Oct. 7, 1958 W. D. GIBBS ET AL 2,855,480

PRECISION ANTI-SHOCK RELAYS

Filed Feb. 6, 1956 2 Sheets-Sheet 1

FIG. 3.

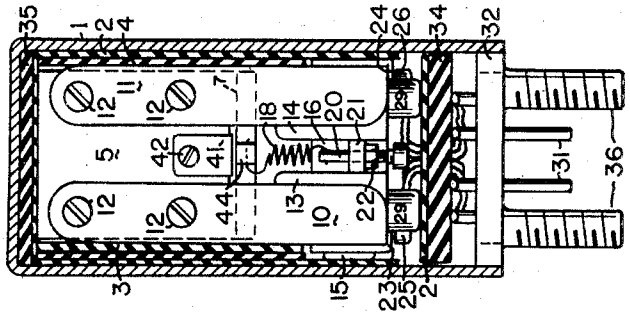


FIG. 2.

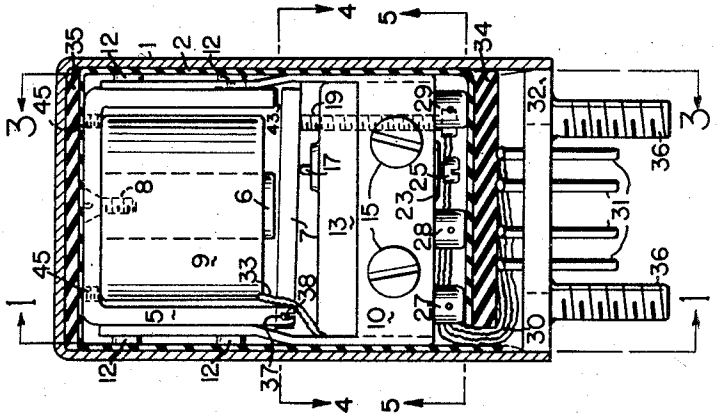
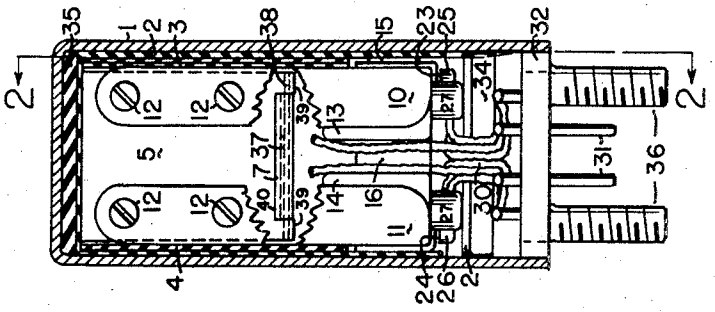


FIG. 1.



INVENTORS

WILLIAM D. GIBBS

BY MALCOLM JEAN CHARLES

ROBERT L. FOWLER

Harry K. Lubcke

AGENT

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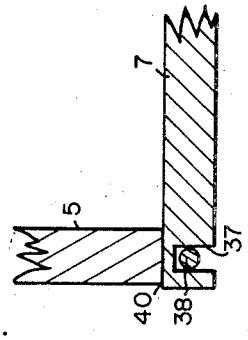


FIG. 6.

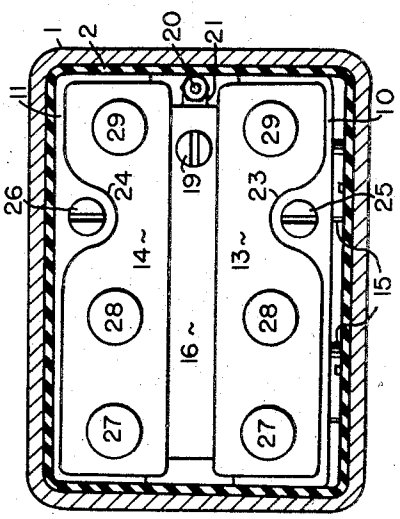


FIG. 5.

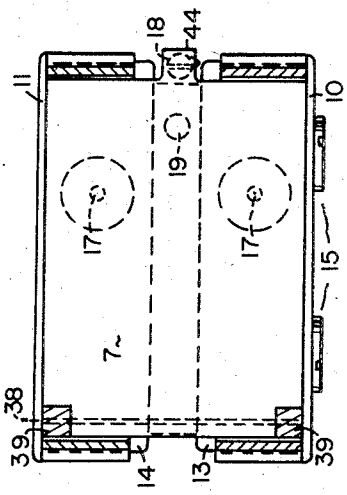


FIG. 4.

