wave form at which the contacts of relay A open.

With these two adjustments possible, the application of alternating current to the electromagnetic hammer 35 may be made to occur at any desired point in the wave form and to continue for a preselected period of time thereafter. In the preferred embodiment of the invention, the application of alternating current to the electromagnetic hammer 35 occurs at the beginning of a positive half cycle and the interruption of this alternating current occurs at the point when the alternating current is just going negative.

This power control circuit is described in more detail and claimed in my copending application Serial No. 418,396, filed March 24, 1954, now Patent No. 2,781,459, issued Feb. 12, 1957.

Now that the power control circuit has been described in sufficient detail to indicate at what point in the alternating-current wave form a circuit is completed by the power control circuit to the electromagnetic hammer 35 for the incremental voltage circuit, it is necessary to ascertain in detail just how the incremental voltage circuit operates. As was previously pointed out, the closure of switch W1 places alternating-current power from source S across the primary winding of transformers T3 and T4 and variac V2. Actually, alternating-current power is not placed across the primary winding of transformer T4 until relay 60 is operated, the primary winding of transformer T4 merely being in shunt of one side of the alternating-current line 11 (through resistor 27). However, when relay 60 operates, one side of the primary of transformer T4 is transferred through contact 1 of relay 60 and resistor 28 to the opposite side of the alternating-current line 12. The operation of relay 60 will be described below.

Rotary switch sections A1, A2, B and C, which each have twenty-two positions, are parts of a conventional stepping switch with a partial double-ended wiper. The stepping switch is actuated by the operation of the stepping magnet 70. The preferred embodiment of this stepping switch steps upon the release of the stepping magnet 70, which is pulled up each time relay 50 is operated. Relay 50, in turn, is operated each time ground is placed on the right side of the coil of relay A by virtue of the operation of relay F. This placing of ground on one side of relay 50 completes a circuit through the coil of relay 50 and negative battery 65 to positive ground, pro-

vided switch W2 is closed. Relay 50, in operating, completes a direct-current circuit from ground through its contact 1 to the coil of the stepping magnet 70 and thence to negative battery and positive ground. As a result, each time relay A is energized, relay 50 operates to pull up the stepping magnet 70. When relay 50 releases (upon the release of relay F) ground is removed from the stepping magnet 70 and wipers step forward one position. Capacitor 51 provides contact protection and blocks the application of ground to the stepping switch magnet 70 when relay 50 is unoperated.

Between each position on switch sections A1 and A2 is a uniform resistance r . These small resistances, bridging adjacent switch positions, allow the wipers 36 and 37 associated with switch sections A1 and A2, respectively, to act as center taps of potentiometers to select certain magnitudes of voltage from the incremental voltage circuit for application to the electromagnetic hammer 35. This is possible because the alternating current from source S is transferred by way of the primary winding of transformer T3 to the secondary thereof and is then placed across switch sections A1 and A2 in series. For example, with the wiper 36 on position 3 of switch section A1, $\frac{3}{44}$ of the voltage placed across the switch sections A1 and A2 by the secondary of transformer T3 is applied to the electromagnetic hammer 35. Similarly, if the switch position were 27, the wiper 36 on switch section A1 would be open-circuited, but the wiper 37 associated with switch section A2 would apply $\frac{27}{44}$ of the voltage across the two switch sections to the hammer 35.

The minimal level of voltage applied to the electromagnetic hammer 35 is determined by variac V2. It will be noted that this voltage is taken off by the wiper of variac V2 and is applied to the lower side of the secondary winding of transformer T4 and from there it is applied to the lower side of transformer T3. As a result of this arrangement, the magnitude of alternating-current voltage placed across the hammer 35 depends upon the magnitude of the minimum voltage, as determined by variac V2, plus the incremental amount of voltage from transformer T3 determined by the operation of switch sections A1 and A2.

