Oct. 13, 1959 H. W. WALTERS, JR 2,908,780

VACUUM RELAY

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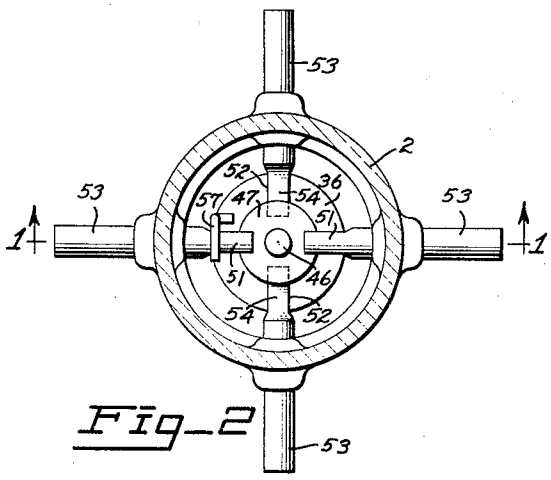

Fig_2

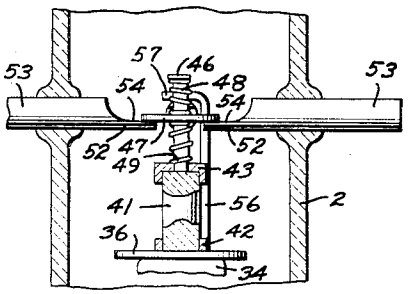

Fig_4

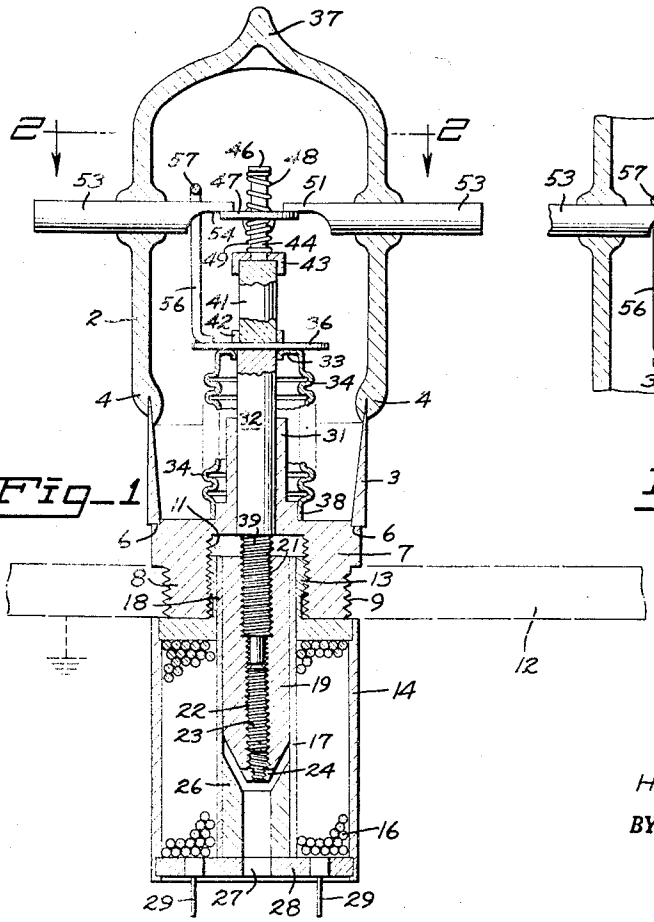

Fig_1

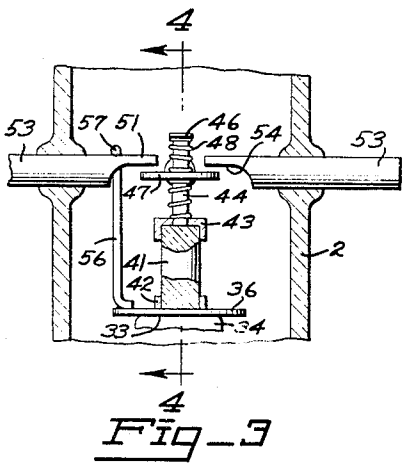

Fig_3

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VACUUM RELAY

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10 Claims. (Cl. 200—87)

My invention relates to electric relays and particularly to a miniature vacuum relay.

One of the objects of the invention is the provision of a vacuum relay in which the mobile contact is insulated from the operative mechanism of the relay.

Another object is the provision of a vacuum relay having simplified mechanical and electrical characteristics when the metallic relay base or housing is at ground potential.

Another object is the provision in a relay of the character described of means for conductively connecting a contact point of one pair of contacts with the grounded housing when the contact plate is engaged between an adjacent pair of contact points.

