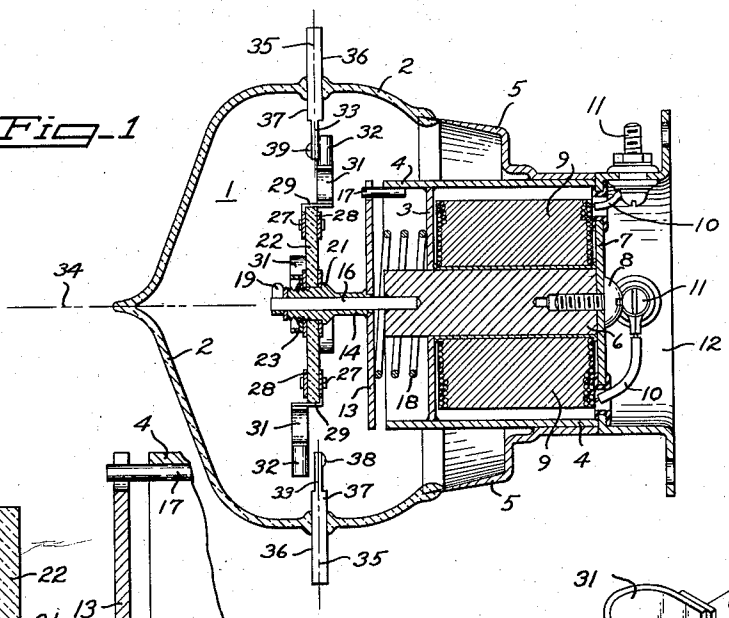
July 15, 1958 L. B. STEWARD ET AL 2,843,701

VACUUM RELAY

Filed Nov. 28, 1955

Fig. 1



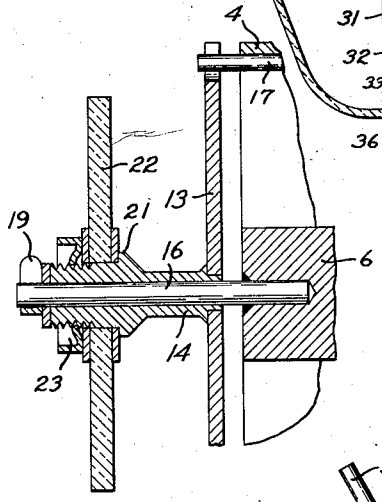


Fig. 3

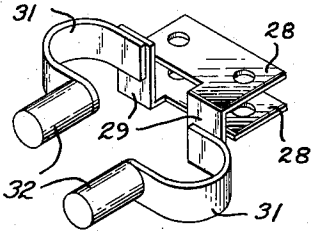


Fig. 4

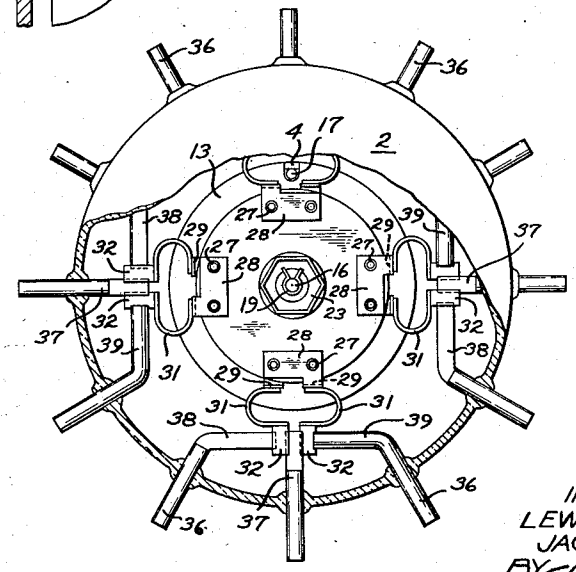


Fig. 2

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# VACUUM RELAY

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10 Claims. (Cl. 200—104)

Our invention relates to a vacuum relay or switch of special usefulness as a transmitting and receiving switch in the communication field.

One of the objects of our invention is the provision of a switch of the type described of low contact resistance, and free of tendency to arc over.

Another object of our invention is the provision of a small size, low operating power, 4-pole double throw switch capable of safely handling comparatively high voltages.