INVENTORS
WILLIAM D. GIBBS
MALCOLM JEAN CHARLES
ROBERT L. FOWLER

BY Harry K. Lubcke
AGENT

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PRECISION ANTI-SHOCK RELAYS

William D. Gibbs, Arcadia, Malcolm Jean Charles, Granada Hills, and Robert L. Fowler, Burbank, Calif., assignors to Electronic Specialty Co., Los Angeles, Calif., a corporation of California

Application February 6, 1956, Serial No. 563,654

8 Claims. (Cl. 200—87)

This invention relates to magnetically operated electrical contacting devices and particularly to a relay of electrical precision having improved characteristics under conditions of mechanical shock and vibration.

While the electrical relay is a device well known in the art for remotely making or breaking contacts in electrical circuits the performance demands of modern electronics call for devices to operate under electrical and mechanical conditions sufficiently rigorous to render the classical relay inoperative. Besides small size and hermetic sealing against all kinds of ambient conditions and agents the operating performance of the relay under mechanical conditions of severe vibration and shocks of many times the acceleration due to gravity (many "g's") must now be exemplary. The relay must be as electromagnetically sensitive as possible to allow operating forces sufficiently large to insure reliability of operation under the mechanical conditions outlined. Furthermore, the mechanical structure must be packaged in such a manner as to avoid deformation under all conditions of use and to avoid failure by fatigue of metal under prolonged vibration.

We have discovered that modern requirements can be met by departing from the prior art in certain important related ways. A tight-fitting and thus low reluctance hinge between the stationary part of the magnetic structure and the armature has been found disproportionately effective in increasing the sensitivity to operating force ratio. In combination with an adjustable piece for maintaining a minimum air gap at the end of the armature opposite the hinge the certainty of the drop out value of the relay is enhanced.

We have departed completely from the practice in the art of building a relay upon a base. Such a structure invites fatigue from cantilever beam action, crowds the operating portion of the relay, and causes differential internal stresses in the structure. Instead, we form the whole of the relay proper in a compact and ruggedly connected structure and connect this to the base by flexible electrical connections. There are no cantilever stresses, the operating portion of the relay is fully accessible during manufacture and for readjustment and two two-dimensional U-brackets each having surfaces in two parallel and one mutually perpendicular planes hold the structure together so that differential stresses therewithin are avoided. The access provided by our structure allows precision screw adjustment of the opening armature stop, of the spring tension opposing the pull of the actuating magnet and of the relation between armature travel and switch contact travel. Through the use of an envelope of electrical insulating material and of compliant pads the relay proper nests within its housing or case and becomes structurally one with it, being supported by at least four sides thereof.

The aspects of the structure recited have a unitary effect upon the operating characteristics of the relay. The coaction thereof determines that the relay will be sensitive, yet rugged, that the operating electrical values will be the same under conditions of vibration or shock

as at rest and that optimum characteristics can be obtained in each relay in factory manufacture or by readjustment in the field.

An object of our invention is to provide a relay of improved operating characteristics under conditions of vibration and mechanical shock.

Another object is to provide means for precision adjustment and readjustment of the operating mechanism of a small relay.

Another object is to reduce the reluctance of the magnetic structure of a relay.

Another object is to form and support the essential structure of a relay to resist internal deformation.

Another object is to prevent failure of the structure due to cantilever fatigue.

Other objects of our invention will become apparent upon reading the following detailed specification and upon examining the related drawing, in which:

Fig. 1 shows the relay in one end elevation,

Fig. 2 shows the relay in side elevation,

Fig. 3 shows the relay in the other end elevation,

Fig. 4 is a horizontal sectional view looking downward from just above the armature,

Fig. 5 is a horizontal sectional view looking upward from just below the switch terminals, and

Fig. 6 is a vertical sectional detail of the armature hinge structure.

In the figures the case has been shown in section so that the relay proper may be seen, and in Fig. 4 it has been omitted for clarity.

In Fig. 2, which shows the greater portion of the general construction numeral **1** identifies a characteristically hollow rectangular parallelepiped magnetic or non-magnetic metal case or housing. Within this is insulating envelope **2**, preferably formed of a hard but flexible fiber. This has the function of insulating the several elements of the relay proper from the housing and of acting as a structural support between the elements and the housing over most of the surfaces involved. It is not important that all portions of every surface be supported but this end is promoted by folding the envelope with two or three thicknesses of the material adjacent to the smaller dimensions of the relay. Such additional thicknesses are indicated at **3** and **4**.

