Sept. 19, 1961 L. J. RACZ ET AL 3,001,046

VACUUM RELAY

Filed May 7, 1958 2 Sheets-Sheet 1

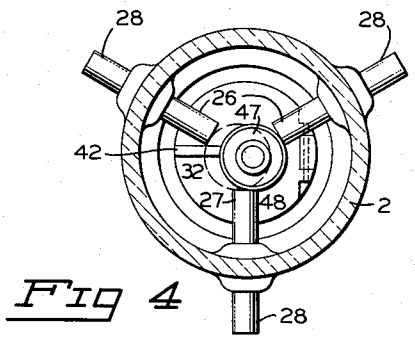


Fig 4

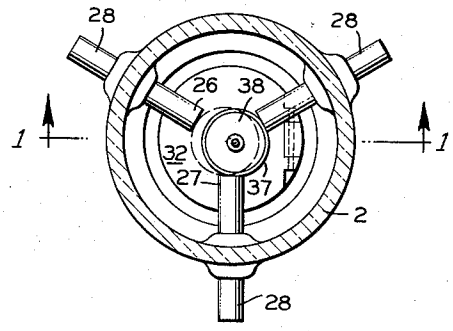


Fig_2

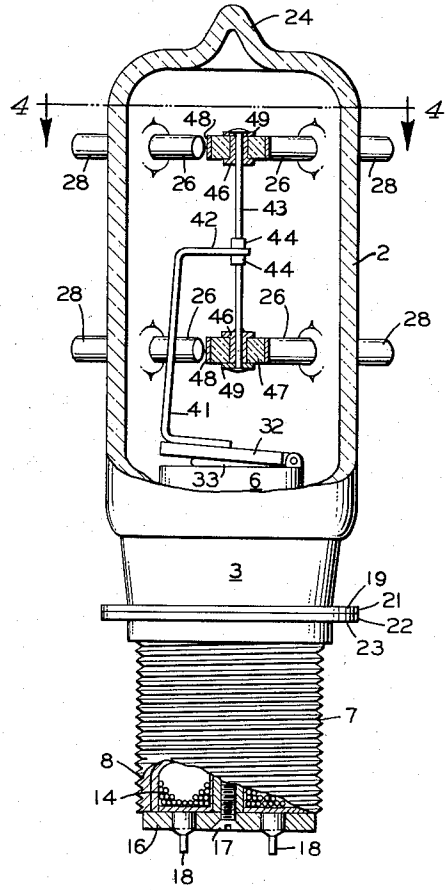


Fig_3

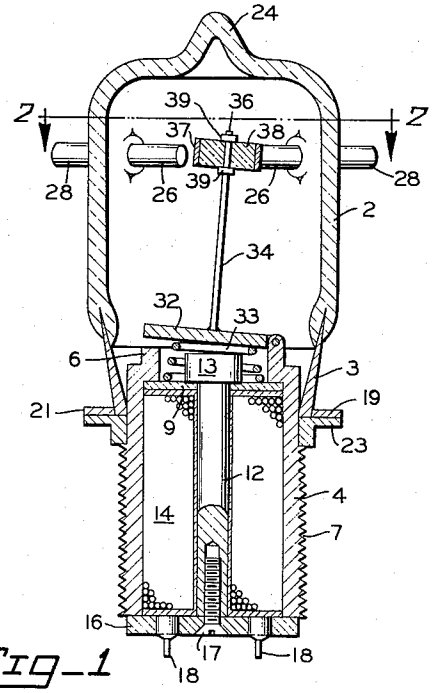


Fig_1

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Fig_7

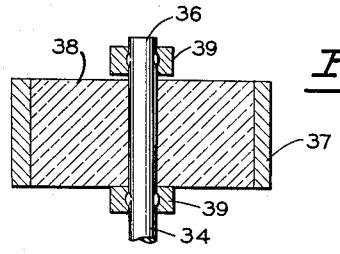


Fig_8

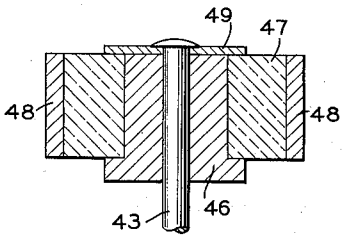


Fig_5

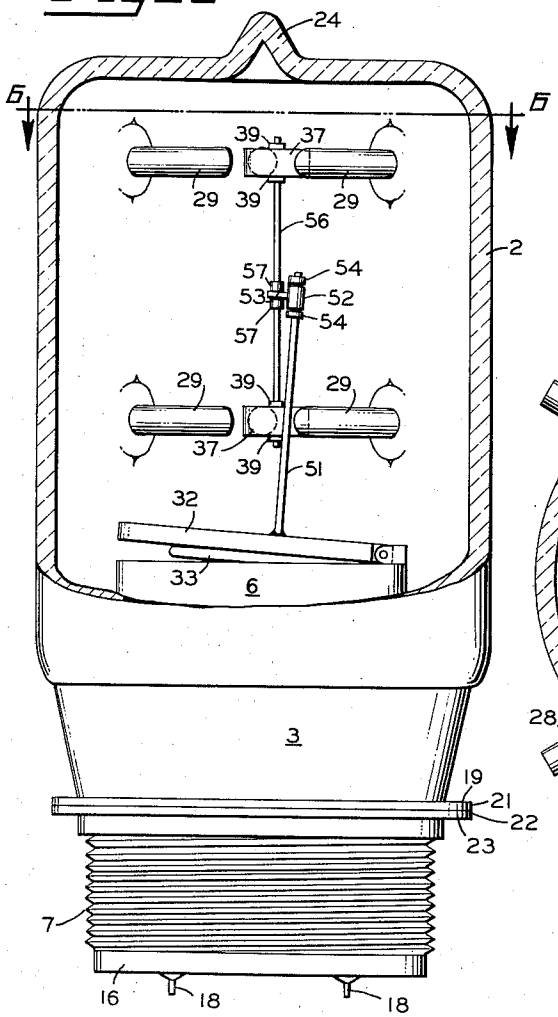
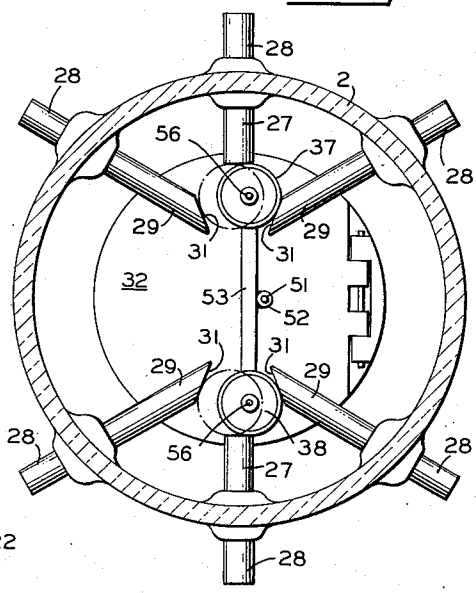


Fig_6



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VACUUM RELAY

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12 Claims. (Cl. 200—87)

Our invention relates to vacuum relays and particularly to solenoid operated, remotely controllable relays of small size and relatively high current carrying capacity.

One of the objects of our invention is the provision of a vacuum relay or switch in which the movable contact rollably engages one of the contact points.

Another object is the provision of a vacuum relay having a contact structure unaffected by atmospheric pressure or humidity changes and characterized by low contact resistance.

Still another object is the provision of a vacuum relay having a contact structure in which vibration is negligible.

A still further object is the provision of a vacuum relay in which the acceleration or G rating of the relay permits its use in missile applications where reliability is a prime consideration.

Another object of the invention is the provision of a high speed miniature vacuum relay in which adherence to close tolerances during assembly of the contact structure is unnecessary.

Still another object of the invention is the provision of a vacuum switch in which the movable contacts are self-aligning and free from objectionable bounce when brought into engagement with adjacent contact points.

The invention possesses other objects some of which with the foregoing will be brought out in the following description of the invention. We do not limit ourselves to the showing made by the said description and the drawings, since we may adopt variant forms of the invention within the scope of the appended claims.

Referring to the drawings:

FIG. 1 is a vertical half sectional view taken in the plane indicated by the line 1—1 of FIG. 2, and showing the invention embodied in a single pole-double throw relay.

