Dec. 4, 1951 E. T. BURTON 2,577,602

METHOD FOR ADJUSTING THE SENSITIVITY OF CONTACT DEVICES

Filed Oct. 1, 1947 2 SHEETS—SHEET 1

FIG. 1

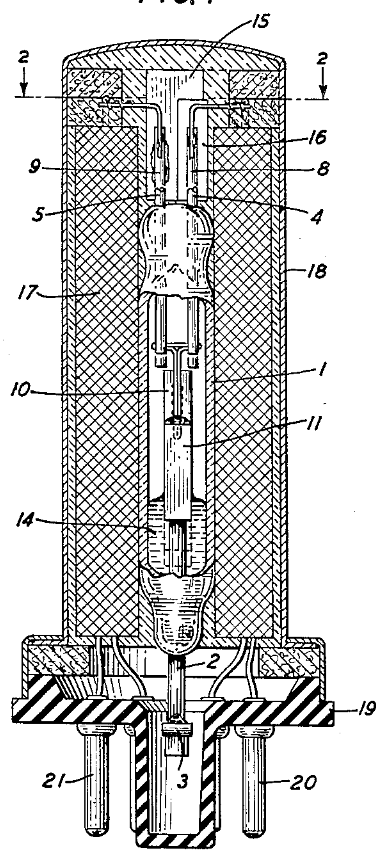

FIG. 3

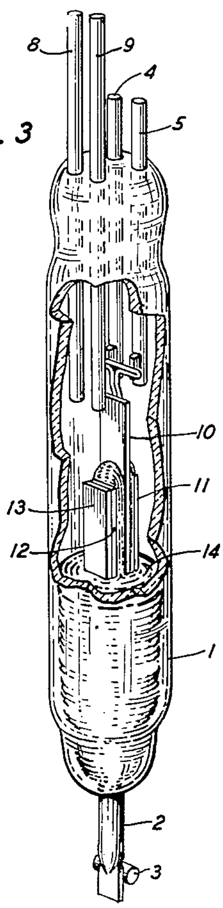

FIG. 2

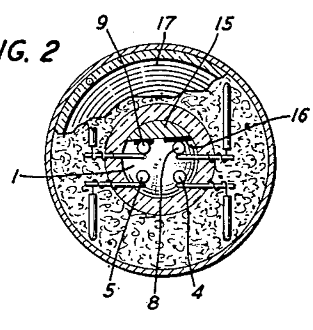

FIG. 4

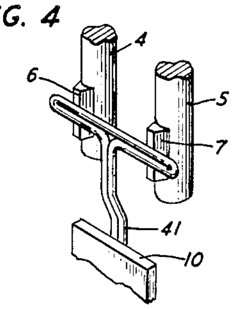

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FIG. 5

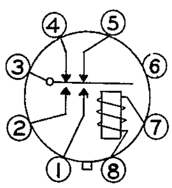


FIG. 6

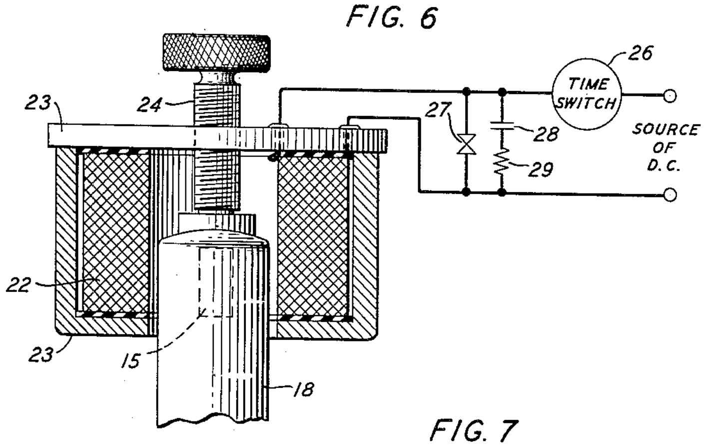


FIG. 7

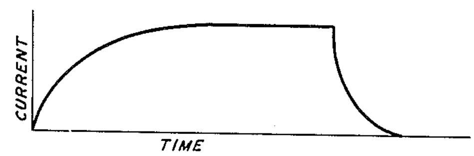


FIG. 8

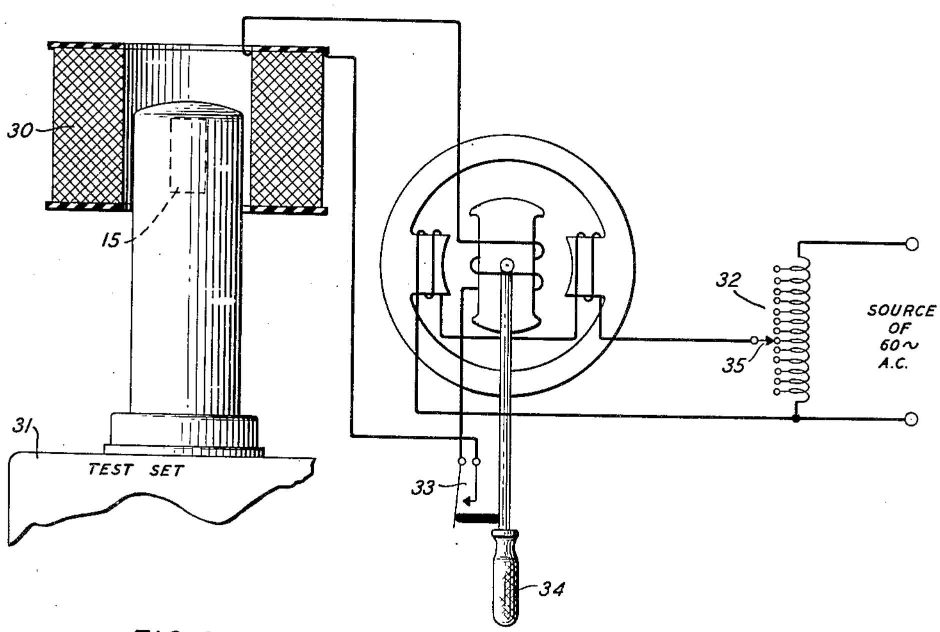
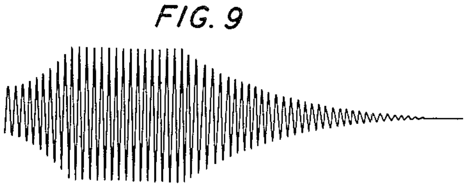


FIG. 9



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2,577,602

METHOD FOR ADJUSTING THE SENSITIVITY OF CONTACT DEVICES

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7 Claims. (Cl. 175—320)

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This invention relates to an improved method for the sensitivity adjustment of circuit makers and breakers and particularly to devices known as glass sealed mercury contact relays.

The object of the invention is to produce an accurately adjusted relay without recourse to mechanical bending, screw adjustment or other mechanical movement of the parts thereof.

Another object of the invention is to provide a relay in which the adjustment is stable and will remain in this condition for over a long period of service.

In accordance with this invention the elements of the relay are assembled, then plotted in a steel cover beyond the possibility of mechanical adjustment or interference with the parts and then adjusted by a magnetic influence externally applied. The elements of the relay are first of all a glass sealed contact arrangement in which an armature is fed by capillary action from a pool of mercury sealed within the glass envelope and which is then filled with hydrogen under high pressure, by way of example, 250 pounds to the square inch. This glass sealed contact device is then placed along the axis of a solenoid and a small permanent magnet is positioned above the contact element in such a position that it will bias the action of the relay but will be little affected by the magnetic influence of the solenoid. This assembly is then placed within a steel cover similar to the covers used on metal radio tubes and the entire assembly filled with wax or other plastic which is then left to harden. A conventional octal base is then attached to this assembly and the proper connections to the pins thereof are made.