Another object of our invention is the provision of a multi-polar vacuum relay in which the contact resistance remains substantially constant for the life of the implement.

Still another object is the provision of a multi-pole double throw switch with very few moving parts, but all of these arranged in a vacuumized chamber to be operated by electro-magnetic means outside the chamber and in which the energizing coil is readily replaceable with one of like or different characteristics.

Another object is the provision of a switch of particular usefulness in radio frequency work because of very low inductance in its contact parts.

Still another important object of our invention is the provision of a vacuum switch in which the electrical demands in aviation use are fully met, as well as those imposed by mechanical shock and vibration. This switch may be immersed in an insulating liquid if the need arises, since the external resistance path is lower than the internal resistance.

A very important object of our invention is the provision of a switch which can be operated with no dependence whatever upon surrounding atmospheric pressure; and which can therefore be used with uniform operating certainty and efficiency at any altitude either in fixed or aircraft installations.

Other objects will be brought out in the following description of the invention. We do not limit ourselves to the showing made by said description and the drawings, since we may use variant forms of the invention within the scope of the appended claims.

Referring to the drawings:

Fig. 1 is a vertical sectional view taken in the long axis of the switch.

Fig. 2 is an end elevation of our relay, the end wall being partly broken away to disclose the underlying parts.

Fig. 3 is a detail on an enlarged scale, of part of the armature assembly.

Fig. 4 is a perspective view on an enlarged scale of a pair of contact points on their mounting brackets.

In terms of broad inclusion our switch comprises a glass bulb closed on one end with a metallic wall to form a vacuumized envelope. The wall is formed in part by a ferrous cylindrical housing concentric with the long axis of the bulb and on which the bulb is secured by a copper seal ring, and in part by a copper



transverse wall across the adjacent end of the housing. The copper wall is brazed to the housing and forms the bottom of a coil chamber therein, lying on the side opposite to the vacuum chamber. A ferrous cylindrical core concentric with the housing is integrally united with the copper wall, extending on one side into the vacuumized chamber and on the other side in to the coil chamber.

Coil means for energizing the core is disposed in the coil chamber of the housing, preferably being mounted on the core itself. A cover plate closing the coil chamber and housing is secured by a single screw into the end of the core so that the coil may be quickly removed and replaced.

Within the vacuumized chamber are a plurality of groups of three contact rods, spaced apart and fixedly mounted in the glass bulb. Each rod is provided with leads external to the chamber and passing through the glass bulb.

A disk or plate armature slidably mounted within the vacuumized chamber is responsive to a compression spring in one direction, and tot he energized coil in the opposite direction, and carries a dielectric disk on which are mounted a pair of spaced contact points adjacent each group of rods. The parts are so arranged that with movement of the armature in one direction, one of the contact points of each pair firmly engages the central contact rod and one side contact rod of the adjacent group of three rods; and with movement of the armature in the opposite direction, the other contact point of each pair engages the same central contact rod and the other side contact rod of the same group of rods.

The armature and dielectric disk are slidably but nonrotatably arranged on a tungsten stem rigidly fixed in the inner end of the core and extending concentrically therewith and with the long central axis of the implement into the vacuumized chamber past the plane through the central contact rods.

A compression coil spring is interposed between the armature and the copper end wall of the vacuumized chamber, and stop means on the free end of the stem retains the contact points in open circuit position relative to the contact rods.

The energizing means for the core is a coil arranged to fit closely over the core and entirely within the housing. When the cover plate is fastened in place by a single screw the magnetic path around the coil is closed so that magnetic efficiency is assured. Since the movable contact points are insulated from their actuating assembly, the latter and its connected housing is never part of the controlled circuit which includes only the fixed contact rods and the movable contact points. In this construction no pigtails are necessary internally, no electrical loops are set up, and clean contacts are assured.

In greater detail, our vacuum relay comprises a vacuumized chamber **1**, within a glass or other dielectric bulb **2**, closed at its base end with the copper wall **3**, brazed into the cylindrical ferrous housing shell **4**. The shell is joined to the glass bulb in hermetically tight unions by the intervening copper seal **5**, brazed to the shell and united to the bulb edge in a well known metal-to-glass seal.