FIG. 2 is a horizontal sectional view taken in the plane indicated by the line 2—2 of FIG. 1.

FIG. 3 is an elevational view with parts of the structure broken away to reveal underlying parts. The view shows the invention embodied in a double pole-double throw relay.

FIG. 4 is a horizontal sectional view taken in the plane indicated by the line 4—4 of FIG. 3.

FIG. 5 is an elevational view with a portion of the envelope broken away to disclose the underlying structure. This view shows the invention embodied in a four pole-double throw relay.

FIG. 6 is a horizontal sectional view taken in the plane indicated by the line 6—6 of FIG. 5.

FIG. 7 is a fragmentary sectional view showing the construction of the rotatably journaled movable contact embodied in the relays illustrated in FIGS. 1 and 5.

FIG. 8 is a fragmentary sectional view similar to FIG. 7, and showing a movable contact of modified construction as embodied in FIG. 3.

FIGS. 1 through 6 are drawn twice actual size, and FIGS. 7 and 8 are drawn eight times actual size.

Broadly considered, the vacuum relay of our invention comprises an evacuated envelope formed by a dielectric bulb closed on one side by a metallic end wall and together defining a vacuumized chamber. Integrally mounted on the metallic wall and extending on both sides thereof is a magnetizable core. Within the chamber,

an armature is pivotally mounted for movement toward and away from the inner end of the core, and core energizing means are provided adjacent the external end of the core operable to move the armature toward the core. Means within the chamber interposed between the armature and the metallic wall operates to pivot or press the armature away from the inner end of the core when the core energizing means are inoperative. Within the chamber and mounted on the bulb wall are a plurality of spaced contact points, each of which is continuous with a lead external to the bulb. A movable contact within the chamber rollably engages one of the contact points, and is movable into and out of engagement with another contact point to make and break a circuit therebetween. Means are provided mounting the movable contact on the armature and for insulating it therefrom.

The technological advances recently made in the missile field place emphasis on the continuing need of vacuum relays and switches of small size, high kv. breakdown rating and high current carrying capabilities. Other desirable characteristics which should be included are freedom from friction and wear in moving contact parts, low inductance in terminal leads, resilient contact pressure resulting in low contact resistance and freedom from bounce and vibration, and self-alignment of the movable contact with the fixed contact points to insure reliability and freedom from the need of maintaining close tolerances in assembly and operation.

To achieve these desirable characteristics we have designed a vacuum relay or switch comprising an envelope including a dielectric bulb 2, closed at one end by a metallic wall including a hollow conical copper flange 3 having one end hermetically bonded to the open end of the bulb, and its other outer end brazed about the periphery of a hollow cylindrical metallic housing 4 intermediate the ends thereof. The inner end 6 of the metallic housing extends into the copper flange, and the outer end of the housing is provided with external threads 7 useful in mounting the relay in a panel. The threads may be formed directly in the housing wall as in FIG. 1, or they may be formed in the periphery of a sleeve 8 as in FIG. 3, which is then brazed about the outer end of the housing.

Within the hollow housing and transversely interposed intermediate the ends thereof is an annular non-magnetic metallic plate 9 having its outer periphery hermetically brazed to the housing wall. A magnetizable core 12, aligned with the housing, extends though the central aperture of the annular plate and is hermetically brazed therein. A head 13 on the inner end of the core within the envelope cooperates with the inner end 6 of the magnetizable housing in forming a magnetic circuit. The core extends outwardly from the plate 9 through the housing and terminates flush with the end of the housing. An energizable coil 14, mounted on a cover plate 16 and fitting snugly within the hollow housing, surrounds the outer end of the core and is detachably secured therein by a screw 17 which clamps the cover plate tightly against the outer ends of the core and housing. Coil leads 18 extending through the cover plate serve to connect the coil in a control circuit operable to energize the coil and magnetize the core.

A common problem in the manufacture of vacuum devices is the exclusion of contaminants from within the envelope just before it is sealed. One method commonly used is to apply an acid rinse to the interior of the envelope. This method is effective, but it is difficult to avoid trapping some of the acid within the envelope. To obviate this costly procedure, we have devised a construction which permits cleaning of the parts before assembly, and subsequent sealing of the envelope

so as to preclude entry of contaminants as a result of the sealing process.