The space within the desirably small rectangular housing is effectively utilized by employing a U-shaped stationary magnetic element **5** in conjunction with a cylindrical pole **6** and a magnetic-circuit-completing armature **7**. The U-shaped piece and the pole are held together with screw **8**. All these elements are preferably formed of soft hydrogen-annealed magnetic iron.

This magnetic structure has an important advantage over others of the prior art in that when screw **8** is loosened and withdrawn pole **6** and the surrounding coil **9** can be withdrawn from the relay. This allows the coil to be easily changed for another of a different number of turns or for replacing a defective coil; also, for obtaining a different gap at pole piece **6**.

The main structural members of our relay are the two U-brackets **10** and **11**. These are characterized as two-dimensional in that these are fastened to the U-shaped magnetic element **5** by two binding head screws **12** at each side thereof and support two switch contacting means **13** and **14** by screws **15** upon surfaces at right angles to the sides fastened to element **5**. Screws **12** in slightly oversize holes in brackets **10** and **11** allow minor structural adjustment of the brackets with respect to element **5** for adjustment in manufacture. After the manufacturing adjustment the threaded ends of screws **12** are preferably soldered to element **5** to surely retain the adjustment. The switch contacting means are held

apart in a rigid structure by milled piece **16**, which is preferably of non-magnetic metal or of phenolic. This piece is shown in Figs. 1, 3 and 5. The screw holes in bracket **10**, the switch contacting means **13** and **14**, and milled piece **16** are of screw pass size, whereas the holes in bracket **11** are threaded. Of course, rivets may be used for fastenings **12** and **15** where manufacturing tolerances are so close that manufacturing adjustment is not required.

Switch contacting means **13** and **14** have been shown as spring-biased double throw contactors in insulated cases, such as microswitches. The actuating rod **17** of each is depressed by the armature of the relay when in the non-energized position shown in Fig. 2 to make contact with the lower contact of each against the bias of the internal spring within the microswitch. External spring **18** of the relay, shown in Fig. 3, assures that the internal spring will be overcome and that the armature will be pressed against threaded adjustable stop **19** when the relay coil is not energized. The effective spring tension is the difference between the two tensions mentioned. Precision adjustment of the external spring is accomplished by adjusting stud **20**. This is fitted into the extension **21** of milled piece **16** and is provided with adjusting nut **22**.

Brackets **10** and **11** have integrally formed projecting lips **23** and **24** at the lower extremities. The lips are threaded and hold switch-positioning screws **25** and **26**. These screws provide a micrometer type adjustment of the travel of the actuating rod **17**, an important adjustment as we have found in practice. By the adjustment of screws **25** and **26**, stop **19** and spring-adjusting stud **20** it is possible to quickly and accurately adjust the relay to optimum operating conditions. This is not possible with relays which require bending stops and spring adjustment and which have no means of adjusting the travel of the switch rod. When our adjustments have been made and the relay is to be sealed or otherwise operated without supervision during the useful life each adjustment is sealed with a brush-full of a suitable compound, such as glyptal.

Each switch contacting means **13** and **14** of the relay is ordinarily fitted with three electrical terminals, **27**, **28** and **29**. Terminals **27** and **28** are connected within the switch to the double throw contacts and terminal **29** to the switch arm. In this relay these terminals are connected by relatively flexible insulated wires which are generally indicated at **30** to appropriate pins **31** forming the external terminals and fastened in an insulating portion of base **32**. Other wires, such as **33**, connect from pins to the winding of coil **9**.

The space occupied by the pins with the wire soldered thereto is such in relation to the height of the relay proper and the housing that compliant silicone rubber pads **34** and **35**, in addition to envelope **2**, fills the interior of the housing vertically. In this way, and more particularly because of intimate support by the sides of the housing, the relay and housing are a unified structure with respect to vibration and shock and there is no possibility of cantilever vibration and fatigue which has so characterized the structures of the prior art.

The base **32** is shown provided with threaded studs **36** set at diagonal corners for mounting purposes. Alternately, these may be omitted and the pins **31** engaged in a miniature vacuum tube socket. Hermetic sealing is accomplished by soldering the case **1** and base **32** at the common seam. Introduction of a dry inert gas, etc., may also be accomplished according to known techniques.

We return to the fine structure of the hinge between the armature **7** and magnetic element **5**. As will be noted from Figs. 1 and 2 a deeper than structurally necessary slot **37** is milled in armature **7** completely across it. A pin in the slot having a rotating fit is shown at **38**. An equivalent slot is milled in the end extensions **39** of magnetic element **5** so that pin **38** may extend the full distance across the element. The outside tab of the end extensions is peened forward in assembly to hold pin **38** fast in each extension **39**. The lever action of spring **18**, stop **19** and rod **17** creates a force to position armature **7** and element **5** in relatively tight juxtaposition all along the mutual extent of each as denoted by joint **40** when the relay is not energized. When the relay is energized magnetic attraction holds armature **7** and magnetic element **5** in intimate and extensive magnetic contact. The extra depth of slot **37** assures that joint **40** shall be the determining factor in this structure and not a restriction of the pin **38** of the hinge. In this way a novel low reluctance hinge is provided.