A magnetic core **6** of ferrous metal is brazed to the wall **3**, extending on both sides of the wall and concentric with the shell in the long axis of the implement. A plate **7**, secured to the core at its outer end, by a screw **8**, provides a closure for the open end of the shell **4**, within which is the coil **9** for energizing the core. Lead wires **10** extending through insulating sleeves arranged in the cover plate provide means for connecting the coil into

a control circuit through external lead screws 11 which extend through the side of the copper mounting flange 12 extending from the plate 7. It is noted that this arrangement facilitates the replacement of the coil assembly with the same or differing electrical values, without disturbing the relay otherwise.

Adjacent the inner end of the core and within the vacuum chamber is a ferrous armature disk 13 fixed on a cylindrical copper sleeve 14, slidably mounted on the stem 16 extending rigidly and concentrically from the end of the core, and prevented from rotation on the stem by the stop pin 17 which engages a slot in the rim of the armature.

A spring 18 surrounding the inner end of the core and bearing against the wall 3 normally presses the armature and sleeve away from the core and against a fixed stop 19 on the stem. The stop is conveniently a wing collar spot welded to the end of the shaft in a position to provide the critically accurate position of the ceramic disk shown in Fig. 1.

The copper sleeve 14 is formed with a flange 21 against which a ceramic plate or disk 22 is firmly secured by a nut 23, threaded on the end of the sleeve and fixed thereon by distortion of the threads against the nut.

The ceramic disk carries on its periphery four evenly spaced groups of pairs of contact points. Riveted rigidly by pins 27 around the perimeter of the ceramic disk at 90° intervals, and arranged in pairs on opposite sides of the disk, are four pairs of oppositely facing identical tungsten bracket plates 28. Each plate is provided along its outer edge with a substantially perpendicular flange 29; and the flanges on each pair extend across the disk in opposite directions to provide a mount for the Inconel U-shaped spring bracket arms 31. Two of these arms oppositely arranged and opening inwardly toward each other, are brazed or spot welded to the flanges of each pair of plates 28; and at the free ends of each arm 31, a short cylindrical tungsten contact point 32 is brazed. These short rods constitute the eight movable contact points of our switch. Inconel is used for the spring bracket arms because it can be annealed, and holds its shape; and most important of all, it retains its spring tension after the bake-out of the implement. The function of the springs which mount the movable contact points on the brittle ceramic disk is to cushion their impact with the fixed contact rods and also compensate for unavoidable minute imperfection in the setting of the moving parts, thus contributing largely to a long operative life.

It will be observed that because of the mounting of each pair of plates 28, the movable contact points of each pair lie on opposite sides of and equally spaced from a plane 33 perpendicular to the central axis 34 of the ceramic disk and its shafts 16. This plane intersects the glass envelope 2 in a line marking the locus of the axes 35 of the fixed contact rods which are sealed into the glass wall of the bulb in groups of three. The exterior parts 36 of these rods constitute leads for connection with the circuits to be controlled. The axis of the entire central rod 37 of each group lies in the plane 33, which defines a position midway between the extended and retracted positions of the armature assembly.

On the inside of the bulb, the central rod 37 is flattened on opposite sides in planes perpendicular to the axis 34 of the implement. On the sides of the central rod of each group are the side rods, each one sealed in the glass wall of the bulb in a radial line, but inside the bulb, bent to lie at right angles to the central rod in end portions 38 and 39. These rods are flattened on one side, rod 38 in planar alignment with the flat near side of the central rod (as viewed in Fig. 2); and rod 39 in planar alignment with the far flat side of the central rod. The flattened ends of the contact rods provide contact surfaces for line engagement by the cylindrical contact points 32 when the latter are moved by the armature to open and close selected circuits.

Fig. 1 shows the parts with four circuits closed, the armature assembly having responded to the pressure of the spring 18, and moved out on the stem 16 against the stop 19. With energizing of the coil 9, the armature assembly is pulled back to seat the armature against the rim of the housing shell, breaking the first four contacts and closing four new ones. In each closing of a circuit, the engagement is that of a straight line on a cylindrical surface with a planar surface.

Because the movable points meet the fixed contact rods firmly with direct linear motion, having no lateral or grinding component, and in line contact within a vacuum, there is a very minimum of wear and sparking, so that our relays have an extremely long useful life. Our relay measuring about 4¼" in diameter by 4½" long and as illustrated and described herein is conservatively rated for 10 amperes R. F. current and a static voltage rating of 10,000 volts per contact. These are safe operating values. In our experiments we have operated our relays with 30 amperes and they will withstand static voltages to 20,000 volts.