Another object is the provision of a relay suitable for controlling radio frequency energy.

Still another object is the provision of a double-break vacuum relay useful for control of high voltage pulses.

A still further object is the provision of a vacuum relay having a low capacitance characteristic between the switch contacts.

Another object is the provision of a vacuum relay in which the mobile contact is provided with built-in overtravel protection.

Still another object is the provision of a solenoid operated vacuum relay in which the solenoid coil is easily removable and replaceable, and armature travel is easily adjusted to extremely close limits.

The invention possesses other objects, some of which with the foregoing, will be brought out in the following description of the invention. I do not limit myself to the showing made by the said description and the drawings, since I 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 showing the mobile contact plate engaging a pair of contact points in response to atmospheric pressure. The plane of section is indicated by the line 1—1 of Fig. 2.

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

Fig. 3 is a vertical sectional view taken in the same direction as Fig. 1, but showing the mobile contact assembly held in altered position by the activated solenoid.

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

All of the figures are drawn enlarged 1¼ times actual size.

The miniature vacuum relay illustrated and described is of the single-pole, double-throw type, and is suitable for use in high radio frequency installations, or in high voltage, high power alternating and direct current systems. It will of course be understood that single-pole, single-throw and double-pole, double-throw, or double-pole, single-throw mechanisms could just as readily be assembled.

The relay may be used for many different purposes, for example, to isolate radio frequency tank circuits, or as a

transmit-receive switch in radio transmitters. The relay can be used to isolate D.C. voltage, such as rapidly removing high voltage from a transmitter in the case of normal or overloads. Selecting different antennas or connecting various transmitters to various antennas is another useful application of the relay.

Because of its small size, approximately 3¼" x 2¾" overall for the relay illustrated, it is ideal for installation where minimum space requirements are important. Because of the extremely small millivolt drop as a result of low contact resistance, the relay is capable of carrying sizable currents at low voltage with no appreciable loss of power.

For the relay illustrated, a current rated at 10 amperes either alternating or direct, may be safely carried. With a grounded base housing and bellows as illustrated, the external resistance is adequate to withstand about 25,000 volts to ground, with approximately 15,000 to 20,000 volts safety factor internally between the contact plate and the housing. The operating solenoid will thus be below the electrostatic and electromagnetic radio frequency fields when the relay is mounted with the base and bellows grounded.

Broadly considered, the miniature vacuum relay of my invention comprises a dielectric shell or bulb closed by a hollow metallic housing hermetically sealed on the open end of the bulb. The metallic housing includes an integral expansible bellows which hermetically seals the envelope thus formed. The bellows is adapted to movably support a contact plate within the vacuumized interior of the envelope. A plurality of pairs of contact rods hermetically sealed in the dielectric bulb provide pairs of spaced contact points within the envelope and terminal leads outside the envelope. Means are provided operatively connected to the contact plate and extending out of the envelope to effect movement of the contact plate to engage and disengage a selected pair of contact points.

In more specific terms, and referring now to the drawings, the vacuum relay of my invention comprises a vacuumized envelope formed by a dielectric shell or bulb 2, symmetrical about a longitudinal axis, and having a hollow rigid metallic base or housing hermetically sealed on one end thereof. The housing is formed by a substantially cylindrical copper wall 3, feathered at its inner end and hermetically bonded in the bead 4 in the open end of the bulb. The outer end of the wall 3 is hermetically brazed on the annular shoulder 6 formed on the apertured body portion 7 of the hollow base or housing. Integrally formed on the body portion 7 and extending axially outwardly therefrom is a cylindrical flange 8 of somewhat reduced diameter, having threads 9 on its outer cylindrical periphery and threads 11 on the inside thereof. The external threads provide means for mounting the relay assembly in a grounded mounting panel 12, shown in dash lines in Fig. 1. Internal threads 11 provide means for removably securing the externally threaded neck 13 of the magnetizable solenoid housing 14, enclosing coil 16 wound on brass tube 17, which is held axially aligned within the housing by tube extension 18 fitting snugly within the neck 13 of the housing.

The brass tube forms a replaceable cylindrical slideway for the independently supported and removable solenoid armature 19, which is axially counterbored to provide a tapped bore 21 of relatively large diameter, and a relatively smaller diameter tapped bore 22 adapted to receive a set-screw 23 therein. The lower end of the armature adjacent the smaller bore 22 is conically formed and provided with a screw-driver slot 24. The conical end of the armature is adapted to seat in and be centered by the complementarily shaped inner end of the axially bored cylindrical stop insert 26. The bore in the

insert is aligned with the armature bore **22** and screw **23**, and also with a central aperture **27** in the solenoid cover plate **28**, which is crimped into the outer end of the solenoid housing. The cover plate retains coil, tube and insert within the solenoid housing and provides coil terminal posts **29** for connecting the coil to an electric power source. The central aperture in the cover plate gives access to a screw-driver, inserted to engage the screw-driver slot **24** for purposes of adjustment subsequently to be explained.