It is desirable to have a small minimum air gap in the magnetic structure at times in order to prevent the armature from sticking after the magnetomotive force produced by current in the coil has ceased or has decreased to a desired value. This we accomplish by means of an adjustable piece of non-magnetic metal or durable plastic **41**, which has a vertically elongated hole under screw **42**. This piece may extend at a right angle over the anvil of the magnetic element **5**, as at **43** in Fig. 2, or may bear only on the lip **44** on armature **7**, which lip also takes the upper end of spring **18**. In either event it will be seen that the minimum gap of the armature to the remainder of the magnetic structure can be adjusted and thus the drop-out characteristic altered at will. It will be appreciated by those skilled in the art that this direct adjustment of but a single air gap gives a desired simplification and certainty of adjustment not found in relays which do not have our low reluctance hinge.

Where a single pole switch is desired, one or the other of switch contact means **13** or **14** may be omitted and the structure conveniently completed by substituting a piece of Bakelite or equivalent material. This material would not have the coacting pin **17**, but we have found that the broad stabilizing effect of joint **40** prevents the armature from moving at an unwanted angle and causes it to pull up squarely with respect to the rest of the magnetic structure.

A preferred embodiment of our invention has been described, the operating characteristics of which are well in advance of the prior art. Other embodiments are possible in accordance with the teaching of this specification. One is a non-hermetic construction, for which we prefer to fasten the relay proper to other equipment or the chassis with which it is associated by screws at the top of element **5** and have thus provided tapped holes **45** for this purpose. The relay may be mounted in any position.

Another embodiment concerns the switch contact means. This may be of any type, either spring biased or conventional.

Various parts may also take different shapes and proportions. The whole structure may be made very small or made larger than the figures herein. These have been made of relatively large scale for sake of clarity.

Having thus fully described our invention and the manner in which it is to be practiced, we claim:

1. In a compact electrical relay having electromagnetic means including an armature and unitary multiple contact means actuated by said armature, the combination of a low reluctance hinge formed between said armature and the remainder of said electromagnetic means, said hinge having a pin structurally free to allow intimate and extensive magnetic contact between said armature and the remainder of said electromagnetic means, independent of said pin and threaded means small with respect to said unitary multiple contact means to alter the structural relation of said unitary multiple contact means to said electromagnetic means for adjusting the coactive relation between said unitary multiple contact means and said armature, said structural relation being such that said armature is in mechanical contact with said unitary mul-

tiple contact means in both the electrical contact and non-contact positions thereof.

2. In a closely juxtaposed electrical relay having electromagnetic actuating means including an armature with joint, actuating means, switch and restraining means disposed in linear sequence and a unitary multiple switch actuated by said armature, the combination comprising a low magnetic reluctance joint formed between said armature and the stationary part of said electromagnetic actuating means, said joint having a pin structurally free of said armature to allow intimate and extensive continuity of magnetic material between said armature and the stationary part of said electromagnetic actuating means independent of said pin, and plural threaded means small with respect to said unitary multiple switch to support said unitary multiple switch to alter the structural relation thereof with respect to said electromagnetic actuating means for obtaining the required coactive juxtaposition between said unitary multiple switch and said armature, said armature thus adjusted being in mechanical contact with said unitary multiple switch both in the actuated and the non-actuated electrical positions of said unitary multiple switch.

3. In a compact electrical relay having an actuating coil, a stationary magnetic structure coactive with said coil, a movable magnetic armature and a unitary multiple switch, the combination of a low magnetic reluctance hinge formed between said armature and said stationary magnetic structure, said hinge having retaining means loose with respect to said armature to allow intimate and extensive continuity of magnetic material between said armature and said stationary magnetic structure independent of said retaining means at said hinge, bracket means to support said unitary multiple switch in relation to said magnetic structure, and screw means small with respect to said unitary multiple switch engaging said bracket means and bearing upon said unitary multiple switch to position the latter for actuation by said armature as moved by magnetic force arising from the flow of electric current in said coil, said armature positioned in mechanical contact with said unitary multiple switch both in the actuated and the non-actuated electrical positions of said unitary multiple switch, and said armature coactively disposed to include said hinge, actuating coil, mechanical contact and a restraining means in linear sequence.