We claim:

1. A switch comprising a vacuumized envelope, a plurality of spaced contact rods hermetically extending through the wall of the vacuumized envelope and constituting terminal leads on the outside of the envelope and fixed contact rods on the inside thereof, a fixed stem inside the envelope, a movable resiliently supported contact point slidably arranged on the stem to selectively engage resiliently and disengage the fixed contact rods, and means to move the movably resiliently supported contact point to its selected position.

2. A switch in accordance with claim 1 in which the contact point is a cylinder and the contact rods present adjacent and aligned planar surfaces meeting the contact point in line engagements.

3. A switch in accordance with claim 1 in which the means for moving the contact point in one direction is a compression spring within the vacuumized chamber and for moving the contact point in the opposite direction is an armature within the chamber and a magnetic coil outside the chamber.

4. A switch comprising a vacuumized envelope, a group of three spaced contact rods extending through the wall of the envelope and constituting terminal leads on the ouside of the envelope and fixed contact rods on the inside thereof, a fixed stem inside the envelope, a dielectric plate slidably arranged on the stem, a pair of spaced contact points mounted on the plate to engage one of the points with the center rod and one side rod when the plate is moved forward and engage the other point with the center rod and the other side rod when the plate is moved backward, and means to move the plate selectively backward and forward.

5. A switch in accordance with claim 4 in which the means for moving the contact point in one direction is a compression spring within the vacuumized chamber and for moving the contact point in the opposite direction is an armature within the chamber and a magnetic coil outside the chamber.

6. A switch in accordance with claim 4 in which the spaced contact points of the pair are resiliently mounted on the dielectric plate.

7. A switch in accordance with claim 4 in which means for moving the dielectric plate includes a magnetic coil and means responsive thereto for effecting backward movement and a spring for effecting forward movement.

8. A switch comprising a vacuumized envelope having a metallic end wall, a magnetic core integral with the end wall and extending on both sides thereof, a stem within the envelope and fixed on the core, a sleeve slidable on the stem, an armature disk fixed on the sleeve, a compression spring interposed between the wall and armature disk

and urging the armature away from the core, a dielectric disk fixed on the sleeve, a contact point mounted on the dielectric disk, a plurality of spaced contact rods extending through the wall of the envelope and constituting terminal leads on the outside of the envelope and fixed contact rods on the inside thereof in position to be engaged by the contact point when the armature responds to the spring, and a magnetic coil around the outer end of the core for energizing the core to pull the armature toward the core and disengage the contact point from the rods.

9. A switch comprising a vacuumized envelope, a group of three spaced contact rods extending through the wall of the envelope and constituting terminal leads on the outside of the envelope and fixed contact rods on the inside thereof, a fixed stem inside the envelope, a dielectric plate slidably arranged on the stem, a pair of spaced contact points within the envelope adapted to engage one of the points with the center rod and one side rod when the plate is moved forward and engage the other point with the center rod and the other side rod when the plate is moved backward, means for mounting the pair of contact points on the dielectric plate comprising a pair of like bracket plates fixed to opposite sides of the dielectric plate, a flange on each bracket plate of the pair extending in a direction opposite to the flange on the other plate and U-shaped resilient bracket arm interposed between the flange of each plate and its associated contact point, and means to move the plate selectively backward and forward.

10. A switch comprising a vacuumized envelope having a metallic end wall, a magnetic core integral with the end wall and extending on both sides thereof, a stem within the envelope and fixed on the core, a sleeve slidable on the stem, an armature disk fixed on the sleeve, a compression spring interposed between the wall and armature disk and urging the armature away from the core, a dielectric disk fixed on the sleeve, first and second contact points mounted on the dielectric disk, three spaced contact rods extending through the envelope wall to provide fixed central and two side contact rods on the inside thereof in such position that when the armature responds to the spring the first contact point engages the central contact rod and one of the side rods, and a magnetic coil around the outer end of the core for energizing the core to pull the armature toward the core to disengage the first contact point and engage the second contact point with the central contact rod and the other side rod.



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