Integrally formed on the body portion **7** and extending axially inwardly therefrom is a tubular extension **31** of reduced diameter constituting a slide bearing or journal for the longitudinally extending metallic stem **32**. The inner end of the stem is integrally brazed to the inner end **33** of an expansible metallic bellows **34**, closed at its inner end by a metallic disc **36** brazed across the end thereof. The disc is also brazed to the inner end of the stem and serves to hermetically close the vacuumized envelope and unite the stem and bellows in a rigid integral structure. The envelope is evacuated through a tubulation **37** in the dielectric end wall of the bulb.

The stem extends outwardly through the open end **38** of the bellows, which is brazed to the hollow base about the bearing tube **31**, and terminates in an outwardly extending threaded shank **39** on which the solenoid armature **19** is demountably and adjustably secured by interengagement of the shank with armature bore **21**. It will thus be noted that with the parts assembled as shown in Fig. 1, the position of the armature on the shank **39** may be readily adjusted by backing off the set-screw **23** and rotating the armature with a screw-driver engaged in the slot **24**. The range of travel of the armature may thus be adjusted to extremely close limits, and the adjustment may be effected without dismantling the solenoid assembly. It should also be noted that by threading the coil housing outwardly, the maximum range of armature travel may be varied considerably to accommodate altered conditions. Both inward and outward movement of the armature are thus closely controllable. Energizing the solenoid effects an outward pull on the stem, outward movement being resisted by atmospheric pressure acting on the interior of the bellows. Expansion and contraction of the bellows, and corresponding movement of the inner end of the bellows and disc **36**, may thus be controlled from outside the envelope. For some installations it may be advisable or necessary to substitute differently rated coils in the solenoid assembly. This may be accomplished merely by unscrewing the coil housing **14** from the threaded flange **8** and effecting the substitution of a differently rated coil. The armature of course remains in adjusted position.

Movably supported on the inner closed end of the bellows within the envelope is a contact plate assembly responsive to atmospheric pressure interiorly of the bellows for movement in one direction, and responsive to the energized solenoid for movement in the opposite direction. The contact assembly comprises a short, dielectric ceramic pillar or post **41**, aligned with the longitudinal axis of the relay and brazed at its metallized lower end on the disc **36**. A metal ring **42** about the lower end of the post brazed to both post and disc helps to strengthen the union.

At its upper end, the ceramic post is metallized and provided with a metal cap **43**, brazed thereon and supporting in turn, an upright axially aligned and integrally brazed tungsten rod **44**, having a stop disc **46** of slightly larger diameter brazed on its inner free end. A tungsten contact plate **47** is axially movably held intermediate the ends of the tungsten rod by coil springs **48** and **49** axially guided by the rod **44** and positioned on opposite sides of the contact plate so as to resiliently press against its top and bottom surfaces. The contact plate serves to bridge the gap between selected aligned pairs of spaced

contact points **51** and **52** within the evacuated envelope and arranged as shown on the inner ends of contact rods **53**, hermetically sealed in the bulb and constituting terminal leads outside the envelope.

The contact points of each pair preferably lie in a common plane and are diametrically opposed with their inner ends spaced apart and flattened to provide a flat surface contact area **54** for surface engagement by the contact plate. The contact resistance is thus reduced to a minimum and results in an extremely low millivolt loss through the contacts.

To facilitate alternate engagement and disengagement of adjacent pairs of contact points, the pairs of contact points are positioned perpendicular to each other, as shown best in Fig. 2, and the contact points of one pair, the pair **51** for instance, are spaced axially from the contact points of the next adjacent and perpendicular pair **52**. This permits the contact plate **47** to be interposed in the space between the pairs of contact points, reacting under the impetus of atmospheric pressure to engage (Fig. 1) the pair of contact points **51**. Spring **49**, compressed between the contact plate and the cap **43** on the ceramic post, serves to retain the contact plate in resilient engagement with the flat surface **54** of contact points **51**.

In Fig. 3, the contact plate is shown drawn down by the energized solenoid into resilient engagement with the pair of contact points **52**. In this instance, the spring **48**, working between the top surface of the contact plate and the stop disc **46** on the tungsten rod, is compressed and retains the contact plate in resilient engagement with the flat surface **54** of contact points **52**. Deenergizing the coil causes the contact assembly to be carried inwardly again, under the impetus of atmospheric pressure acting on the interior of the bellows. The springs **48** and **49** thus provide over-travel protection for the contact plate and contact points, eliminating destructive impacts and preventing bouncing or chattering of the contact plate against the contact points. Dependable operation and long life are thus assured.