Hermetically brazed about the outer end of the copper flange 3 is an annular, radially extending nickel flange 19, the outer periphery 21 of which lies flush with the outer periphery 22 of a second nickel flange 23 brazed about the cylindrical housing 4, when the parts are brought into assembled relationship. The outer peripheries 21 and 22 are now heliarc welded, forming a rigid and hermetic union. Evacuation of the envelope is then accomplished through tubulation 24 formed in the closed end of the bulb. Joining the bulb and housing assemblies by this means also makes practicable subsequent opening and reuse of the envelope. This may be accomplished by grinding off the peripheral edges of the flanges until the seal is broken and the flanges may be separated.

In the embodiment of our invention shown in FIGS. 1 and 3, a set or plurality of sets of contact points are provided. Each set comprises two radially extending contact points 26 and a radially extending common contact point 27 adapted to be electrically connected selectively with either of the contact points 26. Two different circuits may thus be controlled by the use of only three contact points and a common source of power, thus effecting a saving in weight, material costs and time of assembly. The contact points are spaced 120° apart about the bulb and lie in a common plane. Each contact point, including the common contact point 27, is rigidly supported hermetically in the bulb wall at a point axially spaced from the inner end of the metallic housing, and is integrally continuous with a lead 28 external to the envelope and constituting a terminal for connection to an electric power source. In FIG. 3 we have shown two such sets of contact points, with the sets being axially spaced apart. This arrangement provides a double pole-double throw configuration easily assembled and useful where a multiplicity of circuits are to be controlled.

In FIG. 5 we have shown a four pole-double throw relay in which four sets of three contact points each are provided. As shown best in FIG. 6, each set comprises a radially extending common contact point 27 as in the other two embodiments, and two contact points 29, one such contact point being spaced on each side of the common contact point. A flat elliptically shaped contact surface 31 is provided on the inner end of each contact point 29 on which contact may be made. As in the other embodiments, each contact point is integrally continuous with a terminal lead external to the envelope. It will also be obvious from FIGS. 5 and 6 that the sets of contact points are arranged on the envelope in pairs axially spaced apart, each set of each pair being rigidly supported on the envelope diametrically opposite the other set of the same pair.

Means are provided within the evacuated chamber of each embodiment operable to engage and disengage a selected contact point 26 or 29 with an associated common contact point to make and break a circuit therebetween. Pivotally mounted within the evacuated chamber of each relay on the inner end 6 of the housing is an armature 32 having a coil spring 33 thereunder interposed between the armature and the metallic plate 9, and normally pivoting the armature away from the inner end of the core and housing. Energizing the coil 14 imposes a strong magnetic pull on the armature, pivoting it downward to close the gap between core and housing and compressing the coil spring 33. Deenergizing the coil releases the armature which is rapidly pivoted outwardly by the spring 33.

The extremely rapid operation of our relays, ranging from 500 cycles per second for the four pole device shown in FIG. 5 to 2000 cycles per second for the single pole device shown in FIG. 1, is due in part to the fact that spring 33 imposes minimum resistance against initial movement of the armature at the instant the coil is energised. As the armature approaches the core and housing the magnetic force pulling the armature down increases much more rapidly than the spring pressure tending to push the armature away. When the armature has abutted the housing and core, the magnetic field strength is at its peak and the spring is fully loaded. Deenergizing the coil releases the armature and permits the spring to rapidly pivot the armature outwardly.

Mounted on the armature of the single pole relay shown in FIG. 1 is a resilient stem comprising a tungsten rod 34 integrally fixed at one end on the armature and extending away therefrom substantially perpendicularly to terminate in a free end 36 adjacent the contact points. Journaled for rotation on the resilient rod adjacent its free end is a movable contact comprising a conductive metallic ring 37 brazed about the periphery of a dielectric plate 38. The dielectric plate is axially aligned with the rod 34 and is rotatably journaled thereon between collars 39 fixed on the rod. The plate 38 thus serves to insulate the movable contact ring from the resilient rod 34 and the armature assembly.