The primary function of switch section B is to operate relay 60 after the stepping switch has stepped forty-four positions (360 degrees) in order to add the transformer T4 to the minimum voltage level as determined by the variac V2. Relay 60 is a two-winding relay with oppositely wound or sensed coils. Hence, when the wiper 38 of switch section B places ground on the left side of relay 60, it operates, transferring the lower side of the primary winding of transformer T4 from alternating-current line 11 to line 12 by way of its contact 1. Relay 60 will remain in the operated position until such time as the other (right) winding is energized to release the relay, thereby to remove from the circuit the alternating current supplied by transformer T4. In line with this, it is to be noted that swinger 33 of switch section B is so initially positioned that it must step forty-four positions before it engages switch point 22 to operate relay 60.

The switch section C is provided to allow the stepping switch to be returned to its starting position after each reed switch is adjusted. It will be noted that when key 24 is in the "operate" position, ground is applied from contact 3 of key 24, through the swinger 39 of switch section C (if in any position other than as shown) and contact 1 of the stepping magnet 70 to one side of the coil of the stepping magnet 70, thereby completing an operate circuit for the stepping magnet 70. As a result of this self-interrupting step magnet operating and releasing arrangement, whenever a new operate current value is being set, the stepping switch will be stepped until one of the double-ended wipers 39 engages the position 23. If the switch has not stepped to the normal starting position (as shown) when this occurs, an alternate ground from wiper 38 and position 1 of section B is supplied to

the stepping magnet 70 to step it an additional position. When the switch has stepped one more position, wiper 39 of switch section C again supplies operating ground and the switch is stepped until it reaches its original normal position, at which position it stops because of the interruption of ground. Resistor 71 and capacitor 72 provide a leakage path and also isolate the stepping magnet 70 from this ground.

To recapitulate briefly then, a circuit is completed including the incremental voltage circuit through the contacts of relay A to the coil of electromagnetic hammer 35 whenever relay A is operated. Concomitantly, each time relay A is operated, the stepping magnet 70 is pulled up and upon the release of relay A, the stepping switch advances one position, which increases by one increment the magnitude of voltage placed across the hammer 35. The minimum level of this voltage, as noted, is determined by the setting of variac V2 and there are forty-four increments across the secondary winding of transformer T3. After the stepping switch has stepped forty-four positions, the secondary winding of transformer T4 is added to the minimum level of variac V2 and the forty-four increments are available over the new minimum level. In the preferred embodiment of the invention as disclosed in Fig. 4, transformers T3 and T4 are 6.3-volt alternating-current transformers. Hence, eighty-four increments totaling 12.6 volts are provided. This, over a 40-volt minimal setting of variac V2, makes possible a variation between 40 and 52.6 volts. It is, of course, obvious that the transformers T3 and T4 could have different values to provide an infinite number of combinations of voltage variations to be placed across the hammer 35. It should be further apparent that the values of r could be other than equal.

It should be observed that the exemplary range of voltages suggested above is appropriate only because of the particular dimensions and configuration of the reed switches used to perfect the apparatus disclosed and claimed herein. If the reeds were constructed differently or made out of a different material (i. e., having different mechanical properties) a voltage range of 40 to 52.6 volts might not be great enough to cause the hammer to strike the switch envelope with sufficient force to permanently deform at least one of the reeds or again, the range might have too high a minimal voltage and thus over-separate the reeds. However, in any event, the range of voltage needed, for any particular switch configuration, is readily ascertainable by simple trial and error techniques or analytical approximations. As long as the voltage starts low enough and increases to a high enough value, switches may be adjusted in the apparatus, and the only adverse effect will be the time required for adjustment.

The placing of ground by way of the swinger of relay F to one side of the coil of relay A also completes a circuit through relay 40 and over switch W2 to negative battery 65 (positive grounded). This part of the circuit is the test circuit for operate current values. The operation of relay 40 interrupts the circuit associated with the switch under adjustment. Thus, whenever a voltage is being placed across the electromagnetic hammer 35, the test coil 2 for the switch under adjustment is not energized and hence, there is no tendency for the electrodes 9 and 10 of the switch under adjustment to arc, corrode, etc., as a result of the vibrations induced in the switch by the hammer impact.