Means are provided connecting one of the contact points of one pair in circuit with the grounded base housing when the contact plate has been drawn down by the solenoid to engage the adjacent pair of contact points. Integrally mounted on the disc **36** adjacent the outer periphery thereof, is a slender rod **56** extending inwardly parallel to the longitudinal axis of the envelope, and terminating in a contact portion **57** at right angles to the rod **56** and overlying one of the contact points **51**. As shown in Figs. 1, 3 and 4, movement of the contact assembly downwardly by contraction of the bellows, carries the rod **56** downwardly until the contact portion **57** engages the underlying contact point **51**. Thus, energizing the solenoid alternately disengages and engages adjacent perpendicular pairs of contact points, and also establishes a grounding circuit between one of the disengaged contact points and the housing. Atmospheric pressure, on deenergizing the solenoid, alternately disengages and engages the adjacent perpendicular pairs of contact points, and disestablishes the grounding circuit by disconnecting the contact portion **57** from the contact point **51** which it overlies. The parts are preferably proportioned to effect engagement of the contact plate with the adjacent pair of contact points before the ground circuit is established. This insures that spring **48** will be loaded and resiliently press against the contact plate. Conversely, disestablishment of the ground circuit is effected before the contact plate is disengaged from the said adjacent pair of contact points. The grounding circuit thus eliminates the hazards created by unintentional transfer of radio frequency energy between a charged circuit and an adjacent disconnected one.

I claim:

1. A vacuum relay comprising a vacuumized envelope

having a longitudinal axis and including a dielectric shell and a metallic housing hermetically sealed together to close the envelope, fixed contact rods hermetically sealed in said dielectric shell and constituting a plurality of pairs of spaced contact points within the envelope and terminal leads outside the envelope, a mobile contact plate mounted on said metallic housing and movable in one direction by atmospheric pressure to engage or disengage a selected pair of said contact points to make or break a circuit therebetween, and means on the metallic housing operatively connected to the contact plate for effecting movement thereof in a direction against atmospheric pressure.

2. The combination according to claim 1, in which said means operatively connected to the contact plate for effecting movement thereof against atmospheric pressure comprises a metallic stem extending out of the housing, a magnetizable armature adjustably mounted on the outer end of the stem, and a solenoid coil adjustably mounted on the metallic housing and operatively enclosing the armature.

3. The combination according to claim 1, in which a spring is interposed in the mounting of the contact plate on each side of the plate.

4. The combination according to claim 1, in which a part of the mounting of said contact plate is a ceramic post to insulate the plate electrically from said metallic housing.

5. A vacuum relay comprising a vacuumized envelope having a longitudinal axis and including a dielectric shell and a metallic housing hermetically sealed together to close the envelope, fixed contact rods hermetically sealed in said dielectric shell and constituting a plurality of pairs of spaced contact points within the envelope and terminal leads outside the envelope, a mobile contact plate mounted on said metallic housing and movable to engage or disengage a selected pair of said contact points to make or break a circuit therebetween, means grounding one contact point of a pair when said contact plate is conductively engaged with the adjacent pair of contact points, and means on the metallic housing operatively connected to the contact plate for effecting movement thereof.

6. The combination according to claim 5, in which said metallic housing comprises part of said grounding circuit.

7. The combination according to claim 5, in which said grounding circuit includes an expansible metallic bellows having a closed inner end extending into the envelope and a stiffly resilient rod integrally fixed at one end on the inner end of the bellows and extending into the envelope in a free end selectively engageable and disengageable with said contact point.

8. A vacuum relay comprising a dielectric bulb having at one end a metallic end cap hermetically sealed thereto, an expansible metallic bellows integrally mounted hermetically on the end cap and extending into the bulb to a closed inner end, the bulb and end cap and bellows constituting an hermetically sealed vacuumized envelope, a dielectric post within the envelope fixed on the closed inner end of the bellows, a conductive contact plate movably supported on the dielectric post, a plurality of pairs of contact rods hermetically sealed in said bulb and constituting spaced contact points within the envelope and terminal leads outside the envelope, and means within the bellows fixed to the closed inner end thereof and extending out of the envelope to control expansion and contraction of said bellows to effect engagement and disengagement of the contact plate with a selected pair of contact points.

9. The combination according to claim 8, in which adjacent pairs of contact points are axially spaced apart and alternately engaged and disengaged by the contact plate.

10. The combination according to claim 8 in which spring means are provided on the dielectric post to press the contact plate resiliently against the engaged pair of contact points.

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