In the manufacture of relays, particularly neutral relays where no biasing permanent magnet is employed, adjustment is usually achieved by mechanical bending of parts thereof or by screw adjustment or movement of other parts thereof. This adjustment may change from time to time and further adjustment will be needed. In the present device no mechanical adjustment of the parts sealed within the glass tube is possible and since relays of this nature will be made in very large numbers and since it is essential that operating characteristics of the relays be uniform, it becomes of paramount importance that some adjustment for sensitivity of operation be made. Applicant has discovered that by placing a small permanent magnet in proximity to this contact arrangement and then fixing it so that no movement or change in the position thereof can be made during the life of the relay

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that stability in the adjustment may be achieved. Applicant also proposes to place his permanent magnet in such a position that while it will influence the operation of the relay, its electromagnetic coupling to the solenoid is sufficiently reduced by virtue of its position that substantially no change in the strength of the permanent magnet results from the magnetomotive forces used in the solenoid. The above result is accomplished because of the fact that the magnetomotive force of a solenoid with little ferromagnetic material along its axis is concentrated near the center of the winding near the contacts of the switch but is of low concentration near the ends of the winding. As a further factor in the stability of the relay, applicant proposes to cover the entire structure by a ferro-magnetic shield so as to exclude external magnetic fields of ordinary strength during the useful life thereof. Applicant has discovered that if he constructs a relay in this manner and then adjusts the relay by using magnetic influence strong enough to penetrate the magnetic shield and to partially demagnetize the permanent magnet therein that remarkable stability of the relay during its useful life may be achieved.

A feature of the invention may, therefore, be stated as a relay consisting of a glass sealed mercury contact device centered within an operating solenoid biased to the proper sensitivity by a permanent magnet with these elements permanently held in position by a plastic within a magnetic shield.

Another feature of the invention is a method of producing a sensitive and stable relay by fixing all of the mechanical parts against movement within a protecting shield and then adjusting the relay by an external magnetomotive force sufficient in strength to penetrate the magnetic shield and to affect an element of the relay.

Another feature of the invention is a method of producing a sensitive and stable relay by rendering the coil, the contact and the biasing magnet rigid and inflexible within a protecting shield and then adjusting the relay by first over-magnetizing the permanent magnet and then demagnetizing the said permanent magnet until the operation of the relay is within predetermined limits.

Another feature of the invention is the use of an unmagnetized element of permanent magnetic material which is built into the structure of the relay and then properly magnetized after all the elements thereof have been rendered rigid and inflexible.

Other features will appear hereinafter.

The drawings consist of two sheets having nine figures as follows:

Fig. 1 is a cross-sectional view of the completed relay;

Fig. 2 is a cross-sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a perspective drawing with the glass envelope broken away to show the interior construction and arrangement of the contact device;

Fig. 4 is an enlarged perspective view of the armature contact piece resting on its back contacts;

Fig. 5 is a conventional diagram indicating the connection of the relay winding and the armature and various armature contacts to the pins of a conventional octal radio tube base;

Fig. 6 is a diagram illustrating the manner in which the permanent magnet within the relay is magnetized;

Fig. 7 is a graph showing the rise and fall of the direct current used for magnetizing the permanent magnet in the circuit of Fig. 6;

Fig. 8 is a circuit diagram showing how the permanent magnet within the relay after being strongly magnetized is partially demagnetized; and

Fig. 9 is a graph illustrating the manner in which alternating current is applied to the coil of Fig. 8 in order to properly demagnetize this permanent magnet.

The contact device of the present relay consists of a glass tube 1 into which a metal tube 2 is sealed at the bottom. This metal tube is for the usual purpose of exhausting the air from the envelope, introducing the mercury and later pumping the tube full of gas at high pressure. When these operations have been completed then the tube is crushed at its lower end and welded together. The short piece of wire 3 is conducting material which is used in the welding operation in order to produce the proper concentration of welding current and which itself becomes welded to the tube 3.

Into the upper end of the glass tube 1 there are sealed four wires of magnetic material which form the exterior terminals of the device and to which contacts are secured within the envelope. The wires 4 and 5 constitute back contacts of the device and as shown in Fig. 4 these have pieces of contact metal 6 and 7 respectively attached thereto. Similar wires 8 and 9 are used for the front contacts and they are somewhat longer so that they will provide a low reluctance circuit contiguous to the armature piece 10. This armature piece is attached through the use of a light spring 11 to the metal tube 2. Other pieces of mercury wettable material 12 and 13 are also attached to the tube 2 so that the lower end of the armaure 10 will move in a mass of mercury in such a way as to constitute a hydraulic brake such as that disclosed in Patent 2,406,036, granted to C. E. Pollard, Jr. on August 20, 1946. The pool of mercury 14 will rise through capillary action to the space provided between the spring 11 and the plates 12 and 13 and will further rise in the wick 41 made of two parallel wires having their upper ends bent into a T-shaped piece to form a contact cooperating with the two back contacts 6 and 7 and two front contacts similarly attached to the wires 8 and 9.