When the switch has been properly adjusted, which means that the energization of test coil 2 (upon the release of relay 40 when relay F releases) fails to close electrodes 9 and 10, ground is removed from contact 1 of key 24, thereby releasing relay 30. The release of relay 30 removes ground from the power control circuit thereby disabling it. This release of relay 30 completes an obvious circuit over its contact 1 for light 55. The

energization of light 55 indicates proper adjustment of the reed switch has been completed.

It should be apparent, of course, that switch W1 and switch W2 could be multiplied in order to place alternating and direct current on the circuit by the operation of a single switch. A similar obvious modification would be the resetting of the stepping switch to its starting or original normal position and the release of relay 60 by means of same discontinuity which removes ground from relay 30 and, hence, from the power control circuit. Under this circumstance, it would be unnecessary to re-operate key 24 if similar reed switches were to be adjusted and would, in a measure, allow a fully automatic technique to be utilized.

As previously noted in my copending application heretofore identified, capacitors C1 and C3 are optional in order to provide contact protection.

Looking to Fig. 5 which, as previously pointed out, is the specific circuit configuration to be used at X . . . X in place of the circuit depicted in Fig. 4 when it is desirable to adjust a reed switch by release current rather than by operate current. It will be noted that a level of release current just below the operating release current value is selected. The placing of ground on the right side of the coil of relay A operates relay 46, but as soon as capacitor 44 is fully charged the current flowing through the coil of relay 46 is interrupted and the relay releases irrespective of the presence or absence of ground. The circuit for relay 46 is from ground on the swinger of relay F over contact 1 of relay F, through a parallel resistor-capacitor network comprising resistor 43 and capacitor 44, and the coil of relay 46 to negative battery 65. The operation of relay 46 does two things. First, it interrupts a circuit through test coil 2 surrounding the switch under adjustment thereby deenergizing the switch during the time the hammer 35 is energized. This release current circuit extends from ground over contact 2 of relay 46, through test coil 2, resistor 49, ammeter 41, rheostat 42 to negative battery 65 and positive ground. Secondly, the operation of relay 46 places ground over its contact 1 and through resistor 48 to one side of the coil of relay 45.

As a result, relay 45 operates because the other side of its coil is connected to negative battery 65 and positive ground. This circuit, for relay 45, also charges condenser 52. Relay 45, operated, places a short circuit across resistor 49 (through its contact 1) and thereby prepares a circuit which, when relay 46 releases, will allow a heavy soak current to be applied to test coil 2 to assure the closure of reeds 9 and 10. Due to the fact that capacitor 52 is in shunt of the winding of relay 45, relay 45 is slow to release. Hence, a proper choice of a capacitor 52 provides a long enough delay in the release of relay 45, after relay 46 releases, to complete the circuit. The circuit extends from ground through contact 2 of relay 46, coil 2 encircling the switch under adjustment, the short circuit of resistor 49 including contact 1 of relay 45, the ammeter 41 and the rheostat 42 to negative battery 65. The applied heavy soak current through test coil 2 is held to a preselected value of release current, as determined by rheostat 42 and resistance 49 and based on the reading of ammeter 41, upon the release of relay 45. Because the test circuit for either soak or release current is not completed until relay 46 releases, which does not occur until ground is removed from the right side of relay A by the release of relay F (Fig. 4), the reeds 9 and 10 are effectively insulated from the deleterious effects of arcing and corrosion attending the vibrations caused by the impact of the hammer 35 upon the switch.

Whether or not the operate current value or the release current value for a reed switch is used to adjust it depends entirely upon the application of the switch and its associated circuitry. In some instances, it would probably be desirable that the operate current value deter-

mine its adjustment; whereas, in other cases the release characteristics of the reed switch are perhaps to be utilized. In both cases, the principal requirement is that the application of test current should occur when the hammer is not energized. This is, of course, not an absolute requirement, but certainly would tend to minimize the poor effects of arcing, corrosion, etc., which occur upon the making or breaking of contacts carrying current in the presence of vibration.