As shown best in FIG. 2, the dielectric plate serves also to cooperatively relate the contact ring 37 with the contact points 26 and common contact point 27. As shown in full lines in FIG. 2, the contact ring is resiliently held against the common contact point 27 and right hand contact point 26 by movement of the armature away from the core. Energizing the coil to pivot the armature downwardly swings the rod and movable contact transversely to the left. Since the parts are proportioned to effect a resilient contact pressure between the contact ring and the common contact point, transverse movement of the movable contact causes the contact to roll on the common contact point. This rollable relationship between the parts results in a minimum amount of restriction to transverse movement of the movable contact, thus effecting an increase in the operating speed of the relay. In this regard, the length of the rod 34 is also of some importance since it permits a relatively long excursion of the movable contact for only a small movement of the armature. A longer excursion permits wider spacing of the contact points thus increasing the voltage breakdown rating of the relay. In the relay shown in FIG. 1 voltages as high as 18 kv. have been attained before breakdown, while low voltage currents as high as 10 amperes have been carried.

In the embodiment shown in FIG. 3, two axially spaced sets of contact points are provided. Fixed on the armature is a resilient stem comprising a metallic bracket 41 integrally united at one end to the armature and extending freely therefrom substantially at right angles and terminating in an integral radially extending support arm 42 lying intermediate the vertically spaced sets of contact points. Journaled on the free end of the support arm is a resilient metal rod 43 having a collar 44 integrally united thereto on each side of the support arm. The rod extends equally on both sides of the support arm so as to position each end of the rod adjacent one of the sets of contact points. Rotatably journaled adjacent each end of the rod is a movable contact comprising a flanged metal hub 46 integrally united to the rod 43 and having an annular dielectric ring 47 rotatably journaled thereon. Encircling and brazed about the outer periphery of the dielectric ring is a conductive contact ring 48 adapted to rollably engage the associated common contact 27. A stop plate 49 integrally united to the hub 46 and to the end of the rod 43 retains the dielectric ring with its attached contact ring operatively journaled on the hub.

Thus, in FIG. 4, the spring 33 has pivoted the armature outwardly, resiliently pressing both movable contact rings 48 to the right, causing each to lie cradled between and against an associated contact point 26 and the adjacent common contact point 27. Energizing the coil 14 will now pull the armature down, causing the movable contacts to be swung to the left. Since the periphery of the contact ring 48 impinges resiliently against the common

contact point, movement of the contact ring to the left will effect rotation of the contact ring, which continues until the contact ring impinges against the other contact point **26**. The rotatable contact ring is thus continuously rollably engaged with the common contact point.

In the embodiment shown in FIG. 5, a four pole-double throw relay is shown in which four sets of contact points are provided. Integrally united at one end to the armature and extending outwardly therefrom between the diametrically opposed sets of contact points is a resilient rod **51** terminating in a free end approximately midway between the vertically spaced sets of contact points. Pivotally journaled on the outer free end of the rod **51** by means of an integral bearing sleeve **52** is a transverse bar **53** substantially horizontal and parallel to the common contact points **27**. Collars **54** fixed to the rod **51** at opposite ends of the bearing sleeve **52** retain the bar **53** properly positioned within the envelope. Rotatably journaled adjacent its midpoint on the transverse bar at each end thereof is a substantially vertically extending resilient journal shaft **56**, extending equally on both sides of the bar **53** and having opposite free ends terminating in close proximity to the contact points of vertically spaced and aligned sets of contact points. The journal shafts are retained in position on the bar **53** by collars **57** fixed to each shaft on opposite sides of the bar.

Rotatably journaled on each free end of each journal shaft **56**, and lying between the contact points of the associated set, is a movable contact similar to the one described in connection with FIGS. 1 and 2, and shown best in FIG. 7. As in FIGS. 1 and 3, energizing the coil **33** swings the contact assembly to the left, causing the rollably engaged dielectric plate **38** and contact ring **37** to roll toward the other contact point, while retaining its resilient engagement with the common contact. As in the embodiment shown in FIG. 1, the movable contacts are retained in operative position by collars **39** fixed to the shafts on opposite sides of the movable contacts.