After the tube has been evacuated and the proper amount of mercury has been introduced, hydrogen is pumped into it to 250 pounds to the square inch pressure. It has been found that hydrogen at such high pressure raises the boiling point of mercury by a substantial amount so that heavier currents may be made and broken by this device than by a device having a pressure within of conventional degree. It is known that with mercury wetted contacts the mercury will string out into a fine thread as the contact is broken and since this thread has a comparatively high resistance the I^2R loss during the short period in which such a thread is formed has the effect of heating the thread and will tend to raise the temperature of such thread to and beyond the boiling point thereof. Consequently, the use of this very high pressure materially raises the current carrying capacity of the relay.

In this relay, a small piece of permanent magnetic material 15 is attached as by soldering to one of the front contact wires 9 and is insulated from the other wire 8 by a small piece of insulation 16.

The switch as so described is then inserted within a solenoid 17 and this assembly is then placed within a steel cover 18 made of magnetic material so as to provide magnetic shielding for the relay. This assembly is then inverted and filled with a liquid plastic 25 such as hot wax which upon cooling will hold the parts of the relay rigid and inflexible. Therefore, all parts of the relay are beyond reach for adjustment by conventional means. The tube is then attached to a conventional base 19 provided with the pins 20 and 21 and wired up according to the diagram of Fig. 5.

After the relay has been completely assembled, it is inserted into a device consisting of a coil 22 wound in a case 23 of ferro-magnetic material. Since a number of relays of different dimensions may be processed by this device it is provided with a screw 24 of ferro-magnetic material whereby the coil may be adjusted over the top of the relay until the piece of permanent magnetic material indicated by the broken line rectangle 25 is properly positioned. The permanent magnet is then subjected to a very strong magnetic field by connecting the coil 22 to a source of direct current through a time switch 26 adjusted to limit the flow of current to a definite time, by way of example, ten seconds. Circuit elements such as a thyrite rectifier 27, a condenser 28 and resistance 29 are connected to the wiring of the coil 22 so that there will be no oscillation on the break of the circuit by the time switch 26. These circuit elements are provided to make the application of direct current to the current 22 as nearly like that indicated by the graph of Fig. 7 as possible.

Assuming the armature initially rests against contact wires 4—5, the magnetization provided by the coil 22 is sufficient to saturate the steel cover 18 of the relay and penetrate to the piece of magnetic material 15 to strongly magnetize the latter so that the armature will be preferably held over to the front contact wires 8—9 of the relay.

After this operation a coil 30 is slipped over the top of the relay in order to demagnetize the permanent magnetic material 15 sufficiently to adjust the relay to its proper working condition. At this time the relay is connected to a test set 31 which may be similar to that shown in Patent No. 2,432,092 granted to E. B. Ferrell on December 9, 1947 (Serial No. 500,935, filed September 2, 1943). In this case it is desired to energize the coil 30 by alternating current in the manner indicated by the graph of Fig. 9. In order to do this a source of alternating current is connected to a device 32 by means of which the potential delivered to the circuit may be varied. Current then flows through the two poles of a stator. A rotor is connected in series with the coil 30 but in the position shown is held open by a switch 33. When the piece of magnetic material 15 is to be demagnetized the handle 34 is moved in a counter-clockwise direction until the rotor of this device comes in line with the stator whereupon alternating current of a maximum value will flow through the coil 30. The handle 34 is then slowly moved into the position shown so that the amount of current in the coil 30 is gradually decreased in the manner indicated by the graph of Fig. 9. When the circuit to the coil 30 is opened by the switch 33 then the relay may be tested by the test set 31. If the test indicates that the piece of magnetic material 15 has not been sufficiently deenergized for the sensitivity adjustment desired then the contact 35 of the variable device 32 is moved so that the coil 30 may be more strongly energized. In this manner the piece of magnetic material 15 may be demagnetized until the relay responds in the desired manner.