It is to be noted that these two test circuits could be switched in and out of the circuit at will if a simple two-pole, single throw switch were employed to substitute one or the other at X . . . X in Fig. 4.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. Apparatus for accurately adjusting the contact portions of a switch of the type having a rigid envelope and two resilient members sealed in and extending through respective ends of said envelope, said members having cooperating and overlapping portions which are arranged in intimate contact with each other, said apparatus comprising means for resiliently supporting said rigid envelope, variable impact means for causing an increment of separation between said contact portions by striking said rigid envelope with a force sufficient to permanently deform at least one of said members, resilient means for dampening vibrations induced in said switch by the striking of said rigid envelope by said impact means, enabling means for operating and releasing said impact means repetitively, means effective upon releases of said impact means to increase said increment by increasing the force of succeeding impacts, means for detecting whether or not a preselected separation exists between said contact portions, and means effective upon the detection of the preselected separation to disable said enabling means.

2. Apparatus for accurately adjusting the contact portions of a switch of the type having a rigid envelope and two resilient members sealed in and extending through respective ends of said envelope, said members having cooperating and overlapping portions which are arranged in intimate contact with each other, said apparatus comprising means for resiliently supporting said rigid envelope, variable impact means for causing an increment of separation between said contact portions by striking said rigid envelope with a force sufficient to permanently deform at least one of said members, resilient means for dampening vibrations induced in said switch by the striking of said rigid envelope by said impact means, enabling means for operating and releasing said impact means repetitively, means effective upon each release of said impact means to increase said increment each time said impact means is operated by increasing by a fixed amount the force of each succeeding impact, a test coil associated with said switch, a source of direct-current power connectable to said coil, means operative to select a number of ampere turns which will just cause said contact portions to fail to close, said number representing a proper adjustment of said contact portions, means effective upon each release of said impact means to connect said direct-current source to said test coil whereby the presence or absence of continuity through said members may be determined, and means effective upon a proper adjustment of said switch, as evidenced by a failure of said continuity, to disable said enabling means.

3. Apparatus for accurately adjusting the contact portions of a switch of the type having a rigid envelope and two resilient members sealed in and extending through respective ends of said envelope, said members having cooperating and overlapping portions which are arranged in intimate contact with each other, said apparatus comprising means for resiliently supporting said rigid envelope,

a variable source of alternating-current power, an electromagnetic hammer having an energizable winding and operative upon the energization of said winding to cause an increment of separation between said contact portions by striking said rigid envelope with a force commensurate with the magnitude of said applied source and sufficient to permanently deform one of said members, resilient means for dampening the vibrations induced in said switch by the striking of said rigid envelope by said hammer, enabling means for connecting said source to said winding to cause said hammer to strike said switch repetitively, means effective upon releases of said hammer to increase said increment by increasing the magnitude of succeeding applications of said source, means for detecting whether or not a preselected separation exists between said contact portions, and means effective upon the detection of the preselected separation to disable said enabling means.

4. Apparatus for accurately adjusting the contact portions of a switch of the type having a rigid envelope and two resilient members sealed in and extending through respective ends of said envelope, said members having cooperating and overlapping portions which are arranged in intimate contact with each other, said apparatus comprising means for resiliently supporting said rigid envelope, a variable source of alternating-current power, an electromagnetic hammer having an energizable winding and operative upon the energization of said winding to cause an increment of separation between said contact portions by striking said rigid envelope with a force commensurate with the magnitude of said applied source and sufficient to permanently deform one of said members, resilient means for dampening the vibrations induced in said switch by the striking of said rigid envelope by said hammer, enabling means for connecting said source to said winding to cause said hammer to strike said switch repetitively, means effective upon each release of said hammer to increase said increment each time said hammer is operated by increasing by a fixed amount the magnitude of each succeeding application of said source, means for testing for continuity through said members under simulated operating conditions, and means effective upon a proper adjustment of said switch, as evidenced by a failure of said continuity, to disable said enabling means.