4. In an integrated electrical relay having a field-producing actuating coil, a magnetic structure within and surrounding said coil including a movable armature, and a fixed-throw unitary switch, the combination comprising a low magnetic reluctance armature hinge having a deep slot in said armature and a stationary pin loosely disposed therein to allow said armature to assume extensive and intimate contact with the stationary portion of said magnetic structure at said hinge independent of said pin, plural brackets to support said fixed throw unitary switch in relation to said magnetic structure, and a screw small with respect to said fixed-throw unitary switch threaded into each of said brackets and bearing upon said fixed-throw unitary switch to precisely adjust the latter in constant mechanical contact relation to said movable armature for the electrical actuation of said fixed-throw unitary switch by said armature, said armature coactively disposed to include said hinge, actuating coil, mechanical contact and a restraining spring in order therealong.

5. An a unitary electrical relay having only one magnetic-field-producing actuating coil, a magnetic structure within and surrounding said coil including a movable armature, and two microswitches positioned to be actuated by said armature, the combination of a low reluctance magnetic structure to armature joint having a pin attached to said magnetic structure and a deep slot in said armature loosely coactive with said pin to allow extensive and intimate magnetic contact between said magnetic structure and said armature at said joint independent of said pin, two non-magnetic brackets to support said two microswitches in relation to said magnetic structure, and a screw, small with respect to one microswitch, threaded into each of said brackets and bearing upon one microswitch to accurately adjust the position of each microswitch with respect to said movable armature for precise actuation of said microswitches by said armature upon the electrical energization of said actuating coil, said armature positioned in mechanical contact with said two microswitches both in the actuated and the non-actuated electrical states thereof, and said armature coactively disposed to include said joint, actuating coil, mechanical contact and a restraining spring means in linear sequence.

6. In a closely juxtaposed electrical relay having electro-magnetic means including an armature, unitary multiple contact means actuated by said armature, terminals, and a case, the combination of a low reluctance hinge formed between said armature and the remainder of said electro-magnetic means, said hinge having a pin structurally free to allow intimate and extensive magnetic contact between said armature and the remainder of said electro-magnetic means independent of said pin, threaded means small with respect to said unitary multiple contact means, to alter the structural relation of said unitary multiple contact means to said electro-magnetic means for adjusting the coactive relation between said unitary multiple contact means and said armature, said armature positioned in mechanical contact with said unitary multiple contact means both in the electrical contact and the non-contact positions thereof, said armature disposed to include said hinge, the magnetomotive-force-producing portion of said electro-magnetic means, mechanical contact with said unitary multiple contact means and a restraining element in sequence therealong, structurally flexible means to connect the recited electrical elements to said terminals, and means to rigidly support all said elements within said case structurally independent of said terminals.

7. In an electrical relay having a single actuating coil, a stationary magnetic structure coacting with said coil, a movable magnetic armature, a unitary multiple switch, terminals, and a rectangular-like case, the combination of a low reluctance hinge formed between said armature and said stationary magnetic structure, said hinge having a pin loose with respect to said armature to allow intimate and extensive continuity of magnetic material between said armature and said stationary magnetic structure at said hinge, bracket means to support said unitary multiple switch in relation to said magnetic structure, screw means engaging said bracket means and bearing upon said unitary multiple switch to position the latter for actuation by said armature as moved by magnetic force arising from the flow of electric current in said coil, structurally flexible electrical conductive means to connect said unitary multiple switch and said coil to said terminals, and non-yielding enclosing means to substantially surround the elements of said combination, said enclosing means adapted to rigidly support said elements within said case structurally independent of said terminals.

8. In an electrical relay having only one magnetic-field-producing actuating coil, a magnetic structure within and surrounding said coil including a movable armature, two microswitches positioned to be actuated by said armature, a rectangular parallelepiped housing, and insulated terminals for external electrical connections in the base of said housing, the combination of a low reluctance magnetic structure to armature joint having a pin attached to said magnetic structure and a deep slot in said armature loosely coactive with said pin to allow extensive and intimate magnetic contact between said magnetic structure and said armature at said joint, two non-magnetic brackets to support said two microswitches in relation to said magnetic structure, a screw threaded into each of said brackets and bearing upon one micro-

switch to accurately adjust the position of each microswitch with respect to said movable armature for precise actuation of said microswitches by said armature upon electrical energization of said actuating coil, flexible wires to electrically connect said microswitches and said coil to said terminals in said base, and a non-yielding electrical insulating envelope to surround the recited elements save said housing and terminals, said envelope adapted to fully support the surrounded elements within said housing structurally independent of said terminals.

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