An accurately adjusted relay may be thus produced so that the armature 10 normally rests against its back contacts and will upon the energization of the solenoid 17 move to its front contacts on a preferred value of current.

In particular, if it is desired to adjust the operate current sensitivity of the relay to a specified or preferred value, that is, a desired minimum value of current through solenoid 17 which will cause armature 10 to make contact with wires 8—9, piece 15 is overmagnetized with respect to the ultimate adjustment required thereof by the procedure hereinbefore outlined. To be fully assured that piece 15 is overmagnetized it is preferable that piece 15 be magnetized until armature 10 contacts wires 8—9. This contacting of wires 8—9 by armature 10 can be used to actuate an external test circuit whose operation of a lamp or the like will indicate the positioning of armature 10 with respect to the internal structure inasmuch as this structure will usually be enclosed within an opaque container. However, from a generic aspect all that is required in the initial method step is that piece 15 be overmagnetized with respect to the ultimate adjustment required thereof, consequently, it is possible but not commercially practical for piece 15 to be overmagnetized and still not cause armature 10 to move away from its position against contact wires 4—5 in that with this procedure one cannot be absolutely sure that piece 15 is overmagnetized with respect to the ultimate adjustment required. With piece 15 overmagnetized the operate current required is less than that necessary for the specified operate value inasmuch as piece 15 exerts an excessive attraction force upon the armature. To adjust this excessive force piece 15 is demagnetized slightly by the procedure hereinbefore outlined. If in the initial magnetization operation armature 10 was caused to contact wires 8—9, the demagnetization should continue until said armature can just free itself from wires 8—9 and thereby make contact with wires 4—5. In any event after the initial demagnetization step an operate current is caused to flow through solenoid 17 to test the effect of the demagnetization step in bringing the relay to the ultimate adjustment point. If this current is still less than the specified sensitivity value, piece 15 is again demagnetized and an increased amplitude operate current of sufficient value to cause armature 10 to make contact with wires 8—9 is thereafter caused to flow through solenoid 17 to determine whether the degree of demagnetization has raised the operate current to the specified operate value for the relay. This procedure of demagnetizing in small increments and thereafter testing by applying an operate current of increased value is continued until the desired operate current adjustment is attained.

If it is desired to adjust the release sensitivity of the relay to a specified value, that is, the minimum value of current which will allow armature 10 to break contact with wires 8—9 after contact therewith has been established by an operate current, piece 15 is overmagnetized by the procedure hereinbefore outlined. Again, in order to make sure that sufficient overmagnetization has taken place, it is preferable that armature 10 be caused to make contact with wires 8—9 in response to the excessive magnetization of piece 15. However, it should be pointed out that as in the operate adjustment it is not necessary, although it being preferable for the reasons hereinbefore set forth, that piece 15 be overmagnetized to the extent that armature 10 is caused to contact wires 8—9, the exact requirement being merely that piece 15 be overmagnetized with respect to the ultimate adjustment required thereof and this requirement can be attained without causing armature 10 to break contact with wires 4—5. With piece 15 in this condition the release current value required to permit armature 10 to move away from contact wires 8—9 when armature contact is made therewith will be less than the release current value specified. To correct this, piece 15 is demagnetized in accordance with the procedure hereinbefore outlined in a small increment. In the case wherein armature 10 contacts wires 8—9 the demagnetization should continue until said armature just frees itself from wires 8—9 thereby making contact with wires 4—5. The effect of the demagnetization step upon the release sensitivity adjustment is determined thereafter by applying any operate current value to solenoid 17 which will cause armature 10 to contact wires 8—9 and thereafter reducing said current in value until the armature is restored to its position against contact wires 4—5. If the current which caused the armature to move away from contact wires 8—9 is smaller than the release value specified, the demagnetization and testing steps should be repeated until the release current value is brought up to the specified value.

By thus constructing a relay in which the parts are held in a rigid and inflexible manner against mechanical movement and by adjusting the relay by selective deenergization of a biasing permanent magnet potted within a magnetic shield a very sensitive and stable relay may be formed.