5. Apparatus for accurately adjusting the contact portions of a switch of the type having a rigid envelope and two resilient members sealed in and extending through respective ends of said envelope, said members having cooperating and overlapping portions which are arranged in intimate contact with each other, said apparatus comprising a frame, a first and second means attached to said frame to support said rigid envelope at each end, said first support means including a clamping device having two jaws hinged together at one end and lockable together at their other ends, said jaws having resilient inserts to fixedly retain one end of said rigid envelope in said clamping device and to act as shock vibration dampeners therefor, a variable source of alternating-current power, an electromagnetic hammer supported by said frame and having an energizable winding, said hammer operative upon the energization of said winding to cause an increment of separation between said contact surfaces by striking the other end of said rigid housing with a force commensurate with the magnitude of said applied source and sufficient to permanently deform one of said members, enabling means for connecting said source to said winding to cause said hammer to strike said switch repetitively, means effective upon releases of said hammer to increase said increment by increasing the magnitude of succeeding applications of said source, means for testing for continuity through said reeds under simulated operating conditions, and means effective upon a proper

adjustment of said switch, as evidenced by a failure of said continuity, to disable said enabling means.

6. Apparatus for accurately adjusting the contact portions of a switch of the type having a rigid envelope and two resilient members sealed in and extending through respective ends of said envelope, said members having cooperating and overlapping portions which are arranged in intimate contact with each other, said apparatus comprising a frame, a first and second means attached to said frame to support said rigid envelope at each end, said first support means including a clamping device having two jaws hinged together at one end and lockable together at their other ends, said jaws having resilient inserts to fixedly retain one end of said rigid envelope in said clamping device and to act as shock vibration dampeners therefor, a variable source of alternating-current power, an electromagnetic hammer supported by said frame and having an energizable winding, said hammer operative upon the energization of said winding to cause an increment of separation between said contact surfaces by striking the other end of said switch with a force commensurate with the magnitude of said applied source and sufficient to permanently deform one of said members, enabling means for connecting said source to said winding to cause said hammer to strike said switch repetitively, means effective upon each release of said hammer to increase said increment each time said hammer is operated by increasing by a fixed amount the magnitude of each succeeding application of said source, a test coil surrounding said switch, a source of direct-current power connectable to said coil, means operative to select a first and a second level of current, said first level sufficient to insure that said contact surfaces come together and said second level such that said contact surfaces just separate representing a proper adjustment of said reeds, means effective upon the release of said hammer to connect said direct-current source to said test coil thereby to apply said first level to said test coil to cause said contact surfaces to close and to then apply said second level to said test coil whereby the presence or absence of continuity through said reeds may be determined, and means effective upon a proper adjustment of said switch, as evidenced by a failure of said continuity, to disable said enabling means.

7. Apparatus for accurately adjusting the contact portions of a switch of the type having a rigid envelope and two resilient members sealed in and extending through respective ends of said envelope, said members having cooperating and overlapping portions which are arranged in intimate contact with each other, said apparatus comprising a frame, a first and second means attached to said frame to support said rigid envelope at each end, said first support means including a clamping device having two jaws hinged together at one end and lockable together at their other ends, said jaws having resilient inserts to fixedly retain one end of said rigid envelope in said clamping device and to act as shock vibration dampeners therefor, a variable source of alternating-current power, an electromagnetic hammer supported by said frame and having an energizable winding, said hammer operative upon the energization of said winding to cause an increment of separation between said contact surfaces by striking the other end of said switch with a force commensurate with the magnitude of said applied source and sufficient to permanently deform one of said members, power control means for connecting said source to said winding for a preselected period of time and at a preselected repetition rate to cause said hammer to strike said rigid envelope and to release repeatedly, means effective upon releases of said hammer to increase said increment by increasing the magnitude of succeeding applications of said source, means for testing for continuity through said reeds under simulated operating conditions, and means effective upon a proper adjustment of said

switch, as evidenced by a failure of said continuity, to disable said power control means.

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