We claim:

1. A vacuum relay comprising a dielectric bulb closed on one side with a metallic wall and therewith enclosing a vacuumized chamber, a magnetic core integral with the metallic wall and extending on both sides thereof, an armature pivotally mounted within the chamber adjacent the inner end of the core, means pressing the armature away from the core, core energizing means adjacent the external end of the core and operable to move the armature toward the core, spaced contact points within the chamber and mounted on the bulb and each said point being continuous with a lead external to the bulb, a movable contact rollably engaging one of the contact points and rollable thereon into and out of engagement with another contact point to close a circuit therebetween, and means mounting the movable contact on the armature and insulating it therefrom.

2. The combination according to claim 1, in which said movable contact comprises a conductive metallic ring journaled for rotation about its own axis.

3. The combination according to claim 1, in which said means mounting the movable contact on the armature and insulating it therefrom includes a resilient stem fixed on the armature, a dielectric plate rotatably journaled on the resilient stem, and said movable contact comprises a conductive metallic ring fixed about the outer periphery of the dielectric plate for rotation therewith.

4. The combination according to claim 3, in which said resilient stem comprises a rod having one end integrally fixed to the armature and the other end extending freely to adjacent said spaced contact points, and said movable contact is rotatably journaled on the free end of the rod.

5. A vacuum relay comprising a dielectric bulb closed on one side with a metallic wall and therewith enclosing a vacuumized chamber, a magnetic core integral with the metallic wall and extending on both sides thereof, an armature pivotally mounted within the chamber adjacent the inner end of the core, means pressing the armature away from the core, core energizing means adjacent the external end of the core and operable to move the armature toward the core, at least three spaced contact points constituting a set within the chamber and mounted on the bulb and each said point being continuous with a lead external to the bulb, a movable contact rollably engaging one of the contact points and movable into engagement with a second contact point by pivotal movement of the armature away from the core and movable into engagement with a third contact point and disengaged from said second contact point by movement of the armature toward the core, and means mounting the movable contact on the armature and insulating it therefrom.

6. The combination according to claim 5, in which two sets of contact points are provided and a movable contact is operatively associated with each set.

7. The combination according to claim 5, in which a purality of pairs of said contact point sets are provided, the pairs of sets being vertically spaced from an adjacent pair and the sets of each spaced pair being diametrically opposed and provided with a movable contact operatively associated therewith.

8. The combination according to claim 6, in which the contact points of each set are circumferentially equally spaced on the bulb and the sets are vertically spaced and each said movable contact associated with each set is electrically insulated from the other movable contact.

9. In a vacuum relay the sub-combination comprising a dielectric bulb closed on one side with a metallic wall and with said bulb enclosing a vacuumized chamber, a magnetic core integral with the metallic wall, an armature mounted within the chamber adjacent one end of the core and movable therein to make or break a circuit through the relay, means within the chamber pressing the armature away from the core, and core energizing means adjacent the other end of the core and operable to move the armature within the chamber.

10. The sub-combination according to claim 9, in which the core extends on both sides of said wall and said armature is mounted adjacent the inner end thereof and said core energizing means is outside the chamber adjacent the external end of the core.

11. The sub-combination according to claim 9, in which said metallic wall is non-magnetic and is provided with magnetizable inwardly and outwardly extending cylindrical flanges, said armature is pivotally mounted within the chamber on said inwardly extending flange, and said core energizing means comprises an energizable coil enclosed within the outwardly extending flange.

12. The sub-combination according to claim 11, in which a magnetizable cover plate is provided detachably secured to said other end of the core to close the outer end of said cylindrical flange, and said core energizing means comprises an energizable coil fixed on the cover plate and detachable therewith.

References Cited in the file of this patent

UNITED STATES PATENTS

1,783,279	Burnham	Dec. 2, 1930
1,908,430	Lapsley	May 9, 1933
1,912,623	Douglas	June 6, 1933
2,306,585	Appelberg	Dec. 29, 1942
2,485,532	Johnson	Oct. 18, 1949
2,706,753	McGowan	Apr. 19, 1955
2,765,454	Long	Oct. 2, 1956
2,831,074	Schaefer	Apr. 15, 1958