What is claimed is:

1. A method for adjusting the sensitivity of a magnetically shielded make and break contact device of the type wherein a magnetizable armature biased by a permanent magnet coupled thereto is caused to make operative contact with an electrode in response to a current of specified amplitude flowing through a winding which is also magnetically coupled to said armature, com-

prising the steps of overmagnetizing said permanent magnet with respect to the ultimate magnetic adjustment required thereof, demagnetizing said permanent magnet by subjecting same to a demagnetizing magnetic field sufficiently intense to saturate said magnetic shield, testing said contact device by passing a current through the winding thereof to determine the effect of said demagnetization step in adjusting the contact device to the specified sensitivity value, and continuing said demagnetizing and testing steps upon said contact device until the specified sensitivity adjustment is attained.

2. A method for adjusting the operate current sensitivity of a magnetically shielded make and break contact device of the type wherein a magnetizable armature biased by a permanent magnet coupled thereto is caused to make operative contact with an electrode in response to a specified operate current through a winding which is also magnetically coupled to said armature, comprising the steps of overmagnetizing said permanent magnet with respect to the ultimate magnetic adjustment required thereof, demagnetizing said permanent magnet by subjecting same to a demagnetizing magnetic field in incremental steps of increasing intensity, each demagnetizing step being sufficiently intense to saturate the magnetic shield of the device being adjusted, and after each demagnetizing increment testing said contact device by passing an operate current through the winding thereof of sufficient amplitude to cause said armature to make operative contact with said electrode, and continuing said alternate demagnetizing and testing steps upon said contact device until the specified operate sensitivity adjustment is attained.

3. A method for adjusting the release current sensitivity of a magnetically shielded make and break contact device of the type wherein a magnetizable armature biased by a permanent magnet coupled thereto is caused to release operative contact with an electrode in response to a current of specified amplitude through a winding which is also magnetically coupled to said armature, comprising the steps of overmagnetizing said permanent magnet with respect to the ultimate magnetic adjustment required thereof, demagnetizing said permanent magnet by subjecting same to a demagnetizing magnetic field in incremental steps of increasing intensity, each demagnetizing step being sufficiently intense to saturate the magnetic shield of the device being adjusted, testing said contact device by passing a current through the winding thereof a sufficient amplitude to cause said armature to make operative contact with said electrode and subsequently reducing the value of said current until said contact is broken, thereby determining the effect of said demagnetizing steps in adjusting the contact device to the specified sensitivity value, and continuing said demagnetizing and testing steps upon said contact device until the specified release sensitivity adjustment is attained.

4. A method as defined in claim 1 wherein said demagnetizing magnetic field comprises a plurality of alternating magnetic cycles, the peak values of said cycles being of gradually increasing amplitude and thereafter of gradually decreasing amplitude.

5. A method as defined in claim 2 wherein said demagnetizing magnetic field comprises a plurality of alternating magnetic cycles, the peak values of said cycles being of gradually increasing amplitude and thereafter of gradually decreasing amplitude.

6. A method as defined in claim 3 wherein said demagnetizing magnetic field comprises a plurality of alternating magnetic cycles, the peak values of said cycles being of gradually increasing amplitude and thereafter of gradually decreasing amplitude.

7. A method for adjusting the sensitivity of a make and break contact device of the type wherein a magnetizable armature biased by a permanent magnet coupled thereto is caused to make contact with an electrode in response to a current of specified amplitude through a winding which is also magnetically coupled to said armature, comprising the steps of overmagnetizing said permanent magnet with respect to the ultimate magnetic adjustment required thereof, demagnetizing said permanent magnet by subjecting same to a demagnetizing magnetic field comprising a plurality of alternating magnetic cycles, the peak values thereof being of gradually increasing amplitude and thereafter gradually decreasing amplitude, said demagnetization occurring in incremental steps of increasing intensity, testing said contact device after each incremental demagnetization step by passing a current through the winding thereof of sufficient amplitude to cause said armature to make contact with said electrode, and alternately applying said demagnetizing and testing steps to said contact device until the specified operative sensitivity adjustment is